Towards Developing Support Tools for Sustainable Control of Gastrointestinal Nematodes in Sheep

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Seer Jonathan Ikurior

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"To Steven A. Ikurior (Daddy!), Kobe Bryant and Chadwick Boseman: 2020 took nothing from us!"

Abstract

Gastro-intestinal nematode (GIN) parasitism is a major animal health challenge for sheep. Parasitized animals typically display a number of clinical signs, including a reduction in voluntary feed intake, altered grazing behaviour and lethargy. The aim of this thesis was to use remote sensing technologies to advance the development of a methodology where early changes in animal behaviour can be used to help identify sheep suffering ill effects of GIN parasitism, especially in a pre-clinical situation. It was hypothesised that lambs with even modest worm burdens will be less active, graze for less time and spend more time resting than those herd mates that were less heavily parasitized.

The movement and behavioural activity of young and mature, infected and uninfected sheep were monitored in a series of studies using global positioning system (GPS) and tri-axial accelerometer sensors. Key behaviours were identified using machine learning techniques. Also assessed was the influence of host genotype on movement activity.

Accelerometry data accurately identified grazing, resting and walking activities of sheep. The sensors were able to identify the effects of GIN parasitism on movement and behaviour in sheep. Clear evidence was found that GIN were associated with reduced movement and overall activity in growing lambs, with reductions in time spent 'grazing' and 'walking' occurring concomitantly with increases in 'resting' activity, and before effects were recorded on growth rates. Host genotype also had an effect on movement activity of lambs in untreated sheep, but not in treated individuals. Adult sheep, however, showed no consistent changes in movement and behaviour associated with parasitism, as measured by faecal egg counts.

Overall, the findings in this thesis have demonstrated the potential value in remote monitoring of sheep as a diagnostic marker to detect the generally subtle behavioural changes associated with changing GIN infection status. Such monitoring could therefore be used as the basis for deciding whether animals need to be treated with anthelmintic on the basis of individual need, and such decisions could be taken early, i.e. before animals have failed to grow adequately or started to manifest more overt signs of clinical illness such as weight loss.

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List of Abbreviations

Definitions of symbols, acronyms and abbreviations

~	symbol for 'regressed against'
|	symbol used to specify the random effect structure in mixed-effects models
2D	Two-dimensional
3D	Three-dimensional
Acc.	Accuracy
AIC	Akaike Information Criterion
Ad lib	Ad libitum
ANOVA	Analysis of variance
BCS	Body Condition Score
BW	Body weight
CI	Confidence Interval
CL	Confidence Limit
CS	Centered and Scaled
DM	Dry Matter
ESRI	Environmental Systems Resource Institute
FN	False negative
g	Gram
GIN	Gastrointestinal Nematodes
GLM	Generalised linear model
GLMM	Generalised linear mixed-effects models
GPS	Global Positioning System
ha	Hectare

h	Hour
HMM	Hidden Markov Model
IgG	Immunoglobulin G
IgM	Immunoglobulin M
IL	Interleukin
IQR	Interquartile Range
Kg	Kilogram
L_1 ... L_5	First to Fifth Stage Nematode Larvae
LMM	Linear mixed-effects models
LW	Liveweight
LWG	Liveweight gain
NZ	New Zealand
NZTM	New Zealand Transverse Mercator
OOB	Out-of-bag error estimates, bootstrapped data used to build classification trees within a random forest algorithm
PIA	Parasite-induced appetence
Pre.	Precision, proportion of correct positive behavioural classifications
R	The R project for statistical computing
SED	Standard Error of the Difference
Sen.	Sensitivity, proportion of correctly classified new data
Spec.	Specificity
SOP	Standard Operating Procedure
TST	Targeted Selective Treatment
TT	Targeted Treatment
VeDBA	Dynamic vectorial body acceleration

VIF	Variance Inflation Factors

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CHAPTER 1 – SUSTAINABLE CONTROL OF GASTRO-INTESTINAL NEMATODES IN SMALL RUMINANTS: A REVIEW OF THE LITERATURE

1.1 Introduction

Helminth management is a prerequisite for efficient livestock production systems that contribute to sustainable goals for global food security (Sargison, 2020). In pasture-based small ruminant production, gastrointestinal nematode (GIN) infections are the foremost helminth constraint impacting efficient food production systems (Vercruysse et al., 2018). GIN parasitism is a major animal health and welfare impediment for grazing sheep of all ages, as well as being an important source of economic loss to livestock producers (Nieuwhof and Bishop, 2005). To date, control of these parasites has been heavily reliant on the use of broad-spectrum anthelmintics, but there is a global increase in resistance to these chemicals as well as increasing consumer demand for a reduced environmental footprint from the use of anthelmintics (Vercruysse et al., 2018). As a result, attention is being given to improving the utility and efficiency of available control resources, especially anthelmintics (Barger, 1999; Charlier et al., 2014). As an example, a Web of Science literature search (verified 29 May 2020) conducted as part of this review using the terms "gastrointestinal nematodes" AND "sustainable control" AND "ruminants" identified 49 journal papers published between 1990 and 2019. The number of research publications on the subject in the last decade was twice the number reported over the preceding two decades combined. The literature search also revealed that the research focus on sustainable control of GIN was largely skewed (34 of 49) towards using anthelmintics sustainably due to drug resistance rather than adopting some alternative strategy to control infection. This is not a significant problem as anthelmintics will continue to have a pivotal role in management of GIN for some time (Pomroy, 2006) and deserves the research attention. It does highlight the need for increased engagement in other non-anthelmintic methods employed for sustainable control of GIN. Alternative and/or complementary strategies to anthelmintic use against GIN, such as vaccine development, have progressed in recent years with Barbervax® (Wormvax Australia Pty Ltd; Besier et al., 2015; Broomfield et al., 2020) and Wirevax® (Afrivet Business Management Pty Ltd) licenced for use in sheep against *H. contortus* in Australia and South Africa respectively. These vaccines require administration on a monthly basis. Overall, vaccines are not currently at levels capable of impactfully managing GIN (Morgan et al., 2019; Claerebout and Geldhof, 2020).

As such, reduced use of anthelmintics integrated with a combination of non-chemical control strategies such as selective breeding, use of bioactive forages and grazing management will underpin sustainable control (Vande Velde et al., 2018). A classic example of optimized use of anthelmintics is targeted selective treatment (TST), which is treatment given to individual animals at times driven by indicator targets rather than as part of traditional parasite control programmes (Charlier et al., 2014). For a programme such as TST to be effective development of farm-side diagnostics needs to occur that can effectively monitor the impact imposed by parasite burden on animals. Thus, finding and developing phenotypic markers for GIN infection that can be easily monitored has been of research interest for a number of groups (Van Wyk and Bath, 2002; Greer et al., 2009; Kenyon and Jackson, 2012; Höglund et al., 2013; Berk et al., 2017).

An important effect of GIN infection on sheep is a reduction in voluntary feed intake, which impacts their grazing behaviour and performance. Early pen trials (Sykes and Coop, 1976; Abbott et al., 1986; Fox et al., 1989) demonstrated that parasite-induced anorexia (PIA) significantly impacted young ruminants, especially during the phase of acquisition of immunity of infection in parasitized lambs (Sykes, 2008). Some of the earliest findings using pair-fed animals demonstrated that PIA was the single largest cause of reduced performance in parasitized lambs, being responsible for 40 – 90% of the overall cost of infection (Dargie, 1980; Sykes et al, 1997). Although potentially important as indicators of disease, to date changes in behaviour in grazing lambs have received relatively little attention from a research perspective. In part, this has been due to a lack of available and cost-effective technology to objectively measure and monitor animal behaviour while on pasture. The advent of cost-effective remote sensing technology has provided the opportunity to objectively measure feed intake at pasture using indirect proxies (Forbes, 2008). The present requirement is for the development of suitable methodologies which use data from these technologies to provide a means for assessing changes in feed intake – see Section 1.8 for further discussion.

The following review will discuss GIN in New Zealand, the epidemiology and aspects of pathophysiology and the immune response that drives the diagnostic markers that are available or are being considered to support sustainable GIN management. Given the pivotal role of anorexia in limiting ruminant productivity, this review focuses on the known mechanisms that underpin PIA, as these are a pre-requisite for the development of support methods to mitigate its impact. Specifically, advances in the tools and technology that can measure animal behaviour and movement on pasture will be reviewed considering their application to assess two underlying mechanisms of subclinical parasitism. Firstly, the occurrence of appetite suppression with associated altered grazing behaviour. Secondly, the cost of acquiring and expressing an immune response to incoming larvae.

1.2 Gastrointestinal nematodes in New Zealand Sheep

A total of 29 species of GINs have been reported in sheep in New Zealand (McKenna, 2009). Of these gastrointestinal parasitism results primarily due to infections with *Haemonchus contortus*, *Teladorsagia circumcincta* and *Trichostrongylus axei* in the abomasum (Vlassoff et al., 2001). In the small intestine, infections are commonly caused by *Trichostrongylus colubriformis*, *Trichostrongylus vitrinus, Nematodirus spathiger*, *Nematodirus filicollis* and *Cooperia curticei*. The species found in the large intestine are common but generally not considered to be important as they usually occur only in smaller numbers (Sutherland and Scott, 2010) and hence not usually of any pathogenic significance. Most sheep are infected with several species at the same time and this co-infection may result in a synergistic/ additive effect to cause parasitic gastroenteritis (Roeber et al., 2013). Of the common species listed above *C. curticei* is arguably the least pathogenic (McKenna, 2009). These nematodes typically occur in all areas of New Zealand, with some exceptions. In particular, *Haemonchus* requires higher temperatures for their larval development and is more problematic in the warmer climate areas of the North Island and then during the warmer months (Vlassoff et al., 2001).

Understanding the life history of GIN is essential to target effective control. The following account of the life cycle is from Soulsby (1982). Adults located in the above locations (predilection sites) shed eggs that pass out in the faeces of infected sheep onto pasture. Development of free-living stages occurs within the temperature range of about 10°C through until 30°C and also requires the presence of moisture and oxygen. The first stage larvae (L_1) develops and hatches inside the faecal pat. This occurs within 24 hours if optimal temperature (22 – 26°C) and humidity (100%) conditions prevail but is slower if cooler temperatures prevail down to a minimum of about 10°C and less successfully if higher temperatures occur. Moulting to second stage larvae (L_2) occurs after L_1 have had a feed on bacteria and protozoa within the faeces. These two stages are the free-living stages of GI nematodes. The L_2 moult to the third stage larvae (L_3, which is the infective stage) is incomplete leaving the L3 covered by a protective, impermeable sheath. L_3 are released from the faeces following rain and dew when temperatures enable activity and they migrate onto pasture where they can be ingested by grazing sheep. The process from egg to L_3 takes a minimum of 5-7 days and 5 – 10 weeks in suboptimal conditions, completing the free-living phase of their life history to start the parasitic phase in sheep host once ingested. Once the L3 stage has been reached survival depends on activity as this stage is unable to feed and has little control of its activity. Under warm conditions the L3 is active and will rapidly deplete its stored metabolic reserves but at cooler temperature of about 5-10°C it will become inactive and can survive for long periods if not desiccated.

Ingested L_3 remove their protective sheath at different sites based on the species of the larvae. Sites for exsheathment are always proximal to the predilection site and the process may occur within 30 minutes of arrival at the appropriate site. *T. circumcincta* larvae exsheath within the rumen whereas *C. curticei* exsheath within the abomasum of the host. Thereafter, the L_3 relocate within 2 – 5 days, to their predilection sites in order to undergo another moult to become L_4, which again moult into the immature adult. This stage eventually matures into a sexually mature adult from14 days post infection. However, depending on the season and species, L_3 /L_4 larvae could undergo arrested development. The implication for this phenomenon is the prevalence of infection might be underestimated. Nonetheless, the pre-patent period – time from when a sheep ingests a L_3 to when nematode eggs appear in faecal samples – ranges from 14 to 42 days (Soulsby, 1982), and is important for two reasons: 1) The commonly recommended interval of 28 days between anthelmintic dosing in young sheep in New Zealand is aimed at minimising pasture contamination, and 2) nematode egg counts provide, at best, a 'picture' of the levels of larval challenge on pasture, three weeks prior to their measurement since the prepatent period is approximately three weeks. If optimal conditions exist then grazing animals could be ingesting substantial burdens of L_3 even though they appear free from GIN infection due to zero faecal egg counts.

1.3 Epidemiology of gastrointestinal nematodes

Infection with GINs occurs as ruminants graze, where infective larval stages are ingested on pasture. On continuously grazed pasture, ruminants potentially have continuous access to infective larvae when they graze, so long as conditions favourable for larval survival and development prevail. In grazing animals, climate (specifically, temperature and moisture) and farm management play a significant role in the timing of presentation of GIN infection pressure (Sutherland and Scott, 2010). Weather factors play a major role in nematode egg hatching, larval development and survival, as well as subsequent migration onto pasture. Farm management practices around pasture management, cross grazing with other ruminants, use of anthelmintics, can also modulate the survivability and concentration of nematode larvae on pasture (O'Connor et al., 2006). As such, this presents arguably as a challenging aspect of standardised GIN intervention in that 1) timing of required anthelmintic treatment will vary from location to location and 2) in specific locations with defined parasite epidemiology, the execution of control too early or too late mean little production benefits will be conferred and derived respectively (Greer et al., 2009). It is this spatial-temporal complex in variation of larval populations that has challenged predictive tools for seasonal pasture larval contamination (Litherland and Deighton, 2008; Morgan et al., 2013).

There is a seasonal variation in the prevalence of GIN genera on pasture. In New Zealand, the general seasonal pattern of GIN in sheep reflects the levels of infective larvae on pasture Faecal nematode egg count numbers in New Zealand typically peak in autumn months (Vlassof et al., 2001). Severity of infection is higher in younger animals than in older animals that have developed an immune response to GIN, consequently harbouring fewer parasites and shedding fewer nematode eggs onto pasture (Sykes, 2010). The immune response in sheep develops gradually. By about 6 months of age there is a measurable reduction in establishment rate of incoming larvae but it takes a further period until about 18 months of age for this immune response to fully mature (Burke and Miller, 2002). As a result, young sheep account for a greater number of the nematodes eggs shed onto pasture, which bears a relationship to the number of L_3 on pasture (Sutherland and Scott, 2010). A significant risk period of parasitism for grazing ewes is the periparturient period, characterised by lowered immunity in the period around parturition (Vlassof et al., 2001). This is a physiological trade-off between reproductive and immunological requirements. However, by weaning the immune response of the ewe has recovered (Beasley et al., 2010). This trade-off is more evident in the greater intensity of parasitism seen in multiparous ewes, as well as in yearling ewes (Sutherland and Scott, 2010). A cardinal feature of this occurrence is an increase in faecal nematode egg output by ewes, especially around mid-lactation and associated with the phenomenon of the peripartum rise in egg counts (PPR). Egg counts rise about 3 weeks (Pre-patent period) after the drop in immunity. Around this time, the most prevalent nematodes in ewes in New Zealand are *Teladorsagia*. The implication for this phenomenon is that when weaned lambs start grazing, they potentially encounter a new generation of infective larvae on pasture ready to infect them if weather conditions have allowed development of these eggs from the ewes to occur. Ewes make the transition back to shedding low nematode eggs around weaning in early summer (Vlassof et al., 2001).

1.4 Pathophysiology of strongylid nematodes in ruminants

Gastrointestinal nematodes are widely regarded as the most important parasites of ruminants due to the production impairments they elicit (Coop et al., 2002). The effects of parasitism are diverse, presenting sometimes as clinical disease that result in animal morbidity and mortality. Other times, and perhaps more significant, parasitised animals show no overt clinical disease while suffering adverse (sub-clinical) effects on production outputs (Morgan et al., 2013). Much of the use of anthelmintics is to prevent these sub-clinical or production-limiting losses rather than to treat incidences of clinical disease (Stromberg et al., 1997), underscoring its role in affecting key physiological responses associated with a protein losing enteropathy and reduced growth rates (Coop and Holmes, 1996). Depending on the parasite species and the portion of the gastrointestinal (GI) tract they inhabit, the pathological changes are relatively constant for both the abomasum and small intestine in that mucosal hyperplasia and metaplasia are noted. In the abomasum with nematodes such as *T. circumcincta* the consequences are the appearance of thickened mucosa and a change in cell type with a consequent rise in abomasal pH (Fox, 1997). In the small intestine with species such as *T. colubriformis* the consequences are also of a mucosal hyperplasia but with villous atrophy (Fox, 1997). In both locations there is a loss of endogenous proteins via leakage of plasma protein, increased cell turnover, increased mucus protein secretion and gut tissue damage due to parasite activity. If the loss of protein exceeds absorption then there will be a reduced growth rate (Fox et al.,1989; Sykes 1994). To a lesser degree, lowered deposits of calcium and phosphorus for skeletal tissue build-up result in reduced bone growth. Infected animals have been shown to utilise 20% more protein than their uninfected counterparts thereby diverting this nutrient requirement from muscle, bone and wool growth (Sykes, 1994). One would assume that ruminants evolved compensatory responses, including to increase feed (nutrient) intake, to mitigate these effects on productivity but the mechanisms involved are not-straightforward (vanHoutert and Sykes, 1996).

1.4.1 Impact of gastrointestinal strongylid nematodes on appetite and feed intake by ruminants

There are a number of observational studies which generally suggest that one response widely associated with GIN parasite infection in ruminants, housed and pasture-based, is a reduction in voluntary feed intake (Coop et al., 1982; Bell et al., 1988; Coop and Holmes, 1996; Forbes et al., 2007). This reduction in feed intake is associated with depressed appetite (Fox et al., 1989; Coop et al., 2002). A number of early studies investigated the effects of chronic trickle infections with *T. circumcincta* and *T. colubriformis* compared to a pair-fed control group and found that chronic subclinical infections depress appetite from 15-20% (Coop et al., 1982; Sykes et al., 1988). In this section, the mechanisms that underly parasite-induced inappetence (anorexia) and consequently reduced feed intake in ruminants are discussed.

1.4.2 Mechanisms of parasite-induced inappetence

Production losses in ruminants have commonly been attributed to depressed appetite owing to parasitic gastroenteritis (Loyacano et al., 2002; Sykes and Coop, 2001), otherwise known as PIA. The exact mechanism underlying PIA is widely regarded as paradoxical, if not unclear (Greer et al., 2009). The reason being when considering the detrimental effects of poor nutrition on host resistance to GIN, it is unclear why infected individuals will voluntarily reduce feed (nutrient) intake at a time when it would be most beneficial. This is principally where the paradox exists, although, it might be that infected individuals make the choice for, to use the jargon expression, "the lesser of two evils" (Sykes and Greer, 2003). Irrespective, the phenomenon of PIA has benefited from explanations from two basic perspectives (Table 1.1).

Table 1.1 Summary of the suggestions for the mechanisms and functions of parasite induced anorexia.

Mechanism	**Reference**	*Function*	**Reference**
Disruption in the balance of peptides, e.g., cholecystokinin, leptin, gastrin, ghrelin	Forbes, 2008	Disease-coping strategy: to allow infected individuals to reduce intake of parasite larvae	Kyriazakis et al., 1998
		Linked with increased anthelmintic efficacy due to reduced rate of passage of ingesta leading to prolonged exposure of GIN to anthelmintics	Ali and Hennessy, 1993
Associated with pro-inflammatory cytokines, e.g., interleukin (IL) -1, IL-6 and tumour necrosis factor (TNF)-α	Meeusen, 1999, Greer et al., 2005a, b	Disease-coping strategy: to allow infected individuals to have increased diet selectivity and to promote an effective immune response	Kyriazakis et al., 1996, Hutchings et al., 2001
		To provide a reliable supply of endogenous glutamine used for immune development to meet the increased demands for splanchnic tissue metabolism in infected individuals	Sykes, 2008

First, it has traditionally been described as a pathological response to parasites (causal perspective) associated with various appetite modulators such as leptin (Greer et al., 2009), gastrin (Fox et al., 1989), cholecystokinin (CCK, Dynes et al., 1998; Fox, 1997) and ghrelin (Forbes et al., 2009). These modulators are thought to be regulated through afferent signals and feedback mechanisms acting on the ventromedial hypothalamus associated with feed intake. For example, the gastrointestinal hormone CCK infused in the ventral hypothalamus altered feed intake, with increases of 10% seen over non-infused sheep (Dynes et al., 1998). Some further evidence for the role of the ventromedial hypothalamus in regulating inappetence associated with *T. colubriformis* and *T. circumcincta* was shown in immune-suppressed lambs dosed weekly with corticosteroids (Greer et al., 2005, 2009). These lambs were found to ingest feed in excess of 30 % over their non-immuno-suppressed lambs. The evidence for leptin's involvement is less consistent; first speculated to increase alongside an increase in plasma gastrin to reduce feed intake in response to infection with *T. circumcincta* by downregulating neuropeptide-Y synthesis, which stimulates feed intake (Fox et al., 2006). Other investigators did not find significant associations between leptin and immune-mediated reduced feed intake (Greer et al., 2009). In another study, a serum increase in leptin was found to be associated with reduced feed intake in the Scottish Blackface sheep breed infected with *T. circumcincta*, but not Suffolk x Greyface sheep (Zaralis et al., 2008a). Conversely, ghrelin, a peptide associated with upregulating neuropeptide-Y, is known to increase transiently in the blood prior to a meal (Sugino et al., 2002) and it was hypothesised that it would be negatively associated with infection-induced anorexia, but no clear association was found (Forbes et al., 2009). Leptin therefore seems more involved in explaining parasite-induced inappetence than ghrelin, but this is likely due to the latter having just one study investigating it in calves and further studies are warranted.

A second, functional, perspective of anorexia is that it is hypothesised to be an adaptation in parasitized animals to enable animals to selectively avoid pasture which has high numbers of infective larvae. This hypothesis supports the reasoning that PIA may have evolved as a disease-coping strategy with a definite purpose, e.g., to reduce intake of parasite larvae. Furthermore, it is hypothesised that such animals can select diets high in certain nutrients to facilitate them to mount a more effective immune response (Kyriazakis et al., 1998). Albeit, the inability of these hypotheses to predict the extent of anorexia, and discriminate the effects of nematode species and predilection sites on anorexia suggests PIA might be a standard protocol for disease expression (Laurenson et al., 2011).

A further explanation could be whether PIA is just a manifestation of 'sickness behaviour'. By drawing parallels between what characterizes sickness behaviour, including an analysis of pro-inflammatory cytokines necessary for such behaviour, Sutherland and Scott (2010) suggested that anorexia might be a by-product of an animal's attempt to mount an effective immune response against parasites. This appears congruent with other reports (Greer et al., 2005) that have suggested PIA to be an immune-mediated response elicited by cytokines such as interleukin (IL)-1, IL-6 and tumour necrosis factor. If this is true, it highlights the paradox of PIA, in that animals would reduce nutrient (feed) intake at a time when such nutrients would be most advantageous. It also highlights the significance of being able to exclusively attribute depressed feed intake as a direct impact of GIN and what purpose a reduction in voluntary feed intake serves.

The classic 'sickness behaviour' favours survival in viral and bacterial diseases since the immune response can remove these pathogens quickly. With helminth parasites the immune response is largely ineffective, at least at first, and hence the stimulus to reduce appetite is ongoing. Overall, these mechanisms remain insufficiently resolved as to whether they "serve" the parasite or animal host. It is possible to assume that the disease state "serves" the parasite's interests. However, parasitic disease is an unnatural state of affairs due more to husbandry, and the parasites almost certainly evolved to live in "healthy" hosts.

The above discussion illustrates that considerable confusion still persists in attempts to explain the mechanism behind anorexia during parasitism. The evidence reviewed tilts towards the hypothesis that changes driven by the host's immune response occur in the normal functioning of the host; these are mediated in different body systems by a number of different pathways.

1.4.3 Estimating Anorexia and Feed Intake

Anorexia in ruminants has been assessed either directly by measurements of feed intake or by some more indirect measurement such as time spent grazing (Forbes et al., 2004; 2007). Measurements of feed intake between anthelmintic-treated and untreated control groups of animals has been used by studies in domestic (Forbes et al., 2000) and wild ruminants (Worsley-Tonks and Ezenwa, 2015), on the premise that removing nematode parasites with anthelmintics will alter PIA in ruminants reflecting the time allocated to feeding behaviour. Feed intake reductions of up to 30 - 60% in subclinical GIN infections in sheep and cattle have been reported (Forbes et al., 2000; Sykes and Coop, 2001;Poppi et al., 1990). In terms of grazing period, dairy cattle treated with eprinomectin, which persists for up to 14+ days, grazed almost an hour longer than untreated controls during this period (Forbes et al., 2004). Similarly, reindeer calves in a semi-domesticated system treated with ivermectin during the study period, consumed 20% more feed than untreated reindeer (Arneberg et al., 1996).

Another proxy for feed intake is to measure live weight, especially live weight gain. Several studies in cattle have shown a positive correlation between reduced feed intake and reduced liveweight gain (Bell et al., 1988; Forbes et al., 2000, 2004). Suarez et al. (1999) demonstrated, albeit with some bias in their feed intake estimation technique, that daily weight loss rate of 0.43 kg in Angus calves corresponded to a 24.9% reduction in feed intake in these individuals at a time of highest pasture larval contamination. This lends added support for measurement of body weights as a proxy for appetite (Arneberg et al., 1996), all other factors considered. In their study with reindeer, Arneberg et al. (1996) showed that subclinically parasitized individuals showed a correlated decline in liveweight gains consistent with the 20% decline in feed intake that was demonstrated. However, in grazing sheep, feed intake reductions have been less consistently accompanied by significant changes in weight gains (Hutching et al., 2000, 2001). When Thamsborg and Agergaard (2002) found an association between reduced herbage intake and reduced live weight in lambs, the effect of parasitism on intake was eliminated if corrected for liveweight. What is not clearly comparable between reports is how liveweight gain is associated with the intensity (precisely known parasite burden) and duration of infection.

1.4.4 Regulation of parasite induced inappetence

Parasites seldom elicit inappetence in ruminant hosts equally (Sykes, 2008). Within animal host populations, young naïve animals, rams at mating and pregnant or lactating ewes benefit most from removal of parasites via anthelmintic treatment, which significantly reverses observed reductions in feed intake. This is directly related to the development of immunity to GIN, which is discussed briefly below and in detail in Section **1.5**. In young sheep, up to 20% reductions in feed intake have been observed (Sykes and Coop, 1976, Sykes et al., 1988), compared to 25 – 30 % reductions in feed intake in pregnant and lactating adult sheep with exposure to modest levels of parasite infection; both groups presenting as clinically normal. Similarly, dry matter intake in ewes treated with anthelmintics prior to lambing was shown to be higher than for untreated controls (Zhong et al., 2017). These authors also reported superior growth rate in the lambs of the treated ewes. However, to illustrate the complexity, these same authors compared the responses in two sheep breeds, and showed that Ujumqin and Small Tailed Han breeds recorded dissimilar results following anthelmintic treatments. Similarly, Jones et al. (2006) failed to demonstrate any significant effect of moderate GIN infection on feed intake of Soay sheep, attributing their finding to the resilience of this breed of sheep. Further, the number and species of GIN actually present in the animals can determine the level of PIA. For instance, infection of young lambs with *H. contortus* has been shown to cause feed intake reductions beginning 2 weeks post infection and for up to six weeks duration (reviewed in Kyriazakis et al., 1998) compared to *Cooperia* not being particularly pathogenic. This shows how other factors play a role in the regulation of appetite and feed intake.

Some studies such as Laurenson et al. (2011) have also shown that the effect of GIN on appetite is not only associated with the number of adult parasites present but is also influenced by the extent of larval challenge and how that relates to the maturity of the immune response mounted by animals. Young ruminants progressively develop their immune response to GIN over the first 18 months of life. This is first notable from about three to six months of age after which it continues to slowly develop. Development of immunity against GI nematodes, which is dependent on parasite species as well as age of the animals, also plays an important role in the observation of parasite-induced anorexia and feed intake reductions. The cost on the host of this emerging immune response has been explored in studies that found that corticosteroid-induced immune suppression ameliorated feed intake and performance in sheep infected with *T. circumcincta* (Greer et al., 2008) and *T. colubriformis* (Greer et al., 2009). In the latter, it was found that up to 30% of the depressed feed intake associated with *Trichostrongylus* spp. infection in lambs could be alleviated via this immunomanipulation. These authors proposed that the principle here is that by suppressing the developing immune response, suspected to play a role in PIA, one reduced production of the mediators that induce anorexia. Despite these findings, steroids can be considered a 'blunt' tool to manipulate the immune response and might have been simplistically used in these studies. It is possible that comparing a range of administered corticosteroids may have enabled more direct effects to be observed.

1.4.5 Nutrition and feed intake

The role of nutrition on feed intake has been explored by providing different planes (quality and quantity) of nutrition (Forbes et al., 2007). Protein is a key requirement to maintain an effective immune response and growth at the same time. Consequently, reduced quality nutrient intake affects host resistance and resilience to GIN infection (Donaldson et al., 2001). The premise for this approach is that higher quality (particularly protein content) diets available to parasitized ruminants compensate for the protein loss associated with infection (Houdijk et al., 2001, Sykes & Coop, 2001), especially that which is required to mount an immune response to GIN. Indeed, anthelmintic-treated and control dairy heifer calves provided with high quality nutrition of white clover and rye grass did not differ significantly in their live weight characteristics despite the continued presence of a low-level larval challenge on this pasture (Forbes et al., 2007). It follows then that the effect of GIN on feed intake can potentially be modified by nutrition. A diet with a high level of protein in particular will result in a reduction in egg counts and worm burden suggestive of an increased immune response (Coop and Holmes, 1996).

Hutchings et al. (2002) attempted to demonstrate host preference for nutrient poor/low larvae contaminated pasture over nutrient rich/heavy larvae contaminated taller grass, showing greater faecal avoidance behaviour in parasitised sheep in comparison to uninfected controls. Others (Forbes, 2008; Hutchings et al., 1998) have shown reduced feed intake reflected by reduced bite size as measured by comparing swards (height, colour etc.) grazed by infected and uninfected individuals. These studies suggest that in response to GI nematode infections, ruminant hosts trade-off high nutrient, taller but heavily contaminated pastures for low nutrient pasture, and that more complex foraging strategies and behaviours may be involved. This issue is discussed more fully in Section **1.8**).

1.4.6 Conclusion

Gastrointestinal nematodes induce anorectic responses in ruminant animals, but it does not appear that a single mechanism is responsible for PIA. The general hypothesis is that there is an interaction between an animal host's level of nutrition and inflammatory and immune regulators, which elicits a response to parasitic infection in a manner that does suppress appetite (Forbes, 2008; Zaralis et al., 2008b). This depresses feed intake variously but particularly in terms of grazing time. The evidence tilts towards the assertion that GIN parasitized ruminants will exhibit depressed or lowered feeding behaviour, compared to groups of animals that have been either treated with anthelmintics or have been immuno-manipulated variously to minimise the impact of parasite-induced anorexia. Whereas these explanations for parasite-induced anorexia offer no unequivocal answers, what is clear from the literature is that GINs trigger behavioural responses or effects in ruminants, one of such being reduced feed intake, a consequence of depressed appetite. Thus, the development of techniques and strategies that detect change in behaviour can be exploited to measure the impact of parasites on their hosts The next section will review the immune response of individuals to infection as a prelude to discussing the ways in which the adverse effects of PIA can be mitigated. This will be followed by a review of the development of indirect measures of PIA as diagnostic markers of GIN.

1.5 Immune response to gastrointestinal nematodes

The introduction of lambs new to pasture presents a high risk for GIN infection and pasture larval contamination. As introduced in Section **1.4.4**, the immune response in sheep is absent at birth and proceeds to develop slowly over many months until reaching a stable mature level at about 12-18 months of age (Stafford et al 1994; McRae et al 2015). Generally, the immune response is characterised by an acquisition phase and an expression phase. However, the speed with which this immune response develops varies between breeds, between individuals within a breed (Baker et al 1999; Stear et al 2007), between nematode species and the intensity of infection. For instance, expression of an immune response to continuous infection with *T. colubriformis* (Dobson et al., 1990) *and H. contortus* (Barger et al., 1985) have been reported to occur in as early as seven weeks in contrast to other species, such as *T. circumcincta*, which are much slower to develop (Stear et al., 2003).

The final extent of the immune response i.e. how well sheep can resist nematodes, also varies between breeds and individuals within breeds (Gamble and Zajac, 1992; Burke and Miller, 2002; Amarante et al., 2004). These latter two aspects have been used to endeavour to breed sheep that are more resistant to nematodes and develop the immune response more rapidly. The epidemiological consequences are that young lambs without a well-developed immunity to the GI nematodes are an important epidemiological risk for contaminating pasture with eggs and consequently L_3. In addition, sheep this age are in their growth phase and utilise large amounts of energy and protein for growth in competition with the developing immune response. It is this demand from mounting an immune response to GIN that is responsible for the subclinical production loss seen in young animals as they start to develop a level of age-specific immunity to GIN (Greer, 2008).

Generally, gastrointestinal nematodes induce a T-helper 2-type immune response, but the effector mechanisms are still not fully understood. To illustrate the point, these cells are associated with clinical signs such as diarrhoea, but without the immune response, the result will be “resilient sheep” that ignore the worms and consequently do not suffer ill effects. This has been recognised as a vital missing link in current understanding of the immune regulated responses to GIN (Charlier et al., 2017). Notwithstanding, the continual exposure of hosts to L_3 is considered important for the development of good immunity (McRae et al., 2015).

Acquiring a good immune response against GINs obviously offers long-term advantages. However, the cost of its acquisition can, under certain conditions, seriously affect the efficiency of production particularly in intensive production (Sykes, 2010; see also Section **1.4.4**). These studies lend evidence to the hypothesis that the pathological effects associated with GIN are not as much a direct consequence of the parasites eliciting tissue damage as they are a consequence of a 'switched-on' immune response. This aspect has been used to endeavour to breed sheep that are more resilient to nematodes, demonstrating delayed immune recognition. This issue is discussed more fully in Section **1.6.1.3**.

1.6 Control of strongylid nematodes in small ruminants

Management of GINs is undergirded by the objective to reduce host exposure to infective stages, especially for young sheep to a level that will allow for the development of protective immunity, while enabling parasitic stage burdens to be manageable (Coop et al., 1982). This has typically been achieved by use of strategic anthelmintic administration, in combination with grazing and stock management, and immune manipulation in its various forms.

The goal of sustainable parasite control is not to eliminate parasites (Sutherland and Scott, 2010; Sargison, 2020); they are here to stay. The key aim of control approaches is to mitigate parasite induced inappetence by reducing challenge to susceptible animals (Kenyon et al., 2012), and it can also be a matter of mitigating death in the case of *H. contortus*. In this regard, the options for GIN management usually integrate evasive host management (Pomroy, 2006) with drug treatments to interrupt the parasites' life histories, and hence suppress infective stages (Jackson et al., 2009). The support tools to achieve these principles are varied. For instance, climate prediction tools could support understanding of episodes of GIN infection pressure on pasture (Morgan et al., 2013). Genomic tools are helping in the development of vaccines and anthelmintics that will be effective at removing parasites (Roeber et al., 2013). A third class of tools include those that have the potential to support monitoring and diagnosis of infection farm-side. This includes tools that inform optimised use of anthelmintics in individual animals based on monitoring their performance (Kenyon et al., 2009). This review will proceed to discuss the latter category and subsequently focus on the diagnostic markers that support the achievement of this goal. Brief mention of evasive host management strategies and non-anthelmintic options available will follow but the focus of discussion is on optimised use of anthelmintics.

1.6.1 Evasive host management/ non-anthelmintic options

This section touches on management practices, use of vaccines, tannins and nematophagous fungi for GIN control but these are mentioned primarily as a lead-in to breeding for genetic resistance and resilience to GIN.

1.6.1.1 Farm and grazing management

This is a combination of pasture and stocking management principles that exploit the biology and epidemiology of GINs (Pomroy, 2017). Pasture management strategies include *rotational/co-grazing* (exploiting the host specificity of several GINs by using alternative animal hosts to 'clean' pastures) and *rapid pasture rotation* (speed grazing animals on pasture and moving onto another). A challenge for rapid pasture rotation is the longevity of L_3 on pasture which is often much longer than the grazing interval required to maintain pasture quality and avoid excessive overgrowth (Brunsdon, 1980). So, unless combined with cross grazing with other ruminants or some procedure such as pasture removal for hay or silage it may mean that larvae are still available when those particular pastures are next grazed. However, it has been noted that the adoption of new grazing systems to mitigate the effects of GINs has been slow, even when measurable gains are observed (Ruiz-Huidobro et al., 2019). These authors showed that intensive cell grazing was associated with a reduction in the species composition harboured by ewes and their lambs over conventional rotational grazing. Elsewhere, Walkden-Brown et al. (2013) demonstrated that intensive rotational grazing provided significantly lower faecal egg counts and reduced frequency for anthelmintic treatments compared with typical management.

1.6.1.2 Non-chemical control and vaccines

Two non-chemical approaches have been the subject of considerable research in recent years. The use of bioactive forages containing tannins either as a direct alternative to synthetic anthelmintic use or for use in combination with anthelmintics. Both are intended to reduce anthelmintic use (Gaudin et al., 2016). These authors found that tannin-containing nutraceuticals alter the biology of multi-resistant and susceptible nematodes, thus representing an option for their sustainable control. even though they caution about the safety of interactions between condensed tannin-rich plants and chemical actives.

A second approach has been to explore the practical use of nematophagous fungi. These organisms consume nematodes as their source of nutrients (Waller and Larsen, 1993; Braga and de Araújo, 2014). Addition of chlamydospores of these fungi, particularly *Duddingtonia flagrans*, into the diet of ruminants provide the opportunity to massively increase the activity of these fungi in the faeces of ruminants and reduce the population of developing larvae (Larsen et al., 1998). The success of this approach is based on the ability of these spores to remain unchanged while passing through the digestive tract and then concentrating in high numbers the in faeces (Peña et al., 2002).

Besides the foregoing, progress has been made with development and licencing of the *H. contortus* (Barber's Pole) vaccine available commercially in Australia (Barbervax®, Wormvax Australia Pty Ltd) and South Africa (Wirevax®, Afrivet Business Management Pty Ltd). As mentioned in Section **1.1**, these vaccines require a monthly administration frequency to confer protection (Charlier et al., 2017). This leads to reduced use of anthelmintics (Basseto et al., 2018; Kebeta et al., 2020) and presumably sheep can be vaccinated at the same time as other routine handling processes, hence no additional handling burden on the animals nor added labour to stock men. However, less progress has been reported in the development of vaccines for other trichostrongylid nematodes.

1.6.1.3 Breeding for Genetic resistance and resilience to GIN

Exploiting the immunological response of resistance or resilience to GIN as a sustainable approach for parasitic infections has been widely investigated (see Section **1.5)**. It has been recognised that there are variations in the timing and effectiveness of the immune response that can develop in different breeds of sheep (Stear et al., 2007). Following these findings further research established that variation within breeds exists and this led to breeding lines of sheep being established in various locations, principally New Zealand (Bisset et al., 1994) and Australia (Kahn et al., 2003; Woolaston, 1992). In the first instance these flocks were principally used to study the immune response in sheep. However, that then progressed to applying these principles in the commercial sphere and encouraging sheep breeders to select and establish lines of sheep that are able to establish more effective immune responses more quickly (Morris et al., 2010).

In the early stages of this research there was debate about the usefulness of breeding sheep for enhanced resistance versus resilience to GIN. Research has been undertaken to select animals for their ability to mount an enhanced response to GIN and limit its establishment (resistance) or the ability to maintain performance in the face of high faecal worm egg counts (resilience), including in the Romney breed of sheep (Bisset et al., 1996; Morris et al., 2000), Perendale sheep (Morris et al., 2005), and in the Scottish Blackface lambs and the Ile de France and Santa Ines breeds of sheep (Albuquerque et al., 2019). These have been predominantly selected based on high and low faecal worm egg counts, although other diagnostic indicators have been investigated in terms of their variation in resistant and resilient animals, e.g. mucous pallor (Burke and Miller, 2008). Both approaches present benefits based on the unique needs of producers but no consensus view on which approach is undisputedly preferable has been reached as of yet (Morgan et al., 2019).

1.6.2 Optimised use of anthelmintics

Control of GINs is still predominantly reliant on anthelmintic use and it appears they will be the frontline means of control until other interventions (e.g. vaccines) advance to a level commensurate with production indices (Kenyon et al., 2017). Anthelmintics are commonly used strategically to reduce the shedding of eggs such that this will give rise to a reduced L_3 challenge that is still enough to induce protective immunity, while not reaching a level at which consequential production loss occurs (Charlier et al, 2017). The timing of these treatments is governed by the annual production cycle of the host, giving rise to the seasonal presence of naïve or less immunologically capable animals (McRae et al., 2015); and climatic conditions favouring larval development and L_3 survival (Morgan et al., 2013). However, due to poor diagnostics and the wish to avoid risk, the use of anthelmintics in these types of programmes can be high.

Up until about 10 years ago, there were three established classes of broad-spectrum anthelmintics; namely benzimidazoles, macrocylic lactones and imidazoles. In 2008 and 2002, two additional classes (amino-acetontrile derivative and spiroindoles) were introduced to the New Zealand market. Unfortunately, the emergence of widespread anthelmintic resistance to all the three original established classes (Kaplan, 2004; Waghorn et al., 2006; Wrigley et al., 2006; Torres-Acosta et al., 2012) as well as more recent reports for the newer actives (Scott et al., 2013; Bartley et al., 2019; Preston et al., 2019), has led to the consensus view that, strategic use of anthelmintics to achieve acceptable production targets is unsustainable in most circumstances, with utility of combination anthelmintics possibly not being as selective (Leathwick, 2014). However, it is only unsustainable given the current low rate of release of new actives. Therefore, optimising anthelmintic usage in terms of the timing and frequency of treatment with the dual goals of achieving reductions in pasture contamination/ challenge and maintaining performance during periods of high risk of PIA (Kenyon et al., 2009). The options for optimised (reduced and efficacious) use of anthelmintics are largely three-fold: combination of actives (Leathwick, 2013); targeted treatment (TT) and targeted selective treatment (TST) (Charlier et al., 2014). Combination therapy is where two or more drugs with different modes of action are administered simultaneously to target the same parasite, on the premise that the likelihood of surviving is reduced when more than one active is given (Little et al., 2011). These authors also demonstrated that there may be synergism of actives in some cases where the combination has better efficacy than the single actives as demonstrated with the combined oral formulation of derquantel-abamectin against nematodes of sheep. Again, this results in reduced opportunity for an individual resistant worm to survive. For TT the administration of anthelmintics is only given to the whole flock at strategic intervals informed by infection pressure, whist TST proposes the treatment of individuals in the flock based on observed diagnostic indicators (further discussion in Section **1.8.2**). The aim of these optimisation strategies is to delay anthelmintic resistance and maintain a population of nematodes with minimal exposure to anthelmintics and remain susceptible to treatment, a strategy termed "*refugia*" (Van Wyk, 2001). To explain it simplistically, the rationale is that the refugia population is available to enable animals recently treated to get infected with small numbers of larvae that would cross breed with these survivors and produce heterozygous progeny rather than allow a survivor to breed with a survivor and produce homozygous progeny. This relies on the ability of anthelmintics to generally kill heterozygotes but not homozygotes (Pomroy, 2017). However, the number of genes involved in resistance is poorly understood and will vary from anthelmintic to anthelmintic. The rationale is generally believed to be independent on whether heterozygotes are susceptible or not. In that sense, it is about trying to ensure that resistance alleles stay at a low frequency (in heterozygote form) and thus any heterozygote worms breed with susceptible worms and gene frequency does not change. But when heterozygote resistant worms breed with others like them, gene frequency increases., Some of the earliest reports recommending the refugia strategy were based on studies by Martin et al. (1981); they conducted a controlled study following the development of thiabendazole resistance in *H. contortus* with and without a proportion of larvae exposed to the drug at each treatment. Several studies have followed since advocating that only a proportion of the parasite population be exposed to the anthelmintic. The literature in small ruminants demonstrate implementing refugia will not necessarily lead to loss of productivity, while slowing the development of resistance, with much of the benefit depending on the ratio of infra- and supra-parasite populations (Dobson et al., 2011a). This applies to all anthelmintic groups studied so far regardless of mode of action. However, these findings are based on studies conducted *in silico* (Leathwick et al., 2008; Dobson et al., 2011b; Leathwick, 2012, 2013; Berk et al., 2016; Laurenson et al., 2016) and in the absence of empirical evidence, the recommendations on reducing anthelmintic resistance selection pressure by refugia management is predominantly based on sound, but nevertheless theoretical models.

1.6.3 Targeted selective treatment

This involves identifying individual animals for treatment using pathophysiological, parasitological or production-based indicators, rather than whole herd treatments (Greer et al., 2009). This practice embodies an alternative to the usual practice of treating all animals in a group when parasitism occurs, even though most GIN occur in only a small percentage of hosts. It has been recognised that the over-dispersion of parasites could be put to good use if those animals suffering from levels of parasitism sufficient to cause considerable production loss or health effects can be identified and treated individually (Kenyon et al., 2009). There is the potential for lowered costs associated with reduced anthelmintic use, while optimising GIN management by increasing the proportion of parasites in *refugia* as untreated animals provide a pool of susceptible parasites. Labour costs may reduce if less anthelmintic treatments are given but not if labour intensive techniques are used to monitor the level of parasitism in the animals (Morgan et al., 2013; Cornelius et al., 2014). However, savings on drugs alone in TST systems are potentially substantial and such savings could offset the investment in the cost of inputs over a period. A challenge, therefore, to this approach is to find appropriate phenotypic markers for inappetence or sub-target performance that can be easily, and affordably, monitored and these have been the subject of recent research (Table 1.2). Equally, it is paramount to develop methodologies for monitoring and detecting appropriate markers. In all, *refugia*-based control as a concept is at present based on sound but still theoretical models, requiring further understanding of the parameters that influence it (Hodgkinson et al., 2019).

1.7 Diagnostic markers of strongylid nematodes

Diagnosis and diagnostic methods are a prerequisite of both targeted (TT) and targeted selective (TST) chemical control approaches and are at the heart of sustainable control of GIN infection. First, they inform treatment decisions, enabling a reduction in undue use of anthelmintics (Charlier et al., 2014). Second, they endeavour to breed for animals with resistance to GIN infection (Stear and Murray, 1994). To be effective in achieving these goals, diagnostic indicators necessarily need to be 1) easy to use; 2) accurate and repeatable; 3) readily deployable farm-side; and 4) cost-effective (Pomroy, 2017). Preston et al. (2014) classified these diagnostic indicators into three major areas: infection-related (e.g. FEC), immune-related (e.g. Eosinophilia), and inherent indicators (e.g. immune cell markers and cytokines). An alternative classification of the types of markers considers a parasitological group – such as FEC, pathophysiological – as in body condition score, and performance-based, as in liveweight gain (Kenyon and Jackson, 2012). Based on these latter classification, a number of studies have exploited these indicator systems in TT and TST approaches. A summary of markers investigated for TT and TST approaches are shown in Table 1.2, with some discussion on the most commonly available diagnostic tool, FEC.

1.7.1 Faecal nematode egg counts

Counting the number of nematode eggs in faeces is an important and useful part of farm animal veterinary practice, and currently the mainstay for GIN diagnosis. In essence it is used as a proxy to estimate the worm burden in an animal. They also give a measure of pasture contamination. However, many studies have shown that the relationship between FEC and worm burden may be unreliable (Bishop and Stear, 2000), especially as animals get older and the immune response limits egg production by individual worms (McKenna and Simpson, 1987). In addition, the FEC data frequently shows aggregative, negative skewed distribution, and a high coefficient of variation (McManus et al., 2014). This has led to commentaries that the main role of faecal egg counts is in understanding the changing epidemiology of helminth parasites (Sargison, 2013). Nevertheless, it is the main measurement used to evaluate GIN load in most research trials, even though the protocols and analytical methods are not standardised and variation can affect the results (McManus et al., 2014). However, the issue is likely not so much the relationship between FEC and worm burden but the relationship between FEC and performance/survival. It is in the latter of these that most uncertainty exists, as previous sections (**1.4.4 and 1.5**) have already indicated a substantial component of lost production appears to be host mediated. Nonetheless, despite the shortcoming of FECs, it is a useful method (though not very precise) to get an indication of the pasture contamination and for evaluating the efficacy of anthelmintics (Eysker and Ploeger, 2000).

Table 1.2 Some diagnostic markers evaluated for targeted selective treatment of gastrointestinal nematode parasitism in small ruminants

Marker	Type	Individual treatment protocol	Reference
Faecal egg count	Parasitological	> 500 eggs/g	Leathwick et al., 2006a
		> 300 eggs/g	Gallidis et al., 2009
		> Group mean eggs/g	Cringoli et al., 2009
Body condition score	Pathophysiological	Individuals with BCS < 2 were treated	Gallidis et al., 2009
			Besier et al., 2010,
			Cornelius et al., 2014
Anaemia index (FAMACHA ©)	Pathophysiological	The individual decision for treatment is usually based on a score of 3	Malan et al., 2001; Vatta et al., 2001; van Wyk and Bath, 2002; Kaplan et al., 2004; Ouzir et al., 2011; Bentounsi et al., 2012)
Live weight	Performance-based	10 to 15 % of the heaviest individuals left untreated	Leathwick et al., 2006ab
Liveweight gain	Performance-based	Lambs treated if they were in the bottom 75% of their peer group in weight gain and were also deemed to be in poor condition (i.e., evidence of breech soiling).	Stafford et al., 2009
Production efficiency (HappyFactor™)	Performance-based	Individuals with < 0.66 efficiency of nutrient utilisation were treated	Greer et al., 2009; Busin et al., 2013; Kenyon et al., 2013
Milk production	Performance-based	Ewes producing more than 2 litres of milk daily were treated	Hoste et al., 2002,
			Gallidis et al., 2009; Gaba et al., 2010
Diarrhea score	Pathophysiological	Individuals with a DISCO score of 3 (semi-liquid faeces) were treated	Ouzir et al., 2011

DISCO: diarrheoa score

1.8 Grazing behaviour and feed intake of parasitised sheep as a marker of GIN infection

A number of studies have shown that GIN will induce a degree of anorexia (see **Section 1.3**). Hence measuring anorexia may be a useful marker for GIN parasitism. Unfortunately, it is difficult to measure anorexia directly and other measurements are chosen as proxies for this measurement. In terms of parasite induced anorexia (PIA), an ideal behaviour to measure is grazing behaviour (Forbes, 2008). Most research conducted on this topic has adopted one of two approaches, either: 1) investigating strategies used by parasitised individuals to reduce contact with infective larvae during grazing (i.e., avoidance behaviour); or 2) adopting to measure PIA directly using proxies. These research outputs do not always strictly adopt one approach or the other since the principles that underpin them often overlap.

The first approach involving faecal avoidance choices is based on the hypothesis that parasitised individuals graze away from faecal contaminated pasture (i.e., higher L3 contaminated), choosing to reject such pastures even if they are taller and of higher nutrient quality (Hutchings et al., 1999; Section **1.4.5**). The mechanisms involved in this behavioural strategy are varied and may be inherent to the animal (e.g., genetic disposition and infection status). For example, Cooper et al. (2000) found that infected sheep avoided areas of pastures that had been experimentally contaminated with *T. circumcincta* larvae by comparison with uninfected sheep.

On the other hand, external factors such as the age of faecal pats and pasture height are hypothesized to alter grazing behaviour. In sheep parasitised with *T. circumcincta*, Hutchings et al. (1998) found that a pasture with more recently deposited faeces was associated with a reduced proportion of bites taken from that sward together with a reduced bite depth and mass. It is plausible that these grazing choices largely translate into changed feed intake. For instance, uninfected sheep which grazed on larvae contaminated pasture suffered significant reductions in feed intake compared to their counterparts on clean pastures (Thamsborg and Ageergaard, 2002). Collectively, these findings indicate that sheep respond to their external environment differently when they are infected with GIN. However, it is not immediately clear how these behavioral responses can be applied or adopted farm-side, in terms of being suitable markers of infection; but conceptually they provide valuable information on the behavioural strategies sheep have developed to reduce further infective larvae ingestion. Importantly, they show that GIN affect grazing behaviour.

In addition, it has been hypothesized that parasitised animals might compensate for reduced feed intake by selecting a diet of higher nutrient (protein) content (Kyriazakis et al., 1998). There is evidence that diet selection is subject to influence by parasitism with animals showing a greater preference for high protein diets (Kyriazakis et al., 1996) in addition to a greater degree of faecal avoidance, as shown above. However, this hypothesis has been tested with variable results and it remains to be investigated whether either faecal avoidance or diet selection are a direct consequence on inappetence. For instance, Cosgrove and Niezen (2000) investigated whether sheep grazing at pasture would choose pasture of higher nutrient value to compensate for the metabolic deficiency caused by parasites but failed to observe an effect as there was no apparent difference on feed intake or dietary selection in lambs 'trigger-treated' at 1000 eggs/g compared with lambs suppressively treated at 2-weekly intervals. In cattle, Forbes et al. (2007) also did not find evidence that parasitised dairy heifers showed greater preference for a more nutritious diet than treated individuals. However, their study provided additional evidence for parasite induced inappetence in cattle, manifest as reduced grazing time and subtle changes in foraging behaviour.

Consequently, whilst it has been shown that parasitised animals might employ faecal avoidance/diet selective strategies, a more direct approach to measuring grazing behaviour appears worthy; but even so, results are sometimes equivocal. Hutchings et al. (2000) found a reduction of 30.5 % and 39 minutes/day in feed intake and grazing time respectively between uninfected control sheep and infected animals. More recently, sheep selected for resilience (shown to have a delayed GIN recognition) were shown to increase feed intake over their genetically resistant counterparts (Greer et al., 2018). However, in another study Hutchings et al. (2001) did not find an effect of parasitism on grazing time or growth rates between non-parasitised control sheep and two groups of sheep dosed with *T. circumcincta* (trickle infected over three- and 14-weeks duration respectively). This was in spite of their feed intake differing between groups; a 13.5% drop in the parasitised animals dosed daily for three weeks compared to the uninfected control group. Conversely, the group dosed for 14 weeks to induce immunity prior to the study commencing, showed an 11% increase in feed intake over the control sheep. Collectively, these results highlight vital points: firstly, measurements of grazing behaviour in sheep grazing at pasture is likely subject to the influence of a wide variety of factors, which might make demonstration of trends difficult. However, these 'grazing' measurements need to be further elucidated as it would seem to be the most appropriate way of determining the impact that GIN parasitism has on voluntary feed intake in grazing sheep. Secondly, there needs to be an understanding of how changes in grazing behaviour affect animal performance in terms of growth rates. It is possible that some of these strategies may have evolved as a mechanism of resilience, i.e., the ability to maintain performance (live weight) in the presence of infection. In the above cited study by Hutchings et al. (2000) where parasitised sheep reduced feed intake and grazing time, these effects did not appear to affect the live weight gain of parasitised individuals. Conversely, in cattle, there has been demonstrated a greater consistency between reduced feed intake and reduced liveweight gain, specifically observed in a series of studies investigating the effects of parasitic gastroenteritis on feed intake and grazing behaviour (Forbes, 2008). This latter result is consistent with observations of pair-fed housed sheep where reduced growth rates were apparent in the parasitised animals (Sykes and Coop, 1976 and 1977; Coop et al., 1982).

1.8.1 Methods for assessing inappetence/ feed intake

Aspects of this section have been introduced in Sections **1.4.3** and **1.4.5**. The methods for measuring inappetence in grazing ruminants are usually indirect proxies of feed intake, as it may be impracticable to directly measure intake at pasture (Table 1.3). Some of the methods include using synthetic or natural plant constituents (e.g. plant cuticular waxes called n-alkanes) as dietary markers to estimate feed intake by measuring both dietary digestibility and faecal output (Lippke, 2002); estimating intake by inferring from animal performance after direct weighing over short periods (Macoon et al., 2003); measuring sward characteristics before and after grazing (Forbes, 2008); and intake estimates based on standard nutrient requirement (Coop et al., 2002). There are limitations associated with some of these methods; for instance, caution was advised in the early 1990s for the use of controlled release devices in research to estimate feed intake via faecal output owing to inconsistent release rates (Parker et al., 1990; Buntinx et al 1992). Other workers have minimised this limitation by repeated sampling after dosing and using set-stocked lambs to avoid significant dietary changes (Thamsborg and Agergaard, 2002).

In cattle, an established methodology which used jaw movement recorders for studying grazing behaviour (Rutter et al., 1997b) was deployed to observe time spent grazing as an estimate of grazing behaviour in order to determine the magnitude of expression of PIA, while relating observed changes to animal performance (Forbes, 2008). In sheep, investigations using the latter have received relatively little attention from a research perspective. In part, this has been due to a lack of available and cost-effective technology to objectively measure and monitor animal behaviour while on pasture. However, the advent of cost-effective and miniature remote sensing technology has provided the opportunity to objectively measure feed intake in a practical manner and has started to allow some studies in the field although they are still limited in their number so far. For example, a study using global positioning system (GPS) sensors to monitor stud ewes demonstrated a relationship between faecal egg counts and the distance travelled by sheep (Falzon et al., 2013). In another study using tri-axial accelerometers placed on a neck collar to record the temporal dynamics in activity patterns of the animals, parasitized sheep exhibited lower complexity, i.e. less irregularity, in their activity patterns than non-parasitized sheep (Burgunder et al., 2018).

Table 1.3 Measurements for anorexia in (semi)pasture-based small ruminants infected with gastrointestinal nematodes

Proxy measurement	Livestock model system	Study method	Nematode infection	Main finding	Reference
Herbage intake (g DM/day)	Suppressive treated Vs. Trigger treated lambs	*n*-alkane bolus	Natural infection with *Haemonchus*, *Teladorsagia*, *Trichostrongylus*, *Nematodirus*, and *Cooperia*	No effect of parasitism on choice or amount of herbage intake.	Cosgrove and Niezen, 2000
Herbage intake (g DM/day); time spent grazing	Parasitised Vs. non-parasitised lambs	*n*-alkanes; direct observation and vibracorders	Daily dose of 2500 L_3 *T. circumcincta*	Parasitized sheep spent less time grazing each day and had lower daily herbage intakes compared with non-parasitized sheep	Hutchings et al., 2000
Time spent grazing (Min/day)	Parasitised Vs. Immune Vs. Uninfected control lambs	Activity recorders and video	Daily doses of L3 *T. circumcincta* for three (parasitised) and 14 weeks (immune)	Compared with uninfected control sheep, immune sheep had increased rates of herbage intake and activity, and vice versa for parasitized sheep.	Hutchings et al., 2001
Herbage intake; post-grazing sward height (cm)	Lambs in low, medium and high stocking rate groups grazed on contaminated pastures Vs. low, medium and high stocking rate groups grazed on clean pastures	Chrome-oxide bolus; Rising plate meter	An infection dose of 10 000 L_3/40 kg animal from donors naturally infected with predominantly *Teladorsagia* and *Trichostronglus* spp.	No effect of infection on feed intake observed after adjusting for body weight.	Thamsborg and Ageergard, 2002

Table 1.3 ***Con't*** Measurements for anorexia in (semi)pasture-based small ruminants infected with gastrointestinal nematodes

Proxy measurement	Livestock model system	Study method	Nematode infection	Main finding	Reference
Distance travelled (km/day)	Worm egg counts in natural infected adult ewes	GPS	Natural infection; unspecified	Ewes with high egg output showed increased distance travelled	Falzon et al., 2013
Activity level	Treated Vs. Control animals	Accelerometry	*H. contortus*	Decrease in mean activity level	Babayani, 2016
Forage intake (g DM/day)	Untreated, male and female feral Soay sheep Vs. Treated, male and female feral Soay sheep	*n*-alkane	Natural infection with *T. circumcincta*	No detectable effect on intake	Jones et al., 2006
Feed intake (g DM/day)	Treated Vs. Untreated ewes in a semi-grazing system	Daily measurements of feed refusals during indoor feeding	Natural infection during daily pasture grazing, comprising *H. contortus*, *T. colubriformis* and *T. circumcincta*	Significant increase in intake in treated ewes	Zhong et al., 2017

More recently, the degree of anaemia in grazing small ruminants subject to natural *H. contortus* infection was shown to be predicted by individual activity measured by accelerometers which also predicted individual response to treatment (Montout et al., 2020). Clearly, these technologies can allow the development/validation of indirect proxies for assessments of PIA. To date, no method exists that assesses the movement and behavioural cost associated with GIN from these devices and then utilises such information to make targeted treatment decisions for non-blood sucking trichostrongylids. For this to occur, it is paramount that measurements derived from such sensors are shown to be good surrogates for feed intake and grazing behaviour. When undertaking behavioural observations, such as measuring grazing behaviour, it is also vital to understand the theoretical background of making these measurements. The following section will review aspects of recording and analysing measured behaviour and provide a commentary on technology-aided automated behaviour recording. Specifically, GPS and tri-axial accelerometer sensors will be discussed.

1.9 General considerations for measuring behaviour

According to Mononen (2008), an animal's behaviour is defined as its movement in space and time. Within a specified time period, the occurrence of a behaviour of interest is called a behavioural bout, which can either be a relatively short bout (i.e. an event) or a relatively long bout (i.e. a state). The objective of behaviour observational studies is to capture a representative sample of daily activity budgets and behavioural responses to external and internal stimuli, whilst ensuring minimal disturbance on the animal (Altmann 1974). In the field of sheep health and production, behavioural observations have been employed in a wide array of contexts, including to investigate foraging behaviour (Rutter et al., 1997b; Lin et al., 2011; Galli et al., 2011), gait and posture (Radeski and Ilieski, 2017; Barwick et al., 2018a) and maternal behaviour (Dwyer and Lawrence, 2000; Keller et al., 2003). With regard to foraging behaviour, studies have used various sampling methods, including focal animal sampling, scan sampling and all-occurrence sampling to construct metrics like time-activity budgets (Altmann, 1974, Bishop et al., 2014, Robinson et al., 2017). Whilst direct visual observation of behaviour has been useful for behavioural observations, there exist several limitations in the applicability of observational studies (reviewed in Brown et al., 2013). This has paved the way for the proliferation of remote monitoring of animal behaviour using animal-attached bio-loggers (Ropert-Coudert and Wilson, 2005). It is worth mentioning, however, that the use of these bio-loggers for behavioural assessments are not without pitfalls, including: 1) target animals can behave unexpectedly, which an observer would duly note if it were during a sampling period in observational studies; 2) measuring devices can be inaccurate; and 3) sometimes the time sampling intervals used for behaviour measurement might be unsuited to measure a behaviour of interest (Hämäläinen et al., 2016). Notwithstanding, encouraging signs exist in the few studies that have used accelerometers and GPS sensors for monitoring the health and welfare of grazing sheep (Table 1.4).

Martin and Bateson (2007) present a concise guide for the considerations required to measure behaviour and is a handy go-to text for several aspects of behavioural studies. Without delving too deeply, four broad areas of interest highlighted by their introductory guide are the need for preliminary analysis on behavioural studies, validating recording tools, the reliability and validity of measures, and analysis and interpretation of data. The rationale for these points have been underscored in the subsequent sections.

1.10 Global positioning systems (GPS) in animal behavioural research

1.10.1 GPS technology

GPS technology supports time-space location of objects on the earth (Rutter et al., 1997a). This system is made possible by 24 satellites arranged in space with five to eight being visible from any point on earth at any time. The satellites orbit the earth and are responsible for generating and transmitting space-time stamped radio signals to receivers on the earth (GPS receivers). Receivers collect these signals as latitude and longitude coordinates and record these as a position on the earth (location estimates). Between the satellites in space and end-user receivers there is a network of ground-based stations to monitor satellite information (health status and time, and satellite location) to ensure correct operation of the system (Turner et al., 2000). Besides the cost associated with acquiring a GPS receiver alongside proprietary software and equipment, there is no payment associated with using basic GPS signals (Rodgers et al., 1996).

Table 1.4 Use of GPS and accelerometer remote sensing technology for health and welfare monitoring of grazing sheep.

Technology	Study system	Measurements/ health indicator	Reference
Accelerometer- IceTag® Sensor	Investigating posture and behavioural changes in lambs affected with Neuronal ceroid lipofuscinoses (NCL)	Stand, Graze, Walk, Ruminate, Alert or Idle	Cronin et al., 2016
A GPS Lassen iQ module (Trimble Navigation Limited, Sunnyvale, CA, USA)	Investigating the effect of peri-conceptual undernutrition in dam on locomotor activity of lamb offspring	Distance travelled	Donovan et al., 2013
A GPS UNE Tracker II system (Fastrax IT03-02 chipset)	Investigating the relationship between faecal egg counts and movement activity of ewes	Distance travelled	Falzon et al., 2013
Garmin Forerunner 910XT GPS devices (Garmin Limited, Lenexa, KS, USA)	Investigating the effect of restricted placental growth and function in ewes on movement activity of lamb progeny at 30 and 43 weeks of age	Distance travelled	Kaur et al., 2016
Accelerometers – Actiwatches (Actiwatch Mini; Linton Instruments) worn on collars	Investigating circadian behaviour in transgenic Huntington's disease sheep	Total activity	Morton et al., 2014

1.10.2 Use of GPS for health monitoring in livestock

While marine and wildlife studies have historically dominated the literature on GPS animal-based telemetry (Cagnacci et al., 2010; Hebblewhite and Haydon, 2010; Latham et al., 2015; Tomkiewicz et al., 2010), the last few years has seen the production of smaller, low-cost devices capable of being deployed on several other species of animals in a wide range of applications (Fogarty et al., 2018). In domestic ruminants for instance, GPS tracking collars have been used to study activity budgets and hourly activity patterns of Zebu cattle (Schlecht et al., 2004), grazing preferences of sheep (Rutter et al., 1997a) and cattle (Tomkins et al., 2009), and distance travelled by tame red deer (Pépin et al., 2004). The potential exists to use these ground-based sensors to record fine-scale movements of domestic animals to gain insight into their behaviour under normal and / or pathological challenge. This is assuming GPS-based animal monitoring can differentiate changes in movement behaviour of healthy and challenged animal subjects in real time and under field conditions. To date they have only been used in a limited number of studies. For example, Donovan et al. (2013) found an association between periconceptual undernutrition of the dam and reduced movement of their offspring monitored with GPS collars at 18 months of age. Elsewhere, Kaur et al. (2016) used GPS measurements to investigate the effect of placental restriction and function of ewes on the distance travelled by their offspring at 30- and 43 weeks of age. In the field of parasitology, Falzon et al. (2013) found a positive relationship between faecal egg counts (FEC) and distance travelled by ewes monitored with GPS collars over a 24 h period.

There have been few studies using lightweight commercially available GPS devices and they have not yet been validated per se for monitoring small ruminants on pasture, especially when managed in areas with a limited space resource(Fogarty et al., 2018). The advent of cost-effective commercially available GPS tracking collars will likely see their use in sheep for health monitoring purposes increase. For example, all four published papers reviewed where GPS tracking was used for health and welfare monitoring occurred in the 2000s. When measures such as distance travelled are used as proxy or surrogate for other measures, for instance anorexia, it is important to validate both the surrogate measure against itself and also with respect to features of the true measure (i.e., anorexia) for which the GPS sensor data will act as proxy.

1.10.3 Advantages and disadvantages of GPS technology

Video recordings and direct observations in the field have traditionally characterised animal movement and behavioural studies. These methods, whilst beneficial, are plagued by some challenges, namely the labour and time consumed in executing them (McLennan et al., 2015); human observers tend to be perceived as intrusive by animals thereby altering animals' behaviour (Nielsen, 2013). Observers are also faced with the constraint of being unable to make observations in difficult weather, potentially losing data. Video recordings produce large volumes of data and can be time-consuming to process (Tomkiewicz, et al., 2010). In contrast, GPS collars have the advantage of recording fine scale animal location data with a high temporal frequency in a non-intrusive manner (Hebblewhite and Haydon, 2010). Large datasets of space-time points can be collected over a relatively short period, under the same conditions the animal is in without the constraint presented by or to human observers. However, there exists a trade-off between battery life and the frequency of data collection (Swain et al., 2008), and the ability to easily download the stored data.

The battery life of GPS units is a major challenge identified with GPS technology in animal tracking and ecology studies (Brown et al., 2012; Cagnacci et al., 2010). A higher recording frequency will provide better location estimates, but at a cost to battery life (Dewhirst et al., 2016). The result is long-term studies have opted for a lower recording frequency for location data (Nelson et al., 2004, Frair et al., 2005), although lower recording frequencies have been shown to underestimate certain GPS-based metrics, e.g., distance travelled, by up to 93% (Marcus-Rowcliffe et al., 2012). With advancing technology, the dilemma presented by this trade-off has gradually decreased as GPS monitors have improved. In addition, there are other complementary technologies that compensate for the potential inaccuracies in GPS-based location data when intervals are set to longer durations for battery purposes. For example, Brown et al. (2012) presented compelling results of the reduced trade-off between accuracy and longevity by combining GPS-based location data with activity data generated from an accelerometer sensor, since accelerometers consume less power and run for longer (the accelerometer technology is discussed more fully in **Section1.11**). In so doing, they were able to obtain fine-scale location data when the animal was moving, while minimising excessive location data recording when the animal was at rest. Such a direction presents a viable area of research for small ruminant disease monitoring using sensor technologies. More recently, Dewhirst et al. (2016) used a low power approach called drift-corrected dead reckoning (i.e., calculating current position of some moving object by using a previously determined position) to overcome the limitation of recording GPS location data infrequently.

The defined data logging schedule in modern GPS receivers affects location estimates and on occasions can produce location estimate error of several kilometres (Villepique et al., 2008). Indeed, several authors (Cargnelutti et al., 2007, Adams et al., 2013, Forin-Wiart et al., 2015) have assessed reliability and accuracy of GPS receivers for varying purposes, with recorded location errors ranging from 4.4 m to 208 m. The common methodology employed by these studies was on the performance of receivers when providing location estimates when stationary and when in motion. Such assessments assist in the selection of appropriate solutions to correct errors (Schlecht et al., 2004). The suggestion therefore is that using GPS receivers to monitor the fine-scale movement and location of animals could benefit from preliminary analysis on the accuracy and performance of such units (Cagnacci et al., 2010).

The cost associated with GPS receivers represent a challenge for the use of GPS telemetry in animal studies. While the technology affords the mitigation of the human resource cost and risk associated with observers in the field, the GPS receiver can be a substantial investment in itself (Tomkiewicz et al., 2010). A closely related disadvantage to high cost of GPS receivers is that invariably, study sample sizes tend to be smaller, leading to the making of poor or non-representative population-level inferences (Hebblewhite and Haydon, 2010). This has led to questions of just how accurate inferences derived from fine-scale, low power studies can be? The answer, suggests Trotter et al. (2010) would depend on the research question and the methodology involved in making inferences. For the eventual practical application in the field, this technology will need to be applied to all animals if some form of TST regime is to be implemented.

1.10.4 GPS-based location data errors

Aspects of the reliability of GPS receivers in terms of the accuracy that they log location estimates has been mentioned in the previous section (1.10.3). Hulbert and French (2001) and Frair et al. (2010) describe fix success rate error (FSR) and location error (LE) as two common errors associated with GPS receivers. A GPS fix is the process of successfully acquiring a GPS location (D’eon et al., 2002) and the fix success rate error describes an error associated with a receiver’s failed attempt to record a location or point which results in missing datapoints. Location errors are characterised by inaccurate estimated location positions whereby the receiver estimates a location that is different from the actual or “true” position. A range of factors have been associated with producing these errors, namely environmental such as canopy closure, buildings and atmospheric distortions (Parraga Aguado et al., 2017) and technological including the number of satellites available to send signals, frequency at which positions are recorded (i.e. the fix interval), and the GPS receiver itself (Cushman, 2010) . As these satellites are in fixed orbits, the satellites used by any ground station changes over time, although the spatial distribution of orbits should ensure that at least eight are visible at any time (Cagnacci et al., 2010), but in New Zealand at certain times it could be up to 12 (Beavan et al., 2016). The fix acquisition interval set in the GPS monitors has been shown to have a significant influence on the precision of data derived (Forin-Wiart et al., 2015). It has been widely reported that the shorter the interval, the more precise the estimates of location made by receivers will be (Hulbert and French, 2001, Swain et al., 2008). The reverse holds true for log intervals set at longer durations. In their 2015 article, Latham et al. commented that the disparity between the distance estimated from the GPS locations and the real distance moved increases as fix-rate declines (i.e. longer period between fixes).

1.10.5 Processing and analysis of GPS data

It is commonly agreed that obtaining reliable GPS location estimates is contingent on some form of correction (Frair et al., 2010). Early studies on GPS use in wildlife reported mean location errors of up to 1.5 km, with maximum errors measuring up to 8 km (Harris et al., 1990; Fancy et al., 1998,). Whereas contemporary GPS receivers record lower location errors in the range 10 to 28 m (Cain et al. 2005; Hansen & Riggs 2008), on occasion errors up to several km have been found (Villepique et al., 2008), necessitating some form of data correction. However, the challenge is how data should be cleaned or screened without losing vital information while arriving at the right inferences (Ironside et al., 2017). The literature on this subject is extensive, and various methodologies have been reported on how to screen data (Cushman, 2010; Dewhirst et al., 2016; Frair et al., 2010; Schlecht et al., 2004; Smouse et al., 2010; Williams et al., 2016). Features used for data screening include setting a limit on the number of satellites involved in a fix (location estimate). When a fix is obtained from three satellites, the location data is referred to as two-dimensional (2-D); when at least four satellites are used to obtain a location, the fix is said to be three-dimensional (3-D). In terms of the quality of the satellite geometry (i.e., the distribution of satellites across the sky), two associated terms are described, namely horizontal dilution of precision (HDOP; associated with 2-D fix) and positional dilution of precision (PDOP; associated with 3-D fix). Generally, lower values for

HDOP and PDOP represent better quality location estimates. Collectively, the number of satellites used to obtain a GPS position and the quality of satellite geometry can be used as processing tools to screen out poor location estimates (Ironside et al., 2017).

Beside the above methods, GPS location data can be differentially corrected using a procedure called differential GPS (DGPS) (Turner et al., 2000). The purpose of DGPS is to improve the geographical accuracy of GPS positions by correcting or filtering out components of location error in the data recorded by commercial GPS receivers (rovers) by using data from a stationary GPS receiver (base station) with a known geographical position (Rodgers et al, 1996; Moen et al., 1997). The base station data can be used to calculate the magnitude of errors that apply to the GPS receiver which then can be removed from location fixes. For instance, Weih et al. (2009) improved the accuracy of the data collected by three recreational grade GPS receivers by up to 0.9 meters using differentially corrected GPS.

Overall, the use of GPS-based technology for animal movement and location studies must be preceded by an evaluation of the errors in spatial inaccuracy of the acquired location, and missing data in the form of failed location attempts. These errors, especially when combined (Frair et al., 2010), can result in misleading inferences on animal movement and behaviour. Following the foregoing, the data collected by GPS receivers can then be used to infer what an animal is doing. For example, speed measured directly using GPS, or derived from consecutive tracking locations, has been used to infer animals travelling and resting during migration (Camp et al., 2016), and during foraging trips (Gipson et al., 2012).

One question that arises from using GPS based location data is what degree of error is acceptable, or indeed whether the level of precision from an 'accepted' degree of error is adequate to answer a researcher's question. In the context of this present review, Another consideration is whether a GIN infected sheep moves 'differently' than an uninfected sheep, and if so how long it takes for such a change in movement, if any, to occur. If spatial data logged from these animals is compared for an entire day or over several days, then perhaps larger errors might not a problem. However, if the differences occur at short time scales, large errors (defined as >7.8 m, by the US Government; https://www.gps.gov) may swamp the study signal. Therefore, it is paramount that errors associated with units be established early on. It is not currently known if there will be a difference in movement behaviour between infected and uninfected animals nor what or how such a difference reflects in the animal. Hence, the inclination should initially be towards a higher performing receiver to err on the side of caution.

1.11 Accelerometers

1.11.1 Accelerometer Sensor Technology

Accelerometers are electromechanical devices used to measure acceleration forces. They may be uniaxial, biaxial or triaxial. Tri-accelerometers measure movement in three dimensions simultaneously (Shepard et al., 2008). The earliest adoption of accelerometers for measuring animal activity was in an investigation on porpoising behaviour of Adélie penguins (Yoda et al., 1999). Prior to that they had been widely used to monitor human behaviour and health (Mathie et al., 2004). Accelerometers measure movements of the body generating acceleration signals which can be used to determine the intensity of physical activity over time (Chen and Bassett, 2005). Piezoelectric sensors in the accelerometers produce electrical signals proportional to the acceleration it detects (Shepard et al., 2008). Depending on the needs of the researcher, this data can be sampled multiple times per second (hertz, hz) and filtered to remove signals unlikely to be caused by movement such as electrical interference, temperature changes, vibration (Chen and Bassett, 2005). The signals can be summed across a user-defined period (epoch) and acceleration output can read in one to three dimensions, also called vectors, namely anteroposterior (X-axis), vertical (Y-axis), and mediolateral (Z-axis) (Steele et al., 2000).

Accelerometers have the appeal of being relatively low cost and small in size (Chen et al., 2005, Whitney et al., 2007, Guo et al., 2009). Therefore, they have been well suited to monitor animals with a varied size range from large blue whales – *Balaenoptera musculus*, (Goldbogen et al. 2013); to small-bodied alpine chipmunks – *Tamias alpinus,* (Hammond et al. 2016). Further, accelerometers present an opportunity to monitor animal behaviour in a non-intrusive manner, while overcoming the limitation of collecting behaviour data under difficult weather (Brown et al., 2013; Shepard et al., 2008).

Due these qualities, and the fact that accelerometers are flexible in their deployment (Wilson, 2006), they have allowed automatic behavioural monitoring of pasture-based livestock such as cattle, goats and sheep (Moreau et al., 2009; Oudshoorn et al., 2012; Radeski and Ilieski, 2017; Rayas-Amor et al., 2017). They have also been used extensively to monitor specific behaviour in many other species, including Eurasian beavers (*Castor fiber*; Graf et al., 2015), griffon vultures (*Gyps fulvus*; Nathan, 2012), polar bears (*Ursus maritimus*; Pagano et al., 2017) and white tip reef sharks (*Triaenodon obesus*; Whitney et al., 2007).

The adoption of accelerometers, for animal observation studies offers the opportunity to use them to improve animal health, welfare and management (Radeski and Ilieski, 2017). These technologies allow monitoring of animals with minimal influence on the animal (Büchel and Sundrum, 2014) and its environment. Therefore, the time and energy requirements which animals allocate to different behaviours and activities, in response to their internal and external environment, can be investigated (Shepard et al., 2008). Consequently, several accelerometer-informed behavioural studies have sought to validate the ability of these units to predict specific behaviour.

1.11.2 Analysis of acceleration data

There are essentially two main types of variables that can be derived from tri-axial acceleration data that are relevant to the identification of behaviour. These are static acceleration, which is dependent on gravity and describes the posture (e.g. standing or lying) of the animal, and dynamic body acceleration, which reflects the body movement of the animal (Shepard et al., 2008). Static acceleration is measurable due to the subtle effects of the rotation of the earth. Both these variables can be measured in each of the three-dimensional axes with X for 'surge', Y for 'sway' and Z for 'heave' (Fehlmann et al., 2017). Data from the three axes can also be combined to give a general index of body motion.

Static acceleration was first described by Shepard et al., (2008a) and this was calculated over a two second period (= epoch). Every subsequent study to date has also calculated this parameter over a two second period. From these results, the angles of pitch and roll are calculated, and can be converted to a three-dimensional orientation. Pitch is calculated as the arcsine of x and roll as the arcsine of y (Shepard et al., 2008b). Whilst it is possible to use each variable independently the most used approach is to combine all 3 axes together to obtain a measure of acceleration. For this two approaches have been used. Tri-axial dynamic body acceleration (DBA), which represents overall body movement (Fehlmann et al., 2017; Shepard et al., 2008a; Wilson, 2006), is calculated as the difference between raw and static acceleration from each axis, as shown in Equation 1.1;

$$\text{DBA} = |x| + |y| + |z| \qquad \text{(Equation 1.1)}$$

where x, y and z are the derived dynamic accelerations at any point in time corresponding to the three orthogonal axes of the accelerometer. The second approach is to use their vectorial sum (VeDBA), which is computed using the dynamic components of the signal to assess the 'activity level' of the individual given by (Alvarenga et al., 2016), as expressed in Equation 1.2:

$$\mathrm{VeDBA}=\sqrt{x^2+y^2+z^2} \qquad \text{(Equation 1.2)}$$

Measuring these acceleration metrics has permitted an alternative way to infer energy expenditure associated with movements and behaviours (Fahlman et al., 2008; Gleiss et al., 2011; Halsey et al., 2011a; Qasem et al., 2012). In addition, VeDBA is a considered a proxy for speed, having been found to be correlated to the speed of animals (Bidder et al. 2012, Qasem et al. 2012).

1.11.3 Behaviour classification of activity using acceleration signals

It has been demonstrated that various sheep activities on pasture can successfully be categorised from tri-axial accelerometers using the individual axes or a combination of them into classifier models (Alvarenga et al., 2016, Barwick et al., 2018b). An intermediate step is required to translate raw data from accelerometers into specific activities. This involves automated classification of tri-axial data in combination with 'true' observations of the behaviour of animals (Watanabe et al., 2005). Essentially, at least three covariates (X, Y and Z) are used as features to classify observed behaviour into one of the sample (activity) classes. The benefit of having a classification method is it can provide information about the uncertainty of the classification result (Shamoun-Baranes et al., 2012). Therefore, any inferences made on animal behaviour should be considered in the context of the uncertainty in the classifier models.

Several accelerometer brands on the market have fulfilled this intermediate step. Two of the most common examples referenced in published material are the IceTag® (IceRobotics Ltd, Edinburgh, UK; Nielson, 2013, Mattachini et al., 2013, Hogberg et al., 2019) and IceQube® (IceRobotics Ltd, Edinburgh, UK; De Mol et al., 2013, Dolecheck et al., 2015) tri-axial accelerometers. They offer the advantage of providing an easy-to-use output for automatically recorded postures, e.g., standing, lying and number of steps. Studies have been conducted to validate the behavioural classification claims for both these sensors in lambs (Hogberg et al., 2019) and cattle (Finney et al., 2018). Whilst easy to use and relatively hassle-free, there are some drawbacks, namely the limited control over what data to record and when to record it, and limited access to the raw data, with a 'black-box' industry algorithm making behavioural predictions (Nathan et al., 2012). These drawbacks translate into restricted computational application on such behaviour data, invariably limiting inference that can be derived therein.

An alternative is to seek out sensors that provide raw data and offer the advantage of full control over what and when to record, flexibility with logging intervals, and no 'black-box' algorithms. In the literature, by far the most mentioned accelerometer in this category is the HOBO® Pendant G Acceleration Data Logger (Onset Computer Corp., Bourne, MA, USA) (Ledgerwood et al., 2010, Bonk et al., 2013, Nielsen, 2013, Rayas-Amor et al., 2017). This sensor offers the advantage that it has been validated for multiple behaviours in multiple species besides cattle, including goats (Moreau et al., 2009), pigs (Ringgenberg et al., 2010), and turkeys (Dalton et al., 2016). As of writing this review, the maximum memory allowance for the HOBO is 64 KB which means it requires regular removal and data download (http://www.onsetcomp.com). Another factor to consider with this approach is that it requires data and computational work for output such as activity budgets, behaviour bouts and events. Overall, it will depend on the researchers' question and what options are available to them.

1.12 Models and methodology for studies that provide data on feed intake in relation to GIN

The standard model for studies investigating the impact of PIA on feed intake and performance compare uninfected or anthelmintic-treated groups of animals with untreated controls. The anthelmintic protocols used in different studies to assess feed intake of GINs in ruminants have ranged across the spectrum from injectable, short-acting oral e.g. monepantel, to longer acting injectable and topically applied anthelmintics, to sustained release and long acting, intra-ruminal ivermectin boluses (Forbes et al., 2000). However, selectively bred animals (that is for resistance or resilience to parasites) have also been used to investigate the effects of PIA on intake and performance (Greer et al., 2018) and are generally augmented with anthelmintic treatment as a factor. Typically, the number of animals used in investigations have ranged from six to 15. A minimum number of six animals was prescribed for detecting a proportional difference of 10% in organic matter intake using a continuous release device at 90% of the time between infected and uninfected animals (Cruickshank et al., 1986). Hence, it is likely that animal numbers in the range of 10 to 15 per group should suffice for investigating the impact on lambs' feeding behaviour from GIN.

Most of the field studies that have investigated PIA and feed intake in sheep have had to contend with interpreting multiple interacting variables, such as grazing behaviour with feed intake and other growth and parasitological parameters (Hutchings et al., 2000; Cosgrove and Niezen, 2000; Thamsborg and Agergaard, 2002). In several of these instances, statistically significant interaction effects have been found. Whilst interactions are not uncommon in complex systems, they can present difficulties interpreting the biological sense of the findings. In the social sciences, psychologists use a suite of tools to assist with making meaningful inferences from interaction effects, including consideration of the size of these effects. For example, Bodner (2017) and Bauer and Curran (2005) detail the use of the Johnson-Neyman technique, which is a focused comparison test of interactions that highlights the range of values on the covariate scale between which the treatment lines are significantly separated. Whilst these techniques have not been commonly used in parasitology studies, they could be employed to help explain potential interaction effects when investigating the behaviour of sheep in response to GIN parasitism.

The likely design of the proposed studies in the present thesis inevitably lend themselves to recording and collection of data with specific characteristics, requiring specific tools to analyse. Parasite data will be collected as 'Count' data. Due to the skewness of count data, FEC has been analysed parametrically by transforming the data variously, including inverse transformation (Bishop and Stear, 2001), logarithm to base 10 (Greer et al., 2018), which usually accompanied by addition of a constant (e.g., half the measurement increment, or just simply adding '1') since for zero counts the logarithm of zero is not a finite number. Others have opposed the use of transformations for count data (Alexandar, 2012), considering the addition of a value (usually 1) to the whole data when a single zero exists fudging of the data. However, when the dispersion in the count data is smaller and the mean counts are larger, transformation of count data is satisfactory to model FEC. Other approaches have included the use of non-parametric tests (Denwood et al., 2010) and the use of techniques based on skewed distributions such as the Poisson, or negative binomial when there is evidence of overdispersion in the data (Morgan et al., 2005; Brooks et al., 2017). Often geometric means are used to describe parasite count data since the use of arithmetic means are precluded due to the extremely high values that influence the data (reviewed by Alexander, 2012).

Proportional data such as activity budgets, are peculiar because the components sum to 1; attempts to apply statistical methods designed for unconstrained data may therefore lead to inappropriate inference (Regular et al. 2014). To account for this numerical constraint, a Dirichlet mixed model has been proposed (Douma and Weedon, 2019). As the multivariate generalization of the beta distribution, the Dirichlet distribution is useful for analysing compositional data (Regular et al., 2014). Applying this distribution allows for the simultaneous assessment of the effects of covariates on the relative contribution of multiple activities (Gueorguieva et al., 2008). Activity data have also been subject to several transformations, including the Johnson transformation (Burgunder et al., 2018). Other transformations include the scaling and centering of data, especially when multiple continuous covariates exist in the data on different scales (Bro and Smilde, 2003).

1.13 Conclusion

Sustainable control of GI nematodes has become a topical issue due to the increasing prevalence of anthelmintic resistance (Section **1.6.2**). Achieving sustainable control is faced with context-specific challenges including farm management and climate, all of which influence parasite epidemiology. The key aim to sustainable control approaches is to mitigate parasite induced ill health by reducing exposure to infective larvae, but with reduced use of anthelmintics (Besier, 2012). Achieving a balance is incredibly challenging. Accordingly, a "one size fits all" strategy is not appropriate for effective control of GIN as several factors add important variations to the dynamics of the infections. For instance, changing climate patterns will likely increase the length of the parasite season and may equally affect grazing patterns through effects on seasonal grass growth. The consequences of such changes are yet to be fully appreciated but will inevitably require changes from the 'tried and tested' and the adoption of novel approaches. This review has discussed optimised use of anthelmintics and non-pharmaceutical options, such as selective breeding that have been charted to sustainably mange GINs. Specific discussion included the use of tools with the potential to measure and monitor PIA in pasture-based systems and which can inform the use of anthelmintics that serves primarily to enhance feed intake. The need to validate the tools required to achieve this has been highlighted and benefits from promising results in other areas of animal behaviour research. In so doing, it is of pivotal importance to conduct studies under conditions that are as close as possible to the normal conditions of pastoral livestock farming. In addition, validation metrics should be tested for their accuracy in measuring the variables for which they are proxy to (e.g. validating the precision of distance moved as a surrogate for grazing). This review highlights that there is a need for these tools to answer a broad range of questions with regards to their use to assess the impact of GINs; answers which can distil the complexity of optimizing GIN management into support systems to aid veterinarians, advisers and farmers. Consequently, support tools will need to be robust, adaptable and flexible enough to compare treatment groups, but ultimately be able to compare an individual to itself (i.e. to detect change in an individual's own metrics over time) and how that compares to the rest of the stock. Eventually these research findings need to be adapted for use in real-life farming environments. This thesis will not likely address all these themes, but it is the premise upon which investigations will ensue.

1.14 Aims of the Research

Overall, this PhD seeks to expand the understanding of the impact of gastrointestinal nematodes on young and adult sheep and to interpret their behavioural response when they have subclinical burdens of GINs. The overall objective was to determine if behavioural changes are measurable and make suggestions on the utility of these as an indicator for targeted selective treatment of GIN parasitism.

This thesis was directed towards the following specific aims:

1. To conduct a preliminary investigation of the impact of gastrointestinal nematodes on young sheep using a simple measure of overall activity (**Chapter 2**)
2. To ascertain the accuracy of the devices and methods intended to be used for measuring behaviour of sheep (**Chapter 3** and **4**).
3. To undertake studies on growing lambs (**Chapter 5**), and adult sheep (**Chapter 6**) that demonstrate the behavioural changes associated with gastrointestinal nematode parasitism.
4. To investigate the impact of host phenotype (resilience verses resistance to GIN parasitism) on movement and behaviour of sheep (**Chapter 7).**
5. In the general discussion, the main objectives were two-fold: to summarize how GIN parasitism affects movement and behaviour in sheep; and to propose a roadmap for deploying changes in sheep behaviour farm side as a marker of parasitism that could lead to optimal performance through targeted control of GIN infection (**Chapter 8**).

1.15 Declaration

Each research chapter was written as a manuscript intended for publication in a refereed journal, hence some repetitions of background information occur throughout the thesis. **Chapter 2** has been published in Veterinary Parasitology. **Chapter 3** and **4** are intended for submission to Animals (MDPI), and Computers and Electronics in Agriculture respectively. **Chapter 5** was written as two manuscripts intended for submission to Veterinary Parasitology and Applied Animal Behaviour Science. **Chapter 6** and **7** are intended for submission in Veterinary Parasitology.

CHAPTER 2 – GASTROINTESTINAL NEMATODE INFECTION AFFECTS OVERALL ACTIVITY IN YOUNG SHEEP MONITORED WITH TRI-AXIAL ACCELEROMETERS

2.1 Abstract

Animals suffering from parasitism typically display altered grazing behaviour and a voluntary reduction in feed intake. These changes are potentially important as indicators of disease. Recent advances in sensor technologies provide the opportunity to objectively measure animal activity while on pasture. Tri-axial accelerometers measure body movement in terms of acceleration, which can then be used to estimate physical activity over time. This study investigated if tri-axial measures of overall activity can be used to assess the impact of gastrointestinal nematode (GIN) infection in young sheep. To address this, the overall activity, faecal nematode egg count (FEC) and body weight of two treatment groups of Romney X Suffolk ram lambs were compared. Animals were monitored for four days using tri-axial accelerometer sensors mounted on a ram mating harness after 42-days grazing on contaminated pasture. On Day 0, all lambs were given anthelmintics. Subsequently, a Suppressive Treatment Group (n = 12) was treated with anthelmintics every two weeks. An Untreated Group (n = 12) did not receive further anthelmintics. Overall activity levels were monitored from Day 42 – 46. Activity level was calculated as vectorial dynamic body acceleration (VeDBA). Anthelmintic treatment had a significant effect on FEC but there was no evidence found for a treatment effect on body weight growth over the 42-day period. An effect of treatment and lamb starting weight on overall activity was found (beta = –0.74, 95% CI –1.17 to –0.30, p = 0.002), identifying a negative impact of parasitism on activity in heavier animals. These results highlight the usefulness of this approach in assessing the effect of GIN parasitism on sheep monitored remotely. If a threshold value of activity could be determined, it could provide a useful tool for farmers and managers that serves as an early indicator of parasitism in sheep.

Keywords: Activity level; sheep; gastrointestinal nematodes; accelerometers; remote monitoring

2.2 Introduction

Gastrointestinal nematode (GIN) infections are costly, both from a biological and from a management point of view (Vande Velde et al., 2018). These parasites inhabit the gut of animals, including ruminant hosts, eliciting a myriad of pathologies, which vary in intensity and duration. Diagnosing, treating and controlling these infections to optimise productivity outcomes impose labour and financial costs on farmers and managers (Charlier et al., 2017). This is further complicated by widespread increases in anthelmintic resistance, an unavoidable consequence of heavy reliance on the use of broad-spectrum anthelmintics for helminth control (Vercruysse et al., 2018). Ruminants suffering from GIN parasitism typically display a number of clinical signs, including a reduction in voluntary feed intake and altered grazing behaviour (Fox, 1997). These clinical signs and altered behaviours are usually associated with changes in protein and energy allocation to functions such as mounting an immune response to infecting parasites (Walkden-Brown and Kahn, 2002).

Changes in grazing behaviour and activity in GIN infected ruminants has been widely studied. Investigating reindeer calves in a semi-domesticated system, Arneberg et al. (1996) showed that untreated controls consumed 20% less feed than those treated with ivermectin during the study period. In sheep, Hutchings et al. (2000) observed parasite infected animals had a 30.5% reduction in feed intake, which was associated with ~40 minutes less grazing time per day compared with their uninfected counterparts. Young dairy heifers treated with eprinomectin had 30% more daily grazing time than control animals infected with GIN (Forbes et al., 2007). In female Grant's gazelle (*Nanger granti*), Worsley-Tonks and Ezenwa (2015) found that nematode infected animals allocated energy to behaviours differently from uninfected animals, resulting in increased foraging time in the latter. More recently, first season grazing steers infected with GIN have been shown to have a significant increase in time spent laying down compared with treated animals (Högberg et al., 2019).

To date, no method exists that utilises energy use and behaviour change to alert managers to an early GIN infection that they can act on, especially with sheep on pasture. The energetic cost for moving land animals has been assessed traditionally by measuring rates of respiratory gas exchange in the laboratory (Gleiss et al., 2011). In the field, direct visual observations and video recordings have been the conventional approach used to study animal activity patterns. This approach has the limitation of being time and labour intensive. There is also the hindrance of observer bias and inability to continue observation in difficult weather conditions (Brown et al., 2013).

Recent advances in tri-axial accelerometers offer a non-invasive method to measure all small-scale body movements of an individual in the field. This technology generates a highly detailed dataset, recording small movements of the body 24 hours a day, seven days a week. Also, small movements that might not lead to actual displacement of the body are recorded, which are important as they also cost energy. The aim of this study was to investigate whether tri-axial accelerometers can be used to assess the impact of GIN infection in sheep on measures of overall activity. The objective was to explore the simplest measure possible to assess its applicability by the end user without complex machine learning to characterise the different behaviours. This study hypothesises that young sheep developing even modest GIN burdens will graze for shorter periods, idle more and move less and that this will translate into reduced overall activity.

2.3 Material and methods

The study was conducted at the Massey University sheep unit, Palmerston North, New Zealand (40˚ 23'28" S 175˚ 36'21" E 40 m elevation) between June 22 and August 8, 2017, which is during winter in this location. Ethical approval was provided by the Massey University Animal Ethics Committee (Protocol number 17/23).

2.3.1 Animals and experimental design

The trial included 24 ram-lambs commercially sourced from the same farm and was conducted when the animals were 9 – 10 months of age. All 24 animals were crosses of the Romney and Suffolk breeds that had been reared on pasture. The sheep had a mean body weight of 46.9 (standard deviation (SD) 3.21) kg and were grazed on pasture at the study location where other young sheep had previously grazed for at least the previous six months. In addition to pasture, the study animals were offered good quality meadow hay and barley, but over the course of the study, with one or two exceptions, none showed any great interest in these additional feeds. The study was a completely randomised trial and involved two treatment groups of sheep grazing together (n=12/group, total n=24).

The experimental design involved a setup period and a monitoring period. The setup period was for six weeks at the start of which all animals were treated *per os* with monepantel (2.5 mg/ kg body weight; Zolvix® Novartis New Zealand Ltd). On Day -14, animals were ranked by faecal nematode egg count (FEC), grouped in pairs and within each pair were randomly allocated to one of two treatment groups. A Suppressive Group (S) involved individuals being treated with monepantel every fortnight for six weeks. A second Untreated Group (U) received no treatment after Day 0. In the monitoring period (Day 42 to 46), sheep activity was recorded continuously for a total of four days (4 x 24 hours) using tri-axial accelerometer sensors. On 8 August 2017 (Day 46), the sensors were retrieved to download raw acceleration data.

2.3.2 Accelerometer and mounting system

An ActiGraph wGT3X-BT® acceleration sensor (ActiGraph, LLC, Pensacola, FL, USA) that measures acceleration during movement across the vertical, horizontal, and perpendicular axes was attached on the top side of a ram mating harness (MatingMark®) and was positioned on the withers of the sheep (Figure 2.1). This unit employs a reference system that indicates longitudinal (front-to-back or surge, Y), horizontal (side-to-side or sway, X) and vertical (up and down or heave, Z) body axes, respectively (Fig. 1) (ActiGraph Manual, version 1.0.0 August 2013). Before attaching the harnesses to sheep, the sensors were pre-scheduled to collect acceleration data at a sampling rate of 30Hz, which is equivalent to 30 sampling occasions in one second. The accelerometers were 46 × 33 × 15 mm in size and weighed 19 g. The orientation of the sensors was the same on all sheep. The position of the sensors on the harness (at the withers) was suitable to not record activity associated with extraneous activity of the head and neck, for example head shaking. Accelerometers positioned at the withers in goats have been reported to provide an intermediate amplitude of data in each axis, compared with mounting accelerometers on a collar (neck) or chest belt (back) (Moreau et al., 2009). Intermediate amplitude acceleration data better suit the purposes of total activity level estimates (Shepard et al., 2008).

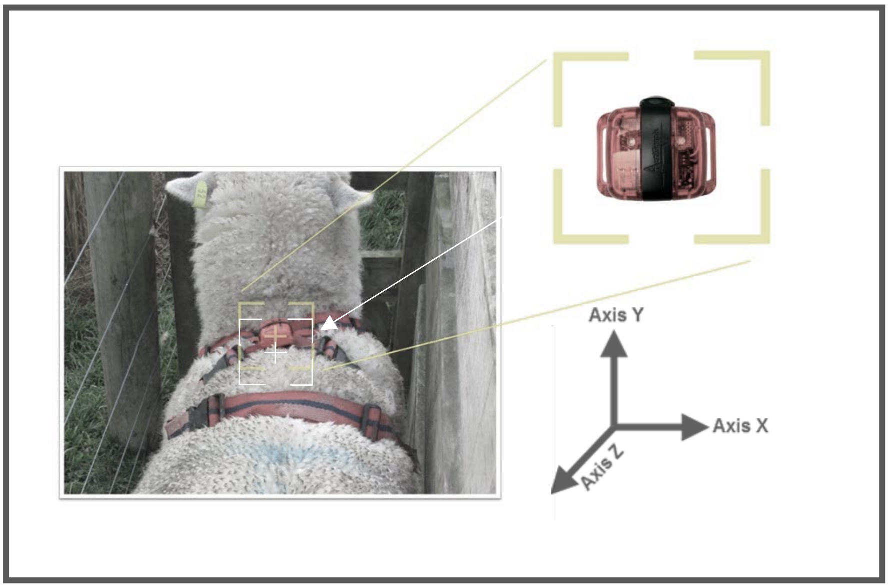

Figure 2.1 Position and axis orientation of an ActiGraph wGT3X-BT® tri-axial accelerometer attached to a ram mating harness on a young sheep.

2.3.3 Parasitological examinations and weighing

Each fortnight rectal faecal samples were collected to determine nematode egg counts using a modified McMaster method, where each egg counted represented 50 eggs per gram (EPG) of faeces (Stafford et al., 1994). On Day 42, a larval culture was undertaken using an additional 5–10 g of faeces pooled from each experimental group, mixed with Vermiculite® and then cultured for 10 days at 20 °C. At the end of the incubation period, Baermanisation retrieved infective larvae, which were identified to genus level. At the same fortnightly interval, body weights were recorded for each sheep, beginning on Day -14 (initial weight) through to Day 42 at the start of the monitoring period. The weighing system collected body weights at a resolution of 0.5kg.

2.3.4 Activity levels

Raw acceleration data were summarised into five second epochs (time durations); Alvarenga et al. (2016) identified the 5s epoch as most suitable out of three durations compared in their study that classified sheep activity at pasture. Following Steele et al. (2000), the activity level of each sheep was calculated at each epoch by deriving vectorial dynamic body acceleration (VeDBA) from its accelerometer using Equation 2.1:

$$\text{VeDBA}= \sqrt{x^2+y^2+z^2} \qquad \text{(Equation 2.1)}$$

where x is the acceleration along the x-axis, y the acceleration along the y-axis, and z is the acceleration along the z-axis (Qasem 2012). Data were subsequently summed over the duration of monitoring to provide a value of overall activity.

2.3.5 Statistical analysis

To verify that ram-lambs were randomly assigned to treatment groups prior to treatment, the difference in FEC was tested using ANOVA. Thereafter, statistical analyses were conducted on data collected from 22 animals. Two animals were excluded from analyses, due to one animal in the untreated group being treated with monepantel when its FEC exceeded subclinical parasitism levels. The monitor from a second animal failed to deploy. Data from the last four hours of monitoring was excluded due to extraneous disturbance[1] of the flock during this time. Faecal egg count data were strongly right skewed and were log transformed for analyses using $\log_{10}$(count+1). Descriptive statistics were used to summarise the results of VeDBA, FEC (egg/gram) and body weight (kg); correlations were evaluated between $\log_{10}$(FEC+1) and body weight, and VeDBA and body weight. When using $\log_{10}$(FEC+1) data in correlation and group difference analyses, both parametric and appropriate non-parametric tests were evaluated and the results were qualitatively similar; thus the results of parametric tests have been selected and reported. After analysis, means of $\log_{10}$(FEC+1) were back transformed to the original scale for reporting as geometric means with confidence intervals.

Multivariate analysis was performed by fitting three separate models, with model assumptions verified using the Shapiro-Wilk's test. In Model 1, the effect of treatment on body weight change over time (difference in most recent and earliest body weight recorded divided by number of days between weights) was analysed. Repeated measures were accounted for by fitting a linear mixed-effects model (LMM) with lamb ID as a random effect using the *lme()* function in the *nlme* R package (Pinheiro et al., 2006). Body weight change was the dependent variable with fixed effects of treatment (two levels; S and U), day of weighing (modelled as a continuous variable) and treatment x day interaction term. An autoregressive correlation structure was used to account for the independence between repeated samples on the same lamb. In Model 2, overall activity was modelled as a function of anthelmintic treatment using a Gaussian general linear model (GLM). The dependent variable was VeDBA, treatment (categorical with two levels, Suppressive and Untreated) was a fixed effect, initial body weight

[1] Sheep erroneously moved when not required.

included as a continuous covariate, and treatment x initial weight interaction term. The Initial weight of animals (range 41.5 – 52 kg), was included in the model to test the influence of starting weight on overall activity between the treatments. Post-hoc analysis of the interaction term was performed using the Johnson-Neyman regions of significance analysis (Bauer and Curran, 2005; Hayes and Matthes, 2009). The Johnson-Neyman technique is a focused comparison test of interactions that highlights the range of values on the covariate scale between which the treatment lines are significantly separated, since regression lines cross at some point (i.e. the assumptions of homogeneity of regression slopes are not met). For this post-hoc analysis, the *johnson_neyman* function in the 'interactions' R package (Long, 2019) was used and the treatment groups were dummy coded (1=S, 2=U). To determine the magnitude of initial body weight moderated treatment effect on activity, an effect size metric was calculated following Bodner's (2017) formula. Briefly, this formula uses a range of unstandardized group mean differences, e.g. from one SD below to one SD above the mean of the covariate (initial body weight in this case), to derive a metric of standardized mean differences across the range. In Model 3 (a GLM), we were interested in whether faecal nematode egg counts could be used as a predictor of activity (instead of treatment). The dependent variable was VeDBA, with $\log_{10}$(FEC+1) and initial body weight included as continuous covariates along with their interaction. All statistical analyses were performed in the R environment (R core Team 2017, version 3.5.2). Alpha values of 0.05 were considered statistically significant.

2.4 Results

2.4.1 Parasitological examinations and weighing

2.4.1.1 Parasitology

Faecal egg counts pre-treatment ranged from 0 – 7900 eggs/g; there was no significant difference in FEC for lambs assigned to the suppressive and untreated groups (n = 24; $F_{1,22}$ = 0.1, p = 0.754); no FEC were detected in both groups at Day 14 post-treatment. At the start of activity monitoring on Day 42, the range of raw FEC data was 0 – 50 eggs/g and 0 – 1250 eggs/g in suppressive and untreated groups respectively. Faecal egg counts were higher ($F_{1,20}$ = 30.23, p < 0.001) in the Untreated Group (n = 10; geometric mean 159.6 eggs/g, 95% CI 42.23 to 602.56) than in the Suppressive Group (n = 12; geometric mean 1.4 eggs/g, 95% CI 0.41 to 4.67).

The results of bulk faecal larval culture for faecal samples collected at the start of the monitoring in both treatment groups is presented in Table 2.1.

Table 2.1 Genera of GI nematodes found from Baermanisation at the start of activity monitoring on Day 42

Parasite genus	Treated group	Untreated group
Haemonchus	Nil	2%
Trichostrongylus	Nil	1%
Cooperia	67%	88%
Teladorsagia	25%	Nil
Oesophagostomum/ Chabertia	8%	9%

2.4.1.2 Body weight change

At setup (Day 0), the mean body weight was 48.1 (SD 3.92) kg and 45.9 (SD 2.90) kg for the Suppressive Group (n=12) and the Untreated Group (n=10) respectively (standard error of the difference between means, SED = 1.49), both groups having similar average weights ($F_{1, 20} = 2.03$, $p = 0.169$). Over the 42 days following treatment, there was an effect of time on body weight change ($F_{1,42} = 48.05$, $p < 0.001$) but no evidence was found for an effect of treatment ($F_{1, 20} = 0.26$, $p = 0.614$); i.e., suppressively treated animals showed similar variation in body weight change to untreated animals. At the start of activity monitoring, the mean body weight was 46.9 (SD 2.90) kg and 45.5 (SD 2.22) kg (SED = 1.12) for the suppressively treated lambs and untreated lambs respectively ($F_{1, 20} = 1.58$, $p = 0.299$) and did not correlate with $\log_{10}$(FEC+1) (Pearson's product-moment correlation, r= - 0.34; 95% CI, –0.667 to 0.093; $p = 0.119$) or VeDBA (Pearson's product-moment correlation, r=0.14; 95% CI, –0.301 to 0.529; $p = 0.54$).

2.4.2 Activity levels

On average, the overall activity for the ram-lambs during the monitoring period was 11.12 x 10^5 VeDBA (95% CI 10.2 x 10^5 to 12 x 10^5). The Shapiro-Wilk test of normality of the residuals of Model's Two (W = 0.926, p = 0.099) and Three (W = 0.961, p = 0.506) showed model assumptions were met. There was a treatment x starting weight interaction on sheep activity (beta = –0.74, 95% CI –1.17 to –0.30, p = 0.002), reflecting a positive relationship between VeDBA and starting weight in the Suppressive Group but a negative relationship (VeDBA = 34.315 – 0.518 initial weight) in the Untreated Group (Table 2.2; Figure 2.2).

Table 2.2 Summary of Generalised linear model showing the effects of Treatment (model 2), log- transformed FEC (model 3), initial weights and their interaction on the mean total activity of young sheep over four days

Estimating overall activity: Model 2					
	beta	SE	t-value	95% CI	p
R^2 = 0.5532, F(3,18) 7.428, p = 0.002					
(Intercept)	1.7245	5.7578	0.299	[– 10.372, 13.82]	0.768
Treatment (Untreated)	32.5906	9.6512	3.377	[12.314, 52.867]	0.003
Initial weight	0.2178	0.1221	1.784	[– 0.039, 0.474]	0.091
Treatment (Untreated)× Initial weight	-0.736	0.2056	-3.581	[– 1.168, – 0.304]	0.002
Estimating overall activity: Model 3					
R^2 =0.2865, F(3,18) 2.41, p = 0.1006					
	beta	SE	t-value	95% CI	p
(Intercept)	2.7924	7.5774	0.369	[–13.127, 18.712]	0.717
Log_{10}(FEC+1)	9.6899	4.5736	2.119	[0.081, 19.298]	0.048
Initial weight	0.1894	0.1614	1.174	[–0.150, 0.528]	0.256
Log_{10}(FEC+1) x Initial weight	-0.2188	0.0986	-2.22	[–0.426, –0.012]	0.040

Note – SE, standard error, CI, confidence interval

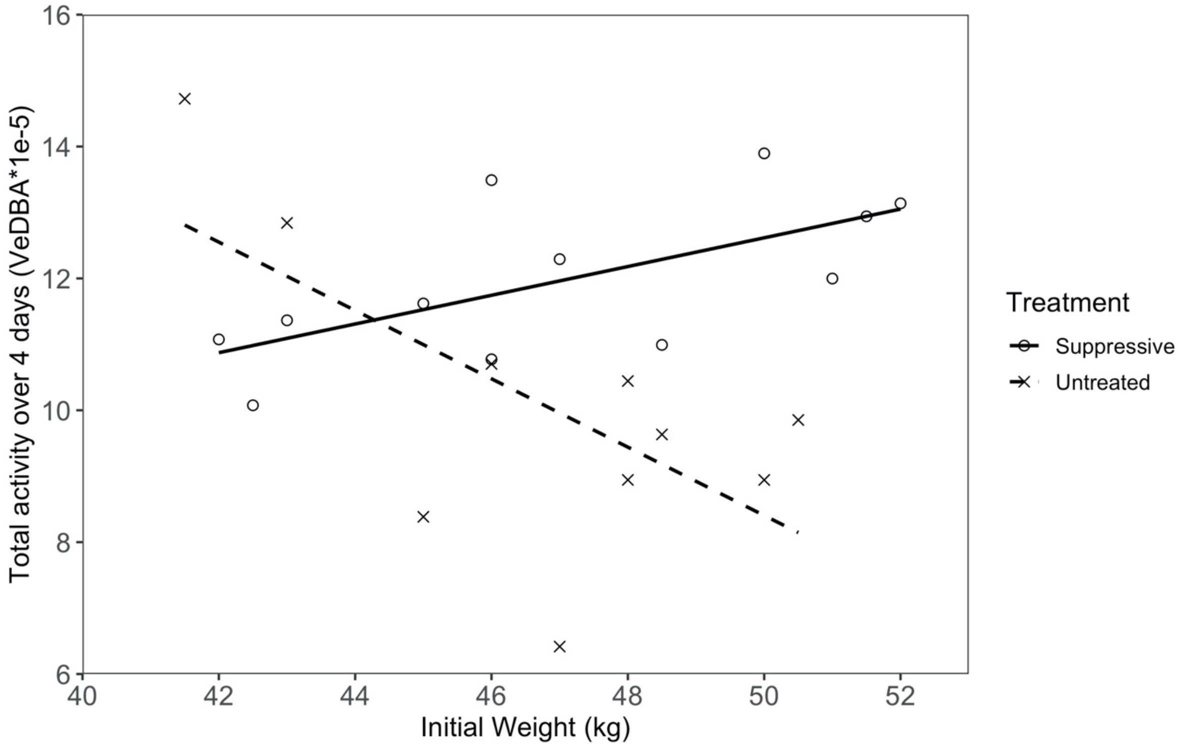

Figure 2.2 Overall activity of two treatment groups of sheep dependent on initial body weight monitored continuously for four days.

This indicated that parasitism had a negative effect on activity in heavier untreated lambs in this study. The Johnson-Neyman post-hoc analysis of the interaction predicted a non-significant interval of 39.76 kg to 46.1 kg as the range on the covariate scale for which the difference between treatment groups was not significant (Appendix 2.3). The effect size metric for this interaction calculated following Bodner's (2017) procedure, showed that the standardised mean difference interval for the effect of treatment on overall activity as a function of initial body weight was 0.327 to –3.293, i.e., from 1 SD below to 1 SD above the mean initial body weight. A two-standard deviation increase in initial bodyweight yielded a -3.62 change in the standardized mean difference, which is large in magnitude according to the guidelines proposed by Bodner (2017). In Model 3 (overall activity modelled as a function of $\log_{10}$(FEC+1), initial weight and their interaction), the interaction between $\log_{10}$(FEC+1) and initial body weight was significant (Table 2.2), showing that for every additional kg of body weight, the activity coefficient for $\log_{10}$(FEC+1) decreased by 0.219 (Figure 2.3). Also shown on Figure 2.3 are the model outputs for initial weight at mean +1 SD and mean –1 SD, which deviate from each other.

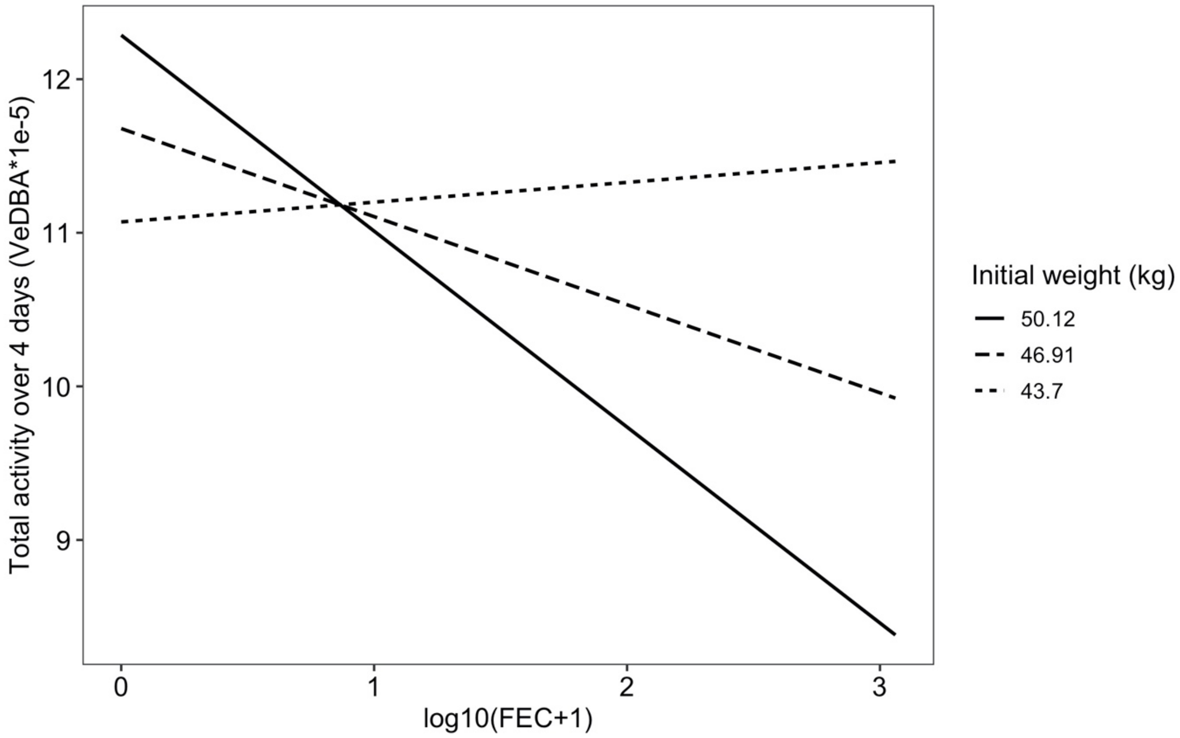

Figure 2.3 Model-based overall activity of sheep as a function of log10(FEC+1) evaluated when initial weight is equal to the mean (46.91 kg), one SD above (50.12 kg) and one SD below (43.7 kg) the sample mean.

2.5 Discussion

The results of this study show that gastrointestinal nematodes reduced sheep activity measured with tri-axial accelerometers. However, the treatment effect interacted with initial bodyweights, which is discussed below. None of the animals included in analyses showed clinical signs of parasitism. Subclinical parasitism was demonstrated using faecal nematode egg counts and nematode genera identified in culture. Faecal nematode egg counts were significantly higher in untreated ram-lambs than their treated counterparts. This result suggests that (i) the activity in sub-clinically infected young sheep is impacted by their GIN infection, at least by the species present in this study; (ii) the extent of the effect is modulated by the starting weight; (iii) it is possible to detect subclinical GIN infection using accelerometers, even for nematode genera that are considered to have low pathogenic effects (Sutherland and Scott, 2010). This supports the view that animal behavioural activity levels have the potential to serve as a sensitive indicator for disease states (Szyszka et al., 2013).

The interaction of initial weights and group treatment on overall activity presents an interesting observation. Generally, lambs in the suppressively-treated group, with low levels of parasites (nematode eggs), were more active when they were heavier (Figure 2.2), with increase in activity appearing proportional to body size. It is conceivable that these heavier animals may have had a greater nutritional requirement and were more active to meet their feed intake requirement. However, the opposite occurred in the untreated group, suggesting a stronger negative effect of parasites in heavier lambs. The reason why light and untreated lambs had higher activity levels than their suppressively treated counterparts is not clear, but this was observed in only two out of 10 individuals. The lighter lambs (mean weights –1 SD) appeared to maintain their activity level with increasing FEC (Figure 2.3), and among those lambs, treatment did not have a detectable effect on activity, as shown from the Johnson-Neyman post-hoc test. The test revealed that treatment had a significant effect on overall activity but only among lambs whose initial body weights were ≥ 46.1 kg. The proportion of lambs that weighed higher than this criterion was 60%; it is for those lambs that the statistically identifiable difference in overall activity among the treatment groups was associated. Results from modelling overall activity as a function of $\log_{10}(FEC+1)$ x initial weight (Model 3) also demonstrated heavier animals with higher FEC were less active than heavier animals with low FEC as shown in Figure 2.3. However, the confidence interval (Table 2) was wide, indicating that individuals with comparable parasite load varied in their activity. Hence, FEC may be an inferior indicator of low levels of subclinical parasitism as has been suggested (Greer et al., 2009; Sargison, 2013). Nonetheless, the association between initial bodyweights and FEC further demonstrates that, heavier animals reduced their total activity when challenged by nematode infections. A possible explanation is that heavier animals would have had a greater feed intake requirement and greater likelihood of acquiring infective larvae on pasture. Thus, it is plausible that decreasing activity as a result of increased parasite load is an attempt to limit exposure to infection. Equally, the demonstration of reduced activity by infected heavier lambs while maintaining live weight growth may be an indicator of resilience.

There was no evidence found for change in body weight among the groups over the trial period in the current study, though behaviour change was observed. Subclinical GIN parasitism in young lambs has been associated with reduced body weight gain (Coop et al., 1982) and reduced productive grazing behaviour has been found in young cattle (Forbes et al., 2004). The animals in the present study were provided with a pasture allowance that was estimated to provide for maintenance but little growth as it coincided with a particularly wet period with little pasture growth. It remains to be investigated what effect parasitism would have on overall activity under different pasture conditions, such as in a time of plenty. In another study where lambs were fed ryegrass/ clover herbage *ad* libitum, an effect of parasitism was found on reduced feed intake without associated change in body weight growth; however, body weights were measured over a comparatively shorter period of two weeks (Hutchings et al., 2000). The sheep in the current study, especially the heavier ram lambs, would likely have had to be active for longer periods each day to meet their requirements. Therefore, the large difference in overall activity (as found following Bodner's (2017) effect size formula) especially in heavier animals, though without associated poor growth performance, further suggests this could be an indicator of resilience and possibly a more sensitive measure of subclinical parasitism than others.

In addition, the composition of the nematodes identified to the genus level was dominated by *Cooperia* species, a mildly pathogenic strongylid nematode (Sutherland and Scott, 2010) and the least pathogenic GI parasite of sheep (Vlassoff et al., 2001). It is conceivable that any impact from such GIN composition would be at the lower end of the subclinical effect spectrum characterised by a change in behaviour. Thus, despite the predominant nematode genus identified in both treated and untreated animals being of low pathogenicity, the geometric mean faecal egg counts in the untreated ram-lambs was over 100 times higher than in the Suppressive Group (159.6 vs 1.4 eggs/g), which is associated with the observed difference in activity. This further demonstrates that activity measures could be used to identify early effects of sub-clinical parasitism in young Romney sheep. Future research that evaluates how activity measures, i.e. VeDBA, relate to foraging behaviour for instance and hence energy intake may further illuminate how nematode parasitism relates to productivity.

Untreated animals showed reduced overall activity, but it remains to be investigated which specific activities are changed. For instance, reduced time spent grazing could result from altered behaviours such as greater faecal avoidance on pasture (Hutchings et al., 2002) or increased diet selectivity (Kyriazakis et al., 1996) as well as a reduction in intake *per se*. In grazing steers monitored with tri-axial accelerometers, Högberg et al. (2019) found an increase in lying bouts in animals experimentally infected with GIN at turn-out. Increase in time spent lying could be interpreted as reduced activity and although in cattle, their results agree with the findings of reduced overall activity in young sheep in the present study. In contrast, in a study by Falzon et al. (2013), GPS-collared stud ewes that were faecal sampled randomly and monitored over a 24-hour period increased their mean distance per step as FEC increased. The reason(s) for this difference requires further study. However, collectively these studies demonstrate the role for remote sensing technologies in detecting changes in activity, or distance moved, in GIN infected individual animals in livestock grazing systems. Deployment of these remote sensing technologies – for instance tri-axial accelerometers and GPS – simultaneously on the same subjects would set the premise for investigating composite measures of behavioural activities and how they change in response to GIN challenge. A logical next step would be to discriminate different activities using accelerometery data, alongside GPS data and then evaluate them as a function of parasite infection using two groups of young sheep: GIN infected and GIN-free control animals.

2.6 Conclusion

In the current study, deploying accelerometers on young sheep allowed the detection of changes in total activity levels in animals with different parasite treatment dependent on their initial weights, and in the absence of clinical signs of parasitism. The results show that animal activity might be influenced even at low to moderate FEC levels. It can be concluded that reduced activity is either a consequence of GIN, as in animals are suffering anorexia and therefore not as active because they are eating less, or that by moving less, parasitised animals conserve energy. These findings suggest that overall activity of sheep measured remotely with accelerometers might be an early indicator of subclinical parasitism, which has the potential to detect behavioural changes in sheep before performance changes. Consequently, if a threshold value of activity could be determined it would provide a tool to managers to identify GIN infection early that they can act upon before loss of production results. It was beyond the scope of the present study to distinguish between different activities, such as grazing, or directional movement, using accelerometer data, although this is the subject of ongoing research

Declaration of competing interest

The authors do not have any conflicts of interest to declare.

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CHAPTER 3 – EVALUATION OF THE SUITABILITY OF GPS-BASED LOCATION DATA FOR ASSESSING BEHAVIOURAL CHANGES ASSOCIATED WITH GASTROINTESTINAL NEMATODES IN SHEEP.

3.1 Abstract

The advent of remote sensing technologies is helping to transform precision livestock monitoring, especially in free-range systems in line with current farming trends and an increased focus on animal welfare. Global positioning system (GPS) sensors are among a list of technologies that have been adopted for animal monitoring. It has been known, however, since their earliest use to track animal movement in the late 1980s, that GPS-based datasets can contain spatial inaccuracies. The focus of this study was to investigate the accuracy of commercially available GPS receivers towards detailing their utility for monitoring movement activity in parasitised sheep. Three tests were used for assessments on seven GPS receivers: static, off-animal motion, and on-animal motion tests. The static test assessed the accuracy of the estimates from the receivers when stationary. In static tests, the accuracy logged by GPS receivers showed that ninety-five per cent of location estimates fell within 4 m of their 'true' position for six of the seven receivers tested. Varying the time interval for the receivers to record a location did not change the accuracy of estimates in four out of five receivers tested for this purpose. Off-animal motion tests mirrored results in the static test and in on-animal motion tests, there was no evidence that the accuracy from any of the GPS receivers investigated (as seen in the other tests) was significantly influenced by the animal. Understanding the errors associated with GPS receivers will assist with the definition of suitable protocols for recording location estimates. Using these results, research into several aspects of the influence of parasitic nematodes on sheep is proposed.

Keywords: GPS receivers, GPS accuracy, remote monitoring, sheep, parasitic nematodes

3.2 Introduction

Ground-based sensors such as global positioning system (GPS) receivers record fine-scale movements of animals (Latham et al., 2015). These devices have the potential to provide insight into the movement patterns of animals under normal or pathological challenge, and could be a useful index for monitoring the physiological, physical and health status of animals (Neethirajan et al., 2017). These devices present an opportunity for potential detection of disease states, assuming that GPS-based animal tracking can differentiate changes in movement behaviour between healthy and affected subjects. Gastrointestinal nematodes (GIN) can induce a level of anorexia and lethargy in parasitised animals (Sykes and Coop, 1976; Fox et al., 1989). Currently, the mechanisms associated with this phenomenon are not fully understood. Evidence exists, however, that associates GIN parasitism with a reduction in voluntary feed intake (Coop et al., 1982, Abbott et al., 1986, Fox et al., 1989). In addition, behavioural changes such as increased avoidance of pasture closest to faecal pats (Hutchings et al., 2001) and increased diet selectivity (Kyriazakis et al., 1996) have been observed. One argument is that behavioural changes may enable parasitized animals to ameliorate the impact of parasitism. It is plausible that animals may increase their movement to allow them to access previously un-grazed (and hence low contamination with faecal matter) areas, and to date, one study has demonstrated a positive relationship between faecal worm egg counts (FEC) and the distance travelled by sheep (Falzon et al., 2013). Conversely, if the distance moved by an individual is considered a proxy for activity such as time spent grazing (Augustine and Derner, 2013), which has been shown to be reduced under parasite challenge (Hutchings et al., 2001; Forbes et al., 2000, 2004), then the collective behaviours of parasitised animals may result in less distance moved. In support of this, in **Chapter 2**, a reduction in overall activity was found in parasitised young sheep monitored with tri-axial accelerometers compared to their treated counterparts (Ikurior et al., 2020).

To date there is little information available on the impact on movement activity of grazing young sheep carrying even modest burdens of nematodes. The usefulness of GPS tracking to examine the implications of GIN on the behaviour of parasitised animals will depend on the accuracy, and repeatability, of the distance measures derived from the GPS receivers. GPS datasets are characterised by errors associated with location fix success and spatial inaccuracy of acquired locations (location errors) (Frair et al., 2004). These errors can lead to incorrect inferences after analysis (Cagnacci *et al.* 2010). When GPS devices are deployed on animals, there can be an additional magnification of these errors associated with unexpected activity (e.g., sudden sprint from potential fright) that target animals sometimes exhibit (Dussault et al., 1999). Moreover, GPS receivers have been known to over-sample periods when animals are idle, leading to conclusions that animals are more active than they are (Bailey et al., 2018). However, technologies continue to evolve, and some of the errors historically associated with location data may also have been lost. In GPS performance tests, attention is given mostly to the accuracy of individual coordinates relative to their true position rather than measures of distance. Werner et al. (2003), stated that the more precise a receiver is, the more reproducible the measurements are under dynamic test conditions. At present there is an increasing variety of GPS receivers on the market, but little information is provided on their ability and suitability to accurately record the position of animals, especially in limited space resources.

The aims of this study were: (i) to investigate how a variety of low-cost, light weight, commercially available GPS receivers perform on and off animal; and (ii) to comment on the utility of location estimates recorded from GPS receivers in relation to the expanding understanding of the movement patterns of parasitised sheep. The hypotheses tested were that: (i) receivers would be accurate to 5 m in static tests, (ii) when in motion, the travel distances predicted by different receiver brands would be within 5 m of a gold standard and of each other, (iii) on a live animal, the distance travelled estimated from each receiver would be similar and (iv) the estimated distance covered by an animal will be cumulatively different between daytime and sunset hours, on the assumption that less travel distance occurs at night.

3.3 Material and methods

3.3.1 Study sites

Assessments were carried out at two locations on the Manawatu Campus of Massey University, Palmerston North, New Zealand. Motion tests were conducted at the University athletics track (40°23'23" S, 175°37'35" E 38 m Elevation), while static and on-animal tests were conducted within a nearby farm block of 2 ha divided into 10 evenly sized paddocks (40°23'28" S 175°36'21" E 40 m Elevation). Both locations were characterised by absence of nearby buildings and trees. Static and motion tests were conducted over the period from June 2017 to July 2020.

3.3.2 GPS receivers

The study was performed with seven commercially sourced GPS receivers. Table 3.1 summarises the basic features of these units.

Table 3.1 Attributes of seven GPS units used in the comparison assessment

Receiver	Type	Supplier	Weight (g)	Intended purpose
Carter GPS	DL	DataCarter	280.7	Livestock logger
i-GotU GT-120	DL	Mobile Action Technology Inc.	26.6	Travel and sports logger
i-GotU GT-600	DL	Mobile Action Technology Inc.	41.7	Travel and sports logger
Garmin Forerunner 920 XT	DL	Garmin Ltd	60.9	Multisport GPS watch
Garmin Forerunner 310 XT	DL	Garmin Ltd	75.8	Multisport GPS watch
Gipsy5	DL	Technosmart Europe srl	236.5	Birds & small mammals GPS tracker
CatLog Gen2	DL	Catnip technologies Ltd	238.8	Domestic and wildlife logger

Note: DL – Data logger

Each unit recorded a time and date-stamped GPS coordinate (latitude and longitude); they also recorded the number of satellites available during GPS fix acquisition. Other outputs included measures of horizontal dilution of precision (HDOP), elevation and speed. These units were selected based on previous usage on animal subjects (Allan *et al.* 2013), customer online reviews, cost, weight and availability for purchase.

3.3.3 Static tests

Seven wooden fence posts were selected at the farm study site. The location of each post was recorded using a real-time kinematic (RTK) GPS precision unit. The RTK had an accuracy of 0.04 m when compared to a known, previously surveyed location (M. Irwin, unpublished data). Each fence post was allocated to one of the seven GPS receivers. For five receivers, four separate epochs (i.e., recording intervals) each of one, 10, 30 and 60 seconds were investigated. The receivers were left to record data on these fence posts for between 12 and 36 hours. Each receiver was tested on at least three separate occasions at each epoch. All comparisons between the receivers were made at the same time in order to ensure the satellites available for triangulation of locations were similar among the receivers. The Garmin brands did not allow for scheduling at epochs of greater than one second and therefore were omitted from the test of longer epochs. The locations of the loggers were then compared to their respective "true" location (based on the RTK reading) allowing for a measure of location error to be derived.

3.3.4 Motion test – Off-animal

The inside lane of a standard athletics track (measuring 400 m) was used to test the distance predicted by each receiver off-animal. All units were set to record GPS locations at one second epoch and then deployed simultaneously from the start point of the track. The receivers were lined side by side and carried on a flat board for ten laps around the track over three separate days. The RTK unit was also carried for two laps. The total distance covered for each lap walked around the track was estimated from the GPS receivers using a series of step lengths (distance between two location estimates) calculated from the GPS coordinates recorded. Step lengths in kilometres were computed from longitude and latitude values using the function *prepData* in the R package *moveHMM* (Michelot et al., 2016). Data points from the respective receivers were mapped and summed to provide a measure of travel distance logged by each receiver.

3.3.5 Motion test – On-animal test

A single ewe-lamb (48 kg) was fitted with all seven GPS receivers on two separate occasions. The total weight of the receivers (961 g) was ~ 2 % of the body weight and thus acceptable for the animal (Moreau et al., 2009). Each sampling occasion was 13 hours in duration, with receivers scheduled to start recording location data from 09.00 to 22.00 hour (first recording) and 15.00 to 03.00 hours (second recording). In this way, both daytime and sunset hours were captured. Location data recording was scheduled at one-second epochs. The total distance covered by the ewe on each sampling occasion was estimated from the GPS receivers using a series of step lengths, using the same method as the off-animal motion test (Section **3.3.4**).

3.3.6 Data management

At the end of each recording period, the receivers were removed and the data were downloaded and managed on their respective platforms (with exception of the Carter unit, which stores data onto an SD card that can be read by most computer operating systems). For the Garmin receivers, data were uploaded to the Garmin website using Garmin Connect software (version 15.7.4.1, Garmin Ltd), and distance in 1-s intervals was downloaded for subsequent data cleaning (to remove satellite artifacts). For the i-gotU receivers, data were downloaded using the software @Trip PC (version 5.0.1601.472, Mobile Action Technology, Inc.). The Gipsy5 receiver was downloaded using the GiPSy5 Utility software (version 1.6, Technosmart Europe srl). The CatLog receiver was downloaded using the CatLog GPS control centre (version 1.4, Catnip technologies, Ltd.).

As the coordinates retrieved from the GPS were recorded as 'world geodetic system' coordinates, they were converted to New Zealand Map Grid coordinates using the geographic information system ArcGIS Programme (ESRI, New York).

3.3.7 Statistical analysis

For the static tests, the location errors (LE) were calculated as the Euclidean distance between the actual location and the distance between each of the estimated locations recorded by GPS receivers. The arithmetic means, medians and histograms of the location error of *n* fixes were generated. Besides the static test data at one second epoch, all other data were strongly positively skewed and required transformation prior to statistical analyses. A one-way ANOVA was used to compare all seven receivers in the static test recording at one-second epoch. To remove skewness of the other data a number of transformations were investigated including the Box-Cox-, log-, square- and cube-root transformations, however, none were effective. Therefore, all other data were analysed using descriptive and nonparametric inferential statistics. The Kruskal-Wallis Test was used to compare receiver by epoch interaction of the five GPS receivers that could be scheduled to record at variable epochs (Carter, i-GotU GT-120, i-GotU GT-600, Gipsy5 and CatLog Gen2). A 'monitor-epoch' variable was created to represent a single value for each GPS receiver at each of the four epochs compared. Multiple pairwise comparisons were performed using a Bonferroni correction and the Dunn Kruskal-Wallis test.

For the off-animal motion athletics track test, differences in the total distance calculated from GPS receivers were evaluated using the nonparametric Skillings–Mack test (Skillings and Mack, 1981). This was followed by application of a Bonferroni correction for pairwise comparisons and performed using the post-hoc Durbin test. Due to a fault which occurred in the i-GotU120 device during charging, location data were not recorded during seven testing laps. Therefore, the Skillings-Mack test was used as it is a generalization of the Friedman test designed for block designs with missing observations. The track lap number was included as a 'blocking variable' in order to ensure comparisons were made among receivers that were carried at the same time.

For the on-animal test, the estimated distance covered by one sheep carrying all GPS receivers was analysed using the Friedman rank sum test with hour of recording included as a blocking variable. Differences in distance covered among receivers were tested by post-hoc pairwise Wilcoxon signed rank test. The distance travelled by the sheep in daytime hours was compared with those in sunset hours using the two-sample Mann-Whitney U test. All data were processed prior to analyses using R, with analyses performed in ArcGIS 9 (ArcMap version 10.5.1, ESRI 2017) and in the R computing environment (R version 3.6.2 2019). A value of alpha = 0.05 was considered significant for all tests.

3.4 Results

3.4.1 Static test

Summary statistics for location error (LE) estimates of all seven GPS receivers scheduled at the one second epoch is shown in Table 3.2. The distribution of all recorded locations for each of the seven units is shown in Appendix 3-1.

Table 3.2 Summary statistics (minimum (min), maximum (max), mean, median and standard deviation) for location error for each of the seven static GPS receivers recoding at one-second epoch

GPS receiver	Location error (m)				
	Min (m)	**Max (m)**	**Mean (m)**	**Median**	**SD**
Gipsy 5	0.02	3.91	1.13	1.05	0.60
Carter	0.04	5.57	1.43	1.27	0.82
Garmin 310	0.06	9.18	3.31	3.89	1.43
Garmin 920	4.01	6.80	4.60	4.20	0.57
i-GotU GT- 120	0.65	44.16	4.35	3.77	2.86
i-GotU GT- 600	0.58	17.54	3.85	3.53	2.20
CatLog	0.08	214.50	13.93	9.39	14.76

At the one-second epoch, a difference in mean location errors was found ($F_{8,12} = 65.57$, $p = <0.001$) among the receivers. Pairwise location error mean comparisons using Tukey's post-hoc analysis to separate receiver means is presented in Table 3.3.

Table 3.3 Least square (LS) mean estimates of location errors (in metres) of seven GPS receivers recorded at three periods showing standard errors (se) and 95% confidence levels.

GPS Receiver	LS mean	se	df	95% CI
Gipsy5	1.11 [a]	0.327	12	0.40 - 1.82
Carter	1.51 [a]	0.327	12	0.80 - 2.23
Garmin310	2.31 [ab]	0.327	12	1.59 - 3.02
Garmin920	2.50 [ab]	0.327	12	1.79 - 3.22
i-GotU GT-600	3.23 [b]	0.327	12	2.52 - 3.94
i-GotU GT-120	3.56 [b]	0.327	12	2.84 - 4.27
CatLog	10.08 [c]	0.327	12	9.37 - 10.79

[a, b, c] values with different superscript are significantly different (Tukey's HSD, $p<0.05$), se (standard error), df (degree of freedom), CI (Confidence interval at alpha = 0.05).

The arithmetic mean location error in metres for five GPS receivers tested at one, 10, 30 and 60 epochs are shown in Figure 3.1; Appendix 3-3.

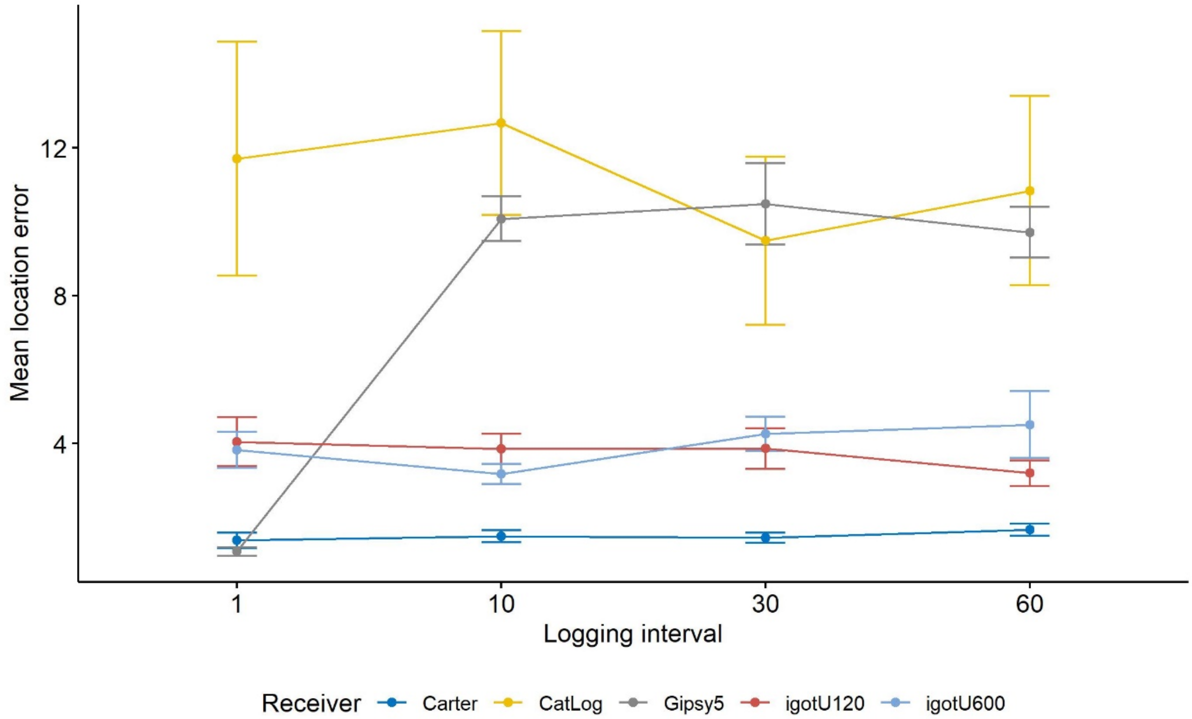

Figure 3.1 Effects of GPS receiver and logging interval (epoch) on average location error (metres) during three periods of static tests. Error bars indicate 95 % confidence interval.

Differences in location error (LE) were found among the 20 'monitor-epoch' categories as assessed using the Kruskal-Wallis test (H (19) = 695.27, P < 0.001). Post-hoc Dunn test between the 'monitor-epoch' categories showed an epoch effect on location error for the Gipsy5 and i-gotU600 receivers. The location error from the Gipsy5 at one second was significantly less than those at higher epochs (10, 30 and 60 seconds); while location errors at 10 and 30 seconds epoch were different in the i-gotU600 (Table 3.4).

Table 3.4 Ranked mean location errors for five GPS receivers tested across four epochs of one, 10, 30 and 60 seconds in static tests.

GPS Receiver	**1**	**10**	**30**	**60**
Carter	120.23[ab]	140.52[ab]	133.75[ab]	168.11[a]
i-GotU600	445.41[ef]	381.91[f]	485.35[de]	482.36[def]
Gipsy5	74.89[b]	785.30[c]	787.08[c]	774.51[c]
i-GotU120	456.40[def]	441.26[ef]	435.36[ef]	374.57[ef]
CatLog	732.11[c]	740.23[c]	643.20[cd]	679.77[c]

[a, b, c, d, e, f] Groups with the same letter are not significantly different (alpha < 0.05; Dunn Post-hoc test)

The location accuracy for Gipsy 5 at the one-second epoch was different from the other three epochs (10, 30 and 60 seconds) tested.

3.4.2 Motion Test – Off-Animal

The Skillings-Mack H test showed that there was a difference in distance moved recorded between the GPS receivers, $\chi2(2) = 8.520$ ($p < 0.001$). Summary statistics for distance recorded (km) logged from all receivers around the athletics track and post hoc contrast test is presented in Table 3.5. Maps showing dynamic tests off sheep are shown in Appendix 3-4.

Table 3.5 The distance moved (m) recorded against the inner lane of a 400 metres athletics track and compact letter display following Post-hoc Durbin test for seven GPS receivers assessed in Off-animal motion test.

Epoch	n	min	max	Mean	Median	SD
Garmin 310	10	313	400	357	364[a]	0.31
Gipsy5	10	389	405	400	402[ab]	0.05
Carter	10	395	406	401	402[ab]	0.03
Garmin 920	10	400	412	405	405[bc]	0.04
CatLog	10	353	640	437	407[bc]	0.84
i-GotU GT-120	3	407	421	413	411[c]	0.07
i-GotU GT-600	10	404	444	423	425[c]	0.10

[a, b, c] values with different superscripts are different from each other (alpha < 0.05; Durbin Post-hoc test p<0.05). Note: n=numbers of hours; min=minimum; max=maximum

3.4.3 Motion test – On-animal test

Summary statistics for each receiver during the on-animal test is given in Table 3.6. An effect of GPS receiver was found on distance moved by the sheep mounting the GPS receivers ($\chi2(5) = 109.71$, $p < 0.001$, Friedman test).

Table 3.6 Summary statistics for distance moved (m) by a sheep mounting six GPS receivers during 13 and 12 hour-periods on two recording days respectively

Receiver	n	min	max	mean	median	SD
Carter	25	67	483	257	264	100
CatLog	25	1235	42480	9450	8238	8201
Garmin920	25	17	310	105	103	76
Gipsy5	25	104	571	339	356	115
i-GotU GT-120	25	50	1428	846	812	388
i-GotU GT-600	25	0	387	115	84	115

Note: n=numbers of hours; min=minimum; max=maximum

From all receivers, the estimated distance moved by the sheep during daytime and sunset hours did not differ ($W = 3107$, $p = 0.205$, Mann-Whitney U test), although the receivers did not all record a similar distance moved by the sheep ($H(11) = 121.48$, $p < 0.001$, Kruskal-Wallis test; Table 3.7).

Table 3.7 Ranked mean (SD) distance moved in kilometres by a sheep mounting six GPS receiver brands during daytime and night-time hours and compact letter display for contrasts following Post-hoc Dunn test.

Receiver	Daylight	Night
Carter	77.2 (15.85)^{abc}	57.1 (19.36)^{abd}
Gipsy5	90.3 (13.52)^{bc}	73.2 (19.83)^{ab}
i-GotU 120	90.1 (37.26)^{bc}	115.5 (9.81)^{ce}
Garmin 920	43.2 (17.51)^{ad}	21.8 (15.35)^{d}
i-GotU 600	45.8 (28.82)^{ad}	22.9 (22.58)^{d}
CatLog	136.9 (9.28)^{e}	138.5 (6.61)^{e}

$^{a, b, c, d, e}$ Groups with the same letter are not significantly different (alpha < 0.05; Dunn Post-hoc test)

3.5 Discussion

3.5.1 Summary of the main results

This study has shown that spatial inaccuracies are still a feature of location estimates derived from commercially available GPS receivers, although smaller inaccuracies were detected than those of previous studies (Adams et al., 2013; Breed and Severns, 2015; Camp et al., 2016; Forin-Wiart et al., 2015) – this suggests that improvements have been made. In the present study, 95 % of the location estimates generated fell within < 4 m of their 'true' position for six of seven receivers tested in static tests. This suggests that these estimates are an acceptable proxy for measuring stationary activity without need for correction techniques. Among GPS receivers, a difference in measures of accuracy was identified in all tests. Whilst this may be indicative of the different firmware that run these receivers (Rempel and Rodgers, 1997), it also shows the non-existence of an industry standard across receiver brands, at least with regards to the performance metrics investigated. Invariably, this demonstrates the importance of undertaking performance and accuracy tests on commercially available receivers to identify units that are most suitable to meet the unique needs of researchers, and to do so in the right contexts. For the purpose of investigating the effect of GINs on movement attributes of sheep, the measures of accuracy investigated in this study show that six of the seven receivers investigated would provide location estimates within 5 metres of the true position of an animal 95 % of the time, and appear suitable for research in a limited space resource.

The variability found among receivers contradicts the hypothesis that location estimates would be similar. The distance estimates generated while attached to a sheep were found not to differ between daytime and sunset hours. The performance of the GPS receivers was consistent across tests, indicating repeatability of results from the different devices in different settings. Importantly, this means there was no evidence to suggest that there was a significant animal-dependent response to performance from any of the GPS devices investigated. These findings suggest that GPS-based location data is well suited for expanding the understanding of the movement patterns of parasitised sheep, albeit with some limitations to consider. These results reiterate suggestions to undertake performance assessments of GPS receivers prior to their use to track animal movement(Hebblewhite and Haydon, 2010; Tomkiewicz et al., 2010). Consequently, in a limited space resource (< 1 ha), these units can be deployed and used to tag animals, but in all cases errors in accuracy necessarily need to be considered in the context of the intended research question.

3.5.2 Static tests and the epoch effect

All the receivers recorded their position to within 11 m of previously marked 'true' locations at the one second epoch. For accuracy purposes, data points with a location error of <10m are deemed accurate enough for fine-scale analysis (Frair et al. 2010). With two exceptions (the

Gipsy5 and i-GotU GT-600), there was no difference in location errors recorded from GPS receivers across all epochs tested . The reason why location errors at 10- and 30-second epochs were different for the i-GotU GT-600 is not clear, although the location error at both epochs (10 and 30 seconds) were individually not statistically different from those at one and 60 seconds respectively. Historically, higher resolutions have needed to be traded-off for longer battery life for receivers and consequently allow more data to be collected (Cagnacci et al., 2010). This is the likely trade-off in accuracy that occurred in the Gipsy5 between the one-second epoch and those ≥ 10 seconds. Otherwise, each receiver showed variation in errors consistently across all epochs tested. If the choice between a one second- or 60-seconds epoch was to have a significant impact on battery performance or data storage, for four of the five receivers tested, there would be no impact on accuracy of increasing the epoch duration. From published results, GPS receivers deployed on ruminants seldom use epochs of 1 second; they typical range from 10 seconds to 10 minutes (Handcock et al., 2009), or they record location data following a specified protocol. For example, Falzon et al. (2013) defined a protocol of four location records, 15 seconds apart every 12 minutes to record the position of each animal in their study. Given that an epoch of one second would likely impact on the battery performance of the units and that 85 % of the receivers showed no evidence that accuracy of fix acquisitions at one second epoch performed better than those at 60 seconds epochs, there does not appear to be an advantage to this high frequency of location data recording for sheep studies with the receivers investigated. This, however, does not account for estimating distance travelled.

3.5.3 Motion tests on and off animal

The approach to test the dynamic (in motion) accuracy of the GPS receivers on the athletics track off-animal was useful in providing an indication for precision in distance travelled as a measure of movement. In six out of seven receivers, an average distance within 25 m of the 400 m track was recorded, with the Garmin 310 recording an average distance that was 38 m less than the true distance. It is noteworthy that three receivers, Gipsy5, Carter and Garmin 920, had recorded average distances within five metres of the 400 m length of the athletics track and gave similar or better accuracies than during the static tests. For these three receivers, the findings agree with reports that found better dynamic accuracy than static accuracy from GPS devices (Werner et al., 2003). Overall, depending on the researcher's needs, the decision on which receiver to use appears to be a matter of recognising what trade-offs (in static or dynamic accuracy) can be allowed to satisfactorily meet the research aims. If the research question required a high degree of detail (i.e., accurate travel distance estimates to the nearest 5 m or less) then choice of GPS receiver is key, or correction techniques may need to be utilised (Dewhirst et al., 2016).

3.5.4. Analysing daytime or sunset data

It does not appear that time of day had a detectable impact on location data collected in this study. The expectation was that sunset hours that are associated with greater periods of rest for sheep would result in less distance travelled. A possible explanation might be cumulative errors associated with recording positions at one second epochs. Bailey et al. (2018) recommended the removal of location data recorded when the animals are at rest and inactive in order to accurately estimate distance travelled using GPS collars. It has been demonstrated that GPS errors during inactivity can artificially increase the cumulative distance between positions by approximately 15 % (Ganskopp and Johnson, 2007). A possible alternative to handle this limitation of cumulative GPS errors during inactivity might be to have a threshold-based data recording system whereby movement data are only recorded above the cut-off for the previously established location errors. For example, the estimated error associated with any two successive estimates is two-times the average location error found. The Carter GPS unit with mean accuracy of 1.8 m (at 60 seconds epoch) for instance, will have an error of 3.6 m. Consequently, there would be merit in having a movement threshold of not less than 4 or 5 m to record true displacement to ensure errors do not influence the interpretations made from the data. A similar approach was taken by Brown et al. (2012), to solve the challenge of oversampling areas when animals are at 'rest' with too frequent sampling epochs and under sampling the details of movement paths with epochs that were too long. They used an on-board accelerometer to provide activity detail in addition to the GPS tag. By dynamically linking the location schedule to animal movement rate, their accelerometer-informed GPS tags reduced the trade-off between collecting detailed movement data and recording movement data for a longer period of time.

If a threshold-based data recording approach is used, it might present a limitation for the detection of activity-states from GPS location data using techniques such as Hidden Markov models (HMMs). Michelot et al. (2016) demonstrated the use of HMMs to infer activity states of individuals from GPS data recorded at regular epochs. However, the inherent nature of a threshold protocol to record GPS data negates the regularity of recorded locations and consequently data collected in this fashion cannot be fitted to HMMs. A possible solution to this would be to use the so-called threshold protocol to record location data from GPS receivers alongside a tri-axial accelerometer to provide an indication of the specific activity individuals are performing at any given time.

3.5.5 Implications of GPS performance metrics on investigating the behavioural response of sheep to GIN parasitism

Based on the performance metrics for measurements derived from receivers investigated in this study, GPS location data can allow a number of aspects of GIN parasitism in sheep to be investigated. To apply GPS location data to advancing the current understanding of the impact of GIN on sheep, distance travelled between infected and uninfected sheep is one variable researchers could measure. This is particularly useful in limited space resources where movement measures such as home range may be difficult to explore due to space constraints. It is useful for instance to validate the hypothesis that sheep, with even modest worm burdens, may move less frequently and graze less than those who are not parasitised. The magnitude and duration of such a difference, if it exists and is detectable, is vital to answering the hypothesis. If a receiver is estimated to have location error of ~ 4 m and a detectable difference between infected and uninfected animals was found to be > 4 m then the error is possibly not an issue. If the contrary is the case, however, one would have the challenge of explaining the true difference from a GPS receiver generated location error artefact. In other words, location estimates occurring within a GPS receiver's estimated location error may be 'swamped' by such errors and hence, limited inference can be deduced.

GPS location data records when static can be used as a proxy for stationary activity with shorter distances estimated between locations (Anderson et al., 2012), which can be applied in relation to GIN parasitism in a number of ways. For example, the influence of GIN infection on the site or patch of pasture a GPS tagged animal chooses to graze could be investigated in relation to geolocated faecal pats and deriving distance grazed from pats. Alternatively, preference for pasture type based on parasite load or immune status could be investigated by determining how much time animals spend in paddock sections sown by pasture of differing nutrient quality. The latter can be used to test the hypothesis that parasitized animals may feed more selectively in order to proportionally increase the protein content of their diet and thus partially compensate for reduced feed intake. Such approaches have been explored by Cosgrove and Niezen (2000) in New Zealand using n-alkane boluses to measure dry matter feed intake per day whereas Thamsborg and Agergaad (2002) used a rising-plate meter to measure post-grazing sward heights. To date few studies have used GPS data to investigate these variables in relation to parasitism. Liddell et al. (2020) recently used GPS collars to demonstrate that sheep with lower parasite burdens spent more time at grazing locations with higher vegetation growth, than their more parasitised counterparts.

A more direct approach for utilising GPS receiver records of stationary activity is to compare the amount of static location data recorded for infected individuals with those recorded for uninfected controls. This could be used as a proxy for time spent idling, which has been shown to be significantly less in young cattle subclinically infected with GIN (Forbes, 2008). Again, a careful consideration of location errors (as tested in static tests) needs to occur prior to use as a proxy, especially if a difference in (non)movement between infected individuals and their uninfected counterparts occurs within the range of the location error found associated with a receiver's records.

3.6 Conclusion

The investigations carried out in the present study allowed the evaluation of static and motion performance metrics from commercially available GPS receivers, on and off an animal subject. Off-animal tests performed against the athletic track proved an effective novel technique in allowing performance tests in measures of distance. With one exception, there was no evidence that the epoch lengths of 10 seconds and above negatively affected the resolution of location estimates. Measures of distance estimated from the receivers on and off the animal performed similarly. Overall, the evidence suggests that the general behaviour of the animal had a negligible effect on the quality of the location estimates from the receivers in comparison to estimates in the static test and motion test on the athletics track. There was also no effect of time of day on the receivers' estimation of the ewe's travel distance, indicating that a movement threshold recording protocol might be necessary to reduce oversampling location estimates when the animal is at rest. Overall, the findings of the current study showed that there is merit in conducting performance assessments on GPS receivers when using these tools to answer research questions, such as to expand understanding of the effect of nematode parasites on movement activity of infected sheep. Practical insight into the movement behaviour of parasitised animals might further show the interplay of parasite-host mechanisms and how host behaviours are altered. It may also be possible to infer whether these responses serve the host or parasite. In sheep, these mechanisms remain poorly resolved but the estimates of travel distance in this study shows it is possible to see how parasites alter this measure in infected hosts. Understanding the effect of static and dynamic variability on location data in relation to an animal's temporal movement budget is important and has provided context on how location data will be collected and analysed going forward.

CHAPTER 4 – WHAT ARE EWE LAMBS DOING? IDENTIFICATION OF SHEEP ACTIVITY ON PASTURE USING THE ACTIGRAPH WGT3X-BT® ACCELEROMETER

4.1 Abstract

A tri-axial accelerometer sensor was evaluated for its ability to identify the diel activity pattern of young sheep on pasture. The study comprised two phases. In phase 1, six ewe-lambs were fitted with an accelerometer mounted on a neck collar, at the same time their activity types were video recorded and classified into mutually exclusive categories: grazing, standing, lying, walking or other. The raw X, Y and Z axis values from the accelerometers were applied directly to classify the activities using Random Forests without transforming the original data, using the video observations as the gold standard to train and validate the classifier model. A prediction model was built to classify behavioural activity of sheep fitted with this tri-axial accelerometer sensor. In phase 2, 10 sheep were each fitted with three accelerometers but on different body locations: neck collar, body harness and head halter. The classifying algorithm developed in phase 1 from the neck location was used to infer the sheep activity from raw accelerometer data recorded continuously for three days, for all three locations and the results were compared. In phase 1 the classifier returned an overall accuracy of 89.6% when compared to the gold standard. This overall classifier accuracy was achieved when the categories lying and standing where combined into one category – 'resting'. Within the classifier, grazing activity was predicted with an accuracy of 94 %, 'resting' at 88 % and 'walking' at 78 %. In phase 2, there was no significant difference in the daily proportion of time inferred for 'grazing' and 'resting' activity between using accelerometer data from collars versus head halters (beta = -0.29, $p = 0.174$ and beta = -0.09, $p = 0.671$ respectively), while the time budget for 'walking' was overestimated at the head halter location (beta = 0.75, $p = 0.001$). For activity inferred from body harness, there was no significant difference with neck collars in inferring 'walking' ($p = 0.731$), whereas 'grazing' was underestimated and 'resting' overestimated using a body harness. These results demonstrate the ability of the ActiGraph wGT3X-BT® to distinguish different activities in ewe-lambs using raw X, Y and Z accelerometer data, demonstrating the diel activity pattern of sheep on pasture. This output can be applied in a variety of contexts to investigate animal health and welfare metrics.

4.2 Introduction

Monitoring of animal activity using non-invasive technologies such as accelerometers can provide an indicator of optimum health, welfare and production (McLennan et al., 2015; Walton et al., 2018. These technologies are widely used in wildlife ecology studies (Whitney et al., 2007, Pagano et al., 2017) and in animal science studies (Chapinal et al., 2011, Hempstead et al., 2017, Bailey et al., 2018) to infer the behavioural responses of host animals to their internal and external environments.

In domestic sheep, accelerometer data has been used to classify the activity of Merino sheep on pasture (i.e. grazing versus lying versus standing) in few sensor validation studies (Alvarenga et al., 2016, Barwick et al., 2018a). These studies investigated behavioural patterns, usually associated with a particular context, e.g., effect of opioids on sheep behaviour (Verbeek et al., 2012), and detection of lameness (Barwick et al., 2018b). In the field of parasitology, measurements of fractal measures of activity in sheep demonstrate behaviour have demonstrated that the relative time spent idling or grazing was indicative of parasitic infection in young cattle (Forbes et al., 2000). However, these methods have seldom been used for parasitology studies in pasture-based sheep. The Actigraph wGT3X-BT® tri-axial accelerometer was mounted on ram mating harnesses to investigate the impact of subclinical levels of gastrointestinal nematode infections on the activity of young sheep (Ikurior et al., 2020). Sub-clinically parasitised sheep showed a reduction in overall activity estimates measured as dynamic vectorial body acceleration (VeDBA). The Actigraph wGT3X-BT® triaxial accelerometer has been used in proximity studies investigating contact between lambs and ewes (Paganoni et al., 2020). Here, we aimed at determining different activity types in pastured sheep in order to allow investigations on the influence of parasites on these behavioural attributes. Each species differs in their signature in the tri-axial data, and hence the developments made in other species (Horses, Morrison et al, 2015; and dogs, Hoffman et al., 2019) cannot be applied to sheep.

For the limited studies reported to date, accelerometers have been applied to sheep using different attachment locations and each may have advantages. It has been suggested that for an accurate indication of individual energy expenditure, accelerometers should be placed close to the centre of mass (Brown et al., 2013), such as on a harness. In an earlier study we positioned the Actigraph on a ram mating harness to infer overall activity of sheep in response to parasitism (Ikurior et al., 2020). However, the placement on top of the shoulder (Figure 4.1) limits the collection of information on head movement associated with grazing. For practical on-farm purposes it is likely that accelerometers will most likely be included in some form of ear tag (Barwick et al., 2018a). The downside to this location is the additional noise associated with small ear and head movements. Attaching the accelerometer to a neck collar will capture some head movement but with limited information from minor head movements. To date, the use of classifier models developed in one placement form have not been applied to other placement locations. As commercial accelerometers are used at different animal positions, it is worth knowing how classifier models developed in one placement location performs at others to inform utility across contexts.

The aim of the current study was to build prediction models to classify activity of Perendale sheep at pasture fitted with a neck collar mounting the Actigraph wGT3X-BT® tri-axial accelerometer . A prediction model was developed from raw X, Y and Z axes acceleration data to classify different behavioural activity types. This study tested two hypothesis: 1) that raw, unmanipulated acceleration data could be used to create an accurate classification model capable of inferring diurnal activity patterns of sheep (Phase 1); 2 that the classification model developed from accelerometers attached to neck collars can be applied to infer activity from accelerometers located on head halters and on a body harness (Phase 2).

4.3 Materials and methods

The study was conducted at the Massey University sheep unit, Palmerston North, New Zealand (40° 23'28" S 175° 36'21" E 40 m elevation) between July 24 and August 9, 2018, which is during winter at this location. Ethical approval to conduct this study was obtained from the Massey University Animal Ethics Committee (Protocol No. 16/134).

4.3.1 Study animals and design

The study comprised two phases: a classification model development phase (P1) and a second phase (P2) to test model performance for different body locations of the accelerometers in identifying diurnal activity of sheep, with the collar as the reference. P1 was conducted with six Perendale ewe-lambs at approximately one year of age. The lambs were part of a mob of 27 animals grazing together. For P2, 10 ewe lambs from the same cohort were used. All animals were treated with anthelmintics just prior to the study and had received a standard combination clostridial and leptospirosis vaccine (Ultravac®7 in 1, Zoetis NZ Inc.) as well as topical insecticide (Clik®, Elanco Animal Health NZ Ltd) to prevent fly strike. The lambs were a mean liveweight of 43 kg (SD= 4.5 kg). To allow visual identification in the paddock from a distance, each ewe lamb was coat-sprayed visibly with a unique colour and number on the hind quarter and lateral sides using scourable spray-mark (Leader Stock Marker).

4.3.2 Accelerometer

For P1 an ActiGraph wGT3X-BT® acceleration sensor (ActiGraph, LLC, Pensacola, FL, USA) that measures accelerations from the individual's amplitude (g) and frequency (Hz) of during movement across the vertical, horizontal, and perpendicular axes was attached onto the top side of a neck collar with a cable tie, and in P2 two additional monitors were fastened to a head halter and a ram mating harness respectively (Figure 4.1).

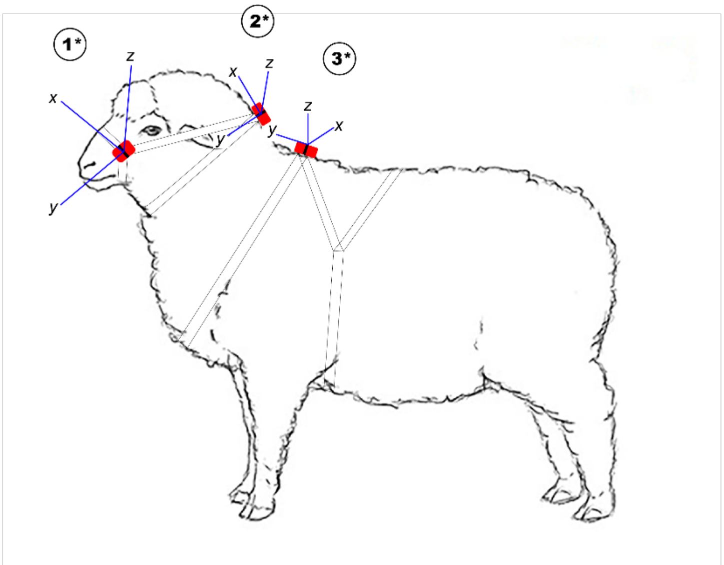

Figure 4.1 The position of the Actigraph tri-axial accelerometer on 1 (head halter), 2 (neck collar) and 3 (body harness) and the axis orientation at each position in relation to the animal's body.

The sensor on the collar employed a reference system that indicates longitudinal (front-to-back or surge, X), horizontal (side-to-side or sway, Y) and vertical (up and down or heave, Z) body axes, respectively (ActiGraph Manual, version 1.0.0 August 2013). Before attaching the sensors to the sheep, they were pre-scheduled to collect acceleration data at a sampling rate of 30Hz, which is equivalent to 30 data points per second. The accelerometers were 46 × 33 × 15 mm in size and weighed 19 g. The orientation of the sensors was the same across all sheep. For comparison in P2, the accelerometers on the withers (body harness) have longitudinal (front-to-back or surge, Y), horizontal (side-to-side or sway, X) and vertical (up and down or heave, Z) body axes which is 90° different to the neck collar. For the head halter the accelerometers have longitudinal (front-to-back or surge, X), horizontal (side-to-side or sway, Z) and vertical (up and down or heave, Y) body axes, respectively. This difference in orientation was corrected and accounted for prior to analysis.

4.3.3 Behaviour ethogram

Four categories of behaviour were defined *a priori* based on previous work by Barwick et al. (2018b) and Alvarenga et al. (2016) in order to compare behavioural categories collected from accelerometery against behavioural observations. These categories included:

1. Grazing – Head down while standing still or slowly moving forward whilst ingesting grass with the muzzle close to the ground
2. Standing – Standing with head up > 5 secs, minimal head movement (left to right)
3. Walking – Head up whilst walking at a slow pace / running at a fast pace. Head raised at or above horizontal plain and eyes open (to include scanning)
4. Lying – lying down with minimal head movement
5. Other – including scratching, playing etc.

4.3.4 Data recording and management

For each phase of the study, raw acceleration data, continuously recorded at 30Hz, were integrated into five second epochs across X, Y and Z axes at each of three body positions per sheep.

4.3.4.1 Model classification phase (P1)

Three experimental tests (ET) were conducted. Lambs were in a grazing paddock (ET One), a holding pen (ET Two) or walked through a lane way (ET Three). Each ET was designed to capture a target activity, with grazing, standing and walking corresponding to ETs One, Two and Three, respectively. All six lambs were filmed during these experiments. Video recordings were made using a Samsung NX300 digital camera (Samsung Electronics America, Inc.). All observations were conducted during daylight hours. The starting times for the six observation sessions per day is shown in Table 1. Video observations were taken from a 100 to 200 m distance using the camera's zoom lens in order to avoid disturbance of the sheep. Although experiment One was designed to capture grazing activity, all other activities were also captured during this time. Lying activity was opportunistically targeted during the late morning period. A mean (SD) of 3.30 h (0.30) of video was recorded for each individual, generating a total video time of ~ 20 hours 40 minutes (Table 4.1). Using the behaviours defined in section **4.3.3**, all videos were watched and coded by the same observer (SJI). An activity profile of each animal was created from videos by annotating and coding activity type at five seconds interval (i.e., five seconds epochs) using CowLog®, an open-source software for coding behaviours from digital video (Hänninen and Pastell, 2009)

Table 4.1 Starting times and duration of focal behaviour observation sessions recorded by video across three experimental periods on ewe lambs (n=6) fitted with a collar mounting an Actigraph® wGT3X-BT accelerometer sensor.

Date	Focal behaviour	Start	End	Duration (mins)
2/08/2018	Grazing	14:09:40	14:39:30	29:59
2/08/2018	Grazing	14:41:05	14:51:00	17:05
3/08/2018	Lying	11:15:00	11:45:55	31:00
9/08/2018	Standing	10:46:50	11:16:35	29:59
9/08/2018	Standing	11:17:15	11:22:15	05:09
9/08/2018	Walking	11:28:00	11:44:55	17:03
11/08/2018	Grazing	13:17:35	13:47:25	29:59
11/08/2018	Grazing	13:48:40	14:18:30	29:59
11/08/2018	Grazing	14:19:10	14:34:10	15:40

4.3.4.2 Within-observer reliability test

This test measures the extent to which a single observer obtains consistent results when repeatedly measuring the same behaviour (Martin and Bateson, 2007). In this part, the intra-observer agreement was tested using Kappa statistic by calculating the level of agreement of activity annotations using a subset of 15 minutes per activity category in four study animals compared to annotations for activity of the same animals during the initial activity coding. There was a time interval of 18 months between the first and second activity coding. The percentage of exact agreement between the first and second coding of the same behaviour by the observer was calculated, and the within-observer variability was assessed using intra-class confusion matrix and kappa coefficients (κ) (Cohen 1968). Kappa results were interpreted according to Fleiss (1981), where values >0.75 suggested 'excellent', 0.4 to 0.75 indicated 'fair-good' and <0.4 indicated 'poor' levels of agreement.

4.3.4.3 Collection of accelerometer data from different body locations (P2)

The sensor data from each body location were collated for a 72 h period commencing at 0900 hr on the day of attachment of the sensors to the lambs (i.e., Tuesday), and presented as three daily blocks, that is per 24 h. As mentioned above the orientation of the X, Y and Z axes differed between attachment methods. We adjusted for this prior to analysis. Then the classification model was applied to deduce activity types at each 5 second interval. We then separately compared the activity budget for the head halter and the harness to the activity budget of the collar.

4.3.5 Statistical analysis

All data computation and statistical analysis were conducted in R 3.4.2 (R Core Team, 2017).

4.3.5.1 Descriptive statistics

The frequency of occurrence of the coded activity were described and two-dimensional plots were used to describe the relationship between activity types and the x-y, x-z and y-z axes.

4.3.5.2 Phase One – Building classifier model

Activities classified as 'other' were removed. Random forest (R package 'randomForest', Breiman et al., 2015) was used to develop an activity classification model using the raw X, Y and Z accelerometer data to predict activity types observed in the labelled dataset, running 1000 iterations. This method implements out-of-bag error estimation for robust and unbiased inferences. In each iteration, random forest randomly samples data points and variables and then combines the output at the end. The output of the out-of-bag random forest model (hereafter called 'classifier') was then used to predict behaviours using the entire labelled dataset, and model predictions were compared to the gold standard (video observations) to compute a confusion matrix to evaluate the performances of the classifier. Two metrics were used for overall classifier performance (across all activities): the overall accuracy and overall misclassification rate. To evaluate the performance of the classifier for each individual activity type separately, four performance metrics were calculated as outlined below in Equations 4.1 to 4.4:

$$\text{Sensitivity}=TP/(TP+FN) \qquad \text{Equation 4.1}$$

$$\text{Specificity}=TN/(TN+FN) \qquad \text{Equation 4.2}$$

Precision= TP /(TP+FP) Equation 4.3

Accuracy= (TP+TN) /(TP+TN+FP+FN) Equation 4.4

Here, TP (true positive) correspond to the number of epochs where the behaviour of interest was correctly predicted by the classifier. TN (true negative) are the number of epochs where the behaviour of interest was correctly classified as not having occurred. FN (false negative) are the number of epochs where the behaviour of interest was observed but not inferred by the classifier. FP (false positive) are the number of epochs where the behaviour of interest was inferred by the classifier but not observed. To further validate the predictive ability of the classifier model, a "leave-one-out" cross-validation was used based on individual sheep removal, as the observations were clustered by individuals. Data points of each individual lamb were removed sequentially from the labelled dataset, the model was trained using the remaining five lambs and validated on the initial lamb removed.

4.2.5.3 Phase Two

For P2, the daily activity budgets (proportion of time spent grazing, resting, and walking) were calculated for each ewe lamb (n=10) and compared between accelerometer placements. The components of compositional data, such as activity budgets, sum to 1 The daily proportions of each activity were summarised as mean per hour of day and described for each placement of the sensor on the animal's body.

A Dirichlet regression with log link was then fitted to model the relative hourly proportion of time spent in each activity for each sheep, as a function of the accelerometer placement and the day. As the multivariate generalization of the beta distribution, the Dirichlet distribution accounts for the numerical constraint associated with compositional data such as activity budgets, whose components sum to 1 (Regular et al., 2014), and allows for the simultaneous assessment of the effects of covariates on the relative contribution of multiple activities (Gueorguieva et al., 2008). The R package 'DirichletReg' (Maier, 2014) was used to model the response variable 'activity budget' (hourly proportion of performing the activities) and the explanatory variables were 'position' (head halter and body halter, reference=neck collar) and 'day' (the trial was run for 3 consecutive days).

4.4 Results

4.4.1 Descriptive statistics for Labelled dataset and 2-D plots (Phase 1)

The activity budget is shown in Table 4.2. Grazing' was the most frequent activity. Activity data described in two-dimensional plots (Figure 4.2) based on each predictor, i.e. X-Y, X-Z and Y-Z axes, where X, Y and Z axes correspond to axis1, axis2 and axis3 respectively.

Table 4.2 Percentage (95 % confidence interval) of overall time of 5 second epochs that were classified as 'grazing', 'lying', 'standing', 'walking/running' or Other from filmed ewe lambs.

Activity	Percentage (95 % CI)
Grazing	38.8 % (38.0 to 39.6)
Lying	20.6 % (19.9 to 21.3)
Standing	21.1 % (20.4 to 21.8)
Walking/ Running	8.6 % (8.1 to 9.1)
Other	11 % (10.5 to 11.5)

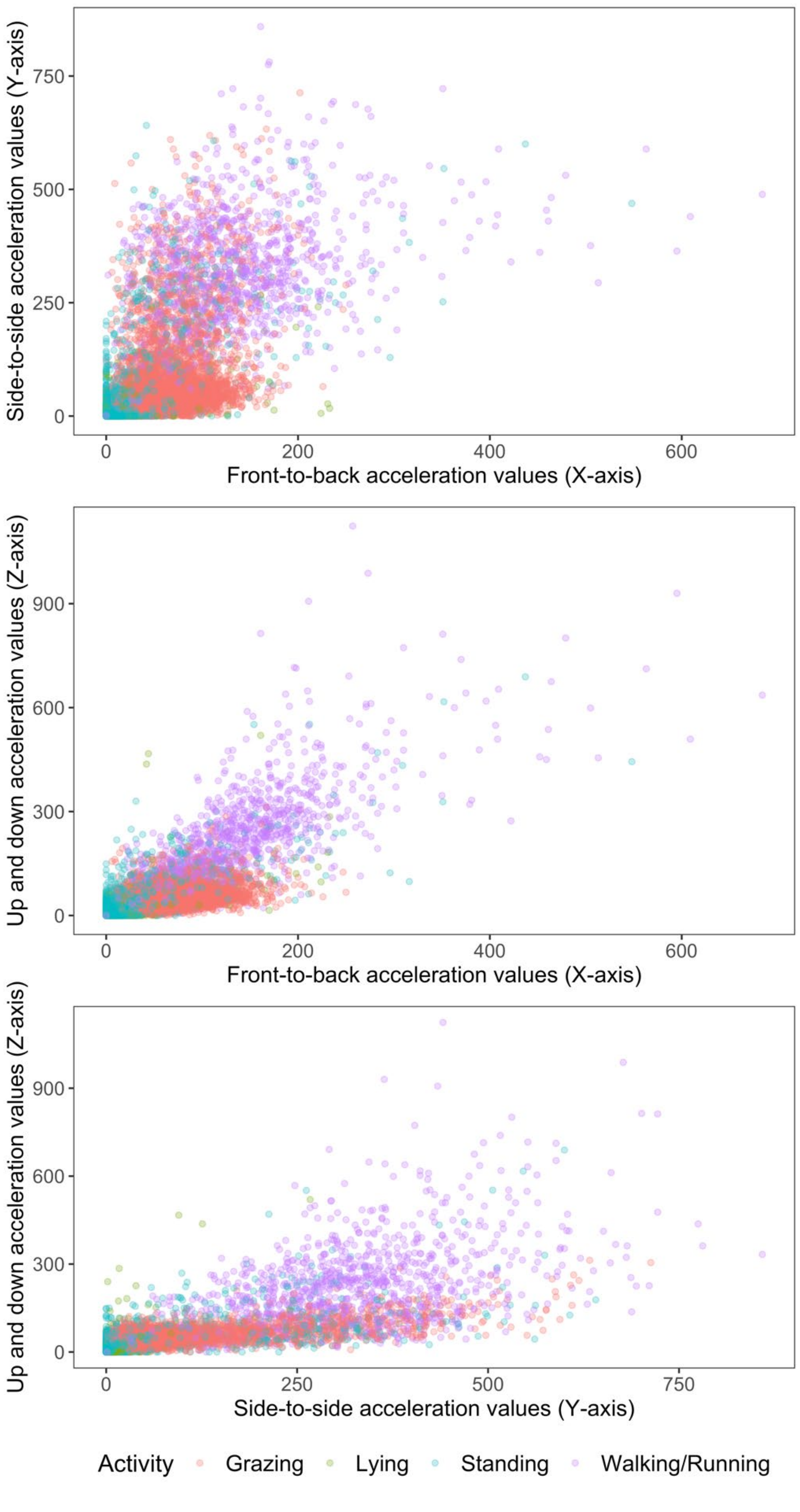

Figure 4.2 2-D scatter plots of acceleration signals recorded in X, Y and Z axes of six ewe lambs during periods of 'grazing', 'standing', 'lying' and 'walking'.

4.4.2 Within-observer agreement test

A summary of the activity data recorded by one observer on two occasions (18 months apart) is shown in Table 4.3. The overall accuracy between the first and second observations was 99 %. Walking and standing behaviours were the most frequent to be misclassified but with a misclassification error ≤ 4 % between the activities. The Kappa value ($\kappa = 0.98$) suggests that there was 'excellent' agreement between the first and second coding of the same observer.

Table 4.3 Count of activity for four ewe lambs at five seconds interval over a one-hour period. Observations coded by one observer on two occasions (18 months apart).

	1st Coding				
2nd Coding	Grazing	Lying	Standing	Walking/Running	Total
Grazing	173	0	0	0	173
Lying	0	177	0	0	177
Standing	0	0	150	6	156
Walking/Running	0	0	3	133	136
Total	173	177	153	139	642

4.4.3 Random Forest model

The best out-of-bag classification model (classifier) was derived by combining standing and lying behaviour into one behaviour (= 'resting'). This improved model prediction and reduced misclassification by 15 %. Two-dimensional scatter plots of 'grazing', 'walking' and the newly categorized 'resting' extracted from the accelerometers mounted on neck collars using raw X, Y and Z acceleration values are shown in Figure 4.3.

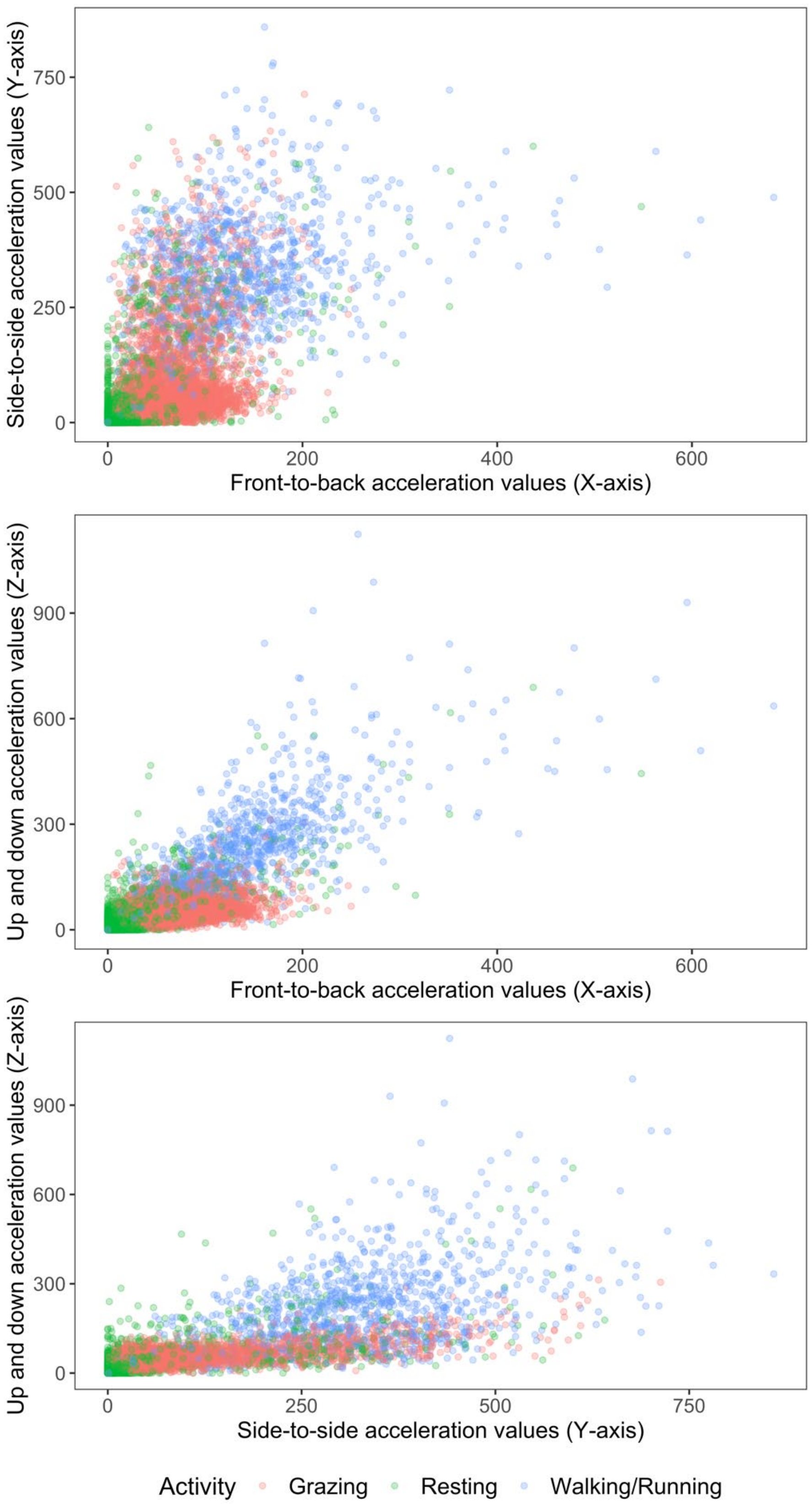

Figure 4.3 2-D scatter plots of acceleration signals recorded in X, Y and Z axes of six ewe lambs during periods of 'grazing', 'resting' (standing or lying activity) and 'walking'.

The confusion matrix of the final model predictions against the observed activities (video recorded) is shown in Table 4.4.

Table 4.4 Confusion matrix of the best classifier using random forest, showing the predicted activity for neck collar-mounted accelerometers recording activity for six sheep during four sampling days (5 seconds epochs). Values across the diagonal (bold) represent those activities that were correctly identified, true positives. Values in the matrix are the number of epochs.

	Predicted activity		
Observed activity	Grazing	Resting	Walking
Grazing	**4562**	154	139
Resting	459	**4650**	103
Walking	256	50	**772**

Out-of-bag misclassification rate: 10.4%

The classifier predicted an overall activity allocation for all sheep of 47 % 'grazing', 44 % 'resting' and 9 % 'walking/ running', to compare to 44 %, 47 % and 9 % respectively for the true observations. The performance metrics calculated from the classifier model for each activity is shown in Table 4.5.

Table 4.5 Performance metrics of random forest classifier algorithm for grazing, resting and walking activities of ewe lambs.

Behaviour	**Accuracy**	**Precision**	**Specificity**	**Sensitivity**
Grazing	91 %	86 %	88 %	94 %
Resting	93 %	96 %	96 %	89 %
Walking	95 %	76 %	97 %	72 %

4.4.4 Leave-one-out cross validation by individual sheep removal

The overall accuracy for each round of prediction was 88 % (Kappa 0.8; 95% CI 87 to 90), 87 % (Kappa 0.8; 95 % CI 85 to 88), 88 % (Kappa 0.8; 95 % CI 87 to 90), 88 % (Kappa 0.8; 95 % CI 86 to 89), 92 % (Kappa 0.9; 95 % CI 90 to 93) and 87 % (Kappa 0.9; 95 % CI 90 to 93) respectively. This resulted in a mean model prediction accuracy of 88 % (SD= 1.7 %). The performance of random forest models analysed at the level of the individual ewe-lambs (i.e. trained by five individuals' labelled dataset to predict the sixth individual) is shown in Table 4.6.

Table 4.6 Performance of the random forest classification algorithm predictions across individual ewe lambs (n=6). Data shown for each lamb when data for other 5 lambs used to develop the algorithm.

Lamb		Grazing				Resting				Walking			
	n	Acc.	Prec.	Spec.	Sens.	Acc.	Prec.	Spec.	Sens.	Acc.	Prec.	Spec.	Sens.
1	1838	89 %	80 %	86 %	94 %	93 %	95 %	96 %	89 %	94 %	80 %	99 %	50 %
2	1853	88 %	85 %	93 %	80 %	90 %	89 %	87 %	93 %	94 %	74 %	97 %	73 %
3	2146	90 %	89 %	89 %	91 %	93 %	91 %	93 %	91 %	93 %	63 %	97 %	52 %
4	1717	89 %	83 %	87 %	92 %	91 %	94 %	94 %	88 %	95 %	83 %	98 %	69 %
5	2887	93 %	90 %	91 %	96 %	93 %	97 %	97 %	88 %	97 %	81 %	98 %	88 %
6	1504	89 %	89 %	84 %	92 %	91 %	95%	98 %	76 %	93 %	64 %	94 %	87 %

n = number of predictions made for individual lamb; Acc. = Accuracy; Prec. = Precision; Spec. = Specificity; Sens. = Sensitivity

4.3.5 Testing the classifier model performance at alternative body positions (phase 2)

The daily activity budgets deduced (proportion of time spent 'grazing', 'resting', and 'walking') using the classifier developed in Phase 1 from the accelerometer data obtained by fitting the accelerometer to a collar (neck, as reference), a halter (head) and a harness (body) are presented in Table 4.7.

Table 4.7 The average daily time spent grazing, resting and walking for three days recorded by tri-axial accelerometers positioned on a neck collar, head halter and body harness of ewe lambs (n = 10).

Activity	**Position**		
	Collar	Halter	Harness
Grazing	38.8 %	34.6 %	7.8 %
Resting	59.8 %	60.5 %	91.9 %
Walking	1.4 %	4.9 %	0.3 %

The proportion of each activity summarised per hour of day for each position of the sensor on the animal's body is shown in Figure 4.8. Collars and halters produced similar proportions of time spent in each activity type. However, results derived from harness accelerometers were different for all three activity types. Resting' was strongly overestimated, whereas the other two types were strongly underestimated.

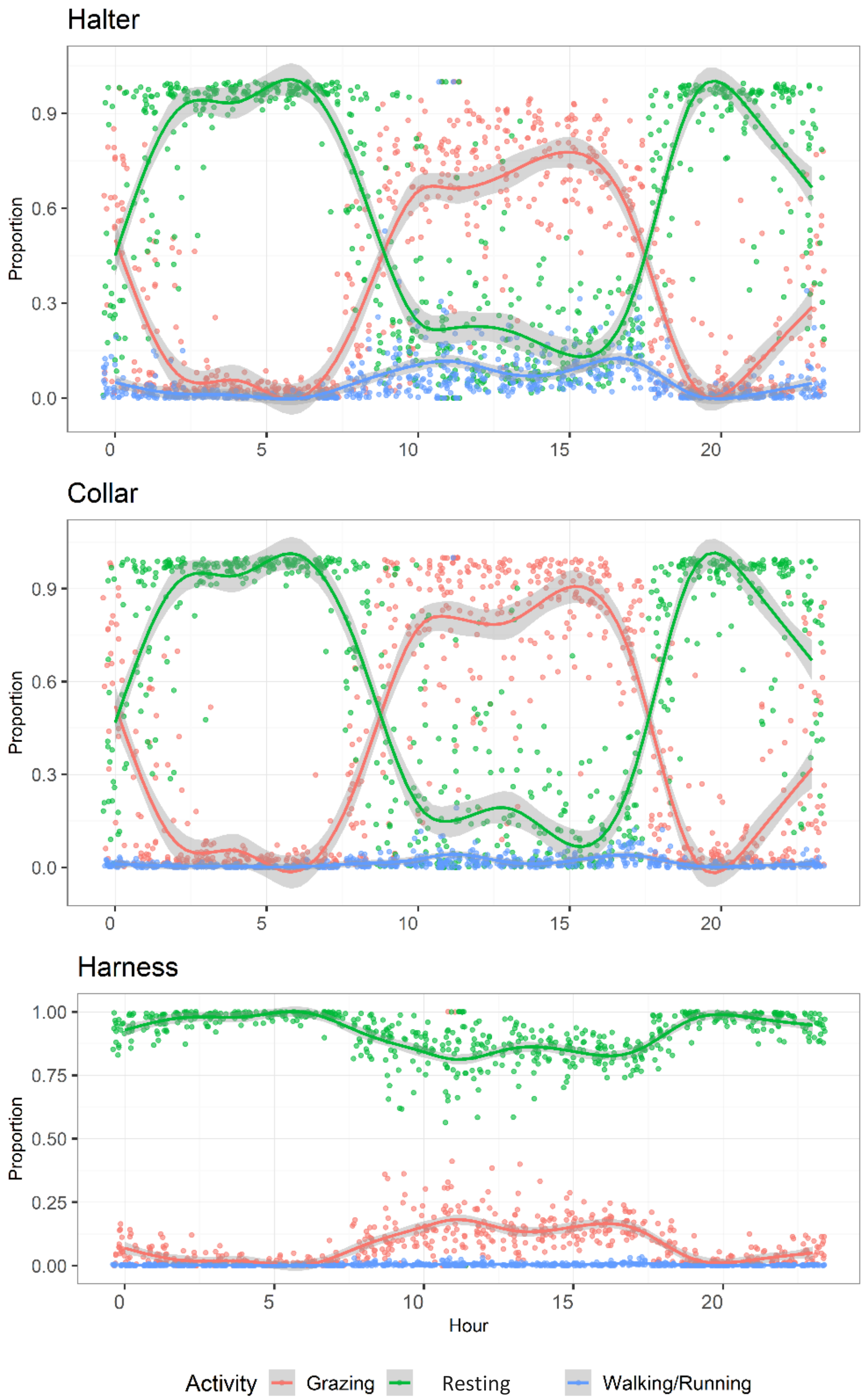

Figure 4.4 Mean daily activity budgets of ewe lambs (n=10) per hour of day allocated to three activities monitored for 72 hours with tri-axial accelerometers at three positions on the animal's body.

Results of the multivariable Dirichlet model to compare accelerometer body placements are presented in Table 4.8. They indicate that predictions of grazing and resting activities were not statistically different using an accelerometer on a head halter, compared to the neck collar. On the other hand, the predicted daily proportion of time spent walking was significantly different between the head halter and collar. Comparing the harness with the collar, the daily proportion of time spent grazing time and resting were significantly different. Only the total walking time did not differ between harness and collar derived data.

Table 4.8 Result of the Dirichlet regression model of the relative allocation of daily activities (grazing, resting, walking/ running) for 10 sheep over 3 days study period. Reference category for the model is the neck collar.

	Estimate	**SE**	***p***
Grazing			
(Intercept)	-1.07	0.21	<.001
Position (Halter)	-0.29	0.22	0.174
Position (Harness)	-0.48	0.23	0.034
Day	1.71	0.08	<.001
Resting			
(Intercept)	-1.11	0.18	<.001
Position (Halter)	-0.09	0.22	0.671
Position (Harness)	1.53	0.23	<.001
Day	1.86	0.07	<.001
Walking			
(Intercept)	-2.36	0.23	<.001
Position (Halter)	0.75	0.22	0.001
Position (Harness)	0.08	0.22	0.731
Day	1.16	0.09	<.001

4.5 Discussion

Results from this study show the utility of tri-axial accelerometers in quantifying the diel activity of sheep on pasture. Acceleration data was used to identify three behavioural activity classes performed by ewe lambs, with the diel pattern of sheep activity captured. The random forest classification algorithm (classifier) had an overall accuracy of ~ 90 % when related to video footage that recorded the behaviour at the same time. This study shows that raw X, Y and Z acceleration data can be used to develop classification algorithms for grazing, resting and walking activity of Romney sheep on pasture, without transforming the data with the creation of summary features. Traditionally, X, Y and Z axis values are used to calculate summary features such as entropy, pitch, roll, signal magnitude area (which distinguishes between periods of activity and rest) and signal vector magnitude (which indicates the degree of movement intensity). These are then evaluated and subsequently tested for accuracy of prediction of activity. Random forests allow for non-linear relationships between the covariates and the outcome (behaviour class membership probability) to be detected (Cutler et al., 2007). This classifier was extended to accelerometer data at two other placement positions to predict activity budgets of lambs, which is discussed below.

Grazing activity had the lowest misclassification rate (6 %) among all activity types predicted by the classifier. With a classification precision of 86 %, grazing activity was however, 10 % less precisely predicted than resting, which was likely due to grazing having a higher rate of false positives than resting. Walking was misclassified as grazing 24 % of the time by the classification model developed from the collar position, which may be attributable to the fact that sheep often quickly alternate between moving with head up and grazing with head down. It is plausible that this difficulty in differentiating these two activity types with higher resolutions relates to the sampling frequency. Using a different In contrast, Barwick et al. (2018a) found that performance measures for walking behaviour were high, with prediction accuracy, precision and sensitivity of 98 %, 93 % and 95 % respectively. In the present study, although walking was only predicted correctly 72 % of the time, it was considered satisfactory to maintain it as a predicted category. Also, it was the intention of the authors to predict grazing behaviour apart from other activities.

Conversely, to improve the accuracy of the final algorithm,. standing and lying were combined into a 'resting' category. The acceleration signals of 'standing' and 'lying' were similar, as seen in Figure 4.2 and Figure 4.3. This would explain the misclassification between both categories and hence warrant combining the categories. This recategorization of 'standing' and 'lying' into 'resting' improved both the accuracy and precision of the classification to 93 and 96 %, respectively. Barwick et al. (2018a) took a similar approach and also merged the classifications of lying and standing behaviour into "inactive" behaviour. It is possible to speculate that the signal only differs at the collar position where animals lay down, but once they stand or are lying the X, Y and Z signal is the same. Overall, this important as activities indicative of inactive states, could also be important in on-farm management as indicators of health issues.

When comparing two other accelerometer placement positions to the collar derived data, at least one activity frequency was not different. One way to look at this is that the classifier developed at the collar position was robust enough to capture activity budgets at other accelerometer placement position. However, care in interpreting this finding is warranted because the other placement positions were not compared the video observations in this study. The results suggest that little activity may have been recorded at the harness position. Hence, resting was overpredicted, with grazing activity underpredicted. A significant difference between collar and harness for walking activity may have been seen because it was a rarely predicted behaviour. Since comparisons were for the time budgets and not the individual classification of the activities, it is conceivable that the harness-placed accelerometers may have recorded walking activity at very different time than the collar. Future studies can corroborate acceleration signatures from these different placement methods and then assess the performance of a classifier derived in one position to the others and vice versa. In all, this finding highlights the challenge of applying classifiers developed from tri-axial accelerometer data from one placement to another placement, not the least applying classifiers developed from other brands and sheep breeds.

These limitations notwithstanding, overall, it is possible to apply this output in a variety of contexts. For example, overall activity data calculated from the Actigraph tri-axial accelerometer allowed the detection of reduced total activity in parasitized young sheep using dynamic vectorial body acceleration (VeDBA; Ikurior et al., 2020). The development of this classifier model can now allow the optimal placement method for further differentiation of activities into effects

Infection with gastrointestinal nematodes is known to affect voluntary feed intake (Coop et al., 1982) which presumably is reflected in grazing activity. Hence, grazing behaviour derived from accelerometer data could be used as a proxy for feed intake, and hence as an early warning sign for nematode infection (Ikurior et al., 2020). It is unlikely that any accelerometer technology to detect grazing activity should be located on a body harness. Head halters on cows that measured jaw movement combined with pedometers showed that dairy cows grazed for longer whilst benefiting from the persistent activity of anthelmintics whilst untreated cows ate less and presumably had to divert resources to mount an immune response against ingested larvae (Forbes et al., 2004).

Further, the results show that for the collar and head halter mounted sensors, the ewe lambs followed a daily activity pattern consistent with the observation of others (Arnold, 1984), indicating more grazing activity in day light hours, with resting predominating sunset hours. The average daily time budget of the ewe lambs (deduced from the collar) by hour of day showed that their grazing activity started to rise at 0600 h, peaking shortly after 1500 h, before starting to decrease (Figure 4.4). This diurnal activity pattern is typical of sheep in Mediterranean climes (Arnold, 1984), although in hot arid environments sheep were shown to graze with less intensity as temperatures rose from 10.00 h to 15.00 h, with grazing steadily rising again from 16.00 h (Patkowski et al., 2019). Generally, sheep graze from sunrise to dusk, stopping sporadically to chew their cud and this grazing period can be up to seven hours of the day (Arnold, 1984). The results in the present study for grazing activity derived from accelerometers are similar to those of Arnold (1984) which were based on visual observations at 15 minutes intervals. We further suggest that our algorithm included rumination activities into the resting category, which might be why the ewe lambs were estimated to 'rest' for upward of five hours on average, compared to the 3 to 4 hours sheep were reported to spend sleeping by Arnold (1984).

4.6 Conclusion

Raw acceleration data from the Actigraph wGT3X-BT® tri-axial accelerometer mounted on a neck collar allowed the classification of three activity categories ('grazing', 'resting' and 'walking') with a high degree of accuracy and without the need to transform the X, Y and Z acceleration data. This classifier also demonstrated ability to deduce the activity budget of at least one activity from accelerometer data positioned at alternative locations on the that was not different from the neck position where it was developed. Overall, the diurnal pattern of activity for sheep was adequately captured, comparing favourably with those of direct observation. This classifier has the potential to be used in a variety of contexts to investigate animal health and welfare metrics in a non-invasive manner, including as an indicator of parasitism, which could meet the requirement for the treatment of individual animals.

CHAPTER 5 – MOVEMENT AND BEHAVIOUR CHANGES IN GASTROINTESTINAL NEMATODE INFECTED AND UNINFECTED LAMBS

5.1 Preface

This chapter describes a field trial involving 24 growing lambs that were monitored remotely with GPS and tri-axial accelerometers from weaning to one year of age. Location data from GPS collars were used to calculate the daily distance travelled per individual, while daily activity budgets of lambs were derived from accelerometry data. The latter was contingent on developing a behaviour-predicting algorithm from accelerometry data in order to infer the activity budgets of lambs. During the development of the algorithm (**Chapter 4**), the GPS data were analysed and results written as a stand-alone manuscript (Section **5.2**). The second manuscript (Section **5.3)** was subsequently written and captures the variation in activity budgets in the same lambs. Together, the results can be used to form a conceptual model combining growth, movement, and behavioural responses of lambs to GIN infection.

As both Sections **5.2** and **5.3** used the same experimental protocol, the methods described are similar. Also similar in the two sections are the model structures used to fit FEC and LWG data.

5.2 GPS collars enable the detection of reduced movement in grazing lambs infected with gastrointestinal nematodes

5.2.1 Abstract

In **Chapter 2**, it was shown that reduced overall activity of young sheep was an early response to sub-clinical levels of gastrointestinal nematodes (GIN). Two conclusions drawn from that study were that young sheep reduced their activity either: 1) as a consequence of GIN, in that animals suffering anorexia move less since they are eating less; or 2) as a mechanism of resilience, proposing that young sheep reduced their overall activity in order to conserve energy and maintain growth. Further investigation was recommended using composite measures of host movement and activity from global positioning system (GPS) and tri-axial accelerometers. Following validation of measurements derived from GPS collars in **Chapter 3**, this experiment was designed to examine the short-term effects of subclinical infection with mixed-natural nematode infection on the daily distance moved by growing lambs. Two groups of three-month-old lambs with a mean liveweight of 29 kg (SD 5.7) were monitored weekly using GPS tracking collars. Lambs were placed on a six weekly anthelmintic treatment schedule, offset by three weeks between the groups. Parasitism in lambs, quantified as faecal worm egg counts, was associated with shorter travel distances (beta = -0.02, 95% CI -0.03 to -0.01, p = 0.004). The results suggest that changes in movement behaviour could be further developed and used as an early indicator of nematode parasite load. This would assist managers in the implementation of targeted treatments. If some sheep in the mob are observed and act as sentinels, this would allow the treatment to be timed most appropriately. Conversely, if the movement of all individuals is monitored, this would allow targeted selective treatments of the infected animals only and at the right time.

Key words: Gastrointestinal nematodes; GPS monitoring; distance travelled; grazing lambs

5.2.2 Introduction

Gastrointestinal nematode (GIN) infections represent a potent risk to the health and welfare of grazing sheep. Younger animals are at greater risk of acquiring infective larvae (L_3) that lead to established burdens of parasites than adult animals assuming both ingest (acquire) the same numbers of larvae in terms of L_3/kg of feed. The higher risk of infection in younger animals is associated with their relatively immature immune response which cannot limit the establishment of L_3 once ingested (Sykes, 2008). To date, GIN management with broad-spectrum anthelmintics has been the mainstay of treatment of young animals whilst they develop their immune response against GIN. However, there is a consensus view that frequent use of anthelmintics for GIN management is unsustainable in most instances as it can result in the selection of high levels of anthelmintic-resistant worm populations (Pomroy, 2017).

For some years it has been recommended that selection for anthelmintic resistance can be reduced by adoption of a variety of Refugia-based strategies (RBS). These strategies aim to limit anthelmintic exposure to a portion of susceptible worms on the pasture or in animals which are not exposed to the last anthelmintic treatment and that are then able to dilute more resistant worms in the next generational cycle (van Wyk, 2001; Kenyon et al., 2009; Leathwick et al., 2009; Dobson et al., 2011a). However, there is limited empirical evidence supporting these RBS strategies as they are based largely on theoretical models, albeit backed by sound reasoning. Consequently, the target of several RBS research projects has been to apply treatments and expose only the appropriate proportion of the worm population to anthelmintic whilst still achieving desirable levels of control of GIN burdens (Charlier et al., 2017). Particular attention has been given to RBS under the two themes: targeted treatments (TT) and targeted selective treatments (TST). TT involve treating the whole flock at times marked by increased GIN risk whereas TST is the use of pathophysiological or performance-based markers of parasitism to inform treatment of individuals rather than the whole-flock (Charlier et al., 2014). A number of markers have been explored in TST in sheep with relative success, including liveweight gain (Stafford et al., 2009), production efficiency (Greer et al., 2009), body condition score (Cornelius et al., 2014), mucous pallor (Malan et al., 2001) and faecal egg counts (Lester and Matthews, 2014).

A number of studies of grazing lambs (Coop et al., 1985) and calves (Bell et al., 1988, Forbes et al., 2000; 2007) have shown a voluntary reduction in feed intake in young ruminants that have become exposed to L3 and that this can occur prior to patent faecal worm egg counts.

Hence, measuring anorexia may be a useful marker for GIN parasitism. Unfortunately, it is difficult to measure how much animals are eating directly and other measurements are typically chosen as proxies (Sutherland and Scott, 2010). Movement can be used as a proxy for individual vigour through its link with nutrition and metabolism (Binning et al., 2017). Movement needs energy but when animals become infected this results in a reduction in voluntary feed intake and invariably the amount of available energy. Furthermore, they may allocate more energy and protein in order to mount an immune response. Hence, even less energy is allocated to movement, so that when parasitized and anorectic, animals that might benefit from eating more, simply struggle. To date, changes in movement behaviour of GIN infected lambs have received relatively little attention from a research standpoint.

The advent of cost-effective remote sensing technology, such as global positioning system (GPS) tracking collars provide an avenue for monitoring the health status of sheep. To date they have only been used in a limited number of studies. For example, Donovan et al. (2013) reported an association between periconceptual undernutrition of the dam and reduced movement in their offspring when monitored with GPS collars at 18 months of age. Elsewhere, Kaur et al. (2016) used GPS measurements to investigate the effect of placental restriction and function of ewes during pregnancy on the distance travelled by their offspring. In parasitology, Falzon et al. (2013) found a positive relationship between faecal egg counts (FEC) and distance travelled by ewes monitored with GPS collars over a 24 h period. The aim of the present study was to investigate whether GIN infection affects individual movement patterns and how the effect might change over time. If so, movement measures, monitored with GPS collars, may be used as an early warning sign of GIN infection. Two hypotheses were tested: i) distance travelled negatively scales with parasite burden; and ii) age modulates the response because older lambs have developed a more mature immune response than recently weaned lambs.

5.2.3 Material and methods

Ethical approval for this study was granted by the Massey University Animal Ethics Committee (MUAEC 16/134).

5.2.3.1 Experimental animals and design

Lambs of the Perendale breed (n=22), averaging 29.9 kg (SD=5.7) live weight, were commercially sourced at weaning (approx. three months of age) from a single farm. All lambs were examined on arrival and were treated with anthelmintics just prior to the study and each received a combination clostridial and leptospirosis vaccine (Ultravac®7 in 1, Zoetis NZ Inc.) as well as topical insecticide (Clik®, Elanco Animal Health NZ Ltd) to prevent fly strike. The lambs were allocated to two groups (n=11/group) with similar live weight distributions. All lambs received an effective anthelmintic treatment (monepantel, 2.5 mg/ kg body weight: Zolvix® Novartis New Zealand Ltd) every six weeks. There was a three-week offset between the time of treatment of the two groups (Figure 5.1). The trial was conducted on a farm block of 1.7 ha divided into 10 evenly sized paddocks at Massey University's Sheep Unit, Palmerston North, New Zealand (40˚23'28" S 175˚36'21" E, 40 m elevation) between December 2017 and August 2018, which spans Summer to Winter months in this region. The lambs were moved between paddocks every two days from December to April when pasture was abundant. From May to August, lambs were given access to two paddocks at a time, but still moved every two days. The pasture was a rye grass clover mix typical for this region. Both groups were grazed together as one mob, alongside nine Blackface lambs of similar age used as pasture maintenance animals for the first four months of the trial (Group C). These additional Blackface lambs were treated with anthelmintics routinely every 28 days as per the standard anthelmintic regime for young lambs in New Zealand (Lawrence et al 2007).

Both groups received anthelmintics on Day -21. On Day 0, Group A lambs were again given a dose of anthelmintic to initiate the 3-weekly offset between groups, with Group B remaining untreated for another three weeks. One period was defined as when both groups had each completed a round of treatment (i.e. lambs in each group being at one, two, three, four and five weeks after treatment). As a result, when Group A was at three weeks post treatment, Group B would be receiving an anthelmintic and vice versa. Lambs that showed a live weight change (loss) of ≥ 5% from one week to the next or worm egg counts indicative of clinical parasitism (≥ 2000 eggs/g) were treated outside of the scheduled experimental treatment. Over the course of the trial, four treatment periods were achieved corresponding to Summer (Period 1), Autumn (Period 2), late Autumn to early Winter (Period 3) and Winter (Period 4) months (Figure 5.1).

Study week	Calendar Week	Period	Week since treatment	
			A (n=11)	B (n=11)
-3	19 Dec 17		*0*	*0*
-2	26 Dec 17		*1*	*1*
-1	3 Jan 18		*2*	*2*
0	9 Jan 18	One	*0*	*3*
1	16 Jan 18	One	*1*	*4*
2	23 Jan 18	One	*2*	*5*
3	30 Jan 18	One	*3*	*0*
4	6 Feb 18	One	*4*	*1*
5	13 Feb 18	One	*5*	*2*
6	20 Feb 18		*0*	*3*
7	27 Feb 18		*1*	*4*
8 - 11	6 –27, Mar 18		*0*	*0*
12	3 Apr 18	Two	*3*	*0*
13	10 Apr 18	Two	*4*	*1*
14	17 Apr 18	Two	*5*	*2*
15	24 Apr 18	Two	*0*	*3*
16	4 May 18	Two	*1*	*4*
17	8 May 18	Two	*2*	*5*
18	15 May 18	Three	*3*	*0*
19	22 May 18	Three	*4*	*1*
20	29 May 18	Three	*5*	*2*
21	5 Jun 18	Three	*0*	*3*
24	12 Jun 18	Three	*1*	*4*
25	19 Jun 18	Three	*2*	*5*
26	26 Jun 18	Four	*3*	*0*
27	3 Jul 18	Four	*4*	*1*
28	10 Jul 18	Four	*5*	*2*
28	17 Jul 18	Four	*0*	*3*
29	24 Jul 18	Four	*1*	*4*
30	31 Jul 18	Four	*2*	*5*

Colour code	
	Baseline tracking
	Tracking
	No Tracking
	Staggers Outbreak
	Trackers unavailable

Figure 5.1 Six weekly anthelmintic treatment regime of two groups of grazing lambs offset by three weeks. "0" represents week of treatment; "1, 2, 3, 4 ,5" represent number of weeks since treatment. One period is a six weeks block in which lambs in both groups are being compared because they are offset, i.e. both groups go one, two, three, four and five weeks without treatment.

5.2.3.2 *GPS tracking protocol*

The study lambs (n=22) were fitted with a GPS collar (Figure 5.2) constructed by DataCarter (www.datacarter.co.nz) and with a u-blox 8® GNSS chipset (www.u-blox.com). Each collar was run by three 'AA' batteries from January to May 2018; from June to July, the units ran on a Tadiran TL5930F, 19AmpHr "D" sized battery. The accuracy of the GPS chipset was previously estimated (**Chapter 3**) with a mean error (SD) from true receiver position of 1.43 m (0.82) when subject to a static accuracy test recording position every one second. Results demonstrated 99.7 % of points fell within 4 m and 95 % within 3.1 m of the known point. In the present study, the collars were programmed to record sheep location based on three criteria: movement, velocity and time. Positions were only recorded when movement exceeded the threshold of 5 metres and velocity was less than 10 metres/second. There was also a time threshold of one minute after which a position was recorded irrespective of movement and velocity. The reason for this threshold schedule was to reduce error associated with oversampling when the animal is at rest (see **Chapter 3** for detailed discussion).

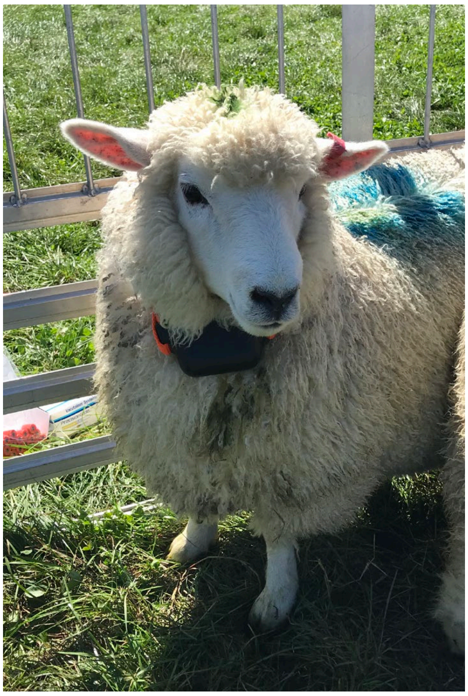

Figure 5.2 Ewe lamb fitted with a GPS collar. GPS chipset sits in the black protective casing below the neck.

5.2.3.3 *Movement monitoring*

On Day –7 (3 January), all lambs were fitted with a GPS collar recording location data for three days. This period was used to habituate the lambs to wearing a collar, as well as to provide a comparison of the distance travelled for both groups when they were at the same stage in the treatment cycle. During the period January to May 2018, batteries lasted for approximately 3 days and the collars were removed every 3 days to download data and charge batteries. To maximise battery life over the remainder of the study (June to July, 2018), collars were left attached to the lambs for only 3 days each week being fitted each Tuesday and removed each Friday. Animals were identified by numbered ear tags and tracking collars were matched based on individual ear tags.

5.2.3.4 Faecal Sampling and weighing

Faecal samples were collected per rectum from all lambs each week during yarding prior to fitting GPS collars and dosing lambs. Faecal egg counts were estimated using a modified McMaster method, where each egg counted represented 50 eggs/g of faeces (Stafford et al., 1994; see Appendix 2.1 for standard operating procedure). Faecal samples were collected between ~ 0830 and 1130 hrs on all occasions. All samples were processed within 36 hours of collection. Parasite identification was carried out on faeces bulked from samples collected on Day -21 (Week -3), by random examination of exsheathed larvae after coproculture for 10 days at 20 °C. At the same weekly interval, individual liveweights were recorded using automated walk-on scales with a weighing resolution of 0.5 kg.

5.2.3.5 Data management

Data for the period 6 March to 30 March 2018 were removed from analyses due to suspicion of an outbreak of Rye Grass Staggers disease in the flock during this time. One lamb died during the experiment in March 2018 for reasons unrelated to the study, all other lambs remained healthy. Data preparation, movement calculations and statistical analysis were conducted in R 3.5.2 (R Core Team, 2018). The *prepData* function in the R package 'moveHMM' (Michelot et al., 2016) was used to calculate the distance between successive GPS locations (step lengths). Step lengths were subsequently summed over 24-hour blocks to calculate the total distance travelled per day. These 24-hour blocks were further investigated to ascertain that location data was recorded for a minimum 95% of the 24 hours, with blocks falling below this 95% threshold removed from analysis. Movement data were considered from the week immediately following an anthelmintic treatment, hence during five weeks. Lambs found to be shedding nematode eggs in excess of 2000 eggs/g before their scheduled six-weekly treatment were treated with anthelmintics and removed from further analyses to the end of that six-week treatment cycle. Live weight (kg) data were used to calculate live weight gain (LWG) by period, calculated as current weight minus earliest weight divided by number of days between weights in consecutive periods.

5.2.3.6 *Statistical Analyses*

All statistical analyses were carried out using R statistical software version 3.4.2 (R Core Team, 2018). The baseline difference in daily travel distance between the two groups corresponds to Week -1, two weeks after both groups received the same anthelminthic treatment (i.e. just prior to initiating the three week offset in treatment). This baseline (mean distance travelled during Week -1) was compared between these two groups using an ANOVA. The response variables to model were 'distance travelled', LWG of lambs and FEC. In the univariate analysis, the effect of 'period' on 'distance travelled' and LWG of lambs were evaluated using linear models, while the effect of period on FEC was tested by the non-parametric Kruskal-Wallis ANOVA test to account for the skewness of this variable.

Model building and selection

If 'period' (recall that this is when both groups had each cycled through one, two, three, four and five weeks after treatment) had a significant effect on any of the response variables in the univariate analysis, the presence of an interaction ('week post treatment' x 'period') was tested in the model. If the interaction was not significant, 'week since start of trial' (which is shown as study week in Figure 5.1), was included as a proxy for time-related factors. Other explanatory variables tested were day (a factor variable representing the 24-hour blocks of GPS recording) and number of 'week since start of trial' (a continuous variable used as a proxy for time-related factors, not to be mistaken with "week post treatment). For all models, a random intercept for each individual (i.e. accounting for difference between individuals), and random slope over time for each individual (i.e. changes over time differ between individuals) were investigated. Also tested was a random effects structure with the individual nested within group or individual alone as a random intercept. Statistical assumptions were checked through graphical analysis of residuals and with the Shapiro-Wilks test for all models fitted. The *vif* function in the 'CAR' R package (Fox et al., 2012) was used to check for collinearity using the variance inflation factor (VIF). Models with above mentioned random structures were compared and final models were selected based on the lowest Akaike information criterion.

Modelling Faecal nematode egg counts

FEC on Day -7 were used to evaluate the efficacy of the initial anthelmintic given on Day -21. FEC data was best fit using a zero-inflated negative binomial generalized linear model, due to overdispersion in FEC data (Model 5.1). Parasite counts are usually overdispersed relative to Poisson, requiring a distribution such as the negative binomial (Alexander, 2012). The R package 'glmmTMB' (Brooks et al., 2017) was used for this model. Fixed effects in this model included 'week post treatment (continuous)', 'liveweight (continuous)', 'presence of co-grazing lambs' (yes; no) and 'week since start of trial (continuous)'. The lamb ID was included as a random effect.

The final model was as follows:

FEC ~ week post treatment + liveweight + presence of co-grazing lambs + week since start of trial + (Lamb ID) (Model 5.1)

To visualise the relationship between FEC and week post treatment, locally weighted scatterplot smoothing (loess) curves, were fitted to the scatterplots of all FEC data.

Modelling Liveweight gain

Values for LWG were transformed using the Johnson transformation ('Johnson R package'; Fernandez, 2014) as the distribution was non-normal. A linear mixed effect model (LMM), fitted with the *lmer* function in the R package 'LmerTest' (Kuznetsova et al., 2017), was used to model the LWG response of lambs to time since anthelmintic treatment (Model 5.2). Lamb ID was included as a random variable. Included as fixed effects were 'week post treatment', 'period', 'week post treatment x period' interaction and the 'presence of co-grazing lambs'.

The final model was as follows:

Liveweight gain ~ week post treatment + period + week post treatment x period + presence of co-grazing lambs + (Lamb ID) (Model 5.2)

Modelling movement (daily distance travelled)

Influences on distance travelled were tested by fitting two linear mixed-effects models (LMM) with the 'lmerTest' R package. Distance was log transformed to meet the assumption of normal distribution of residuals. In Model 5.3, the independent variables included 'week post treatment', 'liveweight', and 'presence of co-grazing lambs' (i.e., presence of blackface lambs) as fixed effects. Other covariates included were 'number of weeks since start of the trial' and 'day' (representing the two 24 h blocks of location data recording). To capture time-related changes such as age of lambs, the development of an immune response and seasonal influence on L_3 available on pasture, initial models included a 'week post treatment' x 'week since start of trial' interaction but this effect was not a significant predictor of movement and was dropped. Log(distance) was back-transformed to present results.

The final model was as follows:

Log(distance) ~ week post treatment + liveweight + day + presence of co-grazing lambs + week since start of trial + (1 | Group/ Lamb ID) (Model 5.3)

In Model 4, the same model structure to Model 3 was used, but replacing 'weeks post treatment' with 'faecal egg counts' as the explanatory variable.

This model was as follows:

Log(distance) ~ FEC + liveweight + day + presence of co-grazing lambs + week since start of trial + (1 | Group/ Lamb ID) (Model 5.4)

Variance inflation factors (VIF) were below the overdispersion threshold of 3 suggested by Zuur et al. (2010), except for 'week since start of trial' which was 6.61 in the movement model.

5.2.4 Results

Effect of time since treatment on parasite load

The larval culture at the start of the study (Day -21) showed the following nematode genera: *Teladorsagia* spp (32%), *Trichostrongylus* spp. (19%) and *Nematodirus* spp. (44%). Over the study period, a total of 654 faecal samples were collected, with 29 faecal samples collected on average per lamb. Based on these, seven 'rescue' treatments were required for lambs with a FEC above 2000 eggs/g (range 2200 to 3450). A faecal sample 14 days after treatment on Day -21 showed all lambs to have 0 eggs/g confirming the high efficacy (>99%) of the anthelmintic treatment. Worm egg counts were similar ($F_{1,20} = 0.01$, $p = 0.91$) between the two groups on Day 0. Throughout the study, nematode egg count data included in analyses ranged from 0 – 1950 eggs/g. Faecal egg counts varied by period, with the highest mean counts recorded during Period 2 (Table 5.1).

Table 5.1 Arithmetic mean faecal egg counts (eggs/g) for six weeks after anthelmintic treatment and range during four periods. Each period is a six-weeks block during which two groups of lambs (n=11/ group) received a short-acting anthelmintic offset by three weeks, then remaining untreated for five weeks). Also included is the season of the year corresponding to the periods.

Period (mean eggs/g)	**n**	**Week post treatment × mean eggs/g**							
		1	2	3	4	5	6	Range	Season
One (106.4) [a]	131	0	2.3	29.6	43.2	272.7	278.6	0 to 1850	Summer
Two (212.2) [a]	118	0	0	0	297.5	730.0	407.5	0 to 1950	Autumn
Three (182.8) [a]	116	0	0	0	70.0	634.2	430.6	0 to 1600	Autumn/ winter
Four (9.5) [b]	117	0	0	2.6	0	13.2	38.1	0 to 300	Winter

[a, b] Different superscripts indicate difference in values (Dunn test, < 0.05); n= number of faecal nematode egg counts.

The highest arithmetic mean counts were recorded during Period 2, and there was a significant difference in FEC among the periods (H (3) = 23.7, p < 0.001, Kruskal-Wallis test; Table 5.1). Contrasts using the Post-hoc Dunn test showed the egg counts in Period 4 were significantly different from periods 1 to 3.

There was a positive relationship between 'weeks post treatment' and FEC (beta = 1.08, 95% CI 0.92 to 1.24, p < 0.001; Figure 5.3), showing that FEC increased over the weeks following anthelmintic treatment.

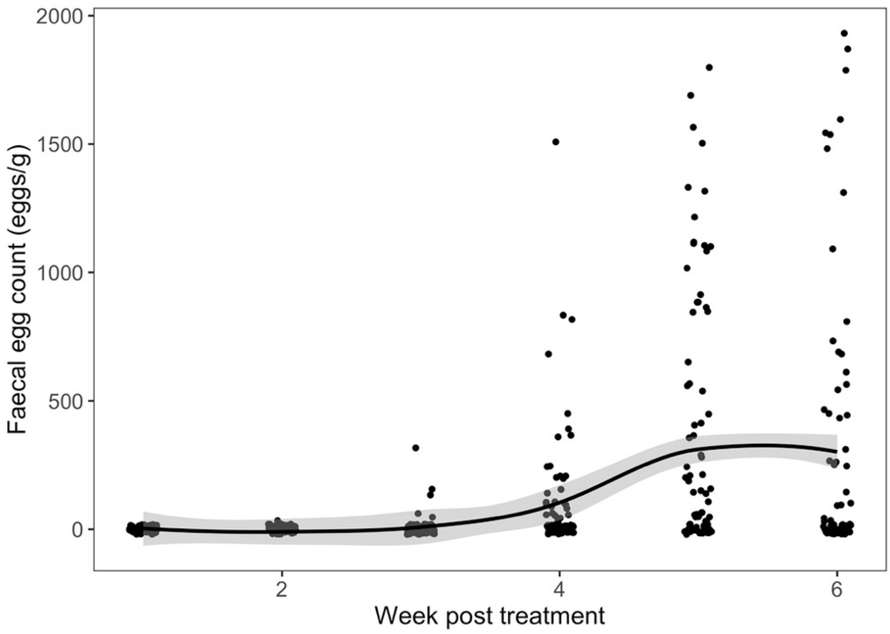

Figure 5.3 The relationship between time since treatment (week post treatment) and faecal worm egg counts (eggs/g) of 24 lambs six weeks after a short acting anthelmintic, pooled across four periods. Loess curve, with 95% confidence interval (CI).

Effect of time since treatment on liveweight gain (LWG)

Lambs in Group A and Group B did not differ significantly in their liveweight ($F_{1,20}$ = 0.09, p = 0.77) on Day 0. Anthelmintic treatment had no overall effect on liveweight gain over the duration of the study (beta = -5 x10^3, 95 % CI -0.05 to 0.05, p = 0.858). Depending on the period, however, there was a trend for treatment to affect LWG in the weeks post treatment ($F_{5,443}$ = 2.15, p = 0.059). This trend was associated with differences in LWG between weeks post treatment during Period 1 and 2 but no evidence of a difference in LWG between weeks post treatment was found during Period 3 and 4 (Table 5.2).

Table 5.2 Least square means and standard error for the variation in liveweight gain (kg/day) of 22 Perendale lambs for six weeks post anthelmintic treatment across four periods.

Period	**Mean live weight gain (kg/day)**							
	WP 1	WP 2	WP 3	WP 4	WP 5	WP 6	se	*p*
One	-1.03^{a}	-0.21^{bc}	0.46^{cd}	-0.63^{ab}	$-0.07b^{cd}$	0.63^{d}	0.24	<0.001
Two	1.36^{c}	0.59^{b}	-0.01^{a}	0.42^{ab}	0.06^{ab}	0.01^{ab}	0.18	<0.001
Three	-0.09^{a}	-0.18^{a}	-0.05^{a}	-0.06^{a}	-0.14^{a}	-0.22^{a}	0.19	0.980
Four	0.26^{a}	-0.14^{a}	0.48^{a}	0.17^{a}	0.10^{a}	0.22^{a}	0.22	0.385

$^{a, b, c, d}$ means with different superscripts are significantly different (Tukey's HSD, $p < 0.05$); WP (week post treatment); se (standard error); *p* (probability).

Distance travelled was positively associated with LWG (beta = 0.26, 95 % CI 0.10 to 0.42, p = 0.002) such that greater distance travelled was associated with a greater LWG (Figure 5.4). However, faecal egg counts were not a significant predictor of liveweight gain, although there appeared to be a trend for reduced growth rates for lambs with higher faecal worm egg count (beta = -2.27×10^{-4}, 95% CI -4.7×10^{4} to 21×10^{5}, $p = 0.07$).

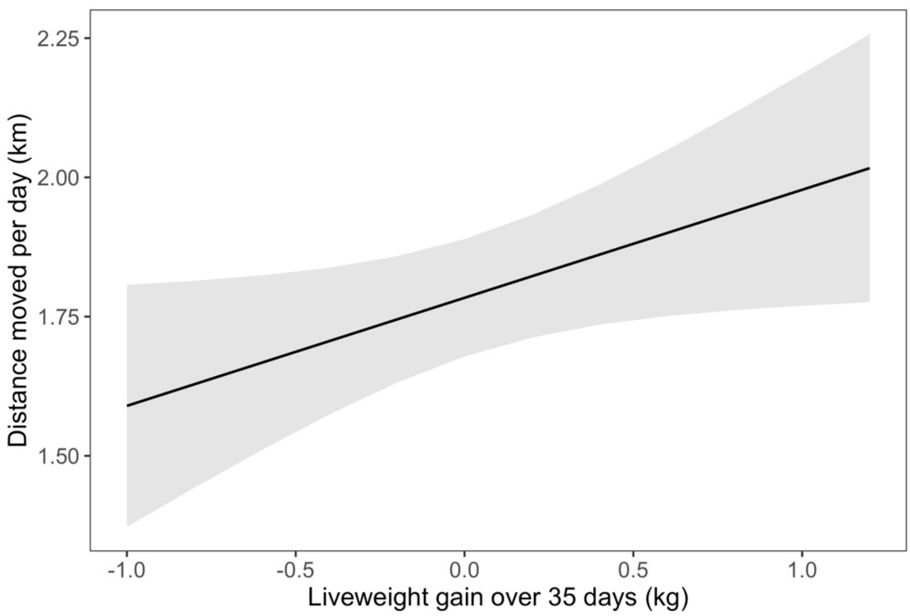

Figure 5.4 The observed relationship between liveweight gain 5 weeks post treatment and distance travelled by individual lambs (n=22) over five weeks (pooled over all four

periods) after receiving a short acting oral anthelmintic with best fit prediction line and 95 % confidence intervals (grey area).

Effect of time since treatment on movement (distance travelled)

The average daily distance travelled for all lambs by period during the trial is shown in Table 5.3. During the habituation period, prior to initiation of 3 weekly offset in anthelmintic treatment , GPS location data was successfully recorded for 20 lambs. There was no difference ($F_{1,18} = 0.27$, $p = 0.62$) in mean ± SD distance travelled between Group A (2.4 ± 0.45; n=11) and Group B (2.3 ± 0.38; n=9) lambs.

Table 5.3 Summary statistics of overall distance travelled (km) by lambs on a six weeks anthelmintic treatment schedule, monitored from weaning to ~ one year of age in four treatment periods (1 to 4) with seasons of the year corresponding to treatment period.

Period	n	LS mean	95% CI	Season
1	22	1.71^{b}	0.52 to 5.60	Summer
2	21	1.53b^{a}	0.58 to 4.09	Autumn
3	21	1.57^{a}	0.50 to 4.91	Autumn/winter
4	21	1.77^{b}	0.58 to 5.38	Winter

LS mean: Least square means (kms). $^{a, b}$ Values with different superscripts are different (Tukey's HSD, < 0.05)

Lambs moved significantly shorter distances per day, the longer it had been (in weeks) since the last anthelmintic treatment (Figure 5.5; Table 5.4).

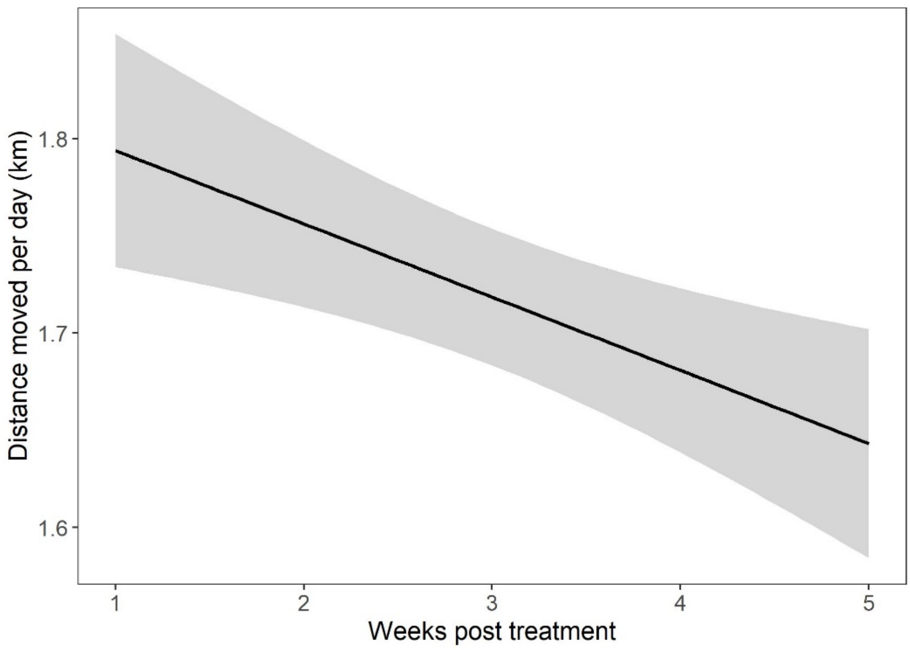

Figure 5.5 The mean distance travelled (95 % confidence intervals (grey area) by grazing lambs (n=22) during five weeks following treatment with a short acting anthelmintic.

Table 5.4 Predictors of movement (km/animal/week) in grazing lambs for five weeks following short-acting anthelmintic treatment

Variables	**beta**	**SE**	**95 % CL**	***p***
(Intercept)	0.50	0.15	[0.20, 0.79]	0.001
WPT	-0.02	0.01	[-0.03, -0.01]	0.004
LW	0.01	0.00	[0.00, 0.02]	0.124
Co-Grazing	-0.12	0.03	[-0.19, -0.05]	0.001
Day (two)	0.05	0.02	[0.01, 0.08]	0.008
WSS	-0.01	0.00	[-0.01, 0.00]	0.001

Note: WPT=Week post treatment; WSS=Weeks since start of trial; LW=live weight (kg); SE=Standard error; 95 % CL = confidence limits

Effect of parasite load (FEC) on movement (daily distance travelled)

A negative relationship was found between faecal egg counts and distance travelled by lambs (beta = -1.5×-10^4, 95% CI -2.1×10^4 to -9.2×10^5, $p = 0.005$). The distance moved was more variable among individuals with higher egg counts than with low egg counts (Figure 5.6).

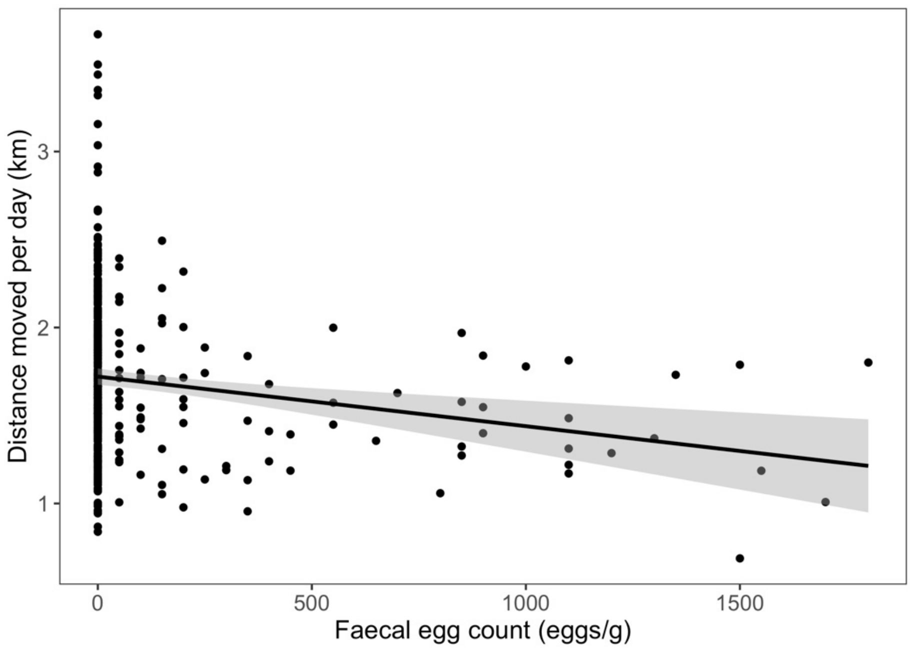

Figure 5.6 Relationship between faecal egg counts and distance travelled in two groups of lambs (n=11/ group) from weaning to one year of age treated with a short acting anthelmintic for six weeks; treatment was offset by three weeks between groups. Best fit prediction line and 95 % confidence intervals (grey area). Data shown is pooled for both groups.

5.2.5 Discussion

Nematode burden (measured as FEC) significantly reduced movement (daily distance travelled) in lambs. Clinical parasitism was not observed in any of the lambs . The presence of additional co-grazing lambs reduced the distance travelled, suggesting an impact of stocking density on movement, with larger groups moving slower (Herbert-Read, 2016). These results suggest that (i) there is a movement response to parasitism, with parasitised lambs moving shorter distances per day; (ii) changes in movement and FEC were not consistently associated with LWG; and (iii) GPS based location data could be used to detect early changes in movement activity of grazing lambs in response to anthelmintics from weaning to one year of age. Throughout our study FEC were low, suggesting movement may be a more sensitive indicator of subclinical GIN parasitism than liveweight changes. Thus, the evidence supports the proposition that movement may be a suitable proxy for the level of anorexia in infected grazing lambs.

Effect of time since treatment on distance travelled

Lambs moved shorter distance per day the more time had elapsed since their last anthelmintic treatment. This negative relationship was consistent over all four treatment periods. Lambs in this study were in the age class that gradually acquire immunity against GIN (McRae et al., 2015). In ruminants, this is a gradual process that occurs over the first 12-18 months of life. Hence, it is conceivable that once the anthelmintic effect waned, parasitised lambs may have traded-off their movement activity in order to mount an immune response, presumably due to the growing burden of gastrointestinal nematodes that would stimulate an inflammatory response in the gut. The pathological processes associated with this response are generally a protein-losing gastroenteropathy with a complex array of changes occurring (Fox, 1997). Pen studies have demonstrated that inflammatory processes inside and outside the gut in tandem with immune effector mechanisms directed at the parasites exact a cost on animal performance (Greer et al., 2005). As infected host attempt to digest and recover some of the protein lost into the gut, this exacts some "cost" in terms of energy and protein (Sykes and Coop, 1976), hence less energy would likely be available for movement activity of these individuals. This could generally manifest as "sickness behaviour" (Sutherland and Scott, 2010 p50) which also may accompany GI parasitism and includes a general effect of depression and malaise. Hence, animals may have been suffering from anorexia, eating less and also not moving as much.

It is equally plausible that the lambs in the present study reprioritised their use of nutrients in favour of immune functions (Sykes, 2010). For instance, the gastrointestinal tract normally consumes 20% of overall energy expenditure (Webster, 1983). Increase in cell turnover caused by GIN infection will undoubtedly have resulted in an increase in energy expenditure, and may cause lambs to reduce their movement in order to conserve energy. Further, reports that parasites depend on hosts for their energy acquisition (Binning et al., 2017), possibly results in further diversion of host resources away from non-essential, yet fitness related functions such as activity and growth (Robar et al., 2011). Consequently, the negative effects of parasites on movement performance may be attributed to GIN-induced changes in energy demands or allocation.

Effect of time since treatment on faecal egg count

The lambs in this study did not progress to being clinically parasitised and their parasitic burdens were generally within the range seen under typical New Zealand farming conditions (Vlassoff et al., 2001). Parasite burden, as judged by FEC, declined immediately after anthelmintic treatment and then as the first GIN established after treatment the FEC started to increase approximately 21 days after treatment. This increase in FEC is consistent with a 2.5 – 3-week prepatent period for the trichostrongylid species involved. FEC data consistently showed that the anthelmintic treatment was effective and barring Period 1, reduced the FEC to 0 eggs/g up to two weeks post treatment. Excluding the seven animals that required rescue treatment, the mean FEC after 6 weeks post treatment was 408 eggs/g, consistent with a low burden and sub-clinical parasitism. However, the maximum FEC at 6 weeks post treatment was 1950 eggs/g, moderately high for sheep this age (McKenna and Simpson, 1987).

The larval cultures at the start of the trial were consistent with typical lamb parasitism expected under NZ conditions (Vlassoff et al., 2001). However, no information on the prevailing genera parasitising lambs during the rest of the study was recorded. At best, it can be assumed that the penalties on movement activity of lambs was attributable to a mixed nematode infection acquired naturally. The strongest movement reduction (based on effect size) occurred in the autumn months (Period 2). This coincides with the time when larval numbers on pasture are reportedly highest (Vlassoff et al., 2001). In the present study, FEC and 'weeks after treatment' were positively associated. The anthelmintic given (monepantel) was clearly effective as no eggs were detected for at least two weeks post treatment in three out of four periods but the effects on movement were noted as larvae would have been establishing within a few days of treatment. Individuals with comparable FEC varied widely in their movement activity. There is a risk in linking FEC itself to movement that the real culprit in curtailing movement is not so much the egg laying adult, but the challenge by incoming larvae and their subsequent establishment. Hence, FEC may not be a reliable indicator of load in terms of the sum total of pathogenic impact of parasites on animal.

Effect of time since treatment on liveweight gain

In the current study, the effect of anthelmintic treatment on growth rates were equivocal, and growth performance appeared to be independent of parasite load (FEC). In Period 1, superior liveweight performance was seen by the sixth week post-treatment in comparison to one week post treatment. However, the opposite occurred during Period 2, with lambs showing significant reductions in LWG between one- and other-weeks post treatment. There was no obvious explanation for a reversed relationship between these two periods. In both, no significant effects on LWG were observed from three to six weeks post treatment, indicating that lambs may have made compensatory adjustments to maintain liveweights after 21 days. No evidence was found that leaving lambs untreated for six weeks had significant penalties on liveweight gain during Periods 3 and 4. In subclinical levels of parasitism, it has been shown that growth of muscle and bone are impaired, appetite is usually depressed, with these changes appearing in animals that appear clinically normal and healthy (Fox, 1997). The impaired growth of muscle and bone is more likely to progress to loss of weight in lambs exposed to higher levels of infection which produce clinical signs of disease. However, the present study was designed to preclude clinical disease arising in the study animals. As there were no attempts to measure the larval challenge during these respective periods it was not possible to determine the reason for the differences but they may involve the developing immune response as the lambs aged.

Nevertheless, movement and LWG were significantly positively associated, with the lambs gaining the most weight also travelling the furthest distance. This can be interpreted to mean that movement includes grazing behaviour. By this logic, lambs moving more would also be grazing more and invariably gaining more liveweight but as noted no consistent change in growth rates were observed between lambs covering the most distance and those travelling less in this study. This may have been an issue associated with the offset of three weeks between groups. That is, environmental conditions differed when each group was at a certain week post treatment; and it has been shown that environmental conditions affect movement (Avgar et al., 2013). Hence, the offset could have added noise to the data. Overall, the finding of the lambs gaining the most weight also travelling the greater distance, demonstrates the utility of movement activity as an index of performance. What remains to be investigated is whether reduced growth rates are associated with a concomitant reduction in travel distance, which will validate the case for movement as a marker to target intervention in individual lambs.

Effect of time (week since start) on movement

In relation to time, measured as weeks since start of trial, lambs showed less movement later in the trial. It is not easy to distinguish whether this was as a result of environmental or age related factors. In terms of age, the assumption was that since older lambs would be further advanced in their development of an immune response to GIN, they would be allocating nutrient resources to other fitness and movement costs. Despite the worm egg output significantly decreasing to low subclinical levels (arithmetic mean of 9.5, range 0 to 300 eggs/g) in Period 4 (the final six weeks of this study), and possibly signalling reduced establishment of L_3, there was still a significant decline in movement in the weeks following anthelmintic treatment. A possible explanation may be that FEC in lambs at this age was not as good an indicator of the performance deficits elicited by subclinical parasitism. Equally, it is possible that an incomplete expression in immunity, generally seen in individuals less than 18 months of age, is still likely to translate to compensatory mechanisms, which may manifest as reduced movement. In subclinically parasitised adult cattle that had acquired functional immunity, grazing behaviour was used to determine the level of parasite induced anorexia (PIA) and to relate observed changes to animal performance (Forbes et al., 2004). These authors demonstrated that PIA was still a common and important mechanism for production losses.

In contrast to the findings presented in the present study, there are reports of FEC associated with an increase in sheep movement. Falzon et al. (2013) found that infection by GIN increased the distance per step covered by ewes. The reason for the apparent difference in results between those in the present study and those reported by Falzon et al (2013) were not immediately apparent. They suggested that ewes with higher nematode egg counts travelled to water troughs more frequently based on parasite load, a reasonable proposition considering they conducted their study in a drier environment compared to the environmental conditions of the present study. In New Zealand, few sheep use water troughs, meeting most of their water needs from grass (Zonderland-Thomassen et al., 2014). This might be one reason the findings of the present study differed from theirs (Falzon et al., 2013). Based on the fact that individuals with similar FEC in the present study varied considerably in the distance they travelled (Figure 5.6), further investigation appears worthy on the role of factors like patch selection based on pasture quality, and genetic history (i.e., resilience or resistance to GIN) on movement activity of lambs, which are known to be associated with regulation of faecal worm egg output in sheep (Morris et al., 1997; Morris et al., 2005). Furthermore, it is possible that some nematode genera elicit these effects on movement more than others. For example, *Nematodirus* spp., whose lifecycle is different from other strongyles, was not considered apart from other strongylids in terms of its effects of sheep movement patterns although it was identified and counted separately during worm egg counts. Future studies could investigate the movement responses based on prevailing species both on pasture and in culture at the time of movement monitoring.

Is movement activity a suitable proxy for the level of anorexia?

Of interest in the current study was whether lamb movement was a suitable proxy for level of anorexia. The factors which induce anorexia in parasitised lambs are not yet fully understood (Greer and Hamie, 2016). It has been postulated that gastrin, cholecystokinin and leptins may be involved (Sutherland and Scott, 2010, p49) but at this time the mechanisms in linking anorexia to the presence of GIN are poorly understood. Consequently, it is not known which factors might be responsible for reducing movement. Objectively, the data in the present study is limited and doesn't allow definitive comments to be drawn with regards movement activity being a suitable proxy for anorexia. It is possible to speculate that reduced movement activity is associated with a general feeling of 'malaise' in these lambs, but the physiological drivers of this remain poorly understood in ruminants. Since movement is a nutrient (energy) costly biological process, the evidence in the present study also suggests lambs may have been conserving or partitioning energy differently the longer they went without exposure to anthelmintics, with significant movement reductions. Nutrient partitioning has been hypothesised to be a reflection of the level of anorexia induced in parasitised individuals (Fox, 1997, Forbes et al., 2000). If protein and energy are being partitioned for functions such as mounting an immune response, and this reflects in the distance travelled by sheep, then movement activity might be a suitable proxy for the level of anorexia in lambs. Future studies should address the question of how movement activity relates to feed intake. For example, it would be possible to GPS tag a group of lambs and then actively measure variables such as intake (g DM/day) and post-grazing sward height (cm).

5.2.6 Conclusion

Mounting GPS collars on lambs allowed detection of reduced daily movement activity in subclinically infected lambs from weaning to one year of age. The results supported the hypothesis that infected lambs would move less. The cost of movement performance appeared to occur on the subclinical-effect spectrum where the cost of growth performance was not seen.

It could be hypothesised that there is a hierarchy in parasite-induced anorexia in that less parasitised animals move as much as is required to allow maintenance requirements, but as parasite-induced anorexia begins to set in, animals first move less, but may still be grazing reasonably close to normally (see Section **5.3.4.3**), before this then too declines. Worm egg counts decreased significantly in older lambs suggesting some evidence of an effective immune response developing but those lambs still showed reduced movement the further away they were from anthelmintic treatment. Overall, the use of movement likely provides a more responsive metric to assess the level of parasitism in young lambs and hence is likely to be a suitable characteristic to be used for targeted selective anthelmintic treatments of lambs.

5.3 – Movement and behaviour changes in GIN infected and uninfected lambs – use of tri-axial accelerometers to identify changes in activity budgets of lambs infected with gastrointestinal nematodes.

5.3.1 Abstract

In **Chapter 4**, a behaviour predicting algorithm was developed from accelerometry data, accurately identifying 'grazing', 'resting' and 'walking' activity of sheep on pasture. Applying this algorithm, the activity patterns of twenty-two lambs naturally infected with gastrointestinal nematodes were monitored from weaning to approximately 11 months of age using the ActiGraph wGT3X-BT® attached to GPS neck collars. These lambs were allocated to two treatment groups on a six-weekly treatment cycle, treated at the same frequency but offset by three weeks from each other. Each lamb was weighed and faecal sampled on a weekly basis. In response to GIN infection, the manifestation of parasite-induced anorexia was investigated using *time spent grazing* and *resting*, the intensity levels of activity ($VeDBA_{ACTIVITY}$) and *liveweight gain* as measures. The parasite burdens measured by individual faecal egg counts were low to moderate (0 to 1950 eggs/g). The overall relative proportion of time that lambs dedicated to grazing versus other activities reduced (beta = -0.015, 95 % CI -0.016 to -0.015, $p < 0.001$) over the 6 weeks post treatment when all periods were considered together, while there was a rise in the proportion of time spent 'resting' (i.e. lying and standing; beta = 0.016, 95 % CI 0.015 to 0.017, $p < 0.001$). Hence, changes in grazing behaviour were associated with a reduction in the total proportion of daily grazing activity and not a reduced intensity of grazing per day ($p = 0.754$). The intensity of 'walking' activity ($VeDBA_{WALKING}$) of the lambs was significantly different from week to week the longer the interval since treatment ($p = 0.012$), but not so for $VeDBA_{RESTING}$ (standing and lying; $p = 0.225$). Overall, these results indicate that under these experimental conditions, both proportion and intensity of activity contributed to defining the behavioural response of parasitised lambs compared to when they were initially treated.

5.3.2 Introduction

The prevention of subclinical infection with gastrointestinal nematodes (GIN) is an important concern in order to limit production losses in young growing sheep. The frequent use of anthelmintics for this purpose has been associated with the development of anthelmintic-resistant genotypes in worm populations (Besier, 2003; Hodgkinson et al., 2019) and, consequently, alternative approaches for parasite control are needed. Parasites exact a production cost on growing ruminants through two closely linked mechanisms, which can be exploited to develop alternative method of GIN diagnosis and control. First, GIN induce a loss of appetite in the host, which reduces feed intake compared with uninfected individuals (Sykes and Coop, 1976; Coop et al., 1982; Abbot et al., 1986; Fox et al., 1989). Early investigations using pair-fed animals in pen studies in which feed intake was measured demonstrated a > 60 % impairment in weight gain of parasitised sheep (Sykes and Coop, 1977). It has been estimated that 40 to 90 % of the overall cost of GIN infection in lambs is associated with a reduction in voluntary feed intake (Coop et al., 1985, Fox 1997). The second associated effect of parasitism is a reduction in the metabolic efficiency of the host which decreases the nutrients available for maintenance and growth (vanHoutert and Sykes, 1996). In brief, GIN induce a protein-losing enteropathy which disrupts the availability of protein for growth in young animals (Sutherland and Scott, 2010). The effects of GIN infection among young animals are not uniform across populations, some animals are more able to tolerate or reject the challenge than others. At present anthelmintic treatments are based on the lowest common denominator within a flock just to ensure that all animals are able to grow satisfactorily. The consequence of this approach is that many young animals may be treated without a need for such treatment.

Previous work reported in this thesis has shown that changes in activity are potentially important as indicators of disease and if measurable could be used an indicator of the need to treat for GIN. In **Chapter 2**, tri-axial accelerometers were able to detect a reduction in overall activity of young sheep infected with GIN. It was recommended that further research be undertaken to ascertain which particular activities may change. Robust computing and automation methods have evolved to enable the prediction of sheep activity on pasture using tri-axial accelerometer data (See **Chapter 4**; Alvarenga et al., 2016; Barwick et al., 2018b). This means activity budgets (proportion of time spent on different activities) can be calculated for each logged individual on a daily basis. Relatively few studies have reported the use of accelerometers to monitor the impact of GIN parasitism of sheep at pasture. For example, Burgunder et al. (2018) used tri-axial accelerometers on neck-mounted collars to monitor activity of sheep. They found that parasitized sheep exhibited lower behavioural complexity, i.e. less irregularity, in their activity patterns than non-parasitized sheep. More recently, the degree of anaemia in grazing small ruminants subject to natural *Haemonchus contortus* infection was shown to be predicted by individual activity measured by accelerometers which also predicted individual response to treatment (Montout et al., 2020).

The aim of the present investigation was to use tri-axial accelerometers to determine the influence of GIN on activity budgets and time allocation of grazing lambs during a period of active growth. This allowed inference on the animals' adaptive response to parasite infection. The following hypotheses were tested: i) lambs would increase their grazing in proportion to resting activity in response to recent anthelmintic treatment, and ii) grazing activity in uninfected lambs would be associated with increased walking. These hypotheses were based on similar measurements in calves (Forbes et al., 2000) in which untreated individuals reduced their time spent grazing compared with calves treated with a sustained-release, intra-ruminal ivermectin bolus.

5.3.3 Material and Methods

A full description of the experimental animals and design for this section was described in Section **5.2.3.1**. The data in this section was derived from the same animals and at the same time as 5.2. Briefly, 22 three-month old Perendale lambs were commercially sourced from one farm and grazed as a single mob. The lambs were blocked on liveweight and randomly assigned to one of two groups and treated with anthelmintics every six weeks with monepantel (Zolvix® Novartis New Zealand Ltd) at a dose rate of 2.5 mg/ kg based on the heaviest body weight. There was a three-week offset between the time of treatment of the two groups. Lambs were grazed together on the same pasture, which was a ryegrass (*Lolium multiflorum*) and white clover (*Trifolium repens*) mix, typical for this region (Charlton and Stewart, 1999). Other young sheep had previously grazed these pastures within the previous six months in order to ensure there was a population of infective GIN larvae present. Data were aggregated into time periods. When both groups had each completed a round of treatment (i.e. lambs in each group being at one, two, three, four and five weeks after treatment), this was counted as a single period. A group may have started the period being at three weeks post treatment but so long as it made it through all five levels of 'week after treatment' (in whatever order) it contributed to that treatment 'period'. If a lamb was treated then no more data was considered from that animal until its next scheduled treatment. All manipulations involving the use of animals were approved by the Massey University Animal Ethics Committee (MUAEC16/134).

5.3.3.1 Activity monitoring

Animals were weighed and sampled on a Tuesday each week with collars attached at the same time. Collars were then removed the following Friday. Hence data on activity was collected during the relevant week post-treatment. Each lamb was fitted with a collar mounted with a tri-axial accelerometer (Actigraph® wGT3X-BT, LLC, Pensacola, FL, USA) to measure acceleration (G). The accelerometer was located on the dorsal aspect of the collar along with a GPS monitors located on the ventral aspect of these same collars as described in Section **5.2**. Accelerometers measured 46 × 33 × 15 mm in size and weighed 19 g (Figure 5.7).

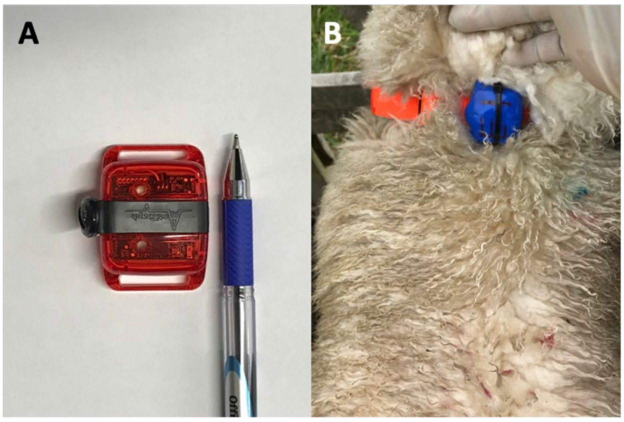

Figure 5.7 The ActiGragh wGT3X-BT® tri-axial accelerometer (A) and orientation on a sheep (B) used to monitor the activity of 22 Perendale lambs weekly from weaning up to one year of age.

The orientation of the sensors was uniform across all sheep. The unit recorded the acceleration during movement across the vertical, horizontal, and perpendicular axes and employs a reference system that indicates longitudinal (front-to-back or surge, Y), horizontal (side-to-side or sway, X) and vertical (up and down or heave, Z) body axes, respectively (ActiGraph Manual, version 1.0.0 August 2013). Although attached to collars, there was very limited movement of these sensors after attachment as they nestled snuggly in a groove in the neck wool, so did not move up and down the neck when the animal lifted or lowered its head while grazing or walking. Prior to the attachment of the collars to the lambs, the sensors were programmed to collect acceleration data at a sampling rate of 30Hz, which is equivalent to 30 sampling occasions in one second. In Chapter 4, a machine learning algorithm was used to classify sheep activity from raw accelerometry sensor data from the Actigraph wGT3X-BT® in combination with video observations of the animals' behaviour and the same algorithm was used with this data. The activity classification algorithm classified three distinct behavioural activities of sheep at pasture, namely 'grazing', 'resting' (lying or standing) and 'walking'. The accuracies of behaviour predicted from the classification algorithm were 94 %, 89 % and 78 % for grazing, resting and walking activities, respectively.

5.3.3.2 Parasitological methods and weighing

Lambs were weighed each week throughout the trial resulting in a total of 30 measurements. At the same time, faecal egg counts (FEC) were estimated using faecal samples collected per rectum from all lambs (Stafford et al. 1994). At the commencement of the study, parasite speciation was carried out by random examination of 100 ensheathed larvae following coproculture of bulked faeces from all animals for 10 days at 20 °C.

5.3.3.3 Data Management

Accelerometer activity data was collected weekly throughout the study. Data collected during the week of treatment (i.e., the three days immediately following treatment) were not used in order to account for any bias associated with lambs only just being treated, but subsequent weeks post treatment (1 to 5) up until the animals were treated again were included in the data analyses. Data for the period 6 March to 30 March 2018 were removed from analyses due to suspicion of an outbreak of Rye Grass Staggers disease in the flock during this time. Activity data that were more than three standard deviations from the mean activity data were considered outliers. Seven points out of 3417 were removed.

5.3.3.4 Statistical analyses

Statistical analysis of data was performed using R software version 3.6.2 with appropriate R packages (R Core Team, 2019).

Live weight and nematode egg counts

Daily liveweight gains for each animal were calculated as the difference between their first and last recorded weight divided by the number of days between the recording dates. To determine the effect of leaving animals untreated on lamb growth, liveweight gains in Weeks 5 and 6 were compared with Week 1. Liveweight gain (LWG) data were fitted to a simple linear regression (LWG = week post treatment) and plotted to examine the normality of residuals and independence in response. The residuals were non-normal on inspection and required transformation prior to statistical analyses. A Johnson transformation was found to be more effective in normalizing the residuals than other transformations that were investigated, including Boxplot-, log-, square- and inverse transformations.

A model (same structure as Model 5.2) of LWG was fitted as a linear mixed-effect model (LMM) with sheep ID included as a random effect. Fixed effects included were 'week post treatment', 'treatment period' and the two-way interaction of 'week post treatment x treatment period'. The 'presence of co-grazing lambs' (yes; no) and 'week since start of trial' were included as covariates.

The arithmetic mean FEC from all lambs was described during each week post treatment in each period. The distribution of FEC data was right skewed and attempts to transform the data were unsuccessful. Consequently, influence on FEC was modelled using a generalized linear mixed-effect model (same structure as Model 5.1), fitted with a zero inflated negative binomial distribution link. Fixed effects in this model included 'week post treatment, 'period', the two-way interaction of 'week post treatment' and 'period' interaction, 'presence of co-grazing lambs' and 'week since start of trial'.

Activity proportions

The effects of anthelmintic treatment and FEC on the activity budgets and activity levels of lambs were examined separately.

To examine the effects of weeks since treatment on activity budgets of lambs in each individual activity category ('grazing', 'resting' and 'walking'), the non-parametric Kruskal-Wallis test was used to compare budgets for lambs across all five weeks post treatment. For the proportion of time spent on an activity in relation to other activities, three generalized linear mixed models (GLMM) for 'grazing', 'resting' and 'walking' activities were constructed, with the occurrence or absence of each activity as the binomial response variable. Fixed effects included 'week post treatment', 'live weight', 'day' and 'week since start of trial' (proxy for age of animal), with individual 'lamb ID' nested within 'treatment period' included as a random effect to account for pseudo-replication. As accelerometers were attached for 3 days of each week, the variable 'day' was included to account for variation between each 24-hour block within that monitoring week.

The GLMM used a binomial error distribution with a logit-link function (Bolker et al., 2009). To improve the fit of the model, following the approach of Zuur et al. (2010), a nested random effect of 'lamb ID' within 'treatment period' was compared with only 'lamb ID' as the random effect and was tested by exploring the change in deviance of the model using ANOVA (chi-squared under one degree of freedom). It was concluded that the nested random effect 'lamb ID' within 'treatment period' improved the fit of the model ($p<0.05$) and this nested random effect was used for further statistical testing.

The final model structure for the proportion of each activity was:

(activity count/ total count) ~ 'week post treatment' + 'period' + 'day' + 'presence of co-grazing lambs' + 'live weight'+ ('week since start of trial' | 'lamb ID')

Further, a Dirichlet Distribution (Douma and Weedon, 2019) was used to model t (Model 5.5) of each activity as a function of 'week post treatment'. The Dirichlet regression is a multivariate generalization of the beta regression for situations where proportions are calculated for more than two categories, i.e. when there are more than two continuous categories. The response variables were vectors of the proportions of grazing activity, resting activity and walking activity, with 'sheep ID' included as a random effect. The covariate 'period' was included to account for extraneous factors .Other covariates included in this model were 'liveweight' and 'presence of co-grazing lambs'.

Activity levels (Dynamic vectorial body acceleration)

Activity levels were derived using a similar approach to that described in **Chapter 2** by estimating overall activity as dynamic vectorial body acceleration (VeDBA), calculated using Equation 2.1, and matching VeDBA to the corresponding activity classified by the algorithm developed in Chapter 4; hence, $\text{VeDBA}_{\text{ACTIVITY}}$. Three $\text{VeDBA}_{\text{ACTIVITY}}$ models, corresponding to 'grazing' (Model 5.6), 'resting' (Model 5.7) and 'walking' activity (Model 5.8) were fitted using linear mixed models (LMMs) with 'lamb ID' included to account for repeated measures. Fixed effects included 'week post treatment', 'period' and the two-way interaction of 'week post treatment' by 'period'. The 'presence of co-grazing lambs' (yes; no), 'live weight' and 'week since start of trial' were included as covariates. The presence of additional lambs was considered as an experimental factor as additional lambs might affect the behaviour of conspecifics (Birrell, 1991). Initial models included the two-way interaction of 'week after treatment' and 'period', but because this variable did not emerge as a significant predictor of $VeDBA_{ACTIVITY}$, it was dropped from all three final activity models. The responses $VeDBA_{RESTING}$ and $VeDBA_{WALKING}$ were log-transformed, and 4th root transformed respectively to normalize the residuals of the model. The predictors 'live weight' and 'week since start of trial' were centered and scaled (cs; Bolker et al, 2009) in order to deduce the importance of each variable relative to the other continuous variables from the model results. The final models were:

$VeDBA_{GRAZING}$ ~ 'week post treatment' + 'live weight' (cs) + 'presence of co-grazing lambs' + 'week since start of trial' (cs)+ 'day' + (1 | 'lamb ID') (Model 5.6)

Log ($VeDBA_{RESTING}$) ~ 'week post treatment' + 'live weight' (cs) + 'presence of co-grazing lambs' + 'week since start of trial' (cs)+ 'day' + (1 | 'group'/'lamb ID') (Model 5.7)

$VeDBA_{WALKING}$ ^ (1/4) ~ 'week post treatment' +' live weight' (cs) + 'presence of co-grazing lambs' + 'period' + 'week since start of trial' (cs)+ 'day' + (1 | 'lamb ID') (Model 5.8)

The fit of each the model was investigated using graphical inspection of residuals versus fitted values, Q-Q plots and with the Shapiro-Wilks test. Statistical analyses were performed in R using appropriate packages ('LmerTest', 'glmmTMB', 'DirichReg'; R Core Team, 2017).

5.3.4 Results

5.3.4.1 Liveweight, liveweight gain and faecal egg counts

Random allocation of lambs to groups was successful in balancing live weights between the groups ($F_{1,20}$= 0.08, p = 0.780). The average liveweights of lambs increased by period, with means (SD) of 33.2 (4.21), 37.8 (4.35), 39.6 (4.04) and 42.6 (3.95) in Periods 1, 2, 3 and 4, respectively. When the lambs were five and six weeks post anthelmintic treatment, higher LWG in Period 1 and lower in Period 2 were seen compared to one week post treatment, but not in the third and fourth periods (Table 5.5; Figure 5.8).

Table 5.5 Least square means and standard error for the variation in live weight gain (kg/day) of 22 Perendale lambs for six weeks post anthelmintic treatment across four periods.

Period	**Live weight gain (kg/day)**							
	WP 1	WP 2	WP 3	WP 4	WP 5	WP 6	se	*p*
One	-1.03a	-0.21bc	0.46cd	-0.63ab	-0.07bcd	0.63d	0.24	<0.001
Two	1.36c	0.59b	-0.01a	0.42ab	0.06ab	0.01ab	0.18	<0.001
Three	-0.09a	-0.18a	-0.05a	-0.06a	-0.14a	-0.22a	0.19	0.980
Four	0.26a	-0.14a	0.48a	0.17a	0.10a	0.22a	0.22	0.385

[a, b, c, d] means with different superscripts are significantly different (Tukey's HSD, $p < 0.05$); WP (week post treatment); se (standard error); *p* (probability at 5 % significance level)

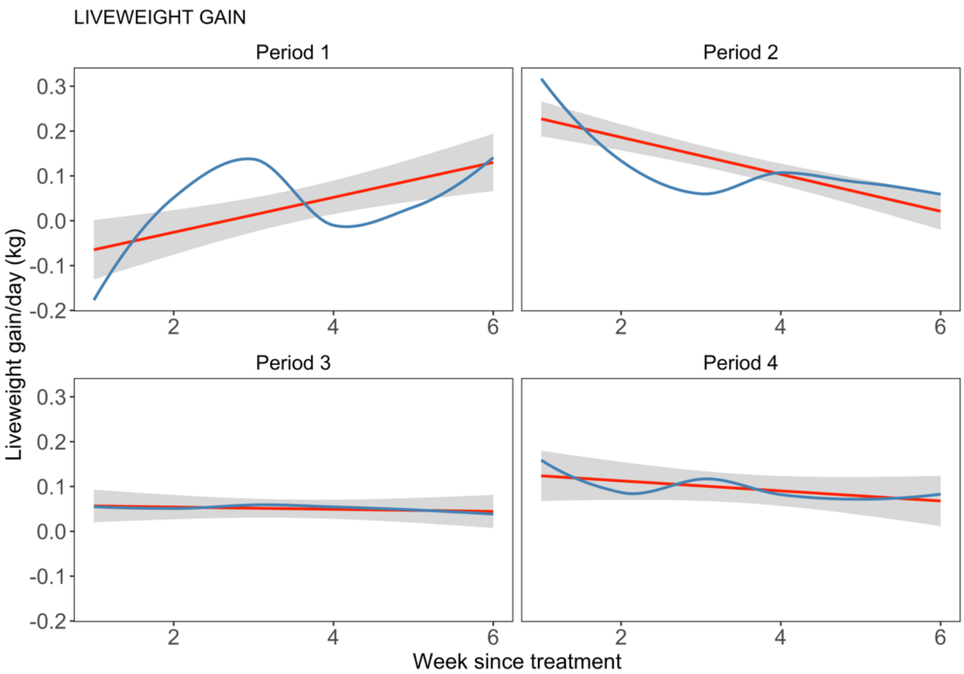

Figure 5.8 The observed smoothed mean distribution (blue line) and predicted (red line ± 95 % confidence interval) relationship between week post anthelmintic treatment and the average daily live weight gain of ewe lambs (n = 22) in each of four periods.

Faecal egg counts in Period 4 were lower than those in Period 1 to 3, with mean counts peaking during Period 2 (Table 5.6). No eggs were detected in faecal samples collected one-week post treatment. Across periods, between two and six weeks post treatment the arithmetic mean (range) egg count (eggs/g) were 1 (0 to 50), 8 (0 to 300), 104 (0 to 1500), 390 (0 to 1800 and 282 (0 to 1950), respectively.

Table 5.6 The arithmetic mean and range of nematode egg counts (eggs/g) pooled from 22 lambs weekly during four periods. Also included are the seasons of the year corresponding to the periods.

Period	**n**	**Mean eggs/g**	**Min**	**Max**	**Season**
One	131	106.4[a]	0	1850	Summer
Two	118	212.2[a]	0	1950	Autumn
Three	116	182.8[a]	0	1600	Late Autumn/ Early Winter
Four	117	9.5[b]	0	300	Winter

[a, b] means with different superscripts are significantly different (Dunn test, < 0.05); n = number of faecal nematode egg counts. Min=minimum; Max=maximum

5.3.4.2 Lamb behaviour time budgets

On average, over the duration of the study lambs spent 38.6 %, 60.2 % and 1.2 % of their time ‘grazing’, ‘resting’ (standing or lying) or ‘walking’, respectively. The daily distribution of these activities is shown in Figure 5.9.

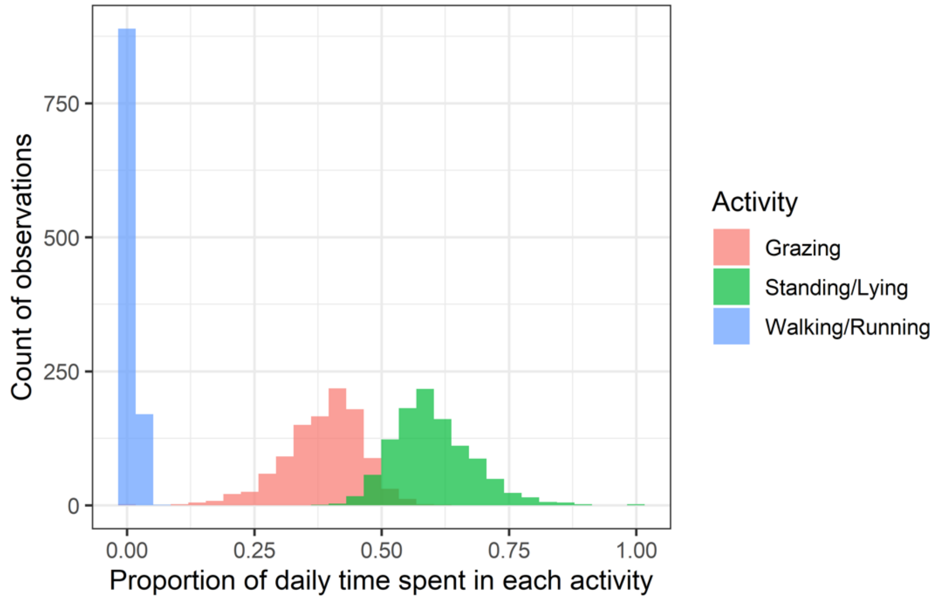

Figure 5.9 The mean proportion of the day ewe lambs (n=22) were estimated to graze, rest (standing and lying) and walk from weaning (~ 3 months of age) to one year of age.

The average daily time budget of the lambs by hour of day showed that their grazing activity started to rise at 0600 h, peaking shortly after 1500 h, before starting to decrease (Figure 5.10)

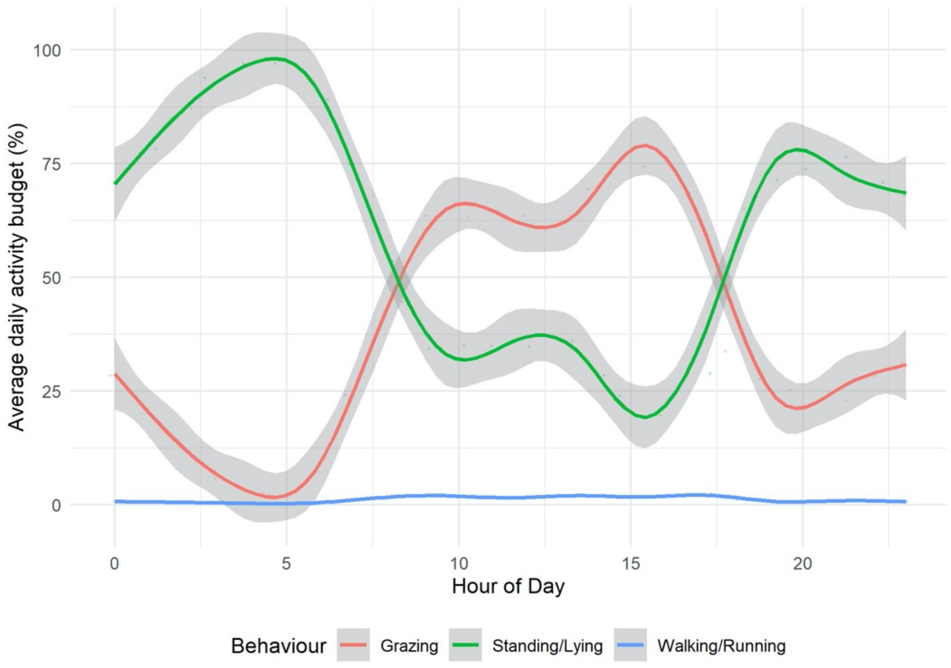

Figure 5.10 Mean proportion of each hour of the day lambs were estimated to graze, rest (standing or sitting) or walk from weaning (~3 months of age) to one year of age.

5.3.4.3 *Effect of time since treatment on time budget of activity*

Generally, the proportions of time that lambs spent on each activity category for five weeks after receiving a short acting anthelmintic varied by period. The proportion of time spent grazing was greatest during week 3 for Period 1, 3 and 4 but in Period 2 the proportion of time spent grazing was at its lowest in during Week 3 post treatment (Figure 5.11).

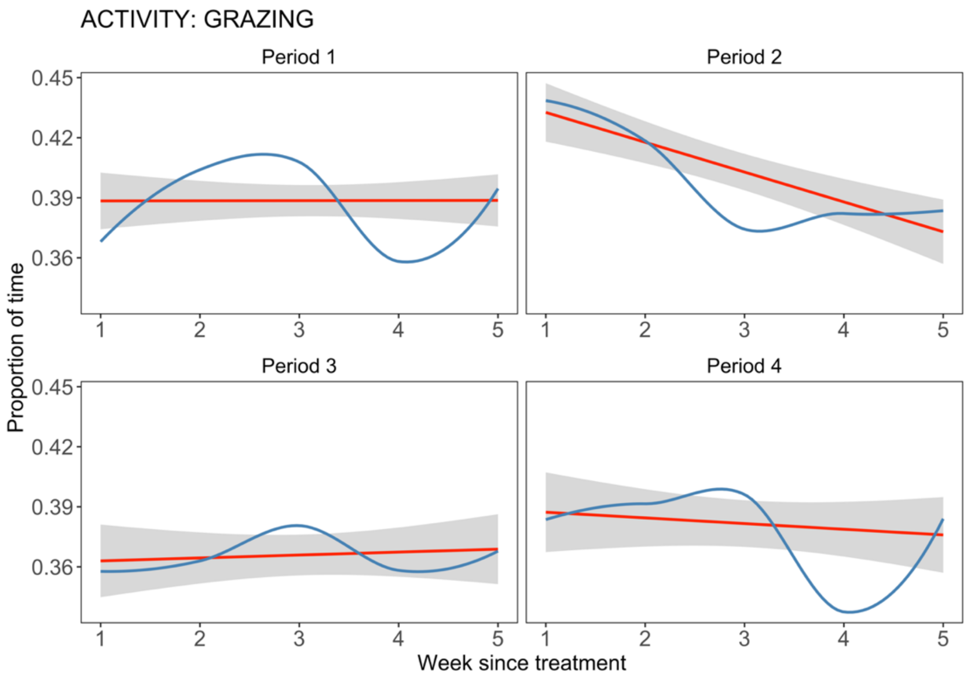

Figure 5.11 The mean proportion of time lambs spent grazing across the six weeks post-treatment showing the slope (red line ± 95 % confidence interval) and observed smoothed mean distribution (blue line) in each of four periods (1, 2, 3 and 4).

The proportion of time spent 'resting' was the direct contrast with 'grazing', being at its lowest during Week 3 for Period 1, 3 and 4 but in Period 2 the proportion of time spent resting was greatest during Week 3 post treatment (Figure 5.12).

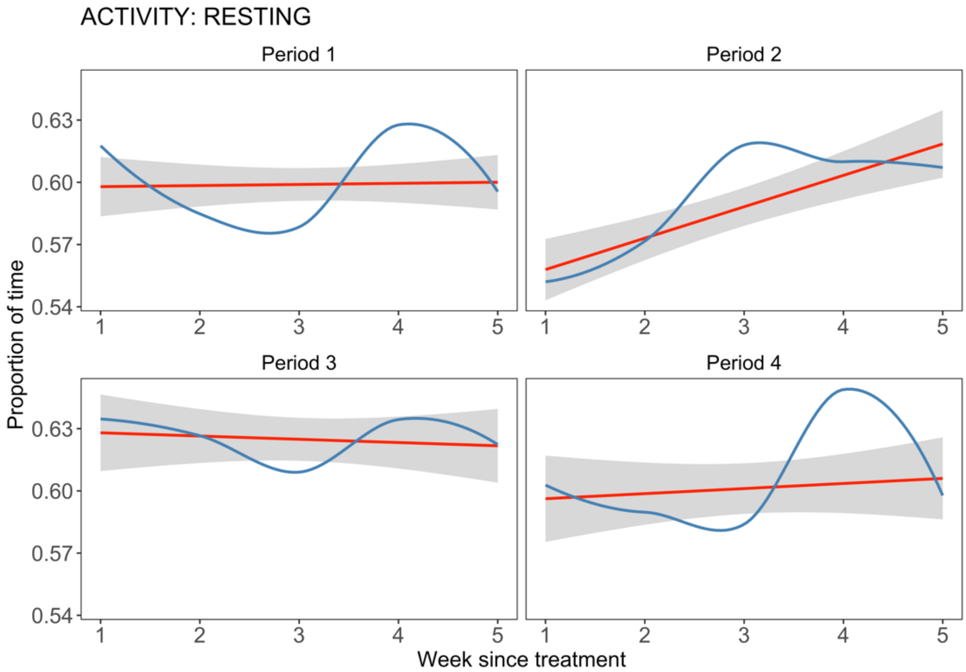

Figure 5.12 The mean proportion of time lambs spent resting across the six weeks post-treatment showing the slope (red line ± 95 % confidence interval) and observed smoothed mean distribution (blue line) in each of four periods (1, 2, 3 and 4).

The proportion of time spent 'walking' was at its lowest during Week 4 in Period 3 and 4, and during Week 5 and Week 3 in Period 1 and 2 respectively (Figure 5.13).

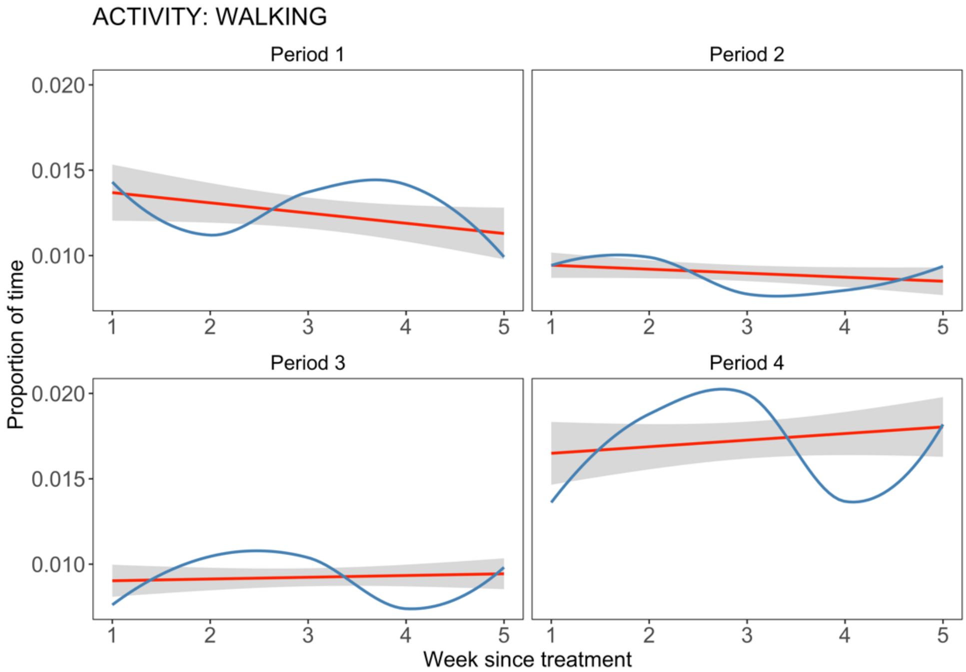

Figure 5.13 The mean proportion of time lambs spent walking across the six weeks post-treatment showing the slope (red line ± 95 % confidence interval) and observed smoothed mean distribution (blue line) in each of four periods (1, 2, 3 and 4).

The overall relative proportion of time that lambs dedicated to grazing versus other activities reduced (beta = -0.015, 95 % CI -0.016 to -0.015, $p < 0.001$) over the 6 weeks post treatment when all periods were considered together. The overall proportion of time spent 'walking' in relation to other activities also reduced (beta = -0.009, 95 %CI -0.012 to -0.006, $p < 0.001$). In contrast the time spent 'resting' versus other activities increased (beta = 0.016, 95 % CI 0.015 to 0.017, $p < 0.001$). The resulting model estimates for activity time budgets are presented in Appendix 5.5.

These results were supported from the additional model fitted using the Dirichlet Distribution, showing that across all periods, the longer the time interval after treatment, the proportion of time lambs spent 'grazing' reduced, while 'resting' increased concomitantly (Figure 5.14).

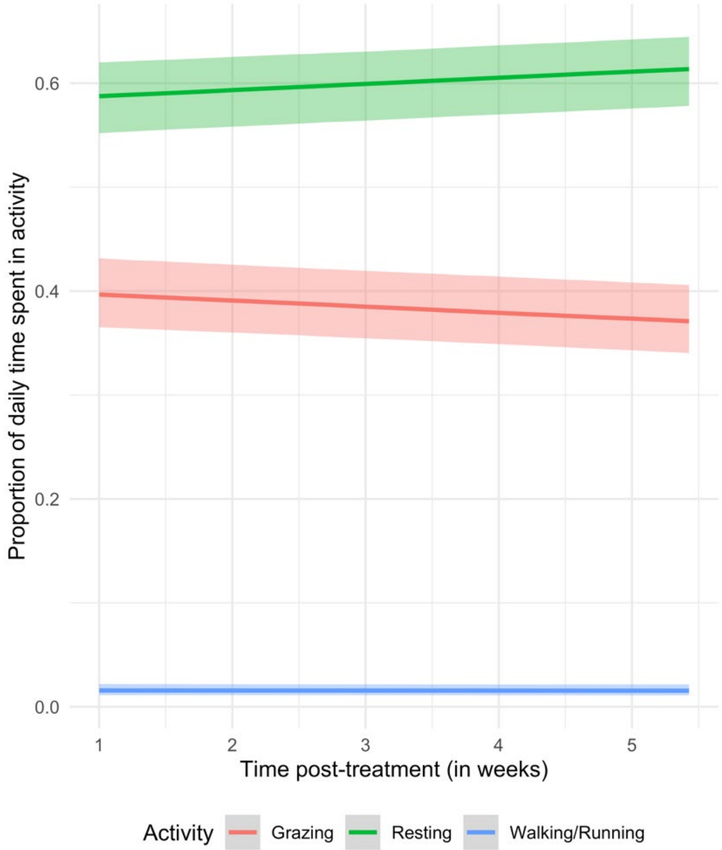

Figure 5.14 The average daily proportion of time 22 ewe lambs spent walking/ running, resting and grazing measured by tri-axial accelerometers over four periods. Results were modelled from a Dirichlet distribution, allowing for the simultaneous assessment of the effects of covariates on the relative contribution of all three activities.

5.3.4.4 Effect of time since treatment on activity levels (VeDBA$_{ACTIVITY}$)

Average daily activity levels measured by vector magnitude ('grazing', 'resting' and 'walking') of lambs pooled across all four periods are shown in Figure 5.15. Also shown in Figure 5.15 are the activity levels compared to faecal egg counts. The resulting model estimates of activity level for all activities are shown in Appendix 5.6. Lamb activity level over time after treatment showed a decrease for 'walking (p = 0.01), but 'grazing' and 'resting' were not statistically affected (p > 0.3). In relation to faecal egg counts, all activity levels reduced significantly at higher egg counts (Figure 5.15; Appendix 5-6).

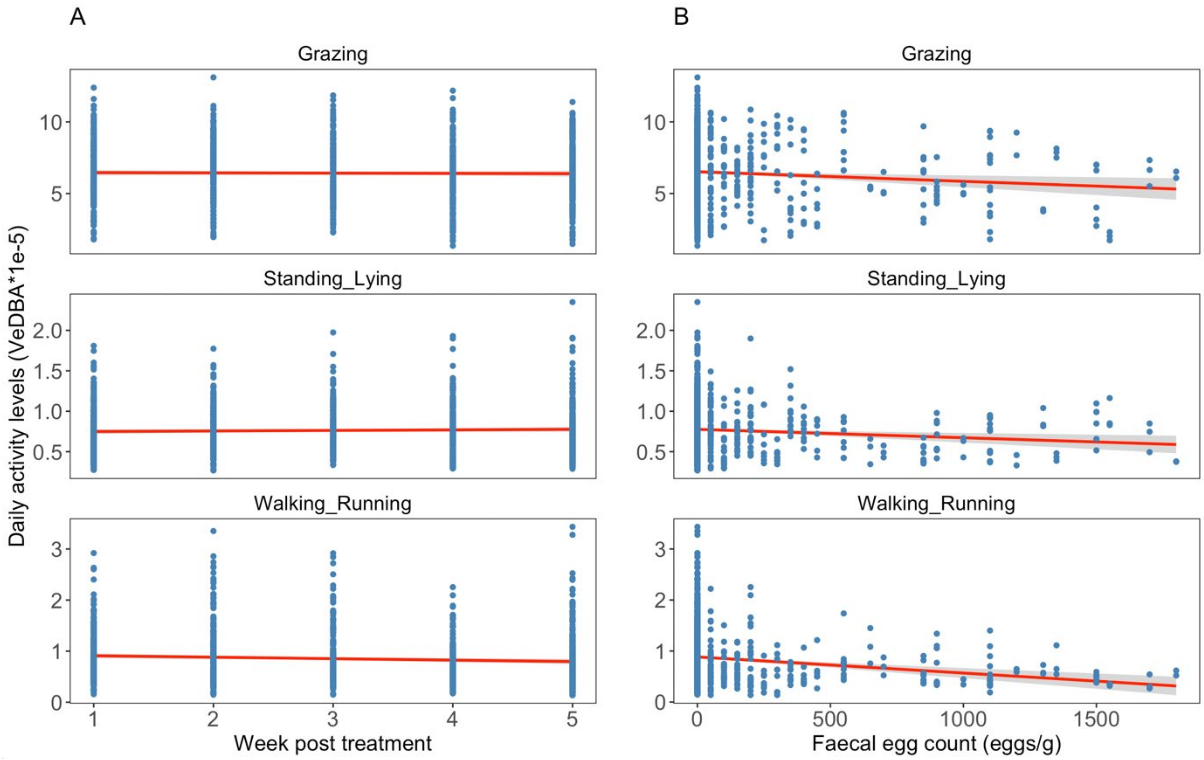

Figure 5.15 The Relationship between the daily activity levels of lambs for 'grazing', 'resting' (standing or lying) and 'walking' behaviour and (A) weeks after anthelmintic treatment and (B) faecal egg counts. Data was pooled over four periods.

5.3.5 Discussion

This study has clearly demonstrated that GIN influence the activity budgets of actively growing lambs. It is apparent that lambs would increase their grazing in proportion to resting activity immediately post-treatment before declining in the subsequent weeks, and this was also reflected in lambs walking for shorter periods as they accumulated a GIN burden. The lambs in this study were grazing naturally contaminated pasture containing a mixture of GIN species with no ability to regulate the infective dose. The study continued from weaning to ~ one year of age. Lambs of this age would typically be treated every 4 weeks until about 6-7 months of age and then at longer intervals until 12-18 months of age (Lawrence et al., 2007). In the present study, the treatment interval was set at 6 weeks which would have allowed a higher burden than normally expected in the first two periods of the study. With a developing immune response, the treatment interval is then usually extended which did not occur here. Lambs acquired low to moderate nematode infections as indicated by faecal egg counts, the level decreasing as the lambs got older and acquired a more effective immune response. None of the lambs included in analyses showed signs of clinical parasitism.

As a generality, the number of weeks post treatment was positively associated with the proportion of time spent resting and associated with significant reductions in the proportion of time spent grazing and walking per day. This indicates a relationship with the slowly increasing burden of GIN and these activities in that the larger the burden the larger the effect on the proportion of that activity. This is similar to the findings for when young cattle were treated with a persistent anthelmintic and were observed to spend a higher proportion of time grazing compared to untreated control cattle (Forbes et al 2000). However, when considering vector magnitudes which measure the magnitude of the effort for an activity it was observed in the present study that the number of weeks post treatment was only negatively correlated with $VeDBA_{WALKING}$, with no significant associations with $VeDBA_{GRAZING}$ and $VeDBA_{RESTING}$. This trend for a reduced $VeDBA_{WALKING}$ with time after treatment is consistent with the reduced proportion of time for this same activity and agrees with the findings in Section **5.2** for GPS measured distance travelled in the same lambs. The absence of an obvious trend for $VeDBA_{GRAZING}$ and $VeDBA_{RESTING}$ with weeks post treatment suggests these are less sensitive measures of the influence of GIN on animal activity. Nevertheless, in **Chapter 2** (Ikurior et al, 2020) the overall VeDBA was reduced in parasitised lambs indicating that trends may still be present. Faecal egg counts in the current study were also negatively correlated with the intensity levels (VeDBA) of all activities measured. These indicated that reduced $VeDBA_{GRAZING}$ and $VeDBA_{WALKING}$ in individuals with higher egg output can be expected. On the other hand, reduced $VeDBA_{RESTING}$ appears counter intuitive as 'resting' implies inactivity, but animals in this defined state are still able to make minor movements. The significant decline with increasing faecal egg count indicates they make fewer of these minor movements whilst 'resting' i.e. the intensity of activity whilst 'resting' declines.

There appeared to be a pattern in the proportion of time spent grazing across period of measurement. The time lambs allocated to daily grazing showed an upward trend up to three weeks post treatment, declining into the fourth week (except for Period 2 where a reduction was observed earlier), only to start trending upward again into the fifth week post treatment; but there was no obvious explanation for the occurrence of this pattern from the data. Changes in grazing activity were substantiated by commensurate significant live weight changes observed among the lambs during treatment Periods 1 and 2. These growth rates mirrored the pattern observed for grazing activity. Live weight gains were not markedly different from week to week over the six-weeks lambs were left untreated in the final two periods. It can only be speculated that as resident immature parasites matured to adults 21 days after treatment, they induced anorectic effects leading to significant reduction in grazing in an attempt to limit further infection. Whilst unexpected that the proportion of time spent grazing started to rise again after 28 days (with bigger egg counts), it suggests that some adjustments in activity time budgets of infected lambs may have started to occur. The mechanisms associated with anorexia are largely elusive, due in part to the fact that infected animals voluntarily reduce their feed (nutrition) intake at a time when it is needed most to ameliorate the complex array of changes occurring as a result of a protein-losing gastroenteropathy, as summarised by Coop and Kyriazakis (2001). In three periods in the current study, the lambs showed behavioural change consistent with attempting to maintain liveweight. The reasons for this occurrence are not immediately clear from the data.

In the present study, the time allocated to grazing increased within seven days of receiving monepantel. Since no attempt was made to measure the relationship between feed intake and grazing time recorded by tri-axial accelerometers, no claims can be made that this also meant intake increased, although in sheep monitored with vibracoders, an increase in feed intake was associated with time spent grazing (Hutchings et al., 2000), and similarly reduced grazing time was associated with reduced feed intake in cattle when monitored with jaw movement recorders (Forbes, 2008). Assuming that grazing time was reflected in feed intake in the present study, then these findings are in accord with those of Kyriazakis et al. (1996), who demonstrated that voluntary feed intake declined or remained static from Week 5 in growing lambs sub-clinically infected with *Trichostrongylus colubriformis* for 27 weeks. They also showed that in a subset of infected lambs treated after nine weeks of infection, feed intake recovered within a few days of receiving anthelmintics. What remains to be investigated at present is how feed intake relates with time spent grazing as measured by accelerometers. In studies to date, this has been reported to be difficult to achieve (Giovanetti et al., 2017).

Of interest, the presence of co-grazing pasture maintenance animals had a positive association with grazing activity. This may be due to a variety of causes. Birrell (1991) showed that stocking rate influenced grazing activity where sheep at a lower stocking rate started grazing earlier in the day than a higher stocking rate in autumn and that this order reversed in the spring. This author suggests this may reflect competition for available pasture with animals at the lower stocking rate achieving satiety more rapidly. In the present study, although not measured, pasture availability was considered more than sufficient for the animals available as indicated by the need to introduce these additional animals to control the excess. Thus, limited available pasture is an unlikely reason for this effect. However, some of the findings associated with changes in activity during the weeks post treatment may have been easier to explain with measurements of pasture quality and biomass.

5.3.6 Conclusion

Tri-axial accelerometers mounted on lambs provided data that allowed identification of the effects of GIN on the activity patterns of lambs observed from weaning to one year of age. This study provided evidence that reduced time allocated to grazing was an important response to subclinical GIN parasitism in infected lambs. Lambs increased their daily time allocation to grazing in response to treatment, before demonstrating a decline in time spent grazing in the subsequent weeks after treatment. This reduced grazing activity was a result of a reduction in the total proportion of daily grazing activity and not due to reduced intensity of grazing per day. The findings show that subclinical infection of lambs naturally infected with GIN markedly reduced the proportion of time spent walking, while there was a rise in the proportion of time spent resting (i.e. lying and standing). The estimated time spent in different activities and the intensities of the effort to perform these activities were highlighted as useful measures for assessing GIN parasitism, the latter being a more sensitive measure of activity changes in GIN infected lambs in relation to faecal worm egg counts of lambs. However, both proportion and intensity of activity contributed to defining the behavioural response of parasitised lambs compared to when they were initially treated. The differences in the model slopes when using either proportion or intensity of activity highlights the relevance of considering the measure that is most suitable for use in relation to specific study questions.

CHAPTER 6 – MOVEMENT AND BEHAVIOURAL ACTIVITIES OF ADULT EWES PRE-MATING IS INDEPENDENT OF FAECAL EGG COUNTS

6.1 Abstract

In **Chapter 5**, global position system (GPS) and accelerometer sensors were used to measure the activity of young growing lambs, and were able to show that the distance moved by the lambs and time spent grazing were affected by sub-clinical levels of gastrointestinal nematode (GIN) parasitism. This may mean that such technologies could be used to better assign treatment to only those animals most in need. Another option for reducing anthelmintic use on farms is to similarly restrict treatments in adult animals, restricting for example the use of anthelmintics pre-mating since farmers in New Zealand commonly drench their ewes premating. To this end, the present study sought to investigate activity patterns in a group of 2.5-year-old Romney ewes prior to mating. All the ewes were faecal sampled on the 15 Jan 2020 and treated at this time. Behaviour monitoring commenced on the 9 Mar (Day 0). Fifty-nine of the ewes were weighed, faecal sampled, body condition scored, and each was then fitted with a collar mounting a GPS monitor and an accelerometer. The collars were left on until 20 Mar (Day 11), when the ewes were again faecal sampled, weighed and body condition scored. The activity monitors started recording on midnight of the 9 Mar, providing 10 days of data, from which average daily distance travelled, daily activity budgets (time spent grazing, resting (lying or standing) or walking) and daily activity levels (intensity of the effort) were calculated. The data were further analysed by categorising the ewes as either moderate to high faecal egg counts (FEC, ≥ 500 eggs/ g) or low (≤ 500 eggs/ g), and low body condition score (BCS, ≤2.5, n=30), intermediate (3, n=15) or high (≥3.5, n=15). Over the 11-day period of the study, the average (SD, range) egg counts rose from 193 (383, 0-1950) to 547 (749, 0-3800), and initial Day 0 egg counts were a poor predictor of the counts measured later on Day 11 (κ_W=0.11). Liveweights and BCS remained unchanged. None of the performance parameters measured between Day 0 and 11 (liveweight, liveweight gain, body condition score) were significantly associated with how much the ewes moved. The relationship between FEC and the mean daily distance travelled by adult ewes was equivocal; on Day 11 FEC were associated with reduced distance moved ($p = 0.032$), but there was no relationship at other times. There was no evidence found for an association between FEC and time allocated to grazing, walking and resting of ewes prior to mating, but liveweight gain and daily grazing activity were significantly

associated ($p = 0.018$) and BCS predicted the intensity of resting activity ($p = 0.017$) such that thin ewes had 'rested' more. The lack of consistent influence of FEC on movement and behaviour may be a consequence of the limitations of using egg counts to predict both the burden of parasites or their impact, but may also reflect the fact that parasitism is just one contributor to poor performance of ewes.

6.2 Introduction

Adult sheep in New Zealand, especially British breeds, have largely developed an immune response by adulthood that is able to control gastrointestinal parasites although not eliminate them entirely (Pomroy 2017; Sutherland and Scott, 2010). Nevertheless, from time to time adult sheep will acquire burdens of gastrointestinal nematodes (GIN) that require treatment. There are also occasions when removal of GIN may be of benefit to the ewe, such as before mating (Kempthorne et al., 1996) and around lambing (Gogolewski et al., 1997). However, the treatment of adult ewes around lambing time and pre-mating, especially with long acting anthelmintics, has been identified as a high-risk management practice associated with being selective for anthelmintic resistant genotypes (Leathwick et al., 2006, Lawrence et al., 2006). In New Zealand, it is common practice to treat adult ewes with anthelmintics prior to mating to remove parasites from the animals which is meant to result in improved live weight performance and better mating outcome (Miller et al., 2015). Gastrointestinal nematodes are not usually a clinical problem at mating (Sutherland and Scott, 2010), although, there is some evidence to suggest that GIN infected sheep are less fecund than uninfected sheep (Kempthorne et al., 1996).

Ideally, only those sheep that would benefit from treatment for GIN would be identified and treated. This targeted selective treatment (TST) approach (Kenyon et al., 2009) uses pathophysiologic or performance-based markers of parasitism to identify individuals who warrant treatment rather than treating the whole herd. Hence, a case can be made for the role of TST in minimizing the risk associated with (re)production deficits while being a viable alternative to whole-herd treatments which are associated with selecting resistant genotypes.

Gastrointestinal nematode parasites can induce a level of inappetence and lethargy in infected animals. The importance of inappetence as a component of production loss resulting from subclinical GIN infections has been demonstrated in studies that have shown that between 60 - 73 % of the reduced growth rate of lambs caused by parasites is directly attributable to a reduction in feed intake (Coop et al., 1982). In an earlier chapter in this thesis (**Chapter 5**) for lambs allowed to graze contaminated pastures for 28 days after receiving a short-acting anthelmintic, parasite load (indicated by FEC) was found to be negatively associated with distance travelled and the proportion of time spent grazing. This was associated with more resting time (i.e., time spent laying down or standing) per day compared to lambs grazing the same pastures but which were between seven and 10 days from receiving anthelmintics. These changes are potentially important as indicators of disease and are viable candidates to drive a TST approach. There is relatively little information on the effect of subclinical GIN infections on movement behaviour and grazing behaviour in pasture-based adult sheep although effects on milk production have been measured in adult cattle which were either treated with an anthelmintic or not (Forbes et al 2004). With current advances in the ability to monitor animal behaviour remotely with technology, such as global positioning system and tri-axial accelerometers, the monitoring of activity changes if detectable from sensor data could be used to assign treatments to individuals. The aim of the present study was to investigate the expression of movement and grazing behaviour of adult ewes naturally infected with varying burdens of GIN, measured using FEC, prior to mating. Two specific questions were addressed: (1) Are host movement and behavioural activities negatively affected by greater parasite load (High-FEC) compared to lower burdens (Low-FEC)? and (2) is reduced distance travelled, reduced grazing time and increased resting time associated with poorer performing ewes (low body condition score and live weight gain)?

6.3 Materials and Methods

6.3.1 Study site and animal management

The experiment was conducted at Massey University's Keebles Farm, New Zealand over the period 15 January – 23 March 2020, which is during the post-weaning period prior to mating in this region. The current study involved 60 ewes aged two-and-a-half years with a mean body weight of 68.1 kg (SD = 6.9). These ewes were part of a cohort of 451 ewes managed as one mob in a long-term whole-of-life study investigating the effect of birth rank, dam age and post-weaning management on the reproductive performance of ewes (Haslin et al., 2019). The ewes were individually identified and were monitored regularly for live weights and body condition. They had been dosed with a long-acting anthelmintic at lambing ('Bionic Hi Mineral Combination Sheep Capsules', Boehringer Ingelheim Animal Health NZ) in August 2019. The animals in the current study were sampled from the Control treatment group (n=102) described in Haslin et al.'s (2019) study to simulate standard ewe growth conditions as much as possible. These control ewes were twin-born ewes born to mature ewes. During this present study, the entire cohort of ewes (n=451), including the study animals, were shifted daily to fresh paddocks from Day 0 to Day 3 of the study. The sizes of these paddocks were 1.3, 1.4 and 1.7 hectares respectively. On Day 4, all the ewes in the Control Group were shifted to a 4.4-hectare paddock where they were set-stocked and remained by themselves till Day 11, which marked the end of the study.

6.3.2 Study design

Sixty ewes were randomly selected from the Control Group (n=102). All the ewes were faecal sampled on the 15 Jan 2020, and high egg counts (mean 442 egg/g, range 0-3650) led to them all being treated with anthelmintics. Thus, on 22 January 2020 (Day -46), all the ewes received a single oral dose of a triple-combination anthelmintic consisting of 0.2 mg/kg abamectin, 8.0 mg/kg levamisole and 4.5 mg/kg oxfendazole (MATRIX Hi-Mineral; Boehringer Ingelheim Animal Health NZ). The ewes were subsequently allowed to graze on contaminated pasture and the start of the study was therefore delayed to the 9 Mar 2020 (Day 0), when continuous behaviour monitoring commenced up to Day 11. The activity monitors started recording on midnight of the 9 of March (i.e from beginning of Day 1), providing 10 days of data, from which average daily distance travelled, daily activity budgets (time spent grazing, resting (lying or standing) or walking) and daily activity levels (intensity of the effort) were calculated. Sheep were then mustered on Day 11 for further measurements of weight and condition scoring, and to retrieve the collars.

6.3.3 Movement and Activity monitoring

The ewes were monitored with both a global positioning system (GPS) collar and a tri-axial accelerometer also attached to the collar. The collars were placed on the necks of the sheep with the GPS unit in a ventral position. The GPS collars were constructed by DataCarter (www.datacarter.co.nz) and contained a u-blox 8 chipset (u-blox®, Switzerland) . In **Chapter 3**, the accuracy of the GPS chipset was estimated with a mean error from actual receiver position of 1.43 and a standard deviation of 0.82 m when subject to a static accuracy test at one second epoch. Results demonstrated 99.7 % of points fell within 4 m and 95.0 % within 3.1 m of the known point. The collars were programmed to record sheep location based on three criteria: movement, velocity and time. Positions were only recorded when movement exceeded the threshold of 5 metres and velocity was less than 10 metres/second. There was also a time threshold of one minute after which a position was recorded irrespective of movement and velocity.

Acceleration was measured with an ActiGraph wGT3X-BT® acceleration sensor (ActiGraph, LLC, Pensacola, FL, USA) that measures acceleration during movement across the vertical, horizontal, and perpendicular axes. This was attached to the dorsal side of the GPS collar on the opposite side to the GPS unit, such that it was carried on the back of the neck of the sheep. This unit employs a reference system that indicates longitudinal (front-to-back or surge, Y), horizontal (side-to-side or sway, X) and vertical (up and down or heave, Z) body axes, respectively (ActiGraph Manual, version 1.0.0 August 2013). Before attaching the collars to the ewes, the sensors were pre-scheduled to collect acceleration data at a sampling rate of 30Hz, which is equivalent to 30 sampling occasions in one second. The accelerometers were 46 × 33 × 15 mm in size and weighed 19 g. The orientation of the sensors was the same on all sheep. A behaviour classification algorithm developed from raw accelerometery data from the Actigraph wGT3X-BT® sensor classified three distinct behavioural activities of sheep on pasture, namely grazing, resting (lying or standing) and walking activities (**Chapter 4**). The accuracy predicted from the classification algorithm was 94 %, 89 % and 78 % for grazing, resting and walking activities respectively.

6.3.4 Measurements

Behaviour monitoring commenced at 00.00 h on 10 March 2020 (Day 1). The ewes were monitored continuously for 10 days with the GPS collars and tri-axial accelerometers. Distance between successive locations or step length were processed from raw GPS records for each ewe using the R package 'moveHMM' (Michelot et al., 2016). Step lengths were subsequently summed over successive 24-hour periods to provide a single value of total distance travelled per day. The daily total distance values were used to calculate the average daily distance travelled by each ewe during the monitoring period. Accelerometry data were collected simultaneously with GPS data. The behavioural activities of grazing, resting and walking were derived from raw accelerometry data as described above. Collars were retrieved to download raw data to estimate the distance travelled and proportion of each behavioural activity for the duration of monitoring.

Individual faecal samples were collected per-rectum for determination of nematode egg counts using a modified McMaster method, and using 2.0 g of faeces. In this method, each egg counted represented 50 eggs/g (Stafford et al., 1994). Samples were collected and processed within 24 h on Day -54, Day 0 and Day 11 corresponding to the pre-trial FEC screening performed to assign ewes to groups, the start and end of behaviour monitoring respectively. Bulk faecal larval cultures to establish the nematode genera infecting ewes were processed on Day 0 and 11 using an additional 5–10 g of faeces from each ewe, pooled and mixed with Vermiculite® and then cultured for 10 days at 20 °C.

The live weight (LW) of the ewes was recorded on Day -54, Day 0 and Day 11. The ewes were weighed using Tru-TestTM MP600 load bars and XR5000 weigh head (Tru-Test Group, Auckland, New Zealand). The weighing system collected live weights at a resolution of 0.1 kg. Body condition scores (BCS; Jefferies, 1961) were measured by palpation of the lumbar vertebrae and associated soft tissue using a scale of one (emaciated) to five (obese) scale by a single assessor on Day 0 and Day 11, coinciding with the start and end date of behaviour monitoring.

6.3.5 Statistical analyses

All movement and activity measurements recorded when the ewes where being moved were removed.

Liveweight gain (LWG) was analysed as the difference in most recent and earliest liveweight recorded divided by number of days between weights. To determine the relationship between BCS and other measures, ewes were categorised as BCS $\leq$2.5, 3.0 or >3.5 corresponding to a low (n=30), mid (n=14) and high (n=15) BCS distribution for assessments performed on Day 11. Cohen's Kappa statistic was used to assess the level of agreement of FEC, BCS and LW data recorded between Day 0 and Day 11. Weighted kappa coefficients (κ_W), which attributes more weight to large measurement differences than to small ones was used (Cohen, 1968). All κ_W results were interpreted according to Fleiss (1981), where values >0.75 suggested 'excellent', 0.4 to 0.75 indicated 'fair-good' and <0.4 indicated 'poor' levels of agreement. The association between LWG and BCS categories were tested using ANOVA. ANOVAs were also used to test for between-BCS group differences in FEC and LW. A Poisson distribution was assumed for FEC in these analyses. The response distance was transformed using the Johnson transformation ('Johnson R package'; Fernandez, 2014) in order to meet the assumption of normal distribution of residuals.

Faecal egg count Groups

Egg count data were analysed by categorising the ewes as either Moderate-to-High (Mod-High) on Day -54 (15 Jan) with a FEC > 500 eggs/g (n = 39) or Low with a FEC ≤ 500 eggs/g (n=21). These categories were also applied to egg counts on Day 0 and Day 11. Egg counts were further categorised based on change in egg counts from Day 0 to 11 as positive (eggs/g increased by >150, n = 33), no change (eggs/g did not change by > or < 150, n = 23) and negative (eggs/g decreased by >150, n = 0). These analyses were repeated using the coding 1 or 0 representing eggs present (non-zero eggs/g) or absent (zero eggs/g) respectively in order to ascertain whether FEC had a presence/absence relationship with other factors. Analyses were conducted independently for each treatment period.

Distance travelled

The effect of parasitism (as indicated by FEC) on distance travelled was examined in ewes with High and Low FEC by fitting the data to six linear mixed effects models: Models 1 and 2 were constructed with the response variables mean daily distance travelled and mean diurnal distance travelled respectively. Both models were fitted with 'FEC-group' (Low, Mod-High), 'BCS group' (three levels) and 'LWG' or 'LW' as explanatory variables and individual included as a random variable.

Of interest in Model 3 was whether change in egg counts and BCS between Day 0 and Day 11 affected distance travelled. For this analysis, a variation in FEC by 150 eggs/g was considered a change in egg count. Based on this criterion, two additional groups, FEC-Gained (n= 33) and FEC-Maintained (n=23) were derived and the response distance travelled was modelled using a similar structure to those described above. A difference in BCS of 0.5 was considered as changed. The resulting values were then categorised as positive (an increase in BCS, n = 19), no change (BCS remained the same, n = 30) and negative (BCS decreased, n = 10).

Behavioural activities

The frequency (number of occurrences per day) and total duration (length of time per day) of grazing, resting and walking activities were described for the ewes. The effects of anthelmintic treatment and FEC on the activity levels (intensity of the activity) and activity budgets (proportion of time allocated to activity) of lambs were examined separately.

Activity levels (VeDBA)

Activity levels were estimated using a similar approach to that described in **Chapter 2**. The overall activity was calculated as dynamic vectorial body acceleration (VeDBA), corresponding to each classified activity modelled as the response variable, i.e. $VeDBA_{ACTIVITY}$. Three $VeDBA_{ACTIVITY}$ models (corresponding to grazing, resting and walking activity magnitudes) were fitted with the same structure as for 'distance travelled' (i.e. as for Model 1). Linear mixed models (LMMs) were used with lamb ID included to account for repeated measures. Fixed effects included 'week post treatment (numeric)', 'treatment period' and 'week post treatment' x 'treatment period' interaction. Initial models included interaction between 'weeks after treatment' and 'treatment period', but because this variable did not emerge as a significant predictor of any of the three $VeDBA_{ACTIVITY}$ models it was subsequently dropped from all three. To normalise the distribution, all $VeDBA_{ACTIVITY}$ date were log transformed and model residuals were tested using graphical inspection of residuals and with the Shapiro-Wilks test to ensure normality was achieved.

Activity budgets

Activity budgets were compared using similar methods as activity levels, but the proportion of each activity was compared. Daily activity budgets (proportion of time spent grazing, resting, and walking) were calculated for each ewe using methods similar to Regular et al. (2014). Thereafter, three generalized linear mixed models (GLMM) for 'grazing', 'resting' and 'walking' activities were constructed, with the occurrence or absence of each activity as the binomial response variable. The fixed explanatory variables were FEC and LWG, with individual ewe set as a random effect.

Additionally, all models were constructed on a subset of the daily data including only the mean sunset to sunrise hours over the ten days of behaviour monitoring (i.e. from 07.10 to 19.40 h; www.timeanddate.com, 2020). All data were processed and analyzed using R version 3.6.2 (R Core Team, 2019), with appropriate R packages ('moveHMM', 'stats', 'lmerTest', 'psych; Revelle, 2019', 'multcomp; Hothorn et al., 2008', 'ggplot2; Wickham, 2016') and significance was accepted at $\alpha \leq 0.05$ for all tests unless otherwise noted. All experimental procedures described here were approved by the Massey University Animal Ethics Committee (MUAEC 19/104).

6.4 Results

Descriptive summaries for FEC, live weight and body condition score collected on Days 0 and 11 are shown in Table 6.1. Mean and median FEC were slightly greater on Day 11 than Day 0. The coefficients of variation for live weight and body condition score were similar on Day 0 and 11, reflecting similar variation in ewes on both days.

Table 6.1 Descriptive statistics of faecal nematode egg counts, live weights and body condition score of ewes monitored with remote sensors continuously for 10 days.

	Faecal egg count (eggs/g)		**Live weight (kg)**		**Body condition score**	
	Day 0	Day 11	Day 0	Day 11	Day 0	Day 11
Mean (SD)	192.6(383.1)	546.6 (758.6)	65.3 (6.4)	65 (6.1)	2.7 (0.6)	2.8 (0.6)
Median(IQR)	50 (150)	325 (400)	64.8 (9.7)	64.5 (7.8)	2.5 (0.6)	2.5 (0.8)
Range	[0, 1950]	[0, 3800]	[51.8, 79.4]	[51, 79]	[2, 4]	[1.5, 4.5]
CV	198.88	393.82	9.77	9.42	21.74	23.36

CV – coefficient of variation; SD – Standard deviation; IQR – Interquartile range

6.4.1 Level of agreement between measures recorded on Day 0 and Day 11.

The data did not provide evidence of agreement between eggs/g counted on Day 0 and 11, as nematode egg counts on Day 0 were poorly related to counts detected on Day 11. The κ_W statistic was 0.11, $p = 0.382$. The weighted Kappa coefficients for Liveweight ($\kappa_W = 0.92$) and body condition ($\kappa_W = 0.75$) were indicative of 'excellent' and 'fair-good' levels of agreement respectively.

6.4.2 Faecal egg count

The prevalence of non-zero FEC was 41% and 48% on Days 0 and 11 respectively. The composition of larvae identified in culture at the start and end of movement and activity monitoring is given in Table 6.2 and show the composition was broadly similar on both occasions.

Table 6.2 Genera of GI nematodes found in larval cultures from pooled from faecal samples of mixed-age ewes at the start (Day 0) and end (Day 11) of movement and activity monitoring prior to mating.

Parasite genus	**Day 0**	**Day 11**
Haemonchus	44 %	68 %
Teladorsagia	18 %	2 %
Trichostrongylus	8 %	4 %
Cooperia	24 %	24 %
Oesophagostomum/Chabertia	6 %	2 %

6.4.3 Relationship between Faecal worm egg counts and body condition score

No detectable difference in FEC were observed between BCS groups (p = 0.20), although a higher variation in egg counts was observed in ewes with high condition scores (Figure 6.1)

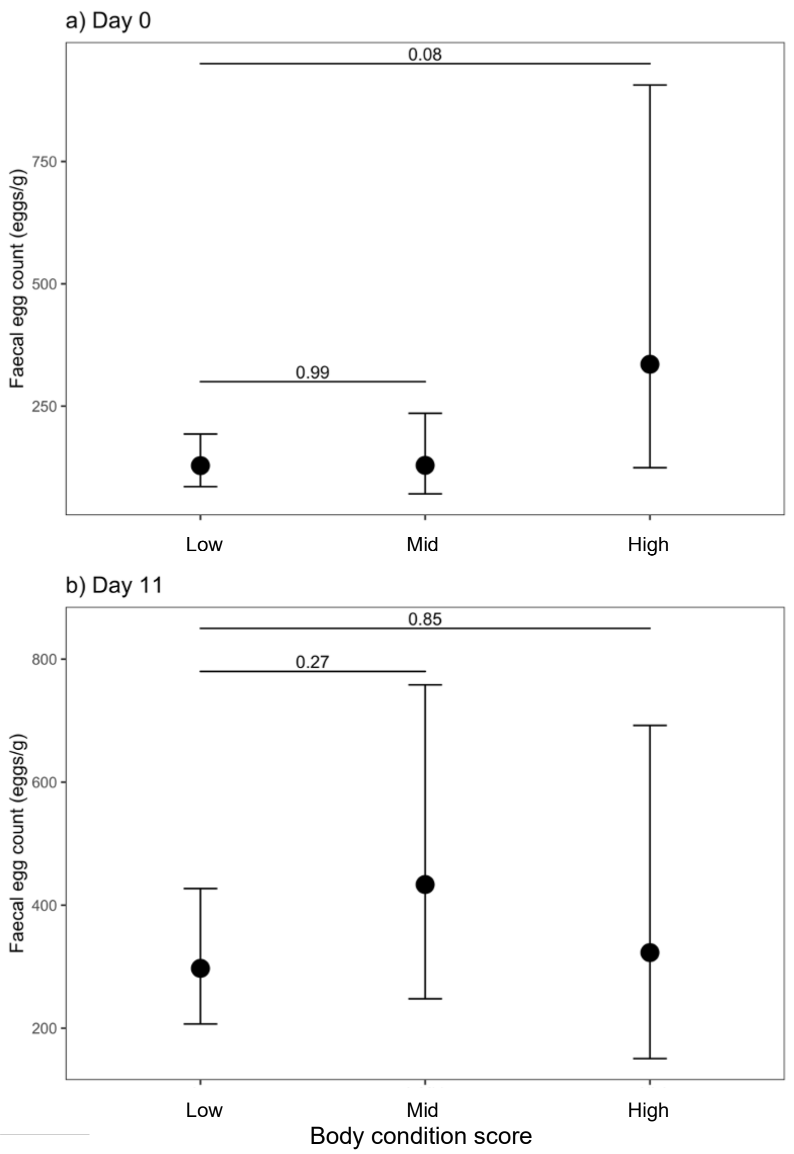

Figure 6.1 Relationship between geometric mean faecal egg counts (95% confidence interval) and body condition score of adult ewes (n=59) recorded on a) Day 0 and b) Day 11 of measurement. Horizontal lines represent the *p* values of the difference between the indicated categories.

6.4.4 Liveweight gain and faecal worm egg counts

Live weight gain after 10 days of monitoring was independent of FEC (Groups, Low and Mod-High) on Day 0 (p = 0.08, Figure 6.2), although there was a larger variation in LWG in the High-FEC group.

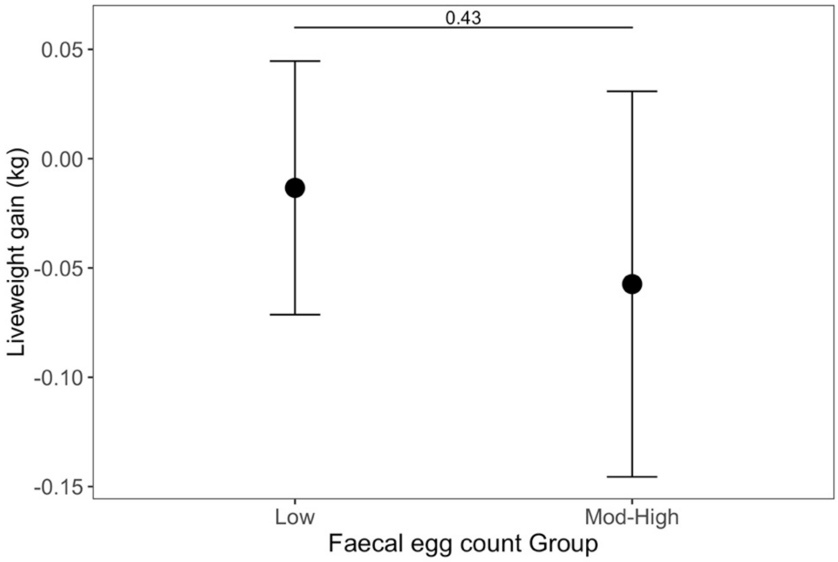

Figure 6.2 The relationship between the faecal egg output of two groups of adult ewes (Low, n = 38 and Mod-High, n = 18) collected and their liveweight gain (kg, 95% confidence interval) from Day 0 to Day 11. Horizontal line represents the *p* value of the difference between the indicated categories.

6.4.5 Body condition score and Liveweight

Liveweight was positively associated with BCS Groups, with low condition scored ewes having significantly lower liveweights than Mid and High BCS groups (Figure 6.3).

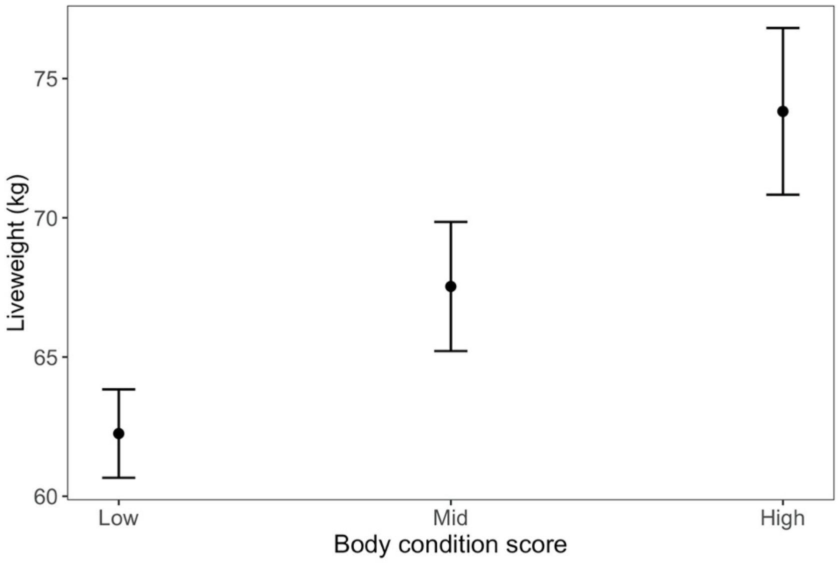

Figure 6.3 Relationship between mean liveweight (kg, 95% confidence interval) and body condition score of adult ewes (n=59) recorded on Day 0.

6.4.6 Ewe daily Movement (distance travelled) and effects of faecal egg counts, body condition score and liveweight gain

Movement data from only 48 ewes were available from the study, as 12 GPS units deployed unsuccessfully; the mean number of location records during 10 days of monitoring per ewe was 17154 (95 % CI 16390 to 17920). On average, ewes travelled a mean daily distance of 4.1 km (95 % CI 4.0 to 4.3), ranging from 440 m to 5.4 km per day. Reduced travel distance was observed in ewes with moderate to high faecal egg counts on Day 11 (p = 0.032, Figure 6.4); but egg counts on Day 0 did not have a detectable influence on distance moved (p = 0.657). None of the other variables tested (BCS, LW or LWG) were significantly associated with movement activity among ewes (Table 6.3).

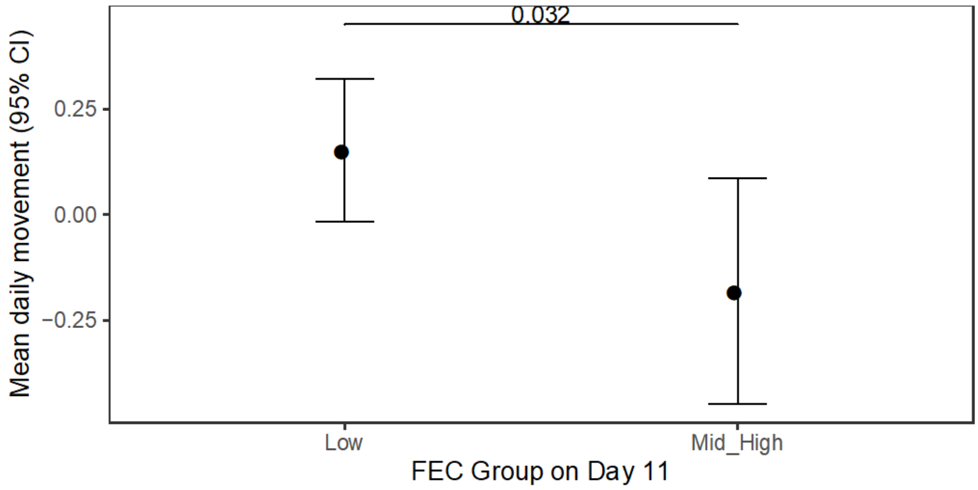

Figure 6.4 Effect of faecal egg counts on the mean daily distance moved (Johnson transformed) of adult ewes (n=48). Error bars indicate 95 % confidence interval. Horizontal line represents the *p* value of the difference between the indicated categories.

Table 6.3 Relationship between nematode parasites (eggs/g, on Day 0 and 11), body condition score (BCS, on Day 0 and 11) and liveweight gain (in grams by Day 11) on the daily distance travelled (km/day) of mixed-age adult ewes (n=48).

Day 0				**Day 11**			
	beta	SE	*p*		beta	SE	*p*
(Intercept)	-1.99	1.37	0.154	(Intercept)	-0.48	1.40	0.731
FEC (Mod-High)	-0.19	0.42	0.657	FEC (Mod-High)	-0.46	0.21	0.032
BCS (Mid)	-0.30	0.26	0.253	BCS (Mid)	-0.04	0.25	0.865
BCS (High)	-0.45	0.38	0.251	BCS (High)	-0.01	0.34	0.975
Day	0.02	0.01	0.093	Day	0.02	0.01	0.094
LW	0.03	0.02	0.172	LW	0.01	0.02	0.746

There was no effect of individual change in FEC on distance moved ($F_{1,40} = 0.17$, $p = 0.683$). However, a negative change in body condition score was associated with reduced distance moved ($F_{2,40} = 3.36$, $p = 0.045$; Figure 6.5).

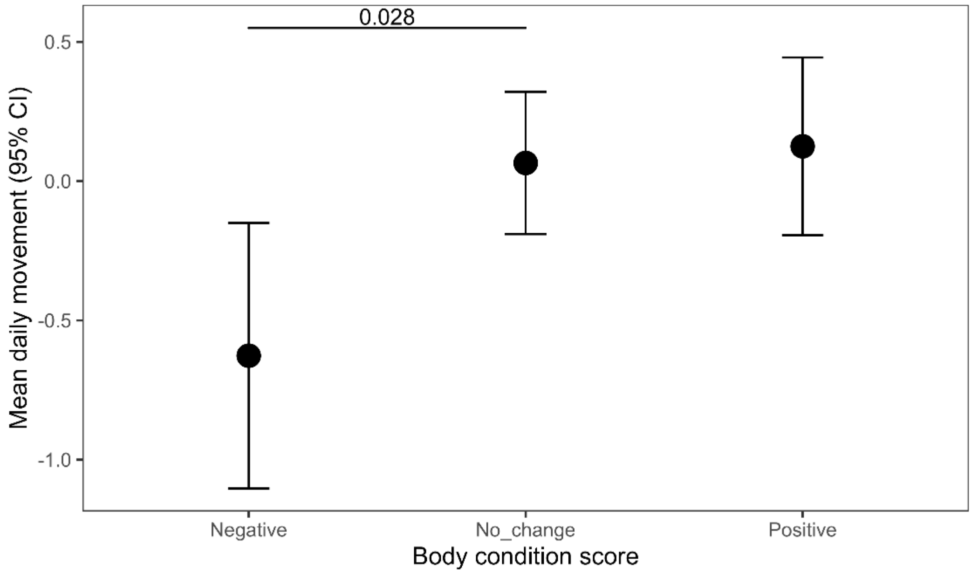

Figure 6.5 Effect of change in body condition score on the mean daily distance moved (Johnson transformed) of adult ewes (n=48). Error bars indicate 95 % confidence interval. Horizontal line represents the *p* value of the difference between the indicated categories.

6.4.7 Daily Activity budgets of ewes and effects of faecal egg counts, body condition and liveweight gain

On average, ewes spent 60 %, 33 % and 7 % of their daily time 'resting', 'grazing' and 'walking' respectively (Figure 6.6).

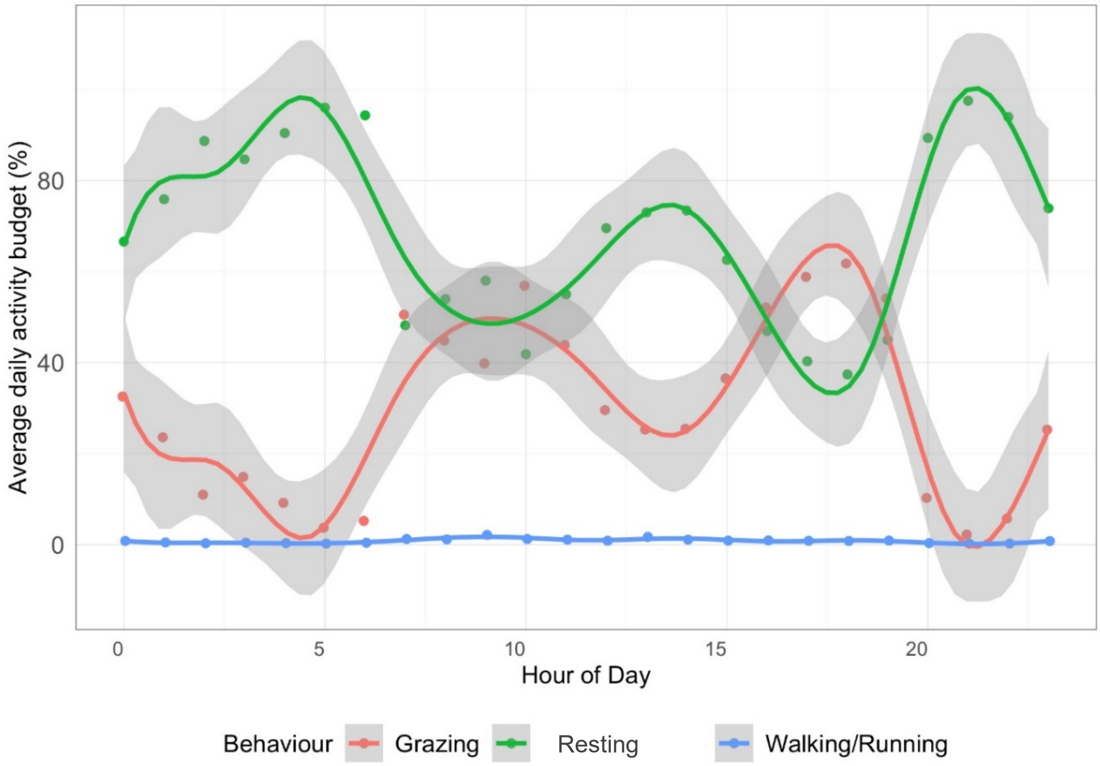

Figure 6.6 Average daily activity budget per hour of day allocated to three behaviours of mixed-age adult ewes (n=59). Loess curves, with 95% confidence intervals.

The ewes showed a diurnal grazing pattern, with grazing time typically increasing from sunrise (07.10 h) and peaking mid-morning, then declining through the middle of the day to rise again late afternoon reaching its highest just before sunset (19.40 h). The pattern also showed other periods of grazing during the day and during the night-time as well. There was little variation between days in the proportion of time allocated to the three behaviours of interest over the study (Figure 6.7).

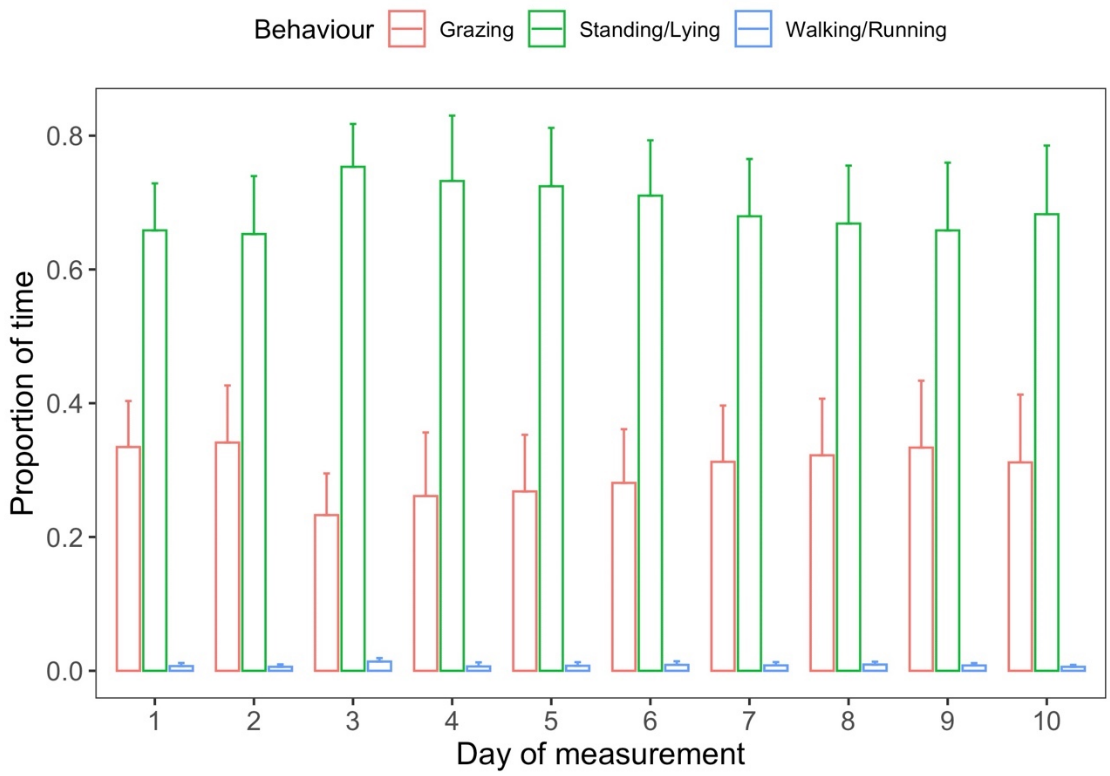

Figure 6.7 The mean proportion of time that mixed-age adult ewes devoted to grazing, resting (standing or lying) and locomotion (walking or running) during 10 days of monitoring with tri-axial accelerometers. Error bars indicate standard deviation.

6.4.8 Activity budgets

The time allocated to grazing, resting and walking activities were not dependent on faecal egg counts (Table 6.4).

Table 6.4 Influence of nematode parasites (eggs/g, on Day 0 and 11), body condition score (BCS, on Day 0 and 11) and liveweight gain (in grams by Day 11) on the proportion of time devoted to grazing, walking and resting behaviour in mixed-age adult ewes (n=59).

Day 0				**Day 11**			
	beta	SE	*p*-value		beta	SE	*p*-value
Resting				**Resting**			
(Intercept)	0.88	0.07	**<0.001**	(Intercept)	0.82	0.07	**<0.001**
BCS (Mid)	-0.09	0.13	0.483	BCS (Mid)	-0.15	0.12	0.232
BCS (High)	0.11	0.14	0.457	BCS (High)	0.14	0.12	0.231
FEC (Mod-High)	0.06	0.20	0.770	FEC (Mod-High)	0.17	0.10	0.094
Day	-0.01	0.00	**<0.001**	Day	-0.01	0.00	**<0.001**
LWG	-0.85	0.32	**0.007**	LWG	-0.79	0.29	**0.006**
Walking				**Walking**			
(Intercept)	-4.82	0.08	**<0.001**	(Intercept)	-4.81	0.09	**<0.001**
BCS (Mid)	-0.19	0.15	0.205	BCS (Mid)	0.03	0.15	0.866
BCS (High)	0.07	0.17	0.698	BCS (High)	-0.11	0.14	0.439
FEC (Mod-High)	0.06	0.24	0.789	FEC (Mod-High)	-0.03	0.13	0.812
Day	-0.01	0.00	**<0.001**	Day	-0.01	0.00	**<0.001**
LWG	0.31	0.37	0.399	LWG	0.45	0.35	0.203
Grazing				**Grazing**			
(Intercept)	-0.92	0.07	**<0.001**	(Intercept)	-0.86	0.07	**<0.001**
BCS (Mid)	0.10	0.13	0.430	BCS (Mid)	0.15	0.12	0.221
BCS (High)	-0.11	0.14	0.444	BCS (High)	-0.14	0.12	0.242
FEC (Mod-High)	-0.06	0.20	0.759	FEC (Mod-High)	-0.18	0.10	0.085
Day	0.01	0.00	**<0.001**	Day	0.01	0.00	**<0.001**
LWG	0.85	0.31	**0.007**	LWG	0.79	0.28	**0.006**

Significant effects are shown in bold. Reference levels are indicated in parenthesis

6.4.9 Activity levels ($VeDBA_{ACTIVITY}$)

Grazing ($VeDBA_{GRAZING}$)

Liveweight gain significantly predicted grazing activity ($p = 0.018$) but FEC and BCS were not associated with intensity of grazing activity. Thus, higher grazing activity were associated with better weight gains (Figure 6.8).

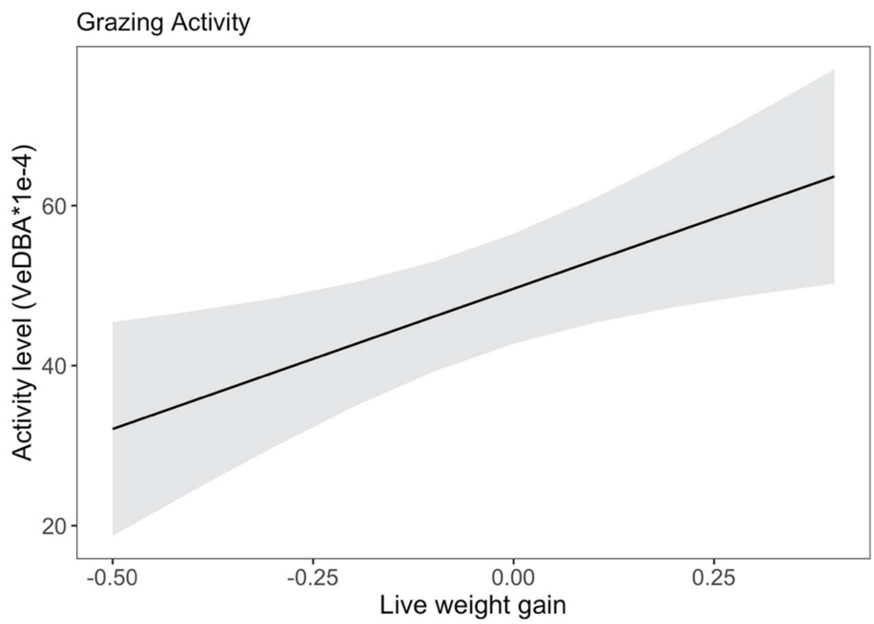

Figure 6.8 Relationship between live weight gain of mixed-age adult ewes (n=59) and mean intensity of grazing activity (grey area is ± 95 % confidence interval) measured for 11 days continuously with tri-axial accelerometers.

Resting (lying and standing behaviour; $VeDBA_{RESTING}$)

There was an effect of BCS on resting activity levels ($F_{2,54} = 4.4$, $p = 0.017$), with low body condition scored ewes (i.e., ≤ 2.5) showing higher $VeDBA_{RESTING}$ than mid and high body conditioned scored ewes (Figure 6.9). Liveweight gain was not a statistically significant predictor of resting activity level.

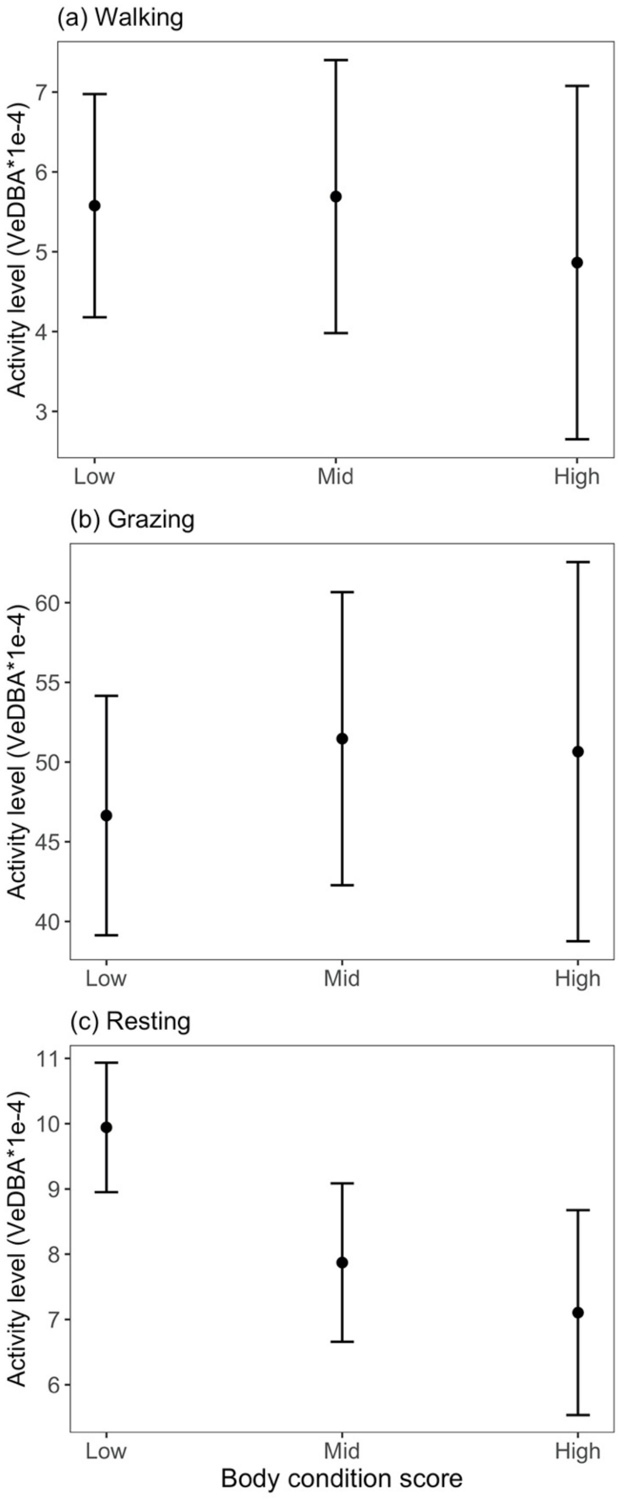

Figure 6.9 Mean Activity levels (95 % confidence interval) of low (n=29), mid (n=15) and high (n=15) body condition scored adult ewes for (a) walking, (b) grazing and (c) resting activities.

Walking (VeDBAWALKING)

None of the independent variables tested (FEC, LW, LWG, BCS) were statistically significant predictors of walking activity.

Results from models of diurnal activity and distance travelled (not presented) were 'qualitatively' similar to those of daily models presented above.

6.5 Discussion

In the present study, GPS and tri-axial accelerometer sensors mounted on adult ewes generated data that allowed daily activity patterns for individual ewes to be deduced, showing significant variation in distance moved, grazing and resting activity. On average, faecal egg counts were considered low to moderate (McKenna and Simpson, 1987). However, the variation in individual daily distance travelled and activity recorded were related to the number of eggs in faeces in the ewes on Day 11 but not Day 0. Weak trends ($p < 0.09$) were also observed between FEC on Day 11 and the proportion of time spent grazing and resting over the whole 10 days of the study. However, these effects were not observed with FEC measured on Day 0. The body condition score, liveweight and liveweight gain of ewes was independent of their faecal egg counts. However, when considering proportional time allocation the ewes gaining the most daily weight were shown to allocate the most time to grazing activity; but parasitism did not appear to be an important factor in determining how much time ewes spent grazing, nor was there an association between the body condition of ewes and grazing activity. Therefore, it does not appear that time spent grazing or resting or walking had a relationship with the FEC of adult ewes; nor was FEC associated with the performance of these ewes.

6.5.1 *The daily activity patterns of ewes*

The predominant daily activity recorded from the ewes was standing and lying. With sheep ruminating between grazing bouts, it is safe to say some of the activity classified as resting contained ruminating bouts (Giovanetti et al., 2017). With that in mind, it can be suggested that most ruminating occurred during the nighttime. In adult cattle, a reduction in ruminating time was found associated with GIN parasitism (Forbes et al., 2007). With ruminating subsumed within resting times in the present study, it cannot be ascertained if ruminating time was affected. Compared to 'resting' and 'grazing', the average daily walking time was relatively short, only 11.5 mins/24 h. These daily allocations were similar to those of ewe lambs seen previously (see Section **5.3**).

6.5.2 Faecal egg counts, movement and activity

Faecal egg counts ranged from low to high, but distinct movement and activity patterns were not consistently found for counts investigated as groups (Low vs. Mod-High), change in egg counts (No change vs. Positive) or FEC detected (Present vs. Absent). Reduced distance moved by the ewes was associated with ewes shedding > 500 eggs/g at the end of behaviour monitoring, but not from ewes shedding the same eggs/g 10 days prior. A biologically plausible reason for this result was not found from the data. The presence of an equivocal influence of FEC on distance moved is not immediately clear but may be a consequence of the limitations of using egg counts to predict the impact of GIN on adult animals. That is, the insensitivity of this method for estimating parasite burden. This study relied on egg counts as a marker of parasitism, and egg counts are more variable in adult sheep than lambs (Brunsdon and Vlassoff, 1985). Further, it has been suggested that faecal egg counts are useful indicators of the individuals contaminating pasture the most, but as a marker for worm burdens, FEC are considered questionable (Greer et al., 2009, Sargison, 2013). For example, when comparing worm burdens with faecal egg counts in ewes, only 88 % of ewes with a FEC < 500 eggs/g had a total worm burden considered low (< 4000 total worm burden) whereas 58 % of ewes with a FEC > 500 eggs/g still had a worm burden considered low (McKenna and Simpson, 1987). Notwithstanding, FEC provides a useful measure for pasture contamination.

It is equally possible that egg counts were at least indicative of true worm burdens and there really was no impact of parasitism on distance moved on Day 0. Egg counts on this day were lower than on Day 11, as shown by a poor agreement statistic. It could be that in adult ewes, an egg-shedding threshold exists whereby movement and behaviour changes are observed when the threshold is exceeded. A worm burden above a certain threshold was hypothesized to be needed to observe a depression in feed intake (Kyriazakis et al., 1998). Nonetheless, when the proportion of time allocated to different activities was investigated in relation to FEC, the results were tenuous at best. The time spent grazing and resting showed a trend (significance at < 0.09) with FEC on Day 11 (resembling the effect of FEC on distance moved), but overall, if the ewes were compensating with a change in behavioural activity, those changes were not identified in this study.

Adult ewes in this system may have adapted to natural levels of GIN infection, at least with regard to their walking, grazing and resting activities, as noted in other study systems (Nelson et al., 2015). Ewes possibly remain relatively permissive of low-level infection versus non-permissive (i.e. resistant vs. susceptible) without really suffering significant ill-effects of those infecting parasites. It is known that animals that secreted high anti-parasite IgA did not necessarily suffer ill-effects (Shaw et al., 2012). So, an immune animal that controls worms using mechanisms such as IgA is likely not going to suffer adverse consequences of mounting that immunity to result in trade-offs that are detectable as change in behavioural activities. In other words, ewes may be parasitised but may not be suffering significant ill effects because the ewes are rejecting many worms without significant compromise to their health and the smaller numbers that do establish are more or less tolerated. Therefore, it may point to the fact that once ewes have matured, egg counts may be high or low but there may not be a significant effect of removing worms for those animals at this time of the year, similar to reports about adult ewes during lactation (Leathwick et al., 2020). This thought is further reflected in the relationship found between performance measures and FEC in this study discussed in the next section.

6.5.3 Performance of ewes, faecal egg counts and activity levels

Parasitism as indicated by FEC was independent of all performance measures. Ewes in high body condition shed similar numbers of worm eggs as those in low condition, meaning parasites may not have had a detectable effect on body condition. Egg counts in the high condition ewes trended towards being higher than those in the low condition ewes. This may be demonstrative of 'resilience' on the part of the bigger ewes, although counts were also a poor indicator of daily liveweight gain after 10 days. It is possible that 10 days was not a sufficient time interval to allow this effect to be seen. However, there was a significant association between both the intensity ($VeDBA_{GRAZING}$) and duration (proportion) of grazing activity and liveweight gains. If the target weights for ewes are defined and equated with grazing activity levels or daily duration of grazing, then thresholds can be set for grazing activity that serves as an indicator of how well ewes are performing. Assuming that parasites are implicated in suboptimal grazing activity, and indeed egg counts are misrepresentative of true burdens, then the lack of a relationship between egg counts and performance measures seen in this study is likely not a problem. In a performance based TST system, decisions for individuals requiring treatment are informed by a show of reduced productivity rather than to any available measures of parasitism such as FEC, again assuming that parasites are involved.

Distinct variations in the proportions of time spent in different activities were not seen in ewes with low, moderate or high body condition. This contrast somewhat with the values of the VeDBA where a higher $VeDBA_{RESTING}$, indicative of more movement whilst resting, was observed for ewes classed with a low body condition. The intensity of activity or activity level can be described in terms of the magnitude of the effort used to perform an activity. This presents some difficultly to interpret the finding that ewes rested with greater 'intensity' when they were thin. It is more intuitive to think of intensity or magnitude of effort for an activity in terms of 'active' behaviour, such as walking or grazing, none of which were associated with BCS of ewes. The intensity of resting activity is difficult to explain as it might be expected that these ewes would have a lower $VeDBA_{RESTING}$ especially as the predominant genus present was *Haemonchus* which might have induced a degree of anaemia and hence less activity rather than more. In addition, thin ewes did not show a difference in grazing activity level, which might indicate that they were compensating with resting but grazing sufficiently to meet their lower maintenance requirements as a result of having a smaller body mass. These findings are in accord with those of Leathwick et al. (2020) in not finding any relationship between ill thrift in adult ewes and parasitism during the period from lambing to weaning. This suggests there may be a separation between poor condition in ewes and parasitism (FEC) since parasitism is not predicting performance parameters. Clearly, there are other factors 'at play'.

6.5.4 Further research

Some of the findings in this study were helpful in supporting the value of the respective technologies used to monitor behaviour by highlighting some new findings and corroborating previous ones from the preceding chapters. For example, the observation that ewes were more active at 'rest' when they were thin (low BCS) was unexpected and difficult to explain but deserving of further investigation. Reduced distance moved predicted by egg counts on Day 11 are similar to results found in lambs (Section **5.2**), although egg counts in the study with lambs were more representative of true worm burdens since they were manipulated using anthelmintics, that is to say animals with zero counts had been recently treated and thus would genuinely have no/few worms present. For activity metrics to be successful as a TST-regime in adult ewes, further research using anthelmintics appears warranted to test the hypothesis that anthelmintic administration to ewes with low grazing activity (duration and intensity) results in a greater improvement in grazing than treatment of other ewes. This anthelmintic-based approach, alongside use of nematode monocultures for infection, may provide more consistent results in terms of behavioural response to GIN. The most abundant genus identified from culture on both Day 0 and 11 was *H. contortus* and it remains to be investigated what the behavioural response of ewes would be to a monoculture of non-blood sucking trichostrongylids. In a recent study using tri-axial accelerometers in sheep and goat systems where *H. contortus* was the prevalent worm, Montout et al. (2020) found that animals with lower burdens of *H. contortus* were characterised not by lower activity levels, but by changes in behavioural variability. They suggest such variability is not easily detectable by statistical analysis of activity metrics, such as magnitude or duration of activity as used in the present study. Using a machine learning approach might enhance the detection of changes in individual ewes in the present study in terms of variability in behaviour from day-to-day. Whilst not performed in this study, the data presented can be further explored using similar methods, which is the subject of other ongoing research.

Since parasites (as indicated by FEC) were found to have a negligible influence on performance parameters, there is clearly a need to investigate other factors that predispose to low or high performing ewes. As a next step, the life history of the ewes in the present study can be compared to their current activity, alongside ongoing information collected on their reproductive performance (especially lamb survival in kilos and kilos of lambs weaned). This would allow the investigation of whether activity premating can inform better lamb survival and weaning percentages. Importantly, the individual history data from these ewes in this study can be used to train models that make it more feasible to "obtain perfect recognition of behaviour in a large number of animals in real-life applications." (Martiskainen et al., 2009).

6.6. Conclusion

Faecal egg counts did not relate consistently to the movement and behavioural activities of ewes prior to mating in this study, although moderate to high egg counts at the end of the study were associated with reduced distance travelled. The activity data collected using tri-axial accelerometers in the present study identified that reduced average daily weight gains were associated with animals that grazed less; and that thin ewes (low BCS) had higher levels of resting activity, but none of these factors were predicted by worm egg counts. These results show that neither technology (GPS or accelerometer) has a distinct advantage over the other in terms of determining which animals should be treated with an anthelmintic as both offered some insights into ewe performance. In terms of focusing farmers towards better ewe performance, egg counts are almost certainly not the most useful parameter to focus on for decision making, especially anthelmintic treatment decisions. However, there are benefits to using FEC to assess the level of pasture contamination occurring at that time. There is benefit in collecting activity metrics from a group of ewes with a rich pedigree of information available on their life history traits. Specifically, an opportunity exists to retrospectively, and prospectively, investigate how these activity measures relate to lambing performance and kilos of lambs weaned per ewe, which is the subject of other ongoing research. The variation in the proportion of daily time that ewes spent resting and grazing, although independent of parasitism, using measures of intensity and duration of activity, can be explored further using other machine learning techniques.

CHAPTER 7 – LAMBS SELECTED FOR RESILIENCE OR RESISTANCE TO GASTROINTESTINAL NEMATODES SHOW DIFFERENCES IN DISTANCE TRAVELLED

7.1 Abstract

Genetic selection either for enhanced immunological responsiveness against gastrointestinal (GI) nematodes (resistance) or an ability to mitigate the effects of parasitism (resilience) has been possible for many years using simple parasitological or performance related phenotypic indicators such as FEC, liveweight gain or requirement for chemotherapy. The objective of this study was to compare the movement behaviour of animals bred for either parasite resistance (n=12) or resilience (n=12). The movement behaviour of two lines of mixed-sex Romney lambs was assessed using GPS monitors attached to collars. Lambs were allocated to one of two paddocks (n=12 per paddock). Each paddock group was balanced for sex and genotype. All lambs in one paddock were treated with a long-acting suppressive anthelmintic while the lambs in the other paddock remained naturally infected. There was a treatment effect in untreated animals with greater movement in resilient lambs and a decrease in movement in resistant animals but only at higher live weights ($p = 0.014$). Among treated lambs, resilient and resistant lambs travelled similar distances ($p = 0.814$). The results highlight that not all animals classified as either resilient or resistant demonstrated the same level of these traits and overall, these findings suggest that the behaviour associated with resilience and resistance may be live weight dependent. Equally, this might be indicative of an incomplete or partial expression of the phenotypic traits that characterise or define lambs branded as resistant or resilient.

Key words: Romney lambs; nematode parasites; movement behaviour; remote tracking; genetic selection

7.2 Introduction

Gastrointestinal nematode (GIN) parasitism is a major constraint to animal health and productivity in grazing lambs (Jackson et al., 2009). Control of gastrointestinal nematodes in ruminants occurs mainly by chemical prophylaxis using broad spectrum anthelmintics but overuse of these drugs has led to widescale drug resistance (Vercruysse et al., 2018). Consequently, alternative strategies to controlling infection are required. Exploiting host variation in GIN susceptibility to breed selectively for resistance (Stear and Murray, 1994; Woolaston and Baker, 1996; Eady et al., 1998) is one immunological approach to partially control infection and developing selection indices that are acceptable to livestock breeders. Diagnostic indicators of GIN, such as faecal egg counts (Bishop et al., 1996; Bisset et al., 1996), mucus membrane pallor (Burke and Miller, 2008) and live weight gain (Morris et al., 2010) have been used as phenotypic markers to select resistance (ability to limit GI parasite establishment) and resilience (ability to maintain performance in the face of parasite challenge) to GI nematodes (Bishop, 2012). Still, the question remains how to measure and distinguish the resilience and resistance of animals to GIN (Morgan et al., 2019) because they remain interlinked phenotypes. Selection for resistance has tended to negatively correlate with performance (Morris et al., 2005), leading to the suggestion for inclusion of performance traits in resistance selection programs or alternatively to simply select for resilient animals capable of performing well at times when infection is significant (Bisset et al., 2001). To date, selection for resilient animals is based predominantly on phenotypic markers that relate to performance under challenge such as liveweight (Kenyon et al., 2009) or requirement for anthelmintic treatment (Morris et al., 2010).

Animals suffering from parasitism typically display a reduction in voluntary feed intake, altered grazing behaviour and lethargy (Forbes et al.,, 2000). Animal movement is potentially an important performance indicator of disease and might be a useful selection trait to derive breeding values for resistance or resilience to GIN. The aim of this study was to determine whether movement behaviour would be different in animals bred for parasite resistance or resilience. The objectives were to: 1) use GPS sensors to compare distance travelled between resistant and resilient animals, and 2) To evaluate the effect of anthelmintic treatment on distance moved between these lines.

7.3 Materials and Methods

This study was carried out at the Ashley Dene research farm in Lincoln University, Christchurch New Zealand. All procedures were carried out with approval from, and in accordance with the Lincoln University Animal Ethics Committee (LUAEC #2018-04).

7.3.1 Animals and experimental design

The movement behaviour was assessed between two lines of Romney lambs that had been selected for either resistance (non-anthelmintic exposed, low egg shedding) or resilience (non-anthelmintic exposed, performance maintaining) for gastro-intestinal parasites for more than 30 years. These selection lines were established by AgResearch in 1979 (Bisset et al., 1996; Morris et al., 2000) and were actively selected within line using faecal egg count (FEC) as an indicator trait as well as the ability to maintain performance in the absence of anthelmintic treatment. These lambs were transferred to Lincoln University in 2008, from which point the lines were maintained with replacement ewe and ram lambs randomly selected from within each line each year (Greer et al., 2018). The lambs were born and reared on pasture at Lincoln University's Ashley Dene Research Farm and weaned at mean of 92 days-of-age. Animals had access to *ad libitum* pasture and were grazed together on paddocks containing predominantly ryegrass to allow for natural infection with mixed parasite species.

This study was a 2x2 factorial design involving 24 mixed-sex, GIN resistant (n=12) and resilient (n=12) lambs at a mean of 144 days-of-age, a period where resistant animals are immune but resilient animals are not (Greer et al., 2018). The two factors were selection line i.e., resistant (RT) or resilient (RL), and anthelmintic treatment status, i.e., treated (T) or untreated (U). Lambs were allocated to one of two groups – 1) lambs suppressively treated at weaning with a long-acting anthelmintic (1 ml per 5 kg, MATRIX®, Boehringer Ingelheim Animal Health NZ) to minimise both parasitism and reduce pasture larval accumulation (Treated) or 2) not treated with an anthelmintic treatment (Untreated). Each treatment group was balanced for the sex of the lamb (male = 12, female = 12) and consisted of a 50/50 split of resistant and resilient lambs. Lambs were 52 days post anthelmintic treatment at the start of the 5 day observation period.

7.3.2 GPS Monitor and tracking attributes

All lambs were fitted with a GPS collar for five days. Collars were manufactured by DataCarter (www.datacarter.com). In **Chapter 3**, the accuracy of the units were estimated and found to have a mean error from actual receiver position of 1.4 m with a standard deviation of 0.82 m. The units were scheduled to record location estimates based on three criteria: movement, velocity and time thresholds between positions. Positions were only recorded when movement exceeded the threshold of 5 metres and velocity was less than 10 metres/second. There was also a time threshold of one minute after which a position was recorded irrespective of movement and velocity. Distance between successive locations or step length were processed from raw GPS records for each animal using the R package *moveHMM* (Michelot et al., 2016). Step lengths were subsequently summed over successive 24-hour periods to provide a single value of total distance moved per day. Mean daily distance was then assessed for each sheep by use of the daily total distance values.

7.3.3 Parasitological examination and weights

At the start of the five-day monitoring period, all animals were faecal sampled *per rectum* to determine FEC using the modified McMaster method, where each egg counted represented 50 eggs per gram (eggs/g) of faeces. At the same time, body weights were recorded for each sheep. Faecal larval cultures were unable to be conducted to interpret infective genera.

7.3.4 Statistical analysis

Descriptive statistics were used to summarise the results of distance travelled (km), body weight (kg) and FEC (eggs/g), with the two-sample Student T-Test used to compare these variables against the different anthelmintic treatments and genotype. The Mann-Whitney U Test was used to explore non-normally distributed variables. Records with a high leverage on the data and >3 standard deviations (SD) from the mean were removed. To test the hypothesis of the study, two models were constructed: a multivariate model (M1) was constructed using the *lmer* function in the R package lmerTest (Kuznetsova et al. 2017) to describe the relationship between the mean daily distance travelled (dependent variable) and the fixed effects of anthelmintic treatment and genotype. Mean distance was not normally distributed and therefore was log-transformed to meet model assumptions and the adequacy of the transformation was assessed using the Shapiro–Wilk's test. Sex was included as a covariate and body weight was nested within anthelmintic treatment to account for dependence due to parasite suppression. Anthelmintic treatment and genotype and their interaction were included following a stepwise-selection procedure; variables remaining in the model only when the model AIC (Akaike's Information Criteria) could not be improved by single term additions or deletions. The model was fitted as a linear mixed effect model (LMM) with sheep ID in day as a random effect to account for individual differences in distance moved, as well as individual differences in movement change over time. Post-hoc Pairwise Tukey's HSD comparison test was used to compare predicted values of distance travelled between resilient and resistant in the two treatment groups with the *emmeans* package (Lenth et al. 2018). In addition, $\log_{10}$(FEC+1) was modelled as a predictor of distance travelled instead of anthelmintic treatment to explore the relationship between infection load and movement of animals (M2). All statistical analyses were carried out using R statistical software version 3.4.2 (R Core Team, 2018).

7.4 Results

7.4.1 Descriptive analysis

The mean number of GPS location records per sheep over the study period was 2348 (95% confidence interval (CI) 2257 to 2438). Daily distance was calculated for data collected from 22 lambs; two GPS units malfunctioned, resulting in zero records for location estimates. On average, sheep moved a mean daily distance of 2.22 km (95% CI 2.12 to 2.32 km) during the observation period. In untreated lambs, RL lambs moved a mean daily distance of 2.29 km (95% CI 2.09 to 2.50) compared with 2.05 km in RT lambs (95% CI 1.91 to 2.20), which was a difference of 11% approaching statistical significance at an alpha of 0.05 ($t(43) = 1.94$, 95% CI –0.0089 to 0.4851, $p = 0.058$). In treated lambs, there was no difference ($t(42) = 1.07$, 95% CI –0.0086 to 0.2815, $p = 0.290$) in mean daily distance moved between resilient (M= 2.31 km, 95% CI 2.16 to 2.47) and resistant (M= 2.22 km, 95% CI 2.11 to 2.32).

FEC ranged from minimal to moderate parasitism (range 0 – 500 eggs/g), except for one RL lamb whose FEC was 3300 eggs/g. Based on this FEC record this lamb was removed from the final analysis as its FEC value was >3 *SD* from the mean FEC and had a high leverage on the data. The arithmetic mean faecal egg count and range seen in treated and untreated lambs is shown in Table 7.1.

Table 7.1 Arithmetic mean faecal egg counts (eggs/g) of treated and untreated lambs bred as resilient (RL) or resistant (RT) to gastrointestinal nematodes

Genotype	Treatment history	Mean eggs/g	Range eggs/g
RL (n=5)	Yes	160	0 to 500
RL (n=5)	No	260	100 to 500
RT (n=6)	Yes	50	0 to 300
RT (n=6)	No	67	0 to 300

FEC values were non-normally distributed and could not be normalised using a transformation and were subsequently analysed using the Wilcoxon Rank Sum Test. The test indicated an effect of treatment on FEC levels (W = 1587.5, p = 0.01) with higher levels in untreated (*Median (Mdn)* = 150, Interquartile range (IQR)=300) than in treated (*Mdn* = 0, IQR=200) animals. The FEC level in resistant lambs showed a typical 'low egg shedding' median (*Mdn* = 0, IQR=100), which was significantly lower (W = 1875, p < 0.001) than FEC levels in resilient lambs (*Mdn* = 200, IQR=200).

Lamb live weights ranged from 27.4 – 51.0 kg with a mean live weight ± SEM of lambs that had received an anthelmintic treatment (41 ± 0.91 kg) compared with lambs that were left untreated (31.7 ± 0.51 kg) ($t(77)$ = 8.86, 95% CI 7.18 to 11.34, p < 0.001). Within anthelmintic treatment groups, RL lambs were 3.3% heavier than RT lambs in treated animals ($t(39)$ = 0.90, 95% CI –1.4 to 2.98, p = 0.372) and 2.9% heavier in untreated lambs ($t(40)$ = 0.74, 95% CI –2.34 to 5.06, p = 0.462). The mean live weights of RL and RT lambs in both treatment groups is presented in Table 7.2.

Table 7.2 Mean live weights (kg) and 95% confidence interval of treated and untreated lambs bred as resilient (RL) or resistant (RT) to gastrointestinal nematodes.

Genotype	Treatment history (n = 6 per group)	Mean kg	Lower CL	Upper CL
RL	Yes	40.4	34.4	46.4
RL	No	32.0	27.5	36.5
RT	Yes	40.1	32.1	48.2
RT	No	31.7	28.8	34.7

Note: n = number of lambs; CL = 95% confidence limit

7.4.2 Multivariate analysis

A Shapiro-Wilk test of normality on model one (W = .968, p = 0.715) indicated it satisfied assumptions of normality and homoscedasticity. After stepwise reduction, AIC improved by 20 units to -23.29. There was evidence to support our hypothesis that in the untreated group, selection line had an effect on the movement of lambs which was dependent on their live weight. This effect was not present in treated animals (Table 7.3, Figure 7.1). The model accounted for sheep and day as random effects (intercept and slope).

Table 7.3 Summary of the effects of Romney Lamb genotype (resistant-RT and resilient-RL), anthelmintic treatment (treated-T and untreated-U) and live weight (LW) over five days on the mean daily movement of lambs estimated from linear mixed model.

Effects	**Coefficient**	**SE**	**95% CI**	**t value**	***p***
(Intercept)	0.2113	0.295591	-0.266 to 0.688	0.715	0.4883
Drench status (T)	0.6949	0.454270	-0.058 to 1.447	1.530	0.1520
Genotype (RT)	1.5006	0.559978	0.583 to 2.418	2.680	0.0201
Drench status (U): LW	0.0194	0.009100	0.004 to 0.034	2.131	0.0545
Drench status (T): LW	-0.0019	0.008223	-0.015 to 0.011	0.243	0.8122
T: RT	-1.4464	0.690336	-2.600 to -0.293	2.095	0.0580
U: RT: LW	-0.0509	0.017676	-0.080 to -0.022	2.879	0.0139
T: RT: LW	-0.0023	0.009682	-0.018 to 0.013	0.240	0.8147

SE, standard error. Reference levels are indicated in parentheses.

Sheep ID had as much of the variance in the intercept as day in the slope (0.014, 0.016, respectively), suggesting lambs did not differ from each other more (intercept) than their observed temporal variation (slope) over the duration of five days. Tukey's HSD pairwise comparison of distance means of RT and RL lambs among treated and untreated groups is presented in Table 7.4. Results from model two indicated FEC levels had a positive predictive effect (β = 0.002) on distance moved, R^2 = 0.22, $F_{1,18}$ = 5.1, p = 0.036, 95% CI (2.0e-05, 0.0006).

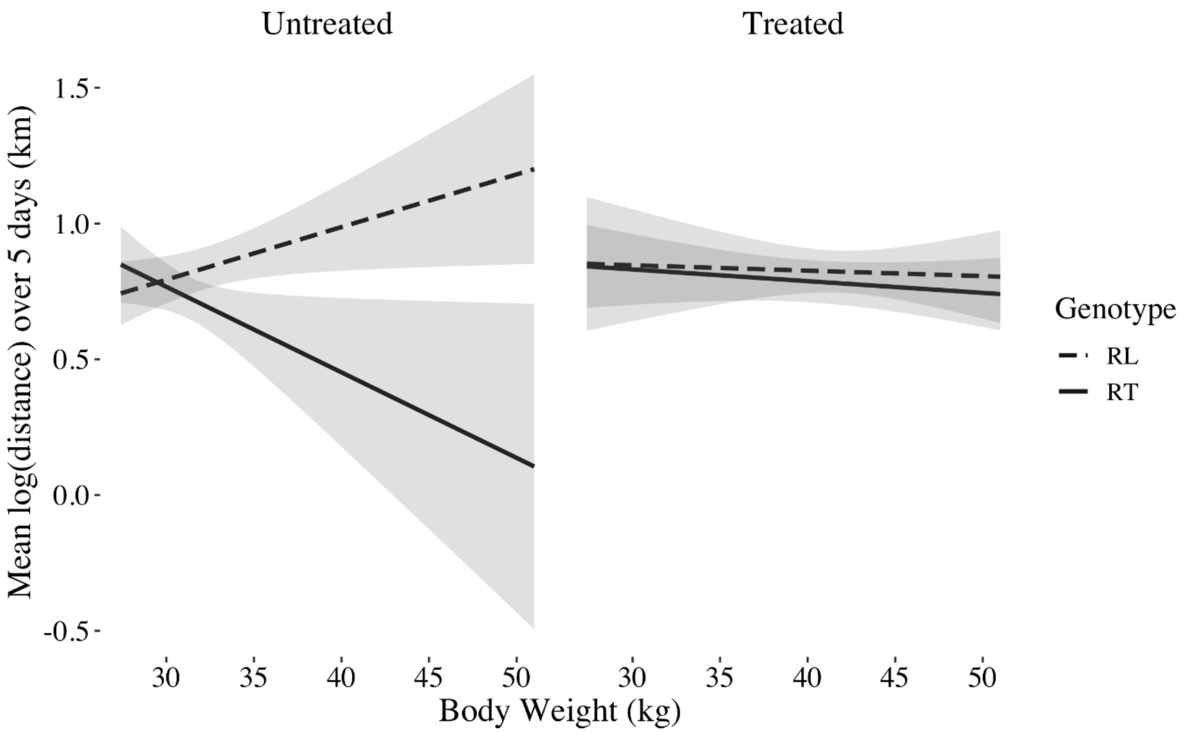

Figure 7.1 Effect of anthelmintic treatment on the mean daily movement (95% confidence interval) of resilient (RL) and resistant (RT) Romney lambs dependent on live weight.

Table 7.4 Post-hoc Tukey's-HSD pairwise comparison of distance moved (km) between resilient (RL) and resistant (RT) lambs in treated (T) and untreated (U) lamb groups.

Contrast	**Estimate**	**SE**	**df**	**t ratio**	***p***
RL(U) – RT(U)	0.35	0.11	12	3.176	0.035
RL(U) – RL(T)	0.08	0.09	12	0.962	0.775
RL(U) – RT(T)	0.11	0.08	12	1.499	0.468
RT(U) – RL(T)	-0.27	0.11	12	-2.371	0.136
RT(U) – RT(T)	-0.24	0.11	12	-2.265	0.161
RL(T) – RT(T)	0.03	0.08	12	0.382	0.980

SE, standard error; df, degree of freedom

7.5 Discussion

The objective of the current study was to use GPS sensors to determine the daily distance moved by GIN resilient and resistant lines of sheep and to investigate the effect of anthelmintic treatment on their movement. In the absence of parasitism (T) there was essentially no difference between the two selection lines, but when parasites were present (U) the lines became divergent, but only at higher liveweights. The heavier RT animals being more skeletally mature and hence perhaps also more mature physiologically (Greer et al., 2018), began to show the trade-off of expressing immunity to parasites, their activity declining as immune processes exacted a cost on animal performance possibly reflecting inflammatory processes inside and outside the gut occurring in tandem with immune effector mechanisms directed at the parasites. The RL lambs at higher body weights were still affected by parasites, but showed increased activity as an effective compensatory mechanism. These results indicate that these selection lines default to moving differently in response to their parasite challenge. When the challenge is lowered, in this case using anthelmintic treatment, the difference in movement is negligible.

This study coincided with what was anticipated to be a period where resistant animals were immune to GIN, but resilient animals were not (Greer and Hamie, 2016). As such, the timing would be appropriate for studying the effects on movement from the varying immune response to GIN among these selection lines, which is reportedly temporal (Hamie et al., 2019). The timing of measurement is important in distinguishing between resistant and resilient animals as, should immunity develop, animals may thereafter display a mixture of both resistance and resilience (Morgan et al., 2019). For instance, resilient animals at this age have been reported to thrive in comparison to their resistant counterparts while sometimes carrying a greater parasite burden (Morris et al., 1997). This is important in interpreting the interaction effect of genotype by live weight, as the same reason could be inferred as to why heavier, untreated resilient lambs moved more ('thriving'), when similar sized untreated resistant lambs reduced movement. The model predicted that an animal weighing > 32 kg or more when it was untreated would move more if it was resilient, and less if it was selected for resistance. It is not clear from the data why lighter weight animals did not show a significant difference in their daily travel distance (Figure 7.1). Resistant lambs may have had a trade-off between the energetic cost of moving and the cost(s) associated with mounting an immune response to GIN. Conversely, delayed GIN recognition in resilient lambs at this age (Greer et al., 2018) may have resulted in this trade-off being less in favour of walking, presumably to better meet their nutrient requirements. This may effectively be analogous to studies that found that corticosteroid-induced immune suppression ameliorated feed intake and performance in sheep infected with *T. circumcincta* (Greer et al., 2008) and *T. colubriformis* (Greer et al., 2009). It lends further support to the hypothesis that the host's immune response is the underlying cause of altered host physiology, which consequently results in altered behaviours in parasitised animals.

There is a case to be made that bigger animals are likely to take larger steps and therefore move greater distance. It is probable that this difference in live weight was the reason that resilient, treated lambs (approx. 3% heavier in this study) moved 4% more than resistant treated lambs, although this difference was not statistically significant. The live weight difference between selection lines among untreated animals was 3%, yet the difference in distance moved was at least three times as much and this difference is likely attributable to a response to parasites on the part of untreated resistant lambs. Nesting live weight in treatment, therefore, seemed an appropriate approach to examine the behavioural response as it compared similar sized lambs from both selection lines that had received a similar treatment (exposed or not exposed to anthelmintics). The movement pattern for resilient untreated lambs appeared consistent with the definition of this group of lambs where liveweight was maintained in the presence of high FEC (Greer et al., 2018).

The relationship between FEC and movement trended towards an increase in distance travelled with increasing FEC levels. Resilient animals demonstrated to be heavier than resistant lambs and moved further than resistant animals whilst harbouring greater FEC. Consequently, this positive relationship between these variables was largely expected. Even though the predictive ability of the model was limited by a low R^2 of 0.22, it provided for consolidation of the information provided from modelling distance moved among selection lines as a function of receiving anthelmintic treatment ; resilient lambs showed an ability to mitigate the effects of parasitism. Falzon et al. (2013) found a similar trend in stud ewes that were faecal sampled randomly and whereby the mean distance per step measured with GPS technology increased as FEC increased. In addition, information on live weight of the stud ewes or their genotypic predisposition to GIN was not provided therefore making direct comparisons to the present study difficult. Nonetheless, it can be assumed the stud ewes were older and further along in their immunity and further investigation on the repeatability of this phenomenon appears worthy.

It is difficult to offer a biological explanation for the interactions between live weights and distance moved in untreated RT and RL lines. For the resilient animals, it is possible to speculate that, some of the lower body weight lambs were not showing evidence of the same level of resilience. Indeed, it may be that the lighter resilient animals are in fact not true resilient animals as they are not phenotypically behaving as resilient animals. However, for the resistant animals that explanation does not necessarily follow. The egg counts for resistant animals were low (range 0 to 300 eggs/g), with most being zero-egg counts but how they are 'demonstrating' resistance might vary between the animals, in terms of their impact on protein metabolism for example. It can be argued that across the body weight spectrum they are using different mechanisms to resist parasites, some which might be associated more with greater trade-offs. Overall, since these animals are only on the spectrum, especially the resistant ones as they all still had some parasites, a possible biological explanation to these phenomena is that these animals are not all using the same mechanisms to achieve the same level of either resilience or resistance. This is one reason why the selection for optimal host phenotypes can be challenging (Morgan et al., 2019). It remains to be determined what influence on movement activity would be seen in older animals (further advanced in their immune response against GIN) between the selection lines.

7.6 Conclusion

Attaching GPS collars to sub-clinically infected Romney lambs selected as either resilient or resistant to GIN allowed the demonstration of movement patterns that were dependent on combination of their genotype, infection status and body weight. The study demonstrated that movement between resilient and resistant animals was similar when they had received anthelmintics but different in untreated lambs. Resilient infected lambs will increase travel distance while lambs selected for resistance will reduce distance travelled. However, some lambs demonstrated a mixture of both resilience and resistance, suggesting the behavioural changes associated with resilience and resistance may only be apparent at greater live weights. Overall, if heritability and repeatability values can be established for behavioural changes in response to these phenotypic traits, the possibility exists to develop the use of remote sensing technology for selectively breeding for either resilience or resistance to GIN infection.

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CHAPTER 8 – GENERAL DISCUSSION

8.1 Introduction and summary of key findings

In order to farm sheep optimally, pragmatic and adoptable advice on sustainable helminth control practices needs to be provided to farmers and advisors to reduce the emergence and spread of anthelmintic resistance. This chapter will expand on this requirement, highlighting the important findings the preceding chapters in this thesis contribute towards achieving that goal and considering them in context of the research gaps that still need to be addressed. The overall aim of the research in this thesis was to make progress on developing technology to assist with applying TST approaches. The studies in this thesis used remote sensors to investigate the behavioural responses of sheep to gastrointestinal nematodes acquired naturally from pasture. Experiments were designed to capture this response during a period of active growth (**Chapter 2**, **Chapter 5** and **Chapter 7**), and in adult sheep (**Chapter 6**). By design, the investigations set out to detect subtle differences in sheep behaviour. Less attention was paid to the gross changes in behaviour that might be seen with clinical disease since the intended goal was to be able to detect subtle changes associated with subclinical parasitism to allow interventions to be made. The challenge was to detect differences in animals that would not be observable by even skilled farmers in any other way, and to do so before they become more severe.

To this end, the main findings from the experiments in this thesis are as follows:

1. Tri-axial accelerometers and GPS collars can be used to detect subtle changes in the behavioural activity and movement of parasitised sheep, in the absence of clinical signs of parasitism.
2. GIN can at times reduce sheep activity and movement. For example, reduced overall activity was observed in infected young Romney x Suffolk sheep (**Chapter 2**); reduced weekly distance travelled in Perendale lambs from three months to one year of age in the weeks following a short-acting anthelmintic (**Chapter 5.2**), reduced proportion of time spent grazing and walking (**Chapter 5.3**); and reduced distance travelled in untreated "resistant" lambs at approximately five months of age (**Chapter 7)** compared to their untreated "resilient" counterparts.
3. In contrast, there were also instances where GIN parasitism was associated with increased host movement, as seen in untreated "resilient" lambs (**Chapter 7**), or

instances where no apparent or consistent impact of GIN on hosts was found (mixed-age adult ewes – **Chapter 6**).

4. Collectively, the relationships in these studies suggest that the effect of GIN infections on host movement and activities is influenced by host age, host genotype, host liveweight, the type of activity being observed and the behaviour parameters used in impact assessments.

As a whole, the investigations described in this thesis demonstrate the potential utility of animal movement and behaviour as a marker of parasitism, however further work is required before it can be applied in a TST setting to effectively control nematode-induced production impacts (Charlier et al., 2014). In the following section, the broad implications of these findings will be discussed in the context of the overall research design, the research limitations, and the links between results across chapters. The differences in the behavioural response of parasitised sheep as a function of age (lambs versus ewes), host factors (resilience versus resistance to GINs) and the behavioural parameters sensitive to this response are also included. Finally, further research required to extend this work by optimising animal behaviour monitoring for sustainable GIN management will be discussed.

8.2 Utility and limitation of the experimental designs used in this research

It is generally recognised that the adverse impact of GIN on their hosts represents a continuum from effectively no impact at the lightest levels of infection, through causing sub-clinical effects with moderate burdens, and clinical disease eventually occurring at higher levels of infection (Sutherland and Scott, 2010, Pomroy, 2017). The work carried out in this thesis sought to determine if it was possible to detect differences in sheep behaviour and activity during periods when sub-clinical effects of GIN parasitism would occur and thus be small in magnitude. For the technologies used in this thesis to prove beneficial they would have to be able to detect such small differences – there being little utility in detecting more significant alterations since these are either already more obvious to an observer or arise too late, the damage already having been done. In this regard, all the experiments conducted in this thesis were designed to preclude clinical disease arising in the study animals. For such animals, the findings in this thesis have demonstrated the potential value in remote monitoring of sheep as a diagnostic marker to detect the generally subtle behaviour changes associated with changing GIN status. Such monitoring could therefore be used as the basis for deciding whether animals need to be treated with anthelmintic on the basis of individual need, and such decisions could be taken early, i.e. before animals have failed to grow adequately or started to manifest more overt signs of clinical illness such as weight loss. Importantly, this would prevent the treatment of animals in a flock that did not require treatment but which would often be treated along with others which were showing evidence of GIN parasitism. Investigations contained in this thesis also examined the impact of host factors such as genotype ("resistant" versus "resilient") and may potentially also be used for selective breeding for either resilience or resistance to infection. Consequently, this further increases the value of remote monitoring when these tools can be used to select such animals without the need for more complicated (and often expensive) selection processes.

It should be noted that for all the grazing studies in this thesis no attempt was made to measure pasture quality and intake due to logistical considerations, financial and time constraints. It is entirely possible that in different circumstances animals would move and behave differently and future studies should incorporate those parameters (see Section **8.9** below). It is possible that these may have affected grazing behaviour and to establish cut-offs, such work will be required to be undertaken and defined. Not having information on these parameters was likely to have made more difficult the task of ascribing activity changes with parasitism and its effects. Further, in **Chapter 5**, the offset of three weeks between groups may have masked some of the effects of parasitism on movement, behavioural activity and growth performance of the groups. The offset of treatment resulted in environmental conditions differing when each group was at a particular 'week post treatment'. This suggests that models predicting movement and behaviour to inform helminth management decisions need to be robust to dynamic environmental and climatic factors which were not considered in this thesis.

8.3 Infecting parasite species and animal hosts

The studies in this thesis build on previous attempts to use remote sensing technologies to monitor activity of sheep infected with GIN (Babayani, 2016, Montout et al., 2020). In particular, this thesis presents evidence for change in behavioural activity of sheep infected largely with non-hematophagous strongylid nematodes in three sheep model systems (i.e. in lambs/ young sheep; sheep selected for resistance or resilience to GIN; and adult sheep). To date, other attempts to remotely monitor activity of sheep have been mainly with animals infected where *H. contortus* was the dominant parasite. Using GPS collars and tri-axial accelerometer sensors remotely, the series of studies in this thesis have successfully tested aspects of previous knowledge in the understanding of how GIN impact the performance of infected individuals, and shed new insight on the movement and behavioural costs exacted by GIN on their hosts. Based on the work of Montout et al. (2020) using *Haemonchus contortus* as the predominant parasite, detection of changes in behaviour and not activity level were associated with parasitism. There is, however, a high likelihood that some of the findings of reduced activity in the current thesis are able to be translated into usable tools for the overall objective of making individual treatment decisions. A potential limitation with regard to the parasites in the present study, however, was not identifying specific parasites' effects on movement and behaviour. The study conditions in the current studies were representative of typical livestock farming in New Zealand in which nematode infections are almost always a mixture of species (Waller, 2006).

8.4 Differences between the behavioural response of lambs and ewes to GIN parasitism

In the studies of lambs (**Chapters 2, 5** and **7**) administering anthelmintics allowed worm burdens to be directly manipulated and arguably presented a better test of the impact of parasitism than constructing groups based on faecal nematode egg count as was the case with the ewes in **Chapter 6**. Among those ewes, the distance travelled per day was less than seen among lambs and showed less daily variation, but in general, animal movement was more sensitive to GIN parasitism (as judged by faecal egg counts) in lambs than in ewes. With the reliance on egg counts as a measure of parasitism in ewes, it is possible that the effects of parasitism were masked, but without worm counts or some other means of assessing burdens or their impacts, there was no means of accurately knowing. The relationship between faecal egg counts and total worm burdens in mature Romney sheep is not as close as in lambs with the correlation coefficient estimated at 0.23 for older sheep (McKenna, 1981). Hence relying on FEC to estimate the worm burden in these older sheep was not very reliable. If ewe worm burdens had also been manipulated with anthelmintics, a different outcome might have become apparent. A follow-up experiment from the ewe study would be to drench half the mob (i.e., half in low-egg count ewes and half in high-egg count ewes) and follow them to observe their movement and behavioural response. From an animal performance standpoint, the ewe study showed that there is little value in simply selecting the high-egg count ewes and selectively treating only those. The weak relationship of faecal egg counts on mature ewe movement and activity highlights the difficulty of detecting deviations from 'normal' behaviour in mature individuals in a flock and then linking those changes to level of parasite infection.

8.5 Performance of the technologies used for monitoring parasitism

The remote sensing technologies used to conduct investigations in this thesis were GPS collars and triaxial accelerometers either alone or concurrently. Both technologies allowed the detection of a parasitism-related response such as grazing activity and in movement. In addition to being suitable to monitor the behavioural activities of individuals, the two technologies were also complimentary to each other. For example, walking activity estimated from tri-axial accelerometers was positively correlated with distance travelled measured from GPS collars when used for both lambs/yearlings and adult ewes. Although, sheep activity was classified using machine learning with video observations as a gold standard, having composite measures derived from two independent systems (GPS and accelerometers) giving similar results provided confidence in the overall validity of the methods. It can be argued, however, that data from the GPS collars do not provide any additional information than is already provided by the accelerometers. Currently, and within the context of the research questions in this study, it appears that accelerometers are more adaptable to on-animal use than GPS technology. However, there are other contexts in which GPS technology may provide additional information, for example, predicting landscape use and establishing the probability of an animal visiting a given patch within a landscape to select resources etc. (Swain et al., 2007), for which accelerometers will be inadequate.

The validation of the GPS and triaxial accelerometer tools (**Chapters 3** and **4**) was invaluable to inform data collection and analysis in order to achieve the outputs and expectations of this thesis. Having access to all the raw data from the remote sensors was most useful to these validations. There are commercially available tri-axial accelerometers that provide information on different behaviours of livestock including lying, standing and walking. An option would have been to utilise one of these existing units and validate them to test the manufacturers claims. For example, the accuracy of two commercial sensors CowScout® (GEA Farm Technologies) and the IceTag® (IceRobotics Ltd.) mounted on dairy cows have recently been measured (Hӧgberg et al., 2020), with the potential to be used for livestock management through behaviour monitoring . However, there are advantages and disadvantages of this approach. It is easier and potentially time saving to use commercial sensors that will produce summary statistics such as the frequency of detected behavioural events or lengths of behavioural periods. There is the potential for a loss of detail associated with not having access to the raw data when attempting to understand and optimise the performance of the sensor. This was a challenge described by Babayani (2016) when attempting to monitor activity levels of sheep and goats in relation to *H. contortus* infection. For the present thesis, there was a need to develop algorithms for an accelerometer brand that was available commercially but for which behavioural classification in animals had not been conducted. However, a benefit of this approach is having access to the raw data, which lends itself to a wide array of robust analysis, such as that used by Burgunder et al. (2018) and Montout et al. (2020). In the present thesis, the algorithm developed from the neck collar position identified three activity types from accelerometry data. The algorithm further estimated similar activity budgets from accelerometers mounted at two other placement positions: a head halter and body harness (**Chapter 4**). This output can be used for other animal behaviour-related investigations.

8.6 Activity parameters sensitive to GIN parasitism

Several activity parameters were calculated from data collected during the experiments in this thesis and the impact of GIN infection in sheep on these parameters were assessed. The use of vectorial dynamic body acceleration (VeDBA) as a simple proxy for overall activity in the preliminary study (**Chapter 2**) provided the initial results upon which further studies in this thesis were conducted. VeDBA was generally simple to compute without tedious data management or processing for analysis. In so doing, a simple methodology not previously used in parasitology studies as the main proxy for sub-clinical parasitism was explored, providing a useful initial assessment of the effect of parasitism in young sheep. Given the findings from **Chapter 2**, the development of more complex machine learning algorithms to predict behaviour of sheep on pasture was undertaken, similar to other studies (Alvarenga et al., 2016, Barwick et al., 2018b). This allowed the host activity time budgets to be calculated, with comparison of the proportion of time spent on each activity between different parasite treatments (**Chapter 5** and **6**). Activity budgets were also found to be sensitive to parasitism and the most likely parameter that could be translated into a field application. In a series of studies investigating the effects of parasitism in grazing cattle, the total time spent grazing was found to be sensitive to parasitism (Forbes, 2008). In the present thesis, once activity (i.e. 'grazing', 'resting' or 'walking') could be inferred from accelerometer data, it was then possible to 'allocate' VeDBA signals associated with these individual activity ($VeDBA_{ACTIVITY}$), which also provided a measure of the magnitude of the effort exerted on specific activity. As a result, both the activity budget (proportion of time spent on an activity) and $VeDBA_{ACTIVITY}$ (magnitude of the effort exerted on activity) could be used to assess the impact of GIN on the host. In some cases, only one of these parameters was sensitive to parasitism in the same individuals. This can be seen in **Chapter 5.3**, whereby activity levels of lambs for 'grazing' and 'resting' (i.e., $VeDBA_{GRAZING}$ and $VeDBA_{RESTING}$) were statistically non-significantly affected by GIN, whereas the activity budgets of these activities in the same lambs were significantly affected. In other instances, there was agreement between different activity parameters. For example, $VeDBA_{WALKING}$ and 'distance travelled' (calculated from GPS data; Section **5.2**), were positively correlated and sensitive to parasitism (**Chapter 5**). Combined, these results provide a measure of confidence in the validity of behavioural parameters used for assessing the effect of subclinical parasitism in sheep.

To further develop remote monitoring tools to enable decisions that allow control of GIN sustainably, consideration needs to be given to the application of the tools in real-life farming environments. This is important because no one-size-fits-all strategy applies to all farming environments, as they affect the variation in the immune status of the animals, pasture contamination and the availability of infective larvae on pasture, and the build-up of the infection in animals. The remainder of this discussion will advance a roadmap for deploying changes in sheep behaviour farm-side as a marker of parasitism that could lead to optimal performance through targeted control of GIN infection.

8.7 Towards developing a system for behaviour based TST in practice

In this section, discussion will focus on how the output of this thesis can be advanced for use in on-farm applications. It is unlikely that the sensors used for the studies in this thesis would be suitable for deployment on a commercial scale farming enterprise. This is mainly due to the time investment required to regularly muster animals, take collars off, download and process data before analysing the information to make management decisions. Another challenge for a technology-driven TST is the cost associated with the technology. Costs are usually associated with acquiring ear tags and setting up a 'controller' platform. For example, a 'smart' activity monitoring ear tag developed for cows cost from $72 per tag and the cost of setting up a platform cost $2,750, with a three-year battery warranty on the tags. In the future, prices are likely to be lower as technology advances and demand for remote monitoring increases. One question to answer, though, is whether every lamb/ewe in a flock would need to wear one sensor or whether they could be applied to a few sheep in the flock to act as 'sentinels'. For a

TST, it might be difficult to decide which sheep to monitor as in order to make a behaviour monitoring TST approach work, every animal in the flock would have to be monitored.

The size of units to mount on animals is another factor to consider. It is likely that ear tags will be the easiest way to apply this technology to sheep. There is currently an ear tag on the market for monitoring cows which weighs 25g and measures 68 x 38 x 15 mm (H x W x D, respectively). It is foreseeable that behaviour monitoring ear tags can be further reduced in size to accommodate use in growing lambs. For this to occur for sheep in New Zealand, legislative support mandating the use of electronic identification tags would be helpful as is currently required for cattle and deer (Morris and Archer, 2007), assuming the fine details of incorporating the technology into the tags can be overcome.

Successful deployment of technology farm-side also depends on the logistics of downloading the data over a user-friendly interface. An ideal scenario would be to collect sensor data at the same time as other husbandry events such as weighing. Further research is required to determine the frequency that farmers would need to handle their stock download data. One option would be to design a dashboard that analyses the metrics of all animals at 'appropriate' time points and then compares those to their previous metrics, both individually and then to the mean of the flock. It is possible that data could be downloaded using Bluetooth technology as animals move through a restricted space, e.g., from one paddock to another. Similarly, there are challenges associated with the analysis and interpretation of the data. The studies conducted in this thesis generally compared one group with another whereas in a field situation such activity measurements would need to be assessed without the benefit of a comparison control group. Hence assessing level of movement regardless of the paddock size, feed availability etc. would need to be achieved. One way to utilize sensor data will be to determine a percentage change from daily movement and activity levels averages. This would require identifying the outliers and also comparing an individual's own metrics to itself. For this to be successful, there would need to be a way of developing a baseline for each animal when healthy in order to detect a deviation from baseline. It does not appear that a monitoring system exclusive for detecting GIN parasitism will be deployed. It is more likely that monitoring for parasitism would be included in a more comprehensive health surveillance system involving other health issues, such as lameness or flystrike. A system whereby users can track data collected through a handheld smartphone app or a web-based dashboard and stay updated through reports on animals showing signs of ill health will be most welcome. A simple GIN-health index can be developed and used to help make the system easy to use. This will no doubt need to be integrated with information on the season of the year, weather forecasts, farm management practices, and results of 'occasional' faecal worm egg counts. Future research can now focus on defining and refining the fine details for such a health index. Following this, the app or dashboard can create a list of "sheep needing attention" alongside a system that will automatically draft aside sheep that might be experiencing ill effects of parasitism.

8.8 Data management and analysis

The experiments in the current thesis produced a large dataset on the movement and behaviour of sheep. Whilst several guidelines and best practice guides exist for managing and exploring big data (Zuur et al., 2010, Cooper and Hsing, 2017), it still requires a substantial time investment to process and generate useable data that will allow inferences to be made. The robust computing power of open source programs such as R make this task considerably easier, however, the most appropriate methodology for analysis of some of the data collected and processed was not easily executed. For example, the time-activity budget data in **Chapter 5 and Chapter 6** needs to be revisited using the Dirichlet modelling approach (Douma and Weedon, 2019), although an attempt was made in **Chapter 5**. The limitation of proportional data is that statistical analyses are not straightforward, since proportions can only take values from zero to one and their variance is usually not constant across the range of the predictor (Douma and Weedon, 2019). Transformations to overcome these problems are, by necessity, often applied but can lead to biased estimates and difficulties in interpretation. In **Chapter 4**, the Dirichlet modelling approach was used with a smaller dataset but its implementation for repeated measures data, where random effects need to be accounted for to reduce autocorrelation, is still in its infancy. Methods to address this deficit in software such as R are underway and in the future, implementation of such methods should become simpler.

8.9 Directions for future research

The work contained in this thesis has been proof-of-concept that measuring the movement and/or activity of sheep could be used as a marker of parasitism and provide the basis of anthelmintic treatment for individual sheep as a TST approach. For this to happen in practice, cut-offs and thresholds of activity need to be investigated and defined and the system evaluated in terms of cost-benefit in terms of lambs growth compared to traditional approaches. It is in adult ewes that a TST could be most crucial in reducing anthelmintic use by targeting the variability of individuals in response to GIN to make treatment decisions. However, the results from this thesis did not indicate parasites were a big challenge in the adult ewes studied, with few relationships with movement and activity observed; further study is warranted as enumerated in **Chapter 6**. Secondly, these tools can be further developed for use as selection tools in a breeding program to select individuals that will be bred to improve resilience to GIN. An important prerequisite in terms of using remote monitoring of behaviour as a selection tool is whether it provides additional advantage of easier-to-measure traits such as live weight that integrates over longer periods. Whereas the test periods with sensors in this thesis were of relatively short duration, it leaves open the question if this relates well to longer term behaviours, and clearly they need to be further developed. Notwithstanding, the findings in all the studies conducted in this thesis were indicative of individual animal differences in activity, as seen in the considerable variability in model predictions and estimates. This variability can be attributed to a number of factors, including the influences of overall health, acquired resistance, management and genetic history. This variability benefits both the identification of individuals that might benefit from anthelmintic treatment (in a TST setting), as well as in selecting resilient individuals who may need treatment to a much lesser extent; but the variability needs to be taken into account if these tools will be used. TSTs may not be applicable in all settings due to the investment that is required, hence the need for an economic cost-benefit analysis to precede on-farm application.

To use behaviour as an index for control of GIN, studies will also need to be conducted that have 'clean' pastures and infection with a known parasite burden. This will allow better health and welfare assessments resulting from GIN to be determined. There will also need to be a reference GIN indicator system other than worm egg counts, e.g., using body weight gain with *Teladorsagia* and *Trichostrongylus* dominant infections. Similar work has been conducted in South Africa attempting to develop a behaviour based TST with reference to the FAMACHA system using conjunctival membrane mucus colour as an index for control of haemonchosis (Montout et al., 2020).

Many factors affect grazing behaviour which makes the interpretation of behavioural changes challenging (Rutter et al., 2007b). The study of mature ewes in **Chapter 6** is evidence of this, with variation in grazing behaviour not found associated with parasitism as indicated by FEC. Given that the growth rates and body condition of ewes monitored premating were not associated with parasitism, it may be that parameters other than these performance metrics need to be considered, such as lambing success and eventually weaning success. In addition, the influence of parasitism on the movement and behavioural activity of ewes during the periparturient period may also need to be investigated. Although the reason for variation in ewe activity was not identified, it may be possible to identify a signal that a ewe requires attention if an animal's activity significantly deviates from an established norm. For example grazing behaviour may also be useful for the efficient surveillance of health of the animals on farm.

In a TST setting, activity data can be combined with other performance metrics such as expected live weight gain to make decisions concerning treatments. At present the use of live weight gain is the only feasible tool that can be used to make TST decisions but the present studies (**Chapter 2** and **5**) demonstrated these may not be as sensitive as measuring behavioural changes.

Pastures biomass and quality and other sward characteristics were not analysed or investigated in this series of studies. At shorter sward heights animals have to work harder to get all the grass they need (Allden and Whittaker, 1970), so an impact of parasitism could be expected to be greater when grass is short. Even when the grass swards are tall, there is the added risk that grazing closer to the sward base exposes host to more dense area of infective larvae population (Hutchings et al., 2002). These pasture-related factors were not considered in relation to the response of animals in this thesis. The measurement of sward dynamics in replicate-type experimental designs may have provided additional evidence of the impact of sward type, height and quality on movement and behavioural activities associated with parasitism. Future studies would benefit from establishing the relationship between pasture characteristics, including main species, biomass (kg DM/ha), quality (metabolizable energy, crude protein, Neutral Detergent Fibre) and how remote sensors measure an animal's grazing time and feed intake. This is of pivotal importance given that pasture biomass, variation and quality are strong indicators of time spent grazing and may have been useful in explaining some of the variation in grazing activity shown in **Chapter 5** and **Chapter 6**.

In **Chapter 2**, ram-lambs were used in the trial, and mixed-sex animals were used in **Chapter 6**. Further investigation is warranted to determine the influence of the sex of individuals on movement and behavioural attributes measured with remote sensing technologies in relation to parasitism. In **Chapter 6,** the sex of the lambs was a significant predictor of distance travelled in both resilient and resistant lambs, with male animals showing greater movement activity.

There is a future possibility of using accelerometers to test the hypothesis that parasitised young sheep select diets higher in protein and energy content compared to non-parasitised sheep. The accelerometer offers a two-way proximity feature that counts the number of times any one receiver monitor comes in contact with a primary monitor. In **Chapter 2**, visual observations of animals offered barley and hay to supplement low pasture availability was limited to the point of offering, not for 24 hours. Although accurate that at the point and time of offering only one or two animals showed interests in these supplements, although it is possible that others may have participated in their consumption outside of that point of observation. A 'primary' monitor could be placed at the location of the supplementary feeder while scheduling the 'receiver' monitors on the sheep to count interactions with the feeder. Currently the supplement consumption is unknown. If the untreated animals consumed more supplement, then it could explain the role targeted nutritional supplementation might have in offsetting parasite induced anorexia and maintaining live weight, while those animals were less active than their treated counterparts. Overall, future studies can explore this theme, using sensor technology to further elucidate the previously investigated approaches used by ruminants to self-medicate (Fishpool et al., 2012).

What remains of major interest is to apply this technology in a real-life farming context. This needs to be weighed up against the economics of investing in technology with the accuracy of measurements. In addition, the ability of the technology to achieve the intended outcome of maintaining an appropriate proportion of drug susceptible parasites while optimising production from animals needs to be examined. The studies in this thesis did not consistently identify an effect of infection on growth when movement and activity changes were seen. Hence, future studies need to assess the risk-benefit of advising treatment based on movement and activity changes. The complexity of optimizing GIN management with respect to these factors suggests that a decision support systems (DSS) to aid veterinarians, advisers and farmers needs to be developed (Morgan et al., 2013). To achieve this, the tools need to be adapted to meet to the criteria of design and functionality. These two processes are not necessarily mutually exclusive but for purposes of distinction, design refers to how tailored a tool is for ease of use by the end user while functionality refers to its primary use. Functionality also includes qualities of being able to deployed on-farm in a cost-effective manner. Tools will have to be adaptable and flexible because no two farming situations present exactly the same conditions. Investigating this last point in different farming environments will be invaluable for adoption of a technology driven diagnostic tool for GIN. This will no doubt require input from parasitologists and product architects. Parasitologists, veterinarians and advisors that interact with farmers understand the motivation and behaviour shift that is required to uptake or reject of a new technology. Such information is imperative for designers to deliver a useable product. All these factors are inextricably linked and need to be considered in designing future studies that use these tools toward the collective outcome of sustainable managing GIN in sheep. Overall, studies in this thesis succeeded in detecting changes in behaviour and activity in GIN infected sheep but there is still considerable further work to be undertaken to show that these observed behavioural changes are repeatable, robust to different grazing systems and different management systems, different sheep breeds, different pasture types and host ages.

8.10 Conclusion

The work undertaken in this thesis has used technology tools to address themes integral to successfully sustainably controlling GIN in sheep, spanning newly weaned lambs up to one year of age, investigating animals selected for either resilience or resistance to GIN, and in adult ewes. These studies demonstrated the potential for the development of movement and behavioural activity both as a diagnostic tool, and as an innovative tool that can be adapted for breeding programs. These tools can be deployed on-farm and integrated with other farm practices, in order to provide responsible, efficient and effective use of anthelmintics. This study highlights the current multi-disciplinary state of science, incorporating movement and behavioural ecology with data science and veterinary medicine.

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Appendices

Appendix 1. Statements of Contribution for each research paper presented in this thesis

Appendix 1-1 Statement of contribution Chapter 2

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Seer Jonathan Ikurior
Name/title of Primary Supervisor:	Professor William Earnest Pomroy
In which chapter is the manuscript /published work: Chapter 2	

Please select one of the following three options:

(●) The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

Ikurior, S.J., Pomroy, W.E., Scott, I., Corner-Thomas, R., Marquetoux, N., Leu, S.T., 2020. Gastrointestinal nematode infection affects overall activity in young sheep monitored with tri-axial accelerometers. Veterinary Parasitology 283, 109188.

( ) The manuscript is currently under review for publication – please indicate:

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Candidate's Signature:	SJIkurior.
Date:	12/03/21
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Appendix 1-2 Statement of contribution Chapter 3

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Appendix 1-3 Statement of contribution Chapter 4

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Appendix 1-4 Statement of contribution Chapter 5

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Appendix 1-5 Statement of contribution Chapter 6

STATEMENT OF CONTRIBUTION
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- The name of the journal:
- The percentage of the manuscript/published work that was contributed by the candidate:
- Describe the contribution that the candidate has made to the manuscript/published work:

◉ It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Candidate's Signature:	SIkurior
Date:	12/03/21
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Date:	12/03/21

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Appendix 1-6 Statement of contribution Chapter 7

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

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Name/title of Primary Supervisor:	Professor William Earnest Pomroy
In which chapter is the manuscript /published work: Chapter 7	

Please select one of the following three options:

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- The name of the journal:
- The percentage of the manuscript/published work that was contributed by the candidate:
- Describe the contribution that the candidate has made to the manuscript/published work:

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Candidate's Signature:	
Date:	12/03/21
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Appendix 2. Supplementary material for Chapter 2

Appendix 2-1 Standard Operating Procedure for counting the number of strongylid eggs per gram

Principle

The counting system relies on 2g faeces displacing 2ml fluid, which together with 28ml NaCI totals 30ml. The volume under each set of gridlines is 0.15ml (1cm x 1cm x 0.15cm) for a total of 0.3ml for a slide. This represents an aliquot of 0.01 of the original implying a multiplication factor of 100 X. As there were 2g of faeces each egg counted represents 50eggs/g.

Materials and Equipment

1. Workbook to record results
2. Scales to weigh faecal material (accuracy ± 0.1g)
3. Small sieve (tea strainer)
4. Small round bowl approx. 100ml capacity
5. Teaspoon
6. Pasteur pipette and rubber bulb
7. Saturated NaCl solution
8. Universal bottle (28ml capacity)
9. McMaster Egg counting slide
10. Microscope
11. Slide tray
12. Disposable rubber gloves
13. Paper towels
14. Hydrometer
15. Beaker for salt solution
16. Household salt
17. Mechanical mixer in salt container

Definitions

FEC = Faecal Egg Count; eggs/g = Eggs per gram; NaCI = Sodium chloride (table salt);

s.g. = Specific gravity

Procedure

a) To make a saturated salt solution add salt to the blue plastic container until quarter full and then fill to near the top with hot water. Turn mixer on full. Test with a hydrometer the solution reads 1.2.s.g. More salt may be added as necessary.
b) Place the required number of sets of utensils on the bench (sets consist of a bowl, sieve and spoon).
c) Place the bowl, sieve and spoon on the scales and press tare then weigh out 2 grams of faeces.
d) Fill a universal bottle with saturated salt solution and pour it into the sieve. Work the faeces through the sieve using the teaspoon. Ensure the sieve is in the liquid whilst stirring. Discard the strainer and rinse any lumps off the spoon.
e) Place the required number of McMaster slides onto a slide tray.
f) Mix the contents of the bowl thoroughly with the teaspoon using a to-and-fro motion and at the same time remove a sample with a pipette. For diagnostic purposes the pipette can be rinsed with water between samples and reused.
g) Place the pipette at the opening of a chamber on the McMaster slide and quickly fill the chamber. Expel the remaining contents of the pipette back into the bowl.
h) Allow the slide to sit for 1-2 minutes to allow the eggs to float to the surface. This will not be necessary when doing 5-10 samples at one time.
i) Using the 10 X objective with 10 X eyepieces or 4 X objective with 15 X eyepieces, focus on the gridlines and air bubbles so that the eggs to be counted are on the same viewing level (never use the 40x objective).
j) Start at one corner of each counting grid and count eggs proceeding up and down the sections of the grid of both chambers. Count all eggs touching the top and left lines of each section but not the bottom or right hand lines. Multiply the total number of eggs by 50 to give the number of eggs per gram of faeces. This should be entered in the workbook.
k) Thoroughly clean all utensils under running water to remove all traces of faeces and replace in storage. Discard faecal samples in the bin for hazardous waste disposal.
l) If the sample weighs less than 2.0g record the weight in the workbook and use the formula: Eggs x 100 + weight to work out the eggs/g.

Appendix 2-2 Standard Operating Procedure Strongylid Larval Culture and Identification

Background – This SOP is the original document written by SM Calder and W.E. Pomroy 25.11.98. The SOP details the procedure for preparing larval cultures and identifying infective larvae from cattle, goat, sheep, horses and deer faeces.

Materials and Equipment

A) **Larval culture**

1. fine grade vermiculite
2. scoop
3. mortar and pestle or spatula
4. deionised water
5. glass jars and lids or plastic trays with glass lids
6. 27°C incubator
7. rubber gloves
8. marker pen, label or masking tape, for identification

B) **Baermann's apparatus**

1. Either 25 cm diameter glass funnels with rubber tubing and clamps attached or plastic bowls (15 cm diameter, 10 cm high with sloping slides)
2. kitchen sieve approximately 22 cm diameter with an aperture of 2 mm
3. clamp
4. stand for glass funnel
5. culture bottles
6. 10°C incubator
7. suction pump
8. measuring cylinder (1L or 2L)
9. Facial tissue or paper handkerchief.

C) **Identifying Larvae**

1. Slides
2. Coverslips
3. aqueous or Lugol's iodine

4. pipettes
5. bulb
6. multi-counter
7. eyepiece with micrometer

Procedure

a) Cleanliness is of utmost importance. Extreme awareness of not contaminating (introducing any foreign nematodes to the culture ie change gloves with each new sample).
b) Vermiculite container: Do not use scoop with dirty hands or gloves. Always remove gloves when needing more vermiculite in sample being cultured.
c) For a bulk culture, all the faecal material is mixed with Vermiculite and water with a spatula or gloved hands depending on which is more convenient, until a consistency is achieved whereby squeezing the culture results in excess moisture being expressed. If the faeces are pelletised they can be left to soak in deionised water until they are soft enough to breakup.
d) For diagnostic cultures a representative sample of faeces is taken from each animal in each group and mixed together (the groups being kept separate).
e) The culture is either placed loosely in glass jars until they are about half full, with the lid loosely applied, or placed in trays to a depth of about 4cm with a glass lid placed on top. The jars or trays must clearly show the date the egg counts were performed, the date the cultures were put up if different from the previous and identification of the sample.
f) The cultures are placed in a 25-27°C incubator for 10 days. Deionised water should be added if the cultures start to dry out. They should be kept moist not wet.
g) After 10 days the culture can be transferred to a Baermann's apparatus. A glass funnel is placed in a stand and a clamp is placed on the rubber tubing. A kitchen sieve is then lined with a single layer of facial tissue and then the faecal culture is added to a maximum depth of 3cm. More deionised water is then added to cover the faeces. Alternatively the sieve can be placed in a plastic bowl with deionised water instead of the glass funnel.
h) The culture is left in the Baermann's funnel for at least 6 hours, preferably overnight. The bottom 100-200ml is tapped off by opening the clamp and allowing the fluid to be collected in a measuring cylinder or beaker. If a bowl has been

used the contents are gently siphoned off from the top of the solution until 2-3cm of fluid is left in the bowl. The sieve may be removed once the level of the solution is below the bottom of the sieve. If the sieve is removed before siphoning the bowl must be left to stand for an hour before siphoning as the sediment will have been disturbed.

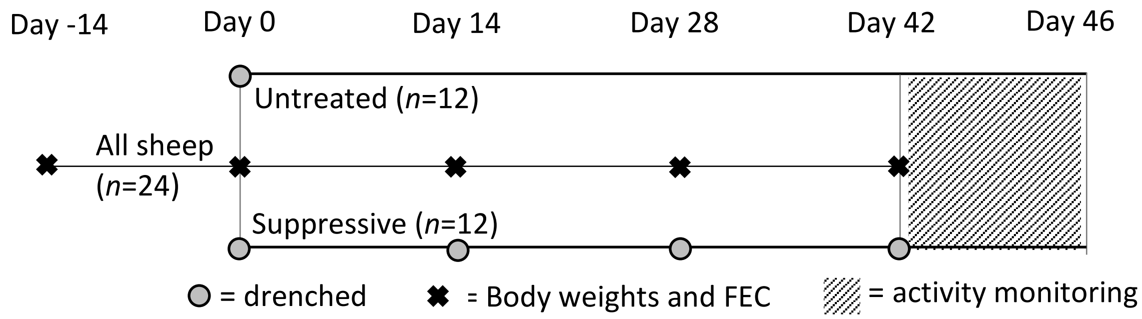
i) The solution is then transferred to a 1-2L measuring cylinder, filled up with deionised water and then left to sediment for 2 hours. The supernatant is then carefully removed from the top of the solution with a suction pump until 100-200ml remains. If the fluid is still dirty it should be re-sedimented until the supernatant is clear. This is most important for the storage of bulk cultures but not essential for diagnostic cultures.

j) Cultures are stored in plastic tissue culture bottles, on their side at a depth of approximately 1 cm in a 10°C incubator. The bottles are clearly labelled with the date and identification.

k) To identify the larvae they are concentrated by standing the culture bottle upright for half an hour. A subsample is removed from the bottom with a pipette and placed on a glass slide with a small drop of Lugol's or aqueous iodine to kill the larvae. Alternatively the slide can be flamed for approximately 3 seconds as this relaxes the larvae and causes them to straighten which aids measuring them. A coverslip is placed on top.

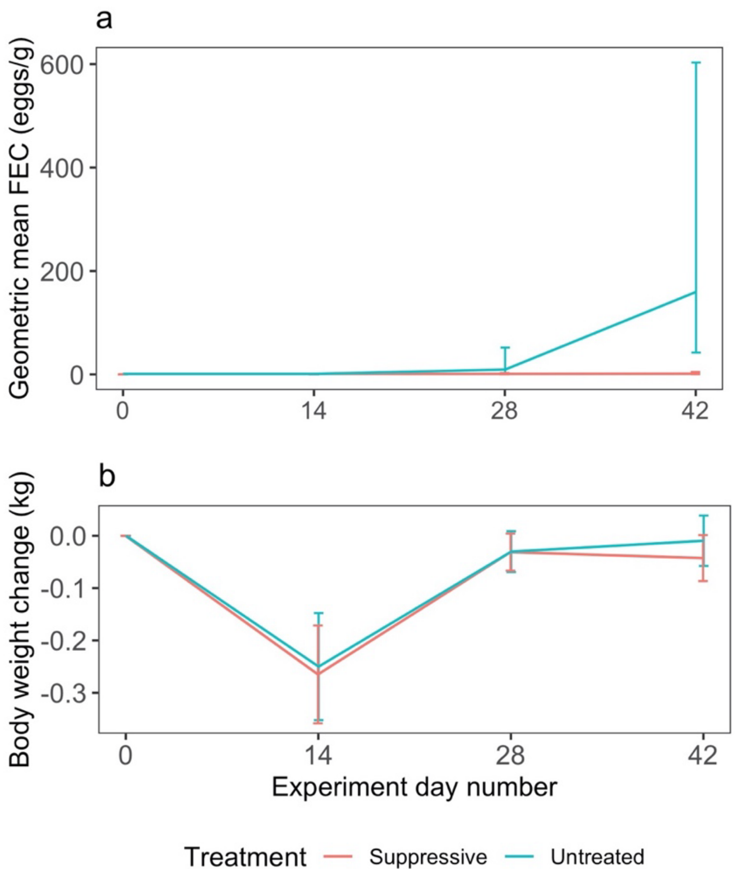
l) The slide is placed under the microscope and examined systematically. A total of 100 larvae are identified if present. The results are recorded in the workbook. Identification is made by reference to a standard text[2].

Appendix 2-3 Timeline of measurement events for overall activity monitoring of ram-lambs in two treatment groups



[2] Manual of Veterinary Parasitological Laboratory Techniques reference book 418. Pages 37 & 38.

Appendix 2-4 The change in (a) geometric mean faecal egg counts (eggs/g) and (b) body weight (kg) for suppressive treated and untreated groups of ram-lambs (error bars indicate 95% confidence intervals).



Appendix 2-5 Significance and magnitude of *treatment* and *initial weight* interaction effect on overall activity

Bodner (2017) demonstrates how unstandardized conditional effects (i.e., group mean differences that vary linearly across a range of continuous covariate) can be expressed in standardized effect size metrics, using the following equation:

$$\hat{\delta}_{Y\,|\,M_i} = \frac{(\hat{\beta}_1 + \hat{\beta}_3 M_i)}{\sqrt{MSR}}$$

where the conditional effect $\hat{\beta}_1 + \hat{\beta}_3 M_i$ equals the model-implied difference in means on Y between the two groups at the specified value of M; *MSR* is the Mean Square Residual from the regression model's ANOVA summary table which is the pooled residual variance in Y across groups and is an unbiased estimator of σ .The process starts by deriving standardized conditional effects for overall activity for 1 *SD* below and above the mean initial body weight. Descriptively, at one standard deviation above the initial weight mean, the overall activity reduced more on average in the untreated animals than in the Suppressively treated animals (i.e., $\hat{\beta}_1 + \hat{\beta}_3 M_i = 32.590 - 0.736 \times 50.12 = -4.298$); at one SD below the initial weight mean, this effect was smaller and opposite in direction (i.e., $\hat{\beta}_1 + \hat{\beta}_3 M_i = 32.590 - 0.736 \times 43.7 = 0.427$). The practical magnitude of these two conditional effects and the difference in these two conditional effects, however, is not clear.

When applying the standardized mean difference metric in the above equation, these standardized mean differences range from

$$\hat{\delta}_{Y\,|\,M_i} = -\frac{4.298}{\sqrt{1.704}} = -3.293$$

to

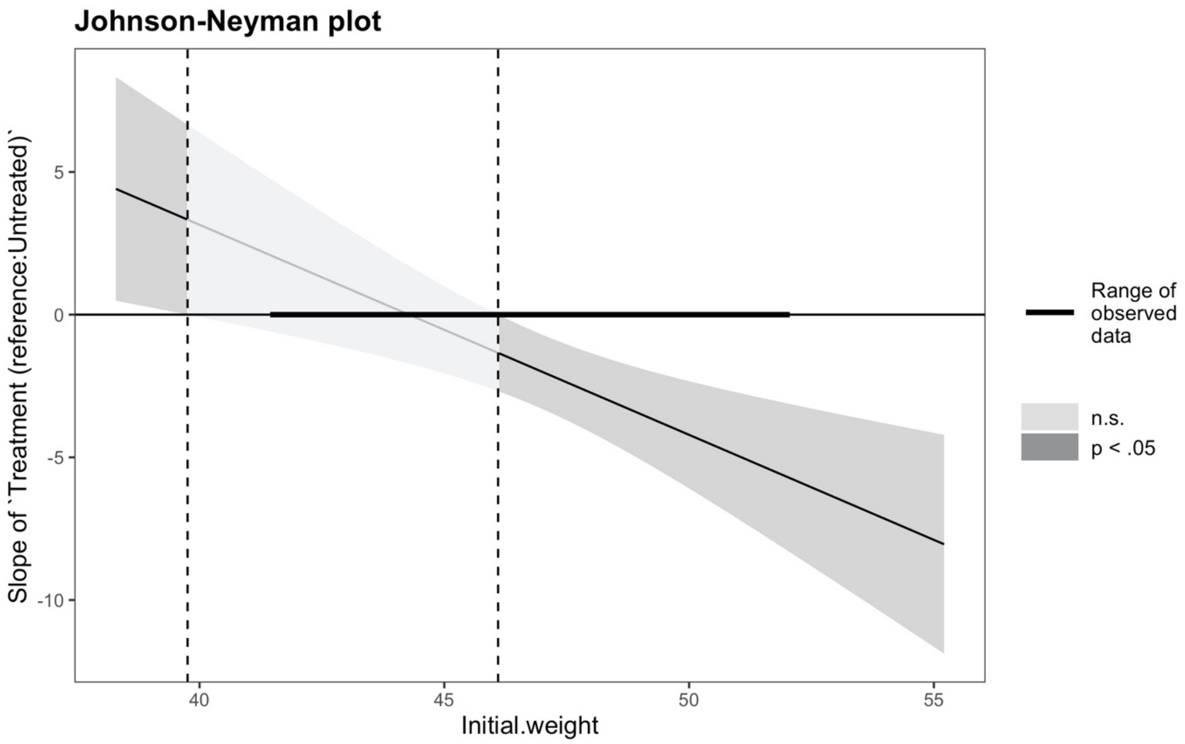
$$\hat{\delta}_{Y\,|\,M_i} = \frac{0.427}{\sqrt{1.704}} = 0.327$$

, respectively and individually would be considered negative and "large" to positive and "small", respectively, using conventional guidelines. Although guidelines do not exist for the comparison of standardized mean differences across a range of interacting covariate values, Bodner (2017)[3] proposed that $\Delta\delta_{Y|M_i} = 0.4, 1.0$, and 1.6 could be considered "small," "medium," and "large" differences, respectively, for a two standard deviation difference in the moderator variable (e.g., from 1 *SD* below to 1 *SD* above the initial body weight mean). Using these proposed guidelines, the difference in standardized mean difference values above (i.e., -3.29 – 0.33 = -3.62) for a 2 *SD* difference in initial body weight would be considered "large" in magnitude.

Appendix 2-6 The conditional effect of treatment on overall activity as a function of initial body weight based on output from the Johnson-Neyman (J-N) post-hoc analysis;

[3] Bodner, T.E. 2017. Standardized Effect Sizes for Moderated Conditional Fixed Effects with Continuous Moderator Variables. Frontiers in psychology, 8, 562-562.

the slope of the conditional effects line equals the interaction parameter value for Model 2 in Table 2.2 of Chapter 2[4].



When Initial body weight (kg) is outside the dotted lines interval [39.8, 46.1 kg], the slope of Treatment is $p < 0.05$. Note: The range of observed values of Initial body weight is [41.5, 52 kg].

For observed data, the J-N analysis indicates that not receiving anthelmintic treatment had a significantly negative effect on overall activity for lambs with initial weights above 46.1 kg.

Appendix 2-7 Data table of overall activity (VeDBA), faecal egg counts (collected on Day 42) and initial body weight used for analysis in Chapter 2.

Sheep ID	Treatment	VeDBA	Initial weight	FEC
1992	Zolvix	1294145.2	51.5	0

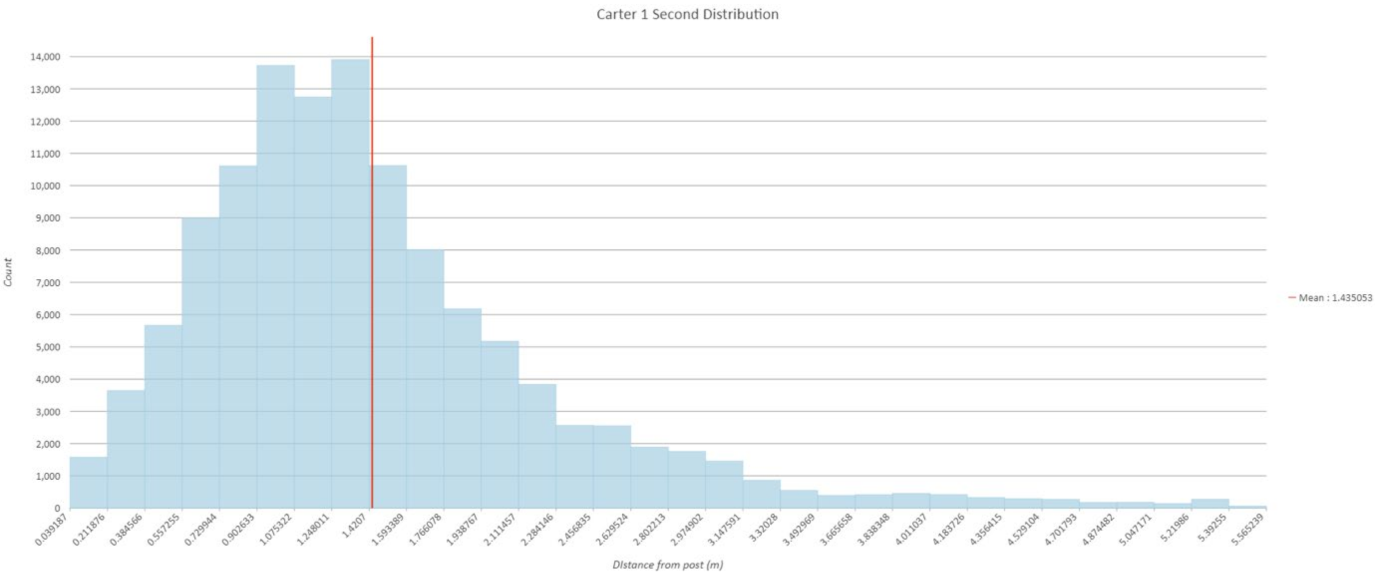
[4] Gastrointestinal nematode infection affects overall activity in young sheep monitored with tri-axial accelerometers

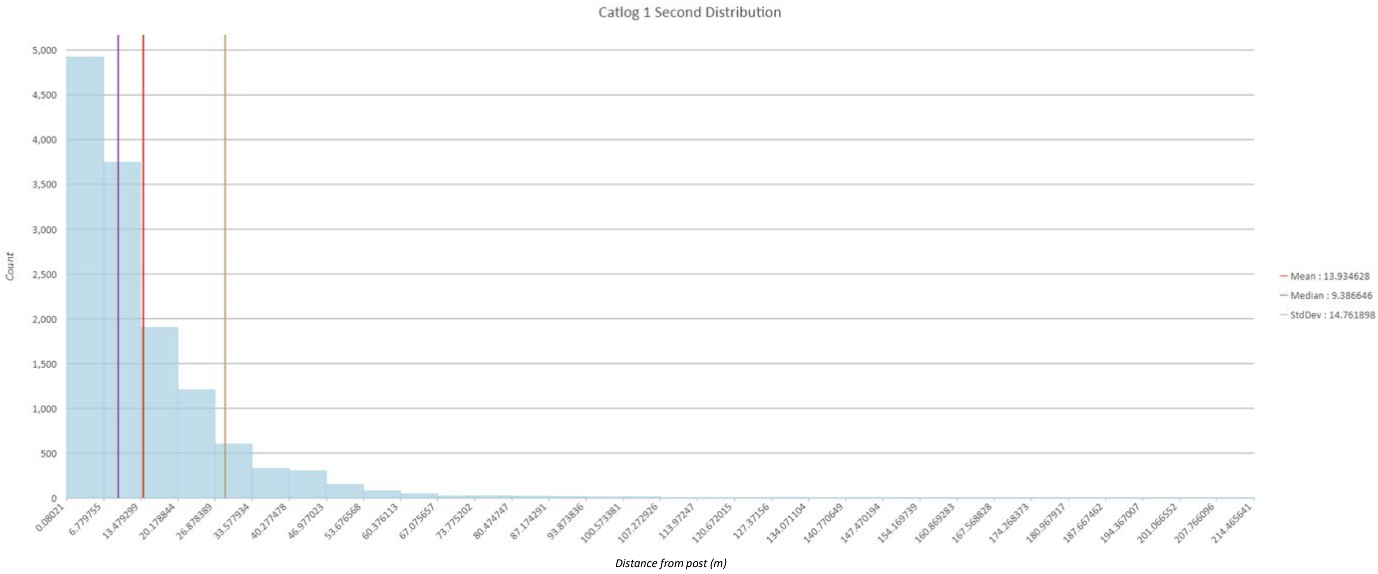
1993	Zolvix	1199827.01	51	0
2407	Zolvix	1007546.03	42.5	0
2437	Zolvix	1136434.98	43	0
2439	Zolvix	1077300.08	46	0
2443	Zolvix	1229182.2	47	0
2445	Zolvix	1099172.62	48.5	0
2460	Zolvix	1107515.58	42	0
1939	Zolvix	1349038.63	46	0
2481	Zolvix	1161987.13	45	0
1986	Control	894317.73	50	0
2409	Control	1472472.23	41.5	1150
2425	Control	838422.13	45	950
2441	Control	985307.63	50.5	200
2446	Control	963333.94	48.5	550
2485	Control	641662.28	47	850
2486	Control	1044411.84	48	750
2491	Control	894398.6	48	250
2494	Control	1070273.35	46	0
2495	Control	1284170.23	43	550

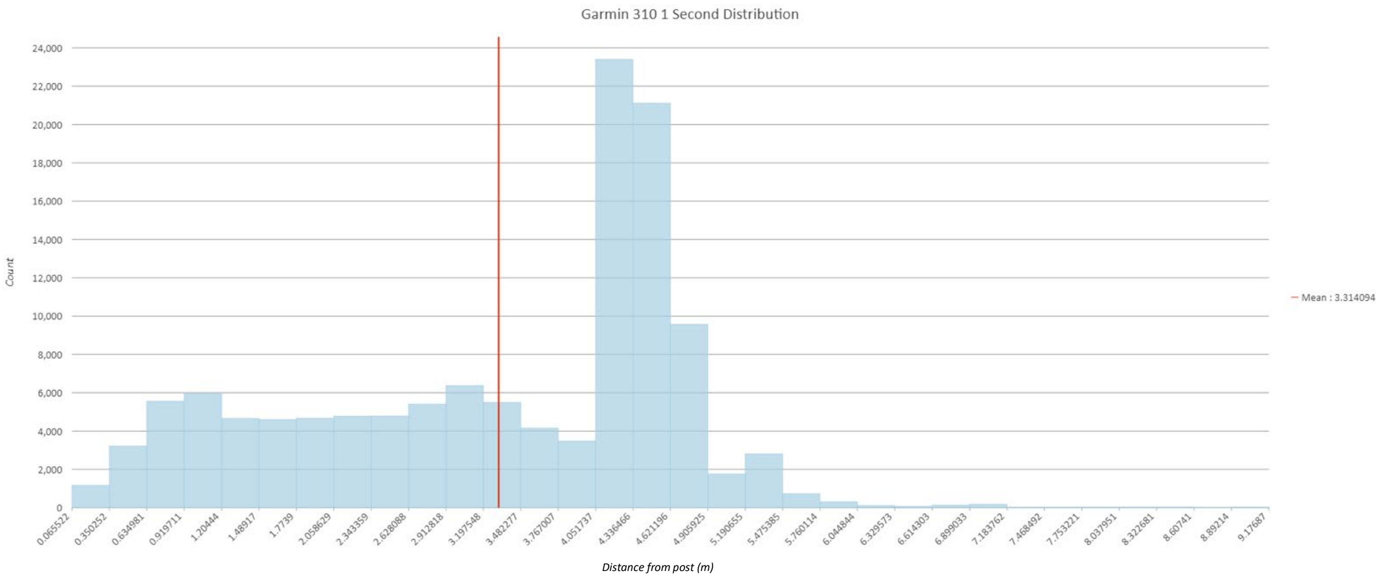
Appendix 3. Supplementary material for Chapter 3

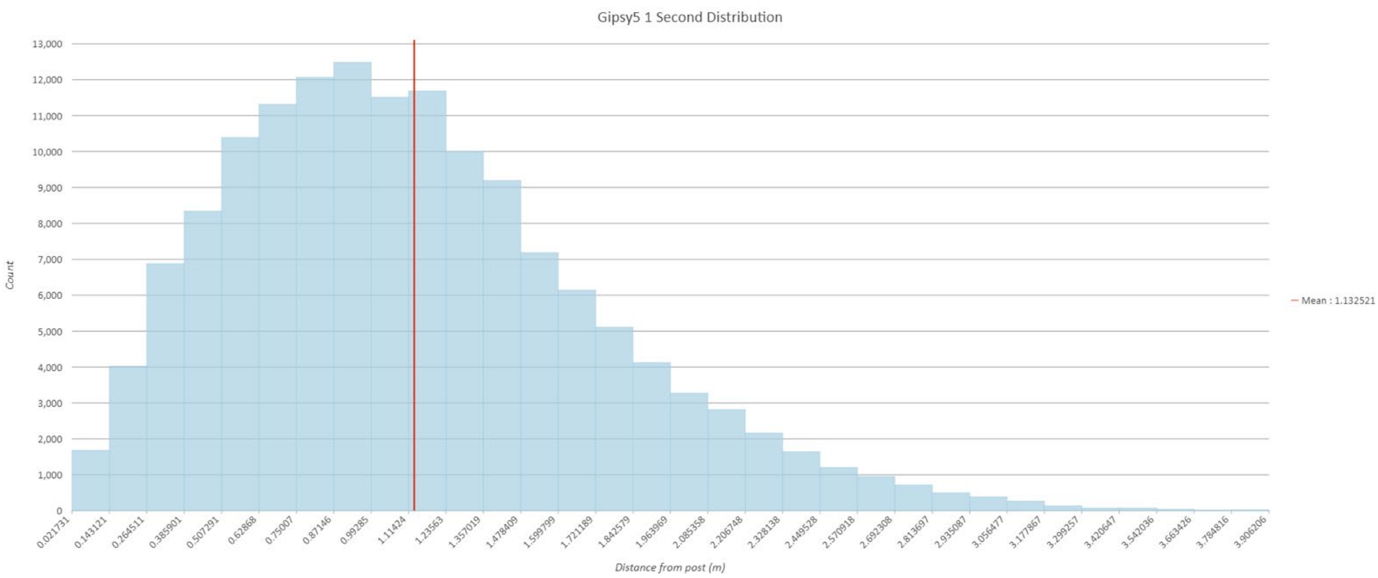
Appendix 3-1 RTK measuring actual location points

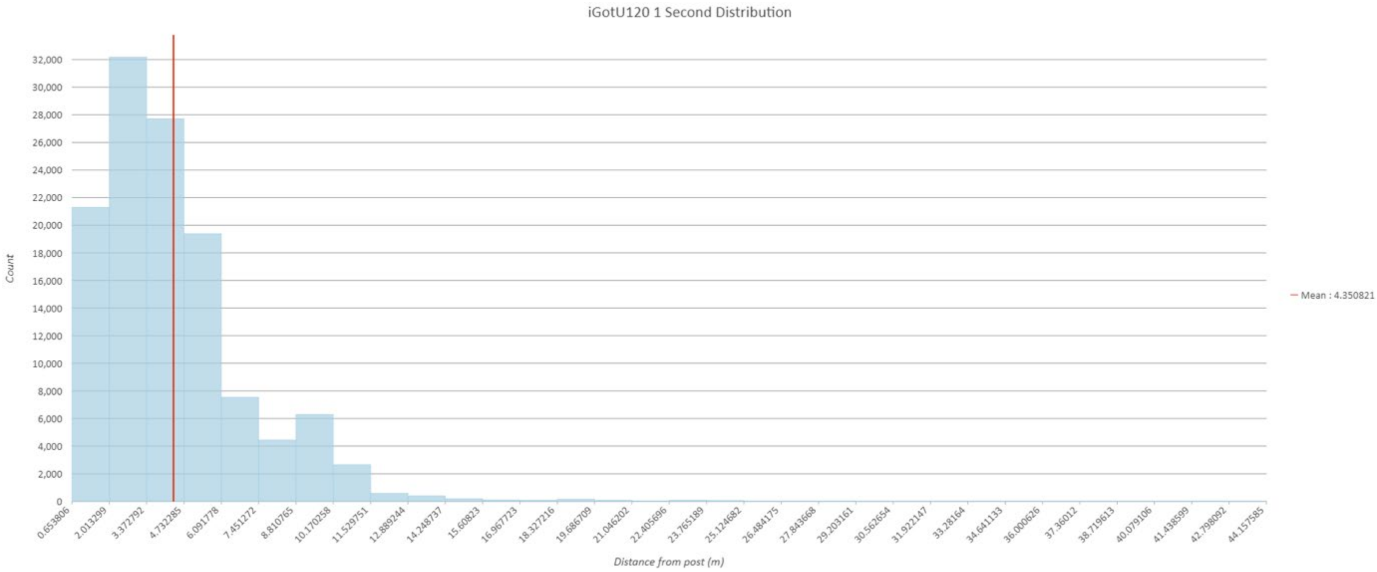
Appendix 3-2 Distribution of location estimates from six GPS receivers recording at one second epoch in static accuracy test

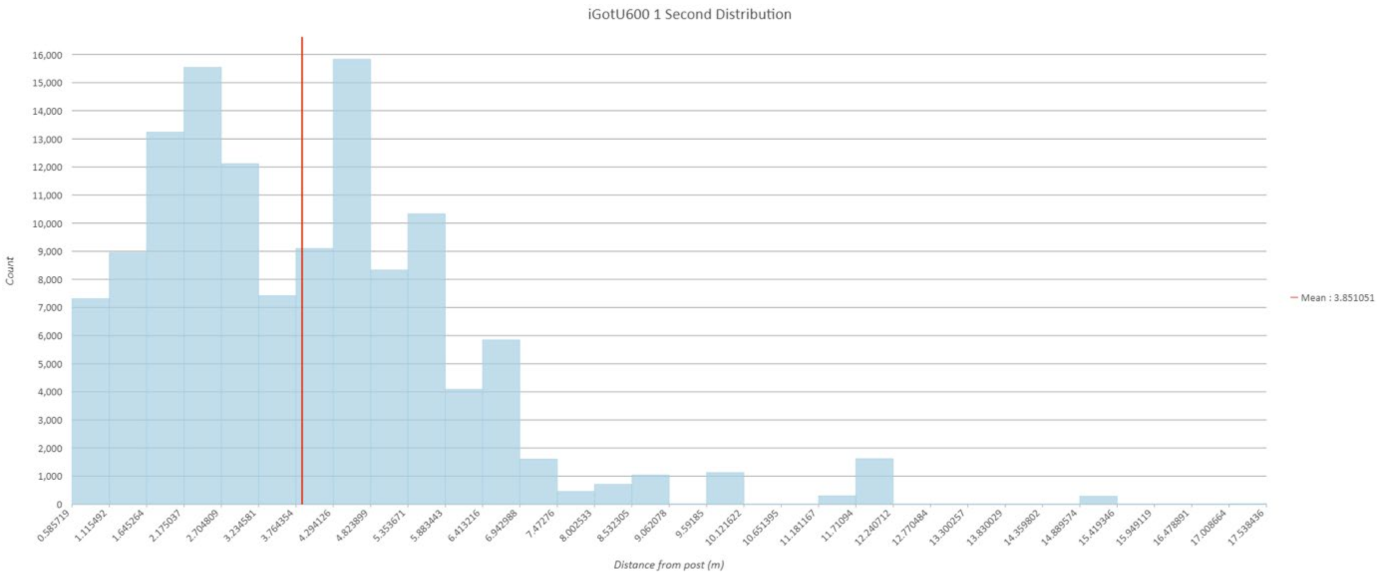



Catlog 1 Second Distribution
Count
Distance from post (m)
Mean : 13.934628
Median : 9.386646
StdDev : 14.761898

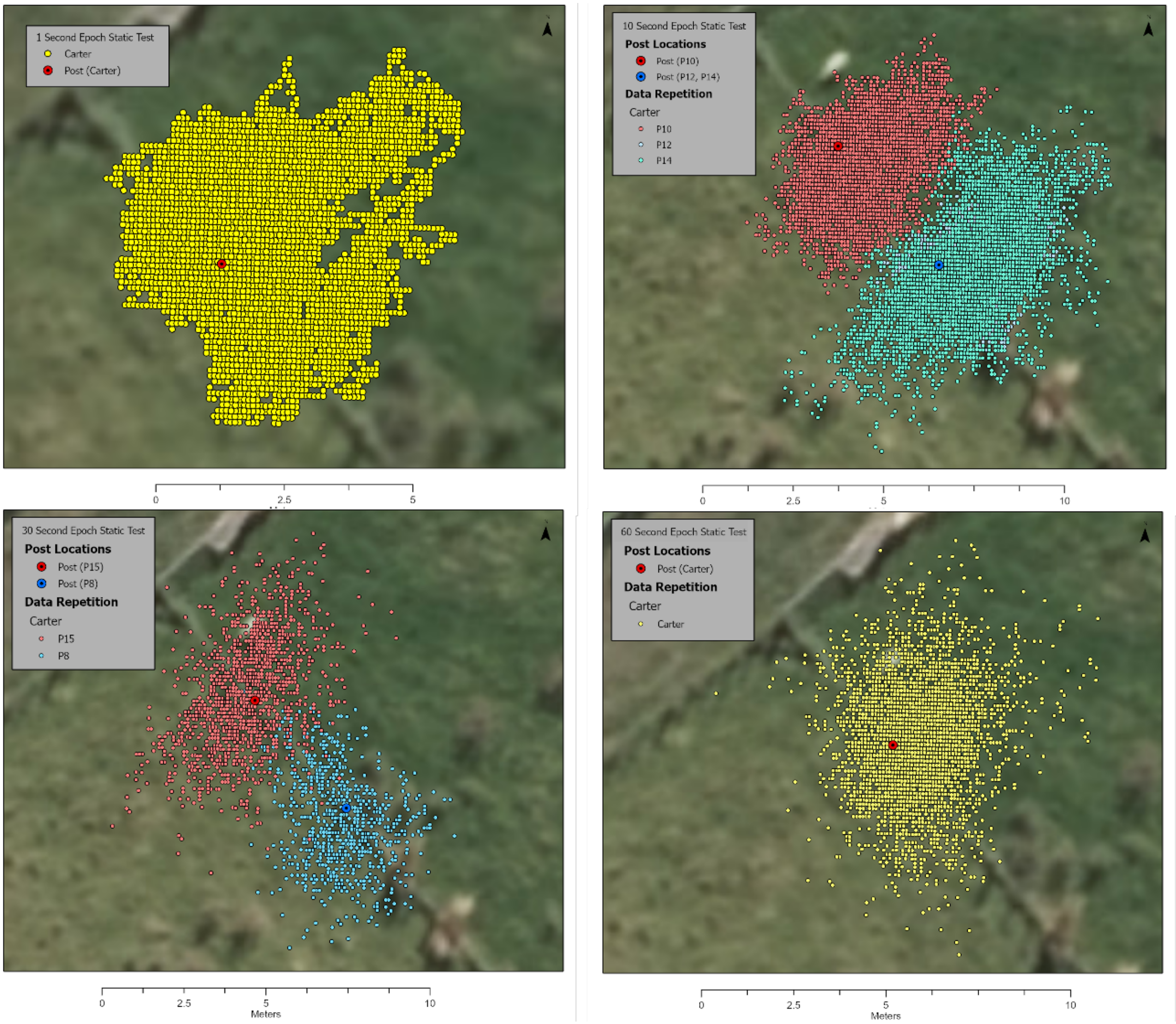

Garmin 310 1 Second Distribution
Count
Distance from post (m)
Mean : 3.314094

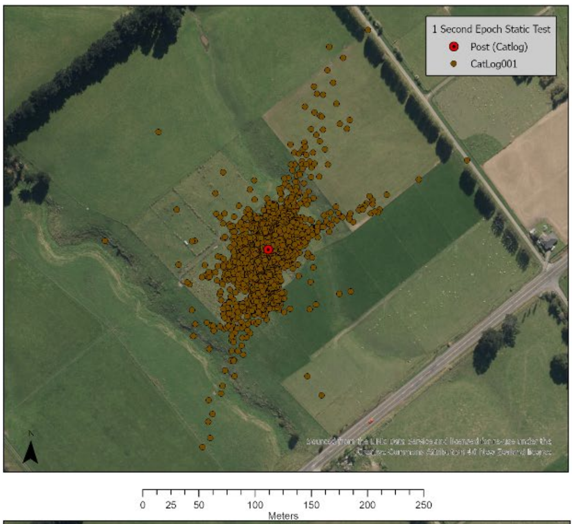

Gipsy5 1 Second Distribution
Count
Distance from post (m)
Mean : 1.132521





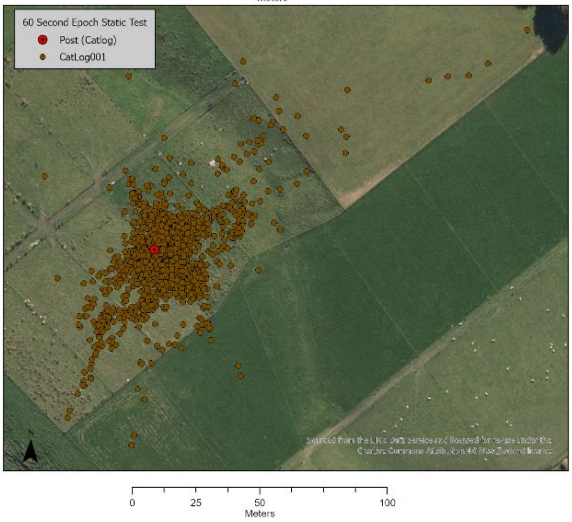
Appendix 3-3 Location estimates from five GPS receiver brands during static tests in relation to their true locations (m). True locations were marked by a real-time kinematic GPS. GPS receivers were programmed to record location data at four sperate epochs (time intervals; 1, 10, 30 and 60 seconds). Tests were repeated on three occasions.

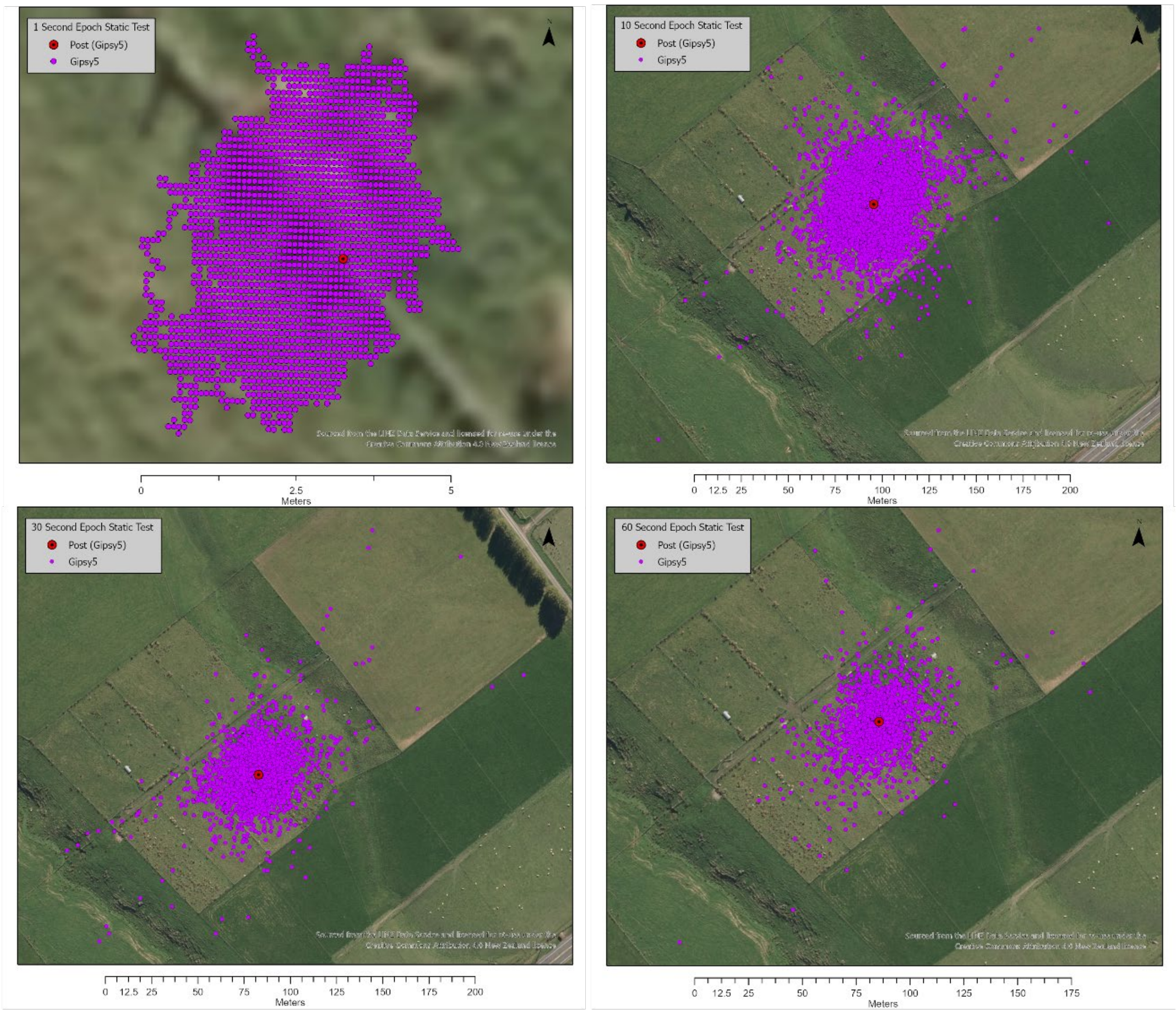

1 Second Epoch Static Test
Carter
Post (Carter)
0
2.5
5
10 Second Epoch Static Test
Post Locations
Post (P10)
Post (P12, P14)
Data Repetition
Carter
P10
P12
P14
0
2.5
5
10
30 Second Epoch Static Test
Post Locations
Post (P15)
Post (P8)
Data Repetition
Carter
P15
P8
0
2.5
5
10
Meters
60 Second Epoch Static Test
Post Locations
Post (Carter)
Data Repetition
Carter
Carter
0
2.5
5
10
Meters

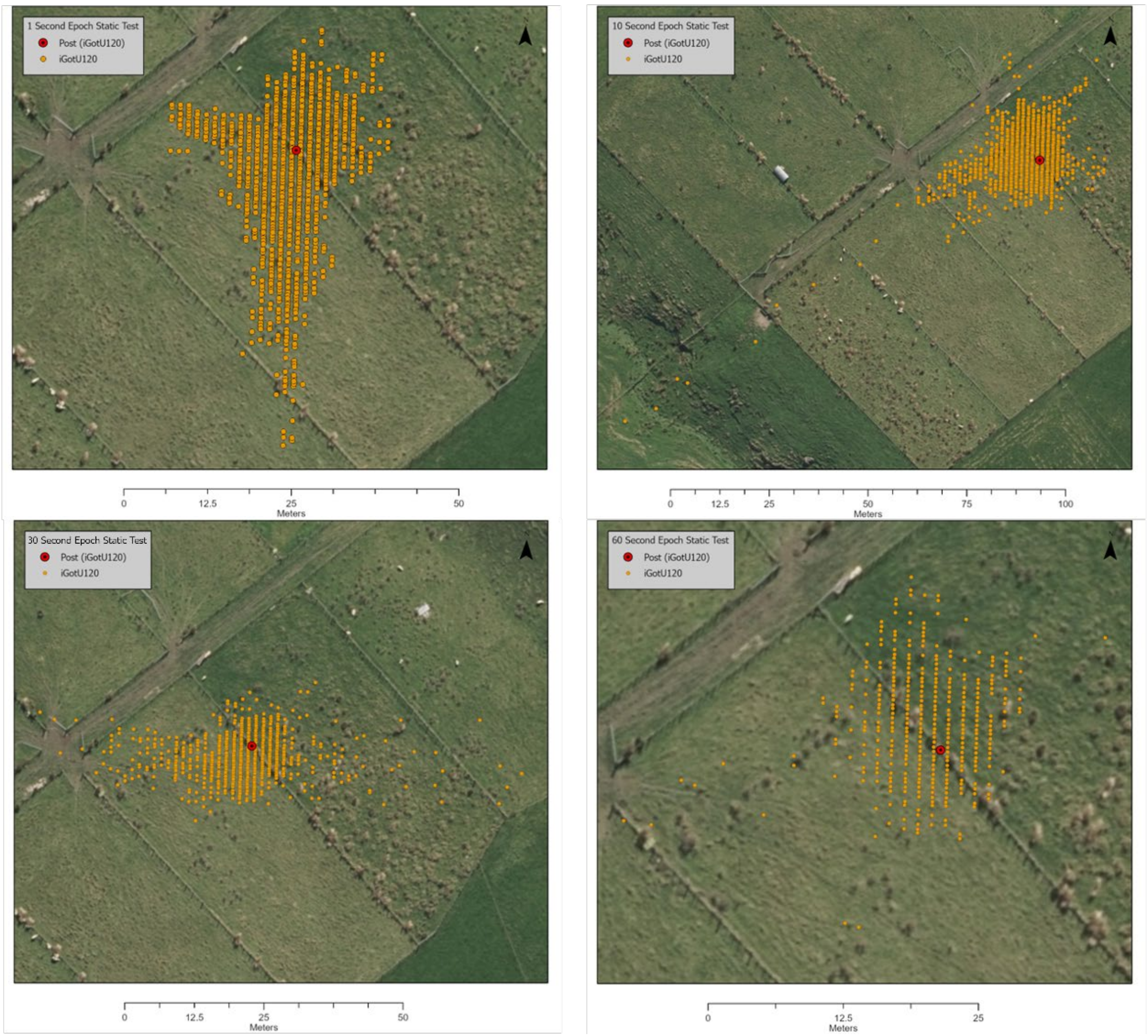

1 Second Epoch Static Test
Post (Catlog)
CatLog001
0 25 50 100 150 200 250
Meters

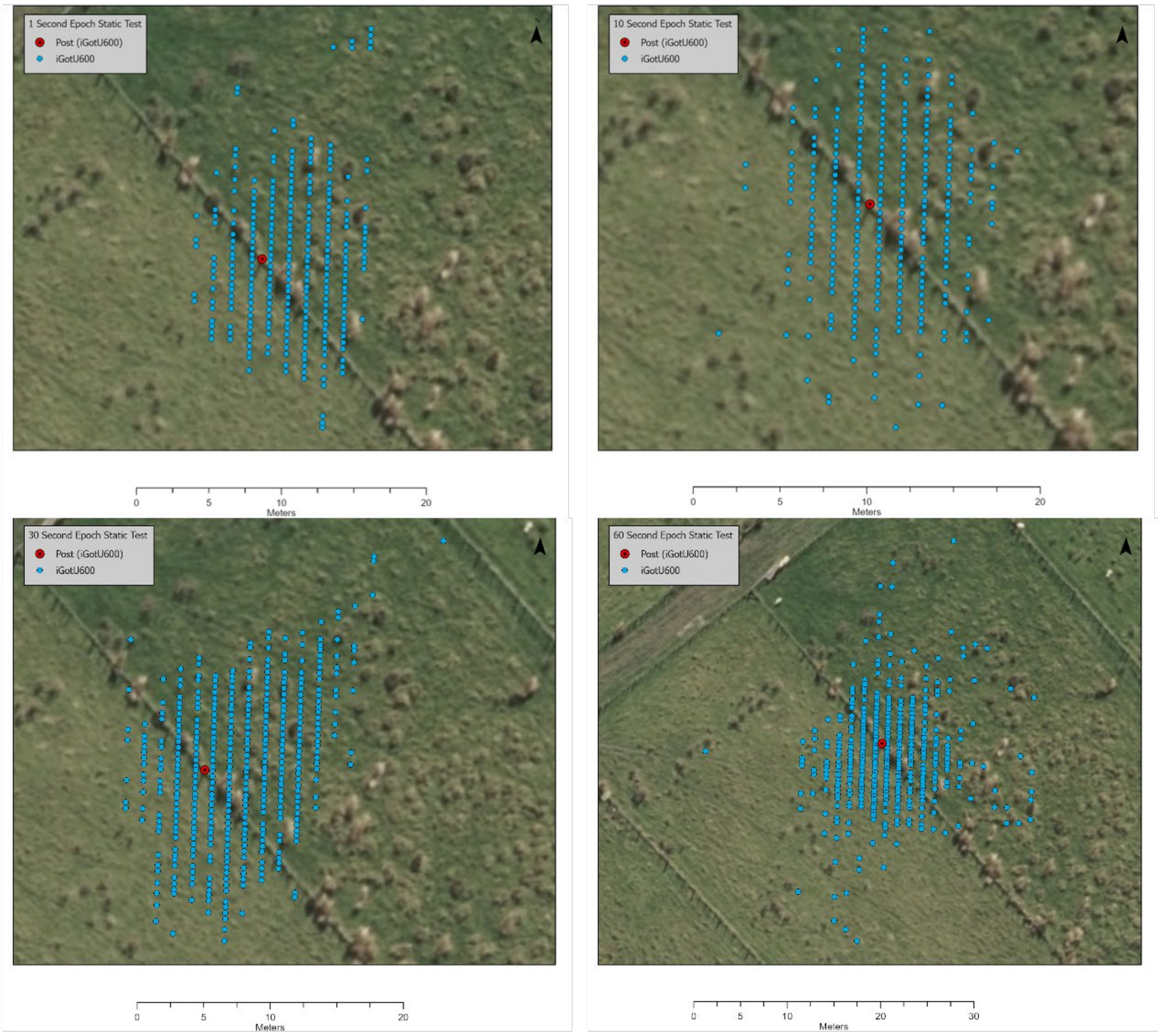

10 Second Epoch Static Test
Post (Catlog)
CatLog001
0 25 50 100 150 200
Meters


30 Second Epoch Static Test
Post (Catlog)
CatLog001
0 25 50 100 150 200 250
Meters


60 Second Epoch Static Test
Post (Catlog)
CatLog001
0 25 50 100
Meters

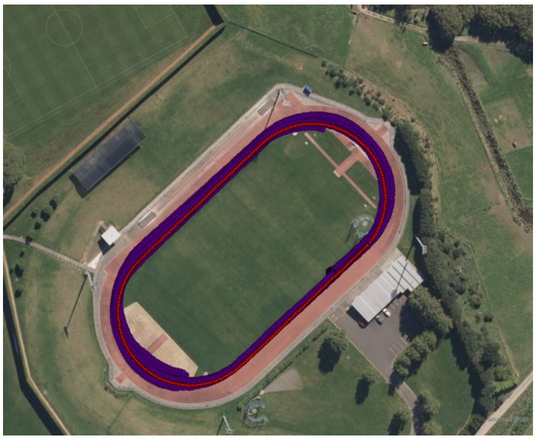

1 Second Epoch Static Test
Post (Gipsy5)
Gipsy5
0
2.5
5
Meters
10 Second Epoch Static Test
Post (Gipsy5)
Gipsy5
0 12.5 25 50 75 100 125 150 175 200
Meters
30 Second Epoch Static Test
Post (Gipsy5)
Gipsy5
0 12.5 25 50 75 100 125 150 175 200
Meters
60 Second Epoch Static Test
Post (Gipsy5)
Gipsy5
0 12.5 25 50 75 100 125 150 175
Meters

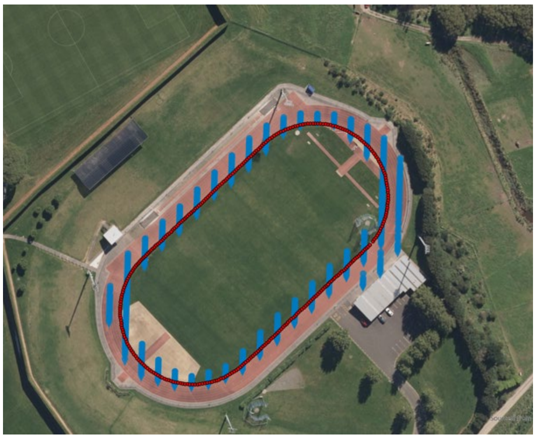

1 Second Epoch Static Test
Post (iGotU120)
iGotU120
0
12.5
25
50
Meters
10 Second Epoch Static Test
Post (iGotU120)
iGotU120
0
12.5
25
50
75
100
Meters
30 Second Epoch Static Test
Post (iGotU120)
iGotU120
0
12.5
25
50
Meters
60 Second Epoch Static Test
Post (iGotU120)
iGotU120
0
12.5
25
Meters



Appendix 3-4 Maps of GPS receiver location estimates on the inner lane of athletics track in relation to the nearest RTK location estimate (in red).

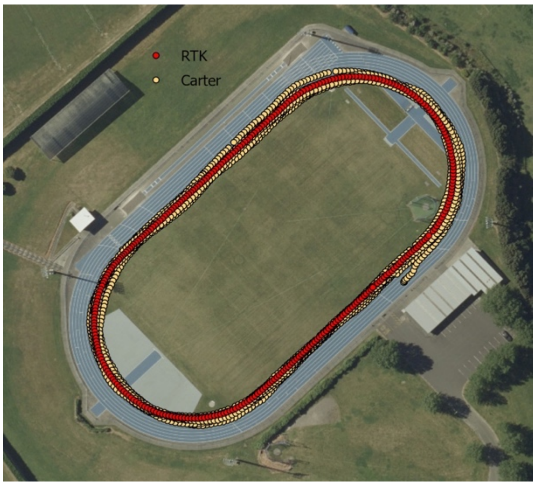

CATLOG


Garmin 310


Garmin 920


GIPSY 5


i-GOTU-600



CARTER[5]

[5] Please note that at the time of developing this figure, the athletics track had been relayed and was now blue, compared to the other figures when the athletics track was coloured red.

Appendix 4. Supplementary data for Chapter 4

Appendix 4-1 Data table used for analysis of the effect on accelerometer position on prediction of behaviour

Position	Sheep ID	Day	Hour	Grazing	Resting	Walking
Collar	Collar_19	1	0	708	9	3
Collar	Collar_19	1	1	415	296	9
Collar	Collar_19	1	2	18	697	5
Collar	Collar_19	1	3	23	691	6
Collar	Collar_19	1	4	10	710	0
Collar	Collar_19	1	5	18	696	6
Collar	Collar_19	1	6	47	655	18
Collar	Collar_19	1	7	108	597	15
Collar	Collar_19	1	8	297	417	6
Collar	Collar_19	1	9	712	3	5
Collar	Collar_19	1	10	713	4	3
Collar	Collar_19	1	11	686	10	24
Collar	Collar_19	1	12	700	2	18
Collar	Collar_19	1	13	692	3	25
Collar	Collar_19	1	14	702	3	15
Collar	Collar_19	1	15	688	2	30
Collar	Collar_19	1	16	708	5	7
Collar	Collar_19	1	17	606	68	46
Collar	Collar_19	1	18	258	374	88
Collar	Collar_19	1	19	190	528	2
Collar	Collar_19	1	20	35	673	12
Collar	Collar_19	1	21	50	668	2
Collar	Collar_19	1	22	15	703	2
Collar	Collar_19	1	23	442	255	23
Collar	Collar_19	2	0	531	186	3
Collar	Collar_19	2	1	26	694	0
Collar	Collar_19	2	2	17	699	4
Collar	Collar_19	2	3	36	677	7
Collar	Collar_19	2	4	42	677	1
Collar	Collar_19	2	5	15	705	0
Collar	Collar_19	2	6	41	679	0
Collar	Collar_19	2	7	7	713	0
Collar	Collar_19	2	8	286	432	2
Collar	Collar_19	2	9	703	11	6
Collar	Collar_19	2	10	554	82	84
Collar	Collar_19	2	11	283	299	138
Collar	Collar_19	2	12	136	569	15

Collar	Collar_19	2	13	716	2	2
Collar	Collar_19	2	14	713	2	5
Collar	Collar_19	2	15	706	5	9
Collar	Collar_19	2	16	679	14	27
Collar	Collar_19	2	17	548	116	56
Collar	Collar_19	2	18	30	686	4
Collar	Collar_19	2	19	6	713	1
Collar	Collar_19	2	20	17	700	3
Collar	Collar_19	2	21	25	694	1
Collar	Collar_19	2	22	3	716	1
Collar	Collar_19	2	23	421	295	4
Collar	Collar_19	3	0	627	83	10
Collar	Collar_19	3	1	416	292	12
Collar	Collar_19	3	2	8	711	1
Collar	Collar_19	3	3	16	703	1
Collar	Collar_19	3	4	11	708	1
Collar	Collar_19	3	5	23	694	3
Collar	Collar_19	3	6	12	706	2
Collar	Collar_19	3	7	14	704	2
Collar	Collar_19	3	8	329	360	31
Collar	Collar_19	3	9	708	3	9
Collar	Collar_19	3	10	696	5	19
Collar	Collar_19	3	11	709	9	2
Collar	Collar_19	3	12	704	9	7
Collar	Collar_19	3	13	714	3	3
Collar	Collar_19	3	14	688	11	21
Collar	Collar_19	3	15	663	39	18
Collar	Collar_19	3	16	619	53	48
Collar	Collar_19	3	17	484	177	59
Collar	Collar_19	3	18	38	666	16
Collar	Collar_19	3	19	5	714	1
Collar	Collar_19	3	20	10	708	2
Collar	Collar_19	3	21	20	695	5
Collar	Collar_19	3	22	19	695	6
Collar	Collar_19	3	23	356	355	9
Collar	Collar_21	1	0	316	402	2
Collar	Collar_21	1	1	118	602	0
Collar	Collar_21	1	2	16	701	3
Collar	Collar_21	1	3	130	585	5
Collar	Collar_21	1	4	4	716	0
Collar	Collar_21	1	5	8	707	5
Collar	Collar_21	1	6	1	719	0
Collar	Collar_21	1	7	215	502	3

Collar	Collar_21	1	8	99	619	2
Collar	Collar_21	1	9	220	494	6
Collar	Collar_21	1	10	104	586	30
Collar	Collar_21	1	11	516	187	17
Collar	Collar_21	1	12	542	164	14
Collar	Collar_21	1	13	529	187	4
Collar	Collar_21	1	14	521	191	8
Collar	Collar_21	1	15	582	133	5
Collar	Collar_21	1	16	534	177	9
Collar	Collar_21	1	17	412	302	6
Collar	Collar_21	1	18	97	612	11
Collar	Collar_21	1	19	34	683	3
Collar	Collar_21	1	20	6	714	0
Collar	Collar_21	1	21	20	695	5
Collar	Collar_21	1	22	12	708	0
Collar	Collar_21	1	23	143	570	7
Collar	Collar_21	2	0	21	697	2
Collar	Collar_21	2	1	31	689	0
Collar	Collar_21	2	2	22	696	2
Collar	Collar_21	2	3	12	705	3
Collar	Collar_21	2	4	30	689	1
Collar	Collar_21	2	5	52	665	3
Collar	Collar_21	2	6	33	686	1
Collar	Collar_21	2	7	15	705	0
Collar	Collar_21	2	8	20	698	2
Collar	Collar_21	2	9	33	681	6
Collar	Collar_21	2	10	280	431	9
Collar	Collar_21	2	11	388	327	5
Collar	Collar_21	2	12	441	276	3
Collar	Collar_21	2	13	488	226	6
Collar	Collar_21	2	14	442	268	10
Collar	Collar_21	2	15	218	492	10
Collar	Collar_21	2	16	442	276	2
Collar	Collar_21	2	17	406	304	10
Collar	Collar_21	2	18	77	643	0
Collar	Collar_21	2	19	21	699	0
Collar	Collar_21	2	20	19	698	3
Collar	Collar_21	2	21	33	687	0
Collar	Collar_21	2	22	79	639	2
Collar	Collar_21	2	23	166	551	3
Collar	Collar_21	3	0	304	408	8
Collar	Collar_21	3	1	25	692	3
Collar	Collar_21	3	2	4	716	0

Collar	Collar_21	3	3	54	663	3
Collar	Collar_21	3	4	7	711	2
Collar	Collar_21	3	5	1	719	0
Collar	Collar_21	3	6	4	716	0
Collar	Collar_21	3	7	20	698	2
Collar	Collar_21	3	8	123	583	14
Collar	Collar_21	3	9	467	244	9
Collar	Collar_21	3	10	466	246	8
Collar	Collar_21	3	11	419	296	5
Collar	Collar_21	3	12	321	380	19
Collar	Collar_21	3	13	65	649	6
Collar	Collar_21	3	14	489	226	5
Collar	Collar_21	3	15	455	243	22
Collar	Collar_21	3	16	470	247	3
Collar	Collar_21	3	17	429	266	25
Collar	Collar_21	3	18	232	484	4
Collar	Collar_21	3	19	24	696	0
Collar	Collar_21	3	20	9	711	0
Collar	Collar_21	3	21	82	615	23
Collar	Collar_21	3	22	5	715	0
Collar	Collar_21	3	23	91	618	11
Collar	Collar_24	1	0	479	230	11
Collar	Collar_24	1	1	270	438	12
Collar	Collar_24	1	2	86	629	5
Collar	Collar_24	1	3	14	705	1
Collar	Collar_24	1	4	40	672	8
Collar	Collar_24	1	5	30	690	0
Collar	Collar_24	1	6	19	700	1
Collar	Collar_24	1	7	11	709	0
Collar	Collar_24	1	8	194	510	16
Collar	Collar_24	1	9	469	246	5
Collar	Collar_24	1	10	553	160	7
Collar	Collar_24	1	11	639	62	19
Collar	Collar_24	1	12	591	107	22
Collar	Collar_24	1	13	628	73	19
Collar	Collar_24	1	14	607	94	19
Collar	Collar_24	1	15	641	69	10
Collar	Collar_24	1	16	612	99	9
Collar	Collar_24	1	17	621	89	10
Collar	Collar_24	1	18	123	579	18
Collar	Collar_24	1	19	13	706	1
Collar	Collar_24	1	20	3	717	0
Collar	Collar_24	1	21	66	648	6

Collar	Collar_24	1	22	13	705	2
Collar	Collar_24	1	23	102	615	3
Collar	Collar_24	2	0	2	716	2
Collar	Collar_24	2	1	16	698	6
Collar	Collar_24	2	2	9	708	3
Collar	Collar_24	2	3	15	700	5
Collar	Collar_24	2	4	10	707	3
Collar	Collar_24	2	5	9	711	0
Collar	Collar_24	2	6	1	718	1
Collar	Collar_24	2	7	1	719	0
Collar	Collar_24	2	8	237	467	16
Collar	Collar_24	2	9	328	380	12
Collar	Collar_24	2	10	16	703	1
Collar	Collar_24	2	11	486	224	10
Collar	Collar_24	2	12	441	269	10
Collar	Collar_24	2	13	141	576	3
Collar	Collar_24	2	14	626	80	14
Collar	Collar_24	2	15	628	89	3
Collar	Collar_24	2	16	615	88	17
Collar	Collar_24	2	17	552	138	30
Collar	Collar_24	2	18	121	587	12
Collar	Collar_24	2	19	2	718	0
Collar	Collar_24	2	20	36	682	2
Collar	Collar_24	2	21	21	698	1
Collar	Collar_24	2	22	9	710	1
Collar	Collar_24	2	23	40	677	3
Collar	Collar_24	3	0	51	667	2
Collar	Collar_24	3	1	57	656	7
Collar	Collar_24	3	2	13	700	7
Collar	Collar_24	3	3	18	698	4
Collar	Collar_24	3	4	3	717	0
Collar	Collar_24	3	5	15	705	0
Collar	Collar_24	3	6	5	713	2
Collar	Collar_24	3	7	4	716	0
Collar	Collar_24	3	8	200	502	18
Collar	Collar_24	3	9	606	95	19
Collar	Collar_24	3	10	575	133	12
Collar	Collar_24	3	11	608	108	4
Collar	Collar_24	3	12	566	140	14
Collar	Collar_24	3	13	593	114	13
Collar	Collar_24	3	14	650	57	13
Collar	Collar_24	3	15	637	66	17
Collar	Collar_24	3	16	623	87	10

Collar	Collar_24	3	17	520	144	56
Collar	Collar_24	3	18	92	620	8
Collar	Collar_24	3	19	10	710	0
Collar	Collar_24	3	20	24	694	2
Collar	Collar_24	3	21	16	704	0
Collar	Collar_24	3	22	19	698	3
Collar	Collar_24	3	23	23	696	1
Collar	Collar_28	1	0	702	8	10
Collar	Collar_28	1	1	352	364	4
Collar	Collar_28	1	2	12	704	4
Collar	Collar_28	1	3	12	707	1
Collar	Collar_28	1	4	19	699	2
Collar	Collar_28	1	5	6	712	2
Collar	Collar_28	1	6	15	704	1
Collar	Collar_28	1	7	14	703	3
Collar	Collar_28	1	8	562	144	14
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Collar	Collar_28	1	10	543	165	12
Collar	Collar_28	1	11	669	10	41
Collar	Collar_28	1	12	699	8	13
Collar	Collar_28	1	13	688	8	24
Collar	Collar_28	1	14	702	7	11
Collar	Collar_28	1	15	712	4	4
Collar	Collar_28	1	16	694	9	17
Collar	Collar_28	1	17	533	161	26
Collar	Collar_28	1	18	123	579	18
Collar	Collar_28	1	19	7	711	2
Collar	Collar_28	1	20	36	681	3
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Collar	Collar_28	1	23	399	311	10
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Collar	Collar_28	2	4	30	688	2
Collar	Collar_28	2	5	4	716	0
Collar	Collar_28	2	6	8	709	3
Collar	Collar_28	2	7	2	718	0
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Collar	Collar_28	2	9	681	31	8
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Collar	Collar_28	2	14	706	8	6
Collar	Collar_28	2	15	709	7	4
Collar	Collar_28	2	16	701	11	8
Collar	Collar_28	2	17	648	52	20
Collar	Collar_28	2	18	150	545	25
Collar	Collar_28	2	19	3	717	0
Collar	Collar_28	2	20	15	702	3
Collar	Collar_28	2	21	11	707	2
Collar	Collar_28	2	22	13	707	0
Collar	Collar_28	2	23	7	712	1
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Collar	Collar_28	3	1	20	696	4
Collar	Collar_28	3	2	503	206	11
Collar	Collar_28	3	3	52	660	8
Collar	Collar_28	3	4	9	710	1
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Collar	Collar_28	3	6	8	711	1
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Collar	Collar_28	3	9	696	7	17
Collar	Collar_28	3	10	697	9	14
Collar	Collar_28	3	11	708	4	8
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Collar	Collar_28	3	14	699	13	8
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Collar	Collar_28	3	16	661	32	27
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Collar	Collar_28	3	20	10	708	2
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Collar	Collar_30	1	4	17	699	4
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Collar	Collar_30	1	13	677	5	38
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Collar	Collar_30	1	17	618	66	36
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Collar	Collar_30	1	20	52	661	7
Collar	Collar_30	1	21	96	619	5
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Collar	Collar_30	2	1	51	665	4
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Collar	Collar_30	2	3	3	717	0
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Collar	Collar_30	2	5	28	687	5
Collar	Collar_30	2	6	2	718	0
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Collar	Collar_30	2	10	497	185	38
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Collar	Collar_30	2	15	555	147	18
Collar	Collar_30	2	16	693	17	10
Collar	Collar_30	2	17	666	30	24
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Collar	Collar_30	3	4	13	706	1
Collar	Collar_30	3	5	17	699	4
Collar	Collar_30	3	6	15	704	1
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Collar	Collar_30	3	10	683	11	26
Collar	Collar_30	3	11	646	49	25
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Collar	Collar_33	1	11	655	52	13
Collar	Collar_33	1	12	599	101	20
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Collar	Collar_33	1	23	81	633	6
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Collar	Collar_33	2	1	18	701	1
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Collar	Collar_33	2	7	15	703	2
Collar	Collar_33	2	8	12	707	1
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Collar	Collar_33	2	11	603	113	4
Collar	Collar_33	2	12	380	336	4
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Collar	Collar_33	2	20	26	689	5
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Collar	Collar_33	3	0	471	245	4
Collar	Collar_33	3	1	500	218	2
Collar	Collar_33	3	2	491	221	8
Collar	Collar_33	3	3	61	658	1
Collar	Collar_33	3	4	9	710	1
Collar	Collar_33	3	5	17	703	0
Collar	Collar_33	3	6	4	716	0
Collar	Collar_33	3	7	19	697	4
Collar	Collar_33	3	8	92	608	20
Collar	Collar_33	3	9	601	100	19
Collar	Collar_33	3	10	545	166	9
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Collar	Collar_33	3	18	275	430	15
Collar	Collar_33	3	19	10	710	0
Collar	Collar_33	3	20	12	706	2
Collar	Collar_33	3	21	20	699	1
Collar	Collar_33	3	22	12	706	2
Collar	Collar_33	3	23	101	611	8
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Collar	Collar_35	1	1	60	657	3
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Collar	Collar_35	1	4	29	688	3
Collar	Collar_35	1	5	13	706	1
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Collar	Collar_35	1	15	693	8	19
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Collar	Collar_35	1	22	32	684	4
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Collar	Collar_35	2	0	10	709	1
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Collar	Collar_35	2	2	10	708	2
Collar	Collar_35	2	3	17	701	2
Collar	Collar_35	2	4	1	719	0
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Collar	Collar_35	2	6	11	709	0
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Collar	Collar_35	3	4	21	697	2
Collar	Collar_35	3	5	15	702	3
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Collar	Collar_35	3	19	15	703	2
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Collar	Collar_40	1	5	4	716	0

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Collar	Collar_40	1	7	8	710	2
Collar	Collar_40	1	8	27	689	4
Collar	Collar_40	1	9	101	613	6
Collar	Collar_40	1	10	416	290	14
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Collar	Collar_40	1	18	66	640	14
Collar	Collar_40	1	19	14	703	3
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Collar	Collar_40	1	22	38	678	4
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Collar	Collar_40	2	3	37	680	3
Collar	Collar_40	2	4	2	717	1
Collar	Collar_40	2	5	1	719	0
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Collar	Collar_40	2	7	30	687	3
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Collar	Collar_40	2	17	511	193	16
Collar	Collar_40	2	18	220	488	12
Collar	Collar_40	2	19	5	715	0
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Collar	Collar_40	2	21	91	628	1
Collar	Collar_40	2	22	179	535	6
Collar	Collar_40	2	23	10	710	0
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Collar	Collar_40	3	2	1	719	0
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Collar	Collar_40	3	4	11	707	2
Collar	Collar_40	3	5	9	711	0
Collar	Collar_40	3	6	7	713	0
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Collar	Collar_40	3	18	15	705	0
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Collar	Collar_40	3	20	3	717	0
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Collar	Collar_40	3	22	10	709	1
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Collar	Collar_41	1	1	33	685	2
Collar	Collar_41	1	2	18	702	0
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Collar	Collar_41	1	4	36	682	2
Collar	Collar_41	1	5	19	700	1
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Collar	Collar_41	1	18	98	607	15
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Collar	Collar_41	2	4	19	701	0
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Collar	Collar_41	2	14	711	8	1
Collar	Collar_41	2	15	716	2	2
Collar	Collar_41	2	16	706	10	4
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Collar	Collar_41	2	19	15	704	1
Collar	Collar_41	2	20	55	664	1
Collar	Collar_41	2	21	16	702	2
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Collar	Collar_41	3	1	208	510	2
Collar	Collar_41	3	2	8	710	2
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Collar	Collar_41	3	6	17	698	5
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Collar	Collar_41	3	16	701	13	6
Collar	Collar_41	3	17	501	172	47
Collar	Collar_41	3	18	35	681	4
Collar	Collar_41	3	19	19	701	0
Collar	Collar_41	3	20	30	688	2
Collar	Collar_41	3	21	15	703	2
Collar	Collar_41	3	22	104	613	3
Collar	Collar_41	3	23	568	136	16
Collar	Collar_42	1	0	650	65	5
Collar	Collar_42	1	1	259	454	7
Collar	Collar_42	1	2	24	688	8
Collar	Collar_42	1	3	53	666	1
Collar	Collar_42	1	4	18	702	0
Collar	Collar_42	1	5	19	700	1
Collar	Collar_42	1	6	29	688	3
Collar	Collar_42	1	7	41	673	6
Collar	Collar_42	1	8	216	500	4
Collar	Collar_42	1	9	667	44	9
Collar	Collar_42	1	10	660	52	8
Collar	Collar_42	1	11	665	16	39
Collar	Collar_42	1	12	687	4	29
Collar	Collar_42	1	13	709	1	10
Collar	Collar_42	1	14	698	6	16
Collar	Collar_42	1	15	710	5	5
Collar	Collar_42	1	16	683	10	27
Collar	Collar_42	1	17	666	26	28
Collar	Collar_42	1	18	208	491	21
Collar	Collar_42	1	19	91	626	3
Collar	Collar_42	1	20	80	634	6
Collar	Collar_42	1	21	32	682	6
Collar	Collar_42	1	22	25	691	4
Collar	Collar_42	1	23	148	563	9
Collar	Collar_42	2	0	229	484	7
Collar	Collar_42	2	1	210	502	8
Collar	Collar_42	2	2	238	478	4
Collar	Collar_42	2	3	10	706	4
Collar	Collar_42	2	4	13	707	0
Collar	Collar_42	2	5	12	708	0
Collar	Collar_42	2	6	3	717	0
Collar	Collar_42	2	7	44	673	3
Collar	Collar_42	2	8	7	711	2
Collar	Collar_42	2	9	557	156	7

Collar	Collar_42	2	10	647	59	14
Collar	Collar_42	2	11	551	150	19
Collar	Collar_42	2	12	346	369	5
Collar	Collar_42	2	13	661	51	8
Collar	Collar_42	2	14	683	33	4
Collar	Collar_42	2	15	666	38	16
Collar	Collar_42	2	16	674	29	17
Collar	Collar_42	2	17	652	56	12
Collar	Collar_42	2	18	111	601	8
Collar	Collar_42	2	19	15	705	0
Collar	Collar_42	2	20	14	705	1
Collar	Collar_42	2	21	373	333	14
Collar	Collar_42	2	22	5	715	0
Collar	Collar_42	2	23	191	522	7
Collar	Collar_42	3	0	44	671	5
Collar	Collar_42	3	1	9	711	0
Collar	Collar_42	3	2	15	704	1
Collar	Collar_42	3	3	34	683	3
Collar	Collar_42	3	4	13	705	2
Collar	Collar_42	3	5	20	698	2
Collar	Collar_42	3	6	12	707	1
Collar	Collar_42	3	7	7	712	1
Collar	Collar_42	3	8	160	547	13
Collar	Collar_42	3	9	708	3	9
Collar	Collar_42	3	10	704	5	11
Collar	Collar_42	3	11	678	27	15
Collar	Collar_42	3	12	697	19	4
Collar	Collar_42	3	13	690	18	12
Collar	Collar_42	3	14	671	28	21
Collar	Collar_42	3	15	626	64	30
Collar	Collar_42	3	16	592	108	20
Collar	Collar_42	3	17	519	145	56
Collar	Collar_42	3	18	96	611	13
Collar	Collar_42	3	19	194	520	6
Collar	Collar_42	3	20	20	700	0
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Collar	Collar_42	3	22	341	365	14
Collar	Collar_42	3	23	544	166	10
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Halter	Halter_19	1	3	13	704	3
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Halter	Halter_19	1	6	40	662	18
Halter	Halter_19	1	7	110	578	32
Halter	Halter_19	1	8	281	423	16
Halter	Halter_19	1	9	669	33	18
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Halter	Halter_19	1	11	575	41	104
Halter	Halter_19	1	12	617	38	65
Halter	Halter_19	1	13	584	39	97
Halter	Halter_19	1	14	627	42	51
Halter	Halter_19	1	15	618	44	58
Halter	Halter_19	1	16	636	31	53
Halter	Halter_19	1	17	538	97	85
Halter	Halter_19	1	18	268	321	131
Halter	Halter_19	1	19	179	534	7
Halter	Halter_19	1	20	39	662	19
Halter	Halter_19	1	21	43	674	3
Halter	Halter_19	1	22	17	697	6
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Halter	Halter_19	2	4	34	683	3
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Halter	Halter_19	2	6	47	670	3
Halter	Halter_19	2	7	7	713	0
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Halter	Halter_19	2	11	207	313	200
Halter	Halter_19	2	12	116	579	25
Halter	Halter_19	2	13	657	34	29
Halter	Halter_19	2	14	669	21	30
Halter	Halter_19	2	15	637	35	48
Halter	Halter_19	2	16	602	50	68
Halter	Halter_19	2	17	468	151	101
Halter	Halter_19	2	18	19	694	7
Halter	Halter_19	2	19	11	709	0
Halter	Halter_19	2	20	12	706	2
Halter	Halter_19	2	21	20	693	7
Halter	Halter_19	2	22	6	714	0
Halter	Halter_19	2	23	453	256	11

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Halter	Halter_19	3	1	293	320	107
Halter	Halter_19	3	2	14	706	0
Halter	Halter_19	3	3	21	698	1
Halter	Halter_19	3	4	12	706	2
Halter	Halter_19	3	5	29	684	7
Halter	Halter_19	3	6	13	704	3
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Halter	Halter_19	3	8	272	368	80
Halter	Halter_19	3	9	434	102	184
Halter	Halter_19	3	10	480	102	138
Halter	Halter_19	3	11	632	53	35
Halter	Halter_19	3	12	654	35	31
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Halter	Halter_19	3	14	583	61	76
Halter	Halter_19	3	15	443	118	159
Halter	Halter_19	3	16	480	79	161
Halter	Halter_19	3	17	326	213	181
Halter	Halter_19	3	18	28	666	26
Halter	Halter_19	3	19	6	713	1
Halter	Halter_19	3	20	11	707	2
Halter	Halter_19	3	21	18	697	5
Halter	Halter_19	3	22	14	701	5
Halter	Halter_19	3	23	289	358	73
Halter	Halter_21	1	0	431	255	34
Halter	Halter_21	1	1	162	547	11
Halter	Halter_21	1	2	29	688	3
Halter	Halter_21	1	3	184	524	12
Halter	Halter_21	1	4	4	716	0
Halter	Halter_21	1	5	13	696	11
Halter	Halter_21	1	6	1	719	0
Halter	Halter_21	1	7	282	424	14
Halter	Halter_21	1	8	152	556	12
Halter	Halter_21	1	9	295	413	12
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Halter	Halter_21	1	11	459	179	82
Halter	Halter_21	1	12	443	232	45
Halter	Halter_21	1	13	473	227	20
Halter	Halter_21	1	14	396	303	21
Halter	Halter_21	1	15	450	245	25
Halter	Halter_21	1	16	486	208	26
Halter	Halter_21	1	17	450	247	23
Halter	Halter_21	1	18	227	473	20

Halter	Halter_21	1	19	70	646	4
Halter	Halter_21	1	20	7	713	0
Halter	Halter_21	1	21	33	680	7
Halter	Halter_21	1	22	21	698	1
Halter	Halter_21	1	23	202	501	17
Halter	Halter_21	2	0	25	694	1
Halter	Halter_21	2	1	52	668	0
Halter	Halter_21	2	2	30	688	2
Halter	Halter_21	2	3	24	693	3
Halter	Halter_21	2	4	39	680	1
Halter	Halter_21	2	5	62	656	2
Halter	Halter_21	2	6	41	678	1
Halter	Halter_21	2	7	26	694	0
Halter	Halter_21	2	8	35	683	2
Halter	Halter_21	2	9	52	658	10
Halter	Halter_21	2	10	402	313	5
Halter	Halter_21	2	11	534	175	11
Halter	Halter_21	2	12	527	180	13
Halter	Halter_21	2	13	507	188	25
Halter	Halter_21	2	14	393	274	53
Halter	Halter_21	2	15	331	365	24
Halter	Halter_21	2	16	456	240	24
Halter	Halter_21	2	17	382	273	65
Halter	Halter_21	2	18	134	575	11
Halter	Halter_21	2	19	26	692	2
Halter	Halter_21	2	20	21	696	3
Halter	Halter_21	2	21	26	688	6
Halter	Halter_21	2	22	136	576	8
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Halter	Halter_21	3	0	391	310	19
Halter	Halter_21	3	1	57	658	5
Halter	Halter_21	3	2	4	716	0
Halter	Halter_21	3	3	85	616	19
Halter	Halter_21	3	4	6	714	0
Halter	Halter_21	3	5	3	717	0
Halter	Halter_21	3	6	7	712	1
Halter	Halter_21	3	7	28	691	1
Halter	Halter_21	3	8	97	577	46
Halter	Halter_21	3	9	454	213	53
Halter	Halter_21	3	10	475	218	27
Halter	Halter_21	3	11	478	238	4
Halter	Halter_21	3	12	322	353	45
Halter	Halter_21	3	13	75	630	15

Halter	Halter_21	3	14	487	207	26
Halter	Halter_21	3	15	448	202	70
Halter	Halter_21	3	16	431	244	45
Halter	Halter_21	3	17	375	242	103
Halter	Halter_21	3	18	200	500	20
Halter	Halter_21	3	19	20	699	1
Halter	Halter_21	3	20	13	706	1
Halter	Halter_21	3	21	87	602	31
Halter	Halter_21	3	22	6	714	0
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Halter	Halter_24	1	0	613	61	46
Halter	Halter_24	1	1	357	334	29
Halter	Halter_24	1	2	79	622	19
Halter	Halter_24	1	3	23	694	3
Halter	Halter_24	1	4	59	645	16
Halter	Halter_24	1	5	36	676	8
Halter	Halter_24	1	6	24	692	4
Halter	Halter_24	1	7	12	708	0
Halter	Halter_24	1	8	259	427	34
Halter	Halter_24	1	9	614	91	15
Halter	Halter_24	1	10	677	28	15
Halter	Halter_24	1	11	570	31	119
Halter	Halter_24	1	12	594	49	77
Halter	Halter_24	1	13	470	117	133
Halter	Halter_24	1	14	504	115	101
Halter	Halter_24	1	15	497	135	88
Halter	Halter_24	1	16	591	57	72
Halter	Halter_24	1	17	631	40	49
Halter	Halter_24	1	18	214	471	35
Halter	Halter_24	1	19	19	698	3
Halter	Halter_24	1	20	9	711	0
Halter	Halter_24	1	21	84	626	10
Halter	Halter_24	1	22	9	706	5
Halter	Halter_24	1	23	119	593	8
Halter	Halter_24	2	0	11	707	2
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Halter	Halter_24	2	2	10	704	6
Halter	Halter_24	2	3	17	694	9
Halter	Halter_24	2	4	17	697	6
Halter	Halter_24	2	5	15	705	0
Halter	Halter_24	2	6	8	710	2
Halter	Halter_24	2	7	2	718	0
Halter	Halter_24	2	8	429	268	23

Halter	Halter_24	2	9	510	172	38
Halter	Halter_24	2	10	34	685	1
Halter	Halter_24	2	11	570	110	40
Halter	Halter_24	2	12	465	216	39
Halter	Halter_24	2	13	176	539	5
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Halter	Halter_24	2	16	642	34	44
Halter	Halter_24	2	17	474	133	113
Halter	Halter_24	2	18	167	519	34
Halter	Halter_24	2	19	9	711	0
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Halter	Halter_24	2	21	28	690	2
Halter	Halter_24	2	22	11	708	1
Halter	Halter_24	2	23	42	655	23
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Halter	Halter_24	3	1	42	654	24
Halter	Halter_24	3	2	24	685	11
Halter	Halter_24	3	3	29	685	6
Halter	Halter_24	3	4	1	719	0
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Halter	Halter_24	3	6	13	705	2
Halter	Halter_24	3	7	9	711	0
Halter	Halter_24	3	8	203	459	58
Halter	Halter_24	3	9	566	53	101
Halter	Halter_24	3	10	632	40	48
Halter	Halter_24	3	11	632	52	36
Halter	Halter_24	3	12	624	43	53
Halter	Halter_24	3	13	608	43	69
Halter	Halter_24	3	14	592	45	83
Halter	Halter_24	3	15	581	58	81
Halter	Halter_24	3	16	605	29	86
Halter	Halter_24	3	17	428	132	160
Halter	Halter_24	3	18	74	609	37
Halter	Halter_24	3	19	9	711	0
Halter	Halter_24	3	20	31	685	4
Halter	Halter_24	3	21	16	698	6
Halter	Halter_24	3	22	19	696	5
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Halter	Halter_28	1	0	551	93	76
Halter	Halter_28	1	1	332	361	27
Halter	Halter_28	1	2	17	700	3
Halter	Halter_28	1	3	9	706	5

Halter	Halter_28	1	4	16	698	6
Halter	Halter_28	1	5	4	713	3
Halter	Halter_28	1	6	26	690	4
Halter	Halter_28	1	7	18	694	8
Halter	Halter_28	1	8	447	200	73
Halter	Halter_28	1	9	317	356	47
Halter	Halter_28	1	10	430	218	72
Halter	Halter_28	1	11	455	45	220
Halter	Halter_28	1	12	548	26	146
Halter	Halter_28	1	13	550	35	135
Halter	Halter_28	1	14	615	36	69
Halter	Halter_28	1	15	636	36	48
Halter	Halter_28	1	16	550	49	121
Halter	Halter_28	1	17	460	178	82
Halter	Halter_28	1	18	135	547	38
Halter	Halter_28	1	19	10	707	3
Halter	Halter_28	1	20	70	642	8
Halter	Halter_28	1	21	20	696	4
Halter	Halter_28	1	22	19	698	3
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Halter	Halter_28	2	2	28	691	1
Halter	Halter_28	2	3	334	370	16
Halter	Halter_28	2	4	31	682	7
Halter	Halter_28	2	5	5	715	0
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Halter	Halter_28	2	8	341	339	40
Halter	Halter_28	2	9	450	178	92
Halter	Halter_28	2	10	113	591	16
Halter	Halter_28	2	11	564	83	73
Halter	Halter_28	2	12	560	64	96
Halter	Halter_28	2	13	498	134	88
Halter	Halter_28	2	14	550	72	98
Halter	Halter_28	2	15	528	69	123
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Halter	Halter_28	2	17	481	125	114
Halter	Halter_28	2	18	107	558	55
Halter	Halter_28	2	19	7	712	1
Halter	Halter_28	2	20	17	696	7
Halter	Halter_28	2	21	17	702	1
Halter	Halter_28	2	22	13	707	0

Halter	Halter_28	2	23	6	712	2
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Halter	Halter_28	3	3	44	667	9
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Halter	Halter_28	3	5	5	713	2
Halter	Halter_28	3	6	14	704	2
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Halter	Halter_28	3	10	440	86	194
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Halter	Halter_28	3	12	447	114	159
Halter	Halter_28	3	13	451	132	137
Halter	Halter_28	3	14	453	120	147
Halter	Halter_28	3	15	366	128	226
Halter	Halter_28	3	16	425	102	193
Halter	Halter_28	3	17	326	158	236
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Halter	Halter_28	3	19	7	704	9
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Halter	Halter_28	3	21	4	716	0
Halter	Halter_28	3	22	167	472	81
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Halter	Halter_30	1	0	404	222	94
Halter	Halter_30	1	1	82	613	25
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Halter	Halter_30	1	4	17	700	3
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Halter	Halter_30	1	9	543	142	35
Halter	Halter_30	1	10	112	573	35
Halter	Halter_30	1	11	476	49	195
Halter	Halter_30	1	12	521	40	159
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Halter	Halter_30	1	14	542	56	122
Halter	Halter_30	1	15	581	41	98
Halter	Halter_30	1	16	560	61	99
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Halter	Halter_30	1	19	398	270	52
Halter	Halter_30	1	20	46	655	19
Halter	Halter_30	1	21	91	613	16
Halter	Halter_30	1	22	39	675	6
Halter	Halter_30	1	23	237	416	67
Halter	Halter_30	2	0	402	298	20
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Halter	Halter_30	2	2	88	606	26
Halter	Halter_30	2	3	6	714	0
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Halter	Halter_30	2	5	34	679	7
Halter	Halter_30	2	6	5	715	0
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Halter	Halter_30	2	8	21	693	6
Halter	Halter_30	2	9	378	297	45
Halter	Halter_30	2	10	366	271	83
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Halter	Halter_30	2	12	523	125	72
Halter	Halter_30	2	13	568	74	78
Halter	Halter_30	2	14	617	52	51
Halter	Halter_30	2	15	453	197	70
Halter	Halter_30	2	16	539	107	74
Halter	Halter_30	2	17	529	96	95
Halter	Halter_30	2	18	264	409	47
Halter	Halter_30	2	19	14	702	4
Halter	Halter_30	2	20	139	547	34
Halter	Halter_30	2	21	19	697	4
Halter	Halter_30	2	22	265	424	31
Halter	Halter_30	2	23	562	134	24
Halter	Halter_30	3	0	445	253	22
Halter	Halter_30	3	1	61	651	8
Halter	Halter_30	3	2	19	697	4
Halter	Halter_30	3	3	18	701	1
Halter	Halter_30	3	4	14	703	3
Halter	Halter_30	3	5	24	690	6
Halter	Halter_30	3	6	11	706	3
Halter	Halter_30	3	7	21	697	2
Halter	Halter_30	3	8	96	512	112
Halter	Halter_30	3	9	281	174	265
Halter	Halter_30	3	10	362	182	176
Halter	Halter_30	3	11	483	113	124
Halter	Halter_30	3	12	391	203	126

Halter	Halter_30	3	13	70	597	53
Halter	Halter_30	3	14	543	95	82
Halter	Halter_30	3	15	571	84	65
Halter	Halter_30	3	16	552	113	55
Halter	Halter_30	3	17	387	149	184
Halter	Halter_30	3	18	276	423	21
Halter	Halter_30	3	19	16	704	0
Halter	Halter_30	3	20	144	545	31
Halter	Halter_30	3	21	71	640	9
Halter	Halter_30	3	22	442	230	48
Halter	Halter_30	3	23	509	162	49
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Halter	Halter_33	1	1	296	416	8
Halter	Halter_33	1	2	342	367	11
Halter	Halter_33	1	3	50	662	8
Halter	Halter_33	1	4	7	711	2
Halter	Halter_33	1	5	14	704	2
Halter	Halter_33	1	6	18	691	11
Halter	Halter_33	1	7	19	696	5
Halter	Halter_33	1	8	38	682	0
Halter	Halter_33	1	9	17	695	8
Halter	Halter_33	1	10	171	531	18
Halter	Halter_33	1	11	521	102	97
Halter	Halter_33	1	12	564	103	53
Halter	Halter_33	1	13	439	247	34
Halter	Halter_33	1	14	401	259	60
Halter	Halter_33	1	15	473	196	51
Halter	Halter_33	1	16	569	127	24
Halter	Halter_33	1	17	480	168	72
Halter	Halter_33	1	18	125	542	53
Halter	Halter_33	1	19	33	677	10
Halter	Halter_33	1	20	21	695	4
Halter	Halter_33	1	21	21	698	1
Halter	Halter_33	1	22	20	692	8
Halter	Halter_33	1	23	83	627	10
Halter	Halter_33	2	0	461	238	21
Halter	Halter_33	2	1	31	688	1
Halter	Halter_33	2	2	26	691	3
Halter	Halter_33	2	3	21	693	6
Halter	Halter_33	2	4	29	690	1
Halter	Halter_33	2	5	1	719	0
Halter	Halter_33	2	6	14	705	1
Halter	Halter_33	2	7	12	705	3

Halter	Halter_33	2	8	11	708	1
Halter	Halter_33	2	9	23	691	6
Halter	Halter_33	2	10	356	319	45
Halter	Halter_33	2	11	584	107	29
Halter	Halter_33	2	12	342	357	21
Halter	Halter_33	2	13	522	163	35
Halter	Halter_33	2	14	383	316	21
Halter	Halter_33	2	15	493	194	33
Halter	Halter_33	2	16	538	128	54
Halter	Halter_33	2	17	586	111	23
Halter	Halter_33	2	18	79	628	13
Halter	Halter_33	2	19	14	700	6
Halter	Halter_33	2	20	25	685	10
Halter	Halter_33	2	21	23	694	3
Halter	Halter_33	2	22	148	572	0
Halter	Halter_33	2	23	554	157	9
Halter	Halter_33	3	0	571	136	13
Halter	Halter_33	3	1	577	135	8
Halter	Halter_33	3	2	332	304	84
Halter	Halter_33	3	3	62	645	13
Halter	Halter_33	3	4	4	713	3
Halter	Halter_33	3	5	8	710	2
Halter	Halter_33	3	6	6	714	0
Halter	Halter_33	3	7	24	692	4
Halter	Halter_33	3	8	95	580	45
Halter	Halter_33	3	9	492	150	78
Halter	Halter_33	3	10	532	152	36
Halter	Halter_33	3	11	508	184	28
Halter	Halter_33	3	12	511	167	42
Halter	Halter_33	3	13	510	184	26
Halter	Halter_33	3	14	512	167	41
Halter	Halter_33	3	15	529	127	64
Halter	Halter_33	3	16	500	159	61
Halter	Halter_33	3	17	364	266	90
Halter	Halter_33	3	18	182	481	57
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Halter	Halter_33	3	21	15	700	5
Halter	Halter_33	3	22	10	707	3
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Halter	Halter_35	1	0	330	375	15
Halter	Halter_35	1	1	63	650	7
Halter	Halter_35	1	2	19	698	3

Halter	Halter_35	1	3	33	681	6
Halter	Halter_35	1	4	38	678	4
Halter	Halter_35	1	5	15	703	2
Halter	Halter_35	1	6	7	713	0
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Halter	Halter_35	1	8	59	644	17
Halter	Halter_35	1	9	28	688	4
Halter	Halter_35	1	10	520	171	29
Halter	Halter_35	1	11	510	63	147
Halter	Halter_35	1	12	583	62	75
Halter	Halter_35	1	13	616	59	45
Halter	Halter_35	1	14	561	60	99
Halter	Halter_35	1	15	623	59	38
Halter	Halter_35	1	16	575	83	62
Halter	Halter_35	1	17	576	79	65
Halter	Halter_35	1	18	288	371	61
Halter	Halter_35	1	19	37	668	15
Halter	Halter_35	1	20	44	669	7
Halter	Halter_35	1	21	49	670	1
Halter	Halter_35	1	22	29	682	9
Halter	Halter_35	1	23	73	614	33
Halter	Halter_35	2	0	11	707	2
Halter	Halter_35	2	1	29	686	5
Halter	Halter_35	2	2	5	712	3
Halter	Halter_35	2	3	16	702	2
Halter	Halter_35	2	4	1	719	0
Halter	Halter_35	2	5	19	700	1
Halter	Halter_35	2	6	16	703	1
Halter	Halter_35	2	7	13	705	2
Halter	Halter_35	2	8	37	679	4
Halter	Halter_35	2	9	149	469	102
Halter	Halter_35	2	10	457	157	106
Halter	Halter_35	2	11	589	75	56
Halter	Halter_35	2	12	654	51	15
Halter	Halter_35	2	13	277	422	21
Halter	Halter_35	2	14	637	51	32
Halter	Halter_35	2	15	379	261	80
Halter	Halter_35	2	16	515	148	57
Halter	Halter_35	2	17	440	177	103
Halter	Halter_35	2	18	353	203	164
Halter	Halter_35	2	19	40	673	7
Halter	Halter_35	2	20	16	701	3
Halter	Halter_35	2	21	62	643	15

Halter	Halter_35	2	22	12	707	1
Halter	Halter_35	2	23	8	709	3
Halter	Halter_35	3	0	456	186	78
Halter	Halter_35	3	1	247	377	96
Halter	Halter_35	3	2	6	714	0
Halter	Halter_35	3	3	13	706	1
Halter	Halter_35	3	4	21	695	4
Halter	Halter_35	3	5	38	676	6
Halter	Halter_35	3	6	20	696	4
Halter	Halter_35	3	7	14	704	2
Halter	Halter_35	3	8	110	570	40
Halter	Halter_35	3	9	469	138	113
Halter	Halter_35	3	10	514	153	53
Halter	Halter_35	3	11	565	113	42
Halter	Halter_35	3	12	397	256	67
Halter	Halter_35	3	13	246	385	89
Halter	Halter_35	3	14	436	165	119
Halter	Halter_35	3	15	497	110	113
Halter	Halter_35	3	16	396	170	154
Halter	Halter_35	3	17	372	202	146
Halter	Halter_35	3	18	10	700	10
Halter	Halter_35	3	19	21	698	1
Halter	Halter_35	3	20	26	693	1
Halter	Halter_35	3	21	26	694	0
Halter	Halter_35	3	22	30	685	5
Halter	Halter_35	3	23	136	576	8
Halter	Halter_40	1	0	457	208	55
Halter	Halter_40	1	1	20	699	1
Halter	Halter_40	1	2	22	693	5
Halter	Halter_40	1	3	20	694	6
Halter	Halter_40	1	4	37	677	6
Halter	Halter_40	1	5	12	708	0
Halter	Halter_40	1	6	22	698	0
Halter	Halter_40	1	7	26	692	2
Halter	Halter_40	1	8	65	646	9
Halter	Halter_40	1	9	166	523	31
Halter	Halter_40	1	10	559	117	44
Halter	Halter_40	1	11	555	83	82
Halter	Halter_40	1	12	639	38	43
Halter	Halter_40	1	13	653	38	29
Halter	Halter_40	1	14	653	41	26
Halter	Halter_40	1	15	634	49	37
Halter	Halter_40	1	16	611	65	44

Halter	Halter_40	1	17	501	137	82
Halter	Halter_40	1	18	176	524	20
Halter	Halter_40	1	19	31	688	1
Halter	Halter_40	1	20	32	685	3
Halter	Halter_40	1	21	450	247	23
Halter	Halter_40	1	22	50	665	5
Halter	Halter_40	1	23	245	456	19
Halter	Halter_40	2	0	22	696	2
Halter	Halter_40	2	1	53	662	5
Halter	Halter_40	2	2	129	567	24
Halter	Halter_40	2	3	45	671	4
Halter	Halter_40	2	4	9	711	0
Halter	Halter_40	2	5	4	716	0
Halter	Halter_40	2	6	21	696	3
Halter	Halter_40	2	7	40	677	3
Halter	Halter_40	2	8	436	269	15
Halter	Halter_40	2	9	561	126	33
Halter	Halter_40	2	10	569	130	21
Halter	Halter_40	2	11	583	85	52
Halter	Halter_40	2	12	373	285	62
Halter	Halter_40	2	13	454	212	54
Halter	Halter_40	2	14	642	53	25
Halter	Halter_40	2	15	644	43	33
Halter	Halter_40	2	16	517	154	49
Halter	Halter_40	2	17	523	119	78
Halter	Halter_40	2	18	233	445	42
Halter	Halter_40	2	19	8	712	0
Halter	Halter_40	2	20	14	702	4
Halter	Halter_40	2	21	93	617	10
Halter	Halter_40	2	22	181	499	40
Halter	Halter_40	2	23	14	705	1
Halter	Halter_40	3	0	430	222	68
Halter	Halter_40	3	1	314	356	50
Halter	Halter_40	3	2	4	716	0
Halter	Halter_40	3	3	25	694	1
Halter	Halter_40	3	4	17	701	2
Halter	Halter_40	3	5	15	704	1
Halter	Halter_40	3	6	9	709	2
Halter	Halter_40	3	7	15	703	2
Halter	Halter_40	3	8	230	435	55
Halter	Halter_40	3	9	558	63	99
Halter	Halter_40	3	10	570	75	75
Halter	Halter_40	3	11	197	501	22

Halter	Halter_40	3	12	415	262	43
Halter	Halter_40	3	13	587	68	65
Halter	Halter_40	3	14	650	53	17
Halter	Halter_40	3	15	551	97	72
Halter	Halter_40	3	16	490	144	86
Halter	Halter_40	3	17	360	246	114
Halter	Halter_40	3	18	33	687	0
Halter	Halter_40	3	19	25	690	5
Halter	Halter_40	3	20	13	707	0
Halter	Halter_40	3	21	25	693	2
Halter	Halter_40	3	22	16	702	2
Halter	Halter_40	3	23	184	514	22
Halter	Halter_41	1	0	545	136	39
Halter	Halter_41	1	1	29	687	4
Halter	Halter_41	1	2	13	706	1
Halter	Halter_41	1	3	52	656	12
Halter	Halter_41	1	4	24	686	10
Halter	Halter_41	1	5	19	696	5
Halter	Halter_41	1	6	31	680	9
Halter	Halter_41	1	7	19	699	2
Halter	Halter_41	1	8	109	606	5
Halter	Halter_41	1	9	446	254	20
Halter	Halter_41	1	10	482	197	41
Halter	Halter_41	1	11	561	43	116
Halter	Halter_41	1	12	673	19	28
Halter	Halter_41	1	13	655	16	49
Halter	Halter_41	1	14	681	19	20
Halter	Halter_41	1	15	670	21	29
Halter	Halter_41	1	16	677	27	16
Halter	Halter_41	1	17	476	121	123
Halter	Halter_41	1	18	115	576	29
Halter	Halter_41	1	19	35	681	4
Halter	Halter_41	1	20	29	687	4
Halter	Halter_41	1	21	375	344	1
Halter	Halter_41	1	22	554	135	31
Halter	Halter_41	1	23	297	353	70
Halter	Halter_41	2	0	532	181	7
Halter	Halter_41	2	1	10	708	2
Halter	Halter_41	2	2	15	704	1
Halter	Halter_41	2	3	15	701	4
Halter	Halter_41	2	4	25	693	2
Halter	Halter_41	2	5	7	712	1
Halter	Halter_41	2	6	21	695	4

Halter	Halter_41	2	7	5	715	0
Halter	Halter_41	2	8	392	308	20
Halter	Halter_41	2	9	523	145	52
Halter	Halter_41	2	10	542	114	64
Halter	Halter_41	2	11	503	154	63
Halter	Halter_41	2	12	632	70	18
Halter	Halter_41	2	13	649	57	14
Halter	Halter_41	2	14	626	80	14
Halter	Halter_41	2	15	633	68	19
Halter	Halter_41	2	16	635	71	14
Halter	Halter_41	2	17	487	171	62
Halter	Halter_41	2	18	25	688	7
Halter	Halter_41	2	19	18	701	1
Halter	Halter_41	2	20	60	656	4
Halter	Halter_41	2	21	22	695	3
Halter	Halter_41	2	22	12	707	1
Halter	Halter_41	2	23	368	347	5
Halter	Halter_41	3	0	387	194	139
Halter	Halter_41	3	1	152	538	30
Halter	Halter_41	3	2	11	707	2
Halter	Halter_41	3	3	29	673	18
Halter	Halter_41	3	4	18	699	3
Halter	Halter_41	3	5	38	678	4
Halter	Halter_41	3	6	23	690	7
Halter	Halter_41	3	7	7	713	0
Halter	Halter_41	3	8	167	475	78
Halter	Halter_41	3	9	476	113	131
Halter	Halter_41	3	10	480	140	100
Halter	Halter_41	3	11	536	114	70
Halter	Halter_41	3	12	565	93	62
Halter	Halter_41	3	13	537	114	69
Halter	Halter_41	3	14	612	85	23
Halter	Halter_41	3	15	607	80	33
Halter	Halter_41	3	16	592	75	53
Halter	Halter_41	3	17	237	254	229
Halter	Halter_41	3	18	34	665	21
Halter	Halter_41	3	19	12	706	2
Halter	Halter_41	3	20	23	691	6
Halter	Halter_41	3	21	22	695	3
Halter	Halter_41	3	22	111	606	3
Halter	Halter_41	3	23	323	238	159
Halter	Halter_42	1	0	570	126	24
Halter	Halter_42	1	1	228	469	23

Halter	Halter_42	1	2	32	680	8
Halter	Halter_42	1	3	58	656	6
Halter	Halter_42	1	4	15	704	1
Halter	Halter_42	1	5	25	693	2
Halter	Halter_42	1	6	24	693	3
Halter	Halter_42	1	7	37	675	8
Halter	Halter_42	1	8	195	515	10
Halter	Halter_42	1	9	588	107	25
Halter	Halter_42	1	10	600	104	16
Halter	Halter_42	1	11	621	45	54
Halter	Halter_42	1	12	646	33	41
Halter	Halter_42	1	13	657	47	16
Halter	Halter_42	1	14	567	107	46
Halter	Halter_42	1	15	565	122	33
Halter	Halter_42	1	16	512	136	72
Halter	Halter_42	1	17	499	169	52
Halter	Halter_42	1	18	178	501	41
Halter	Halter_42	1	19	83	629	8
Halter	Halter_42	1	20	103	610	7
Halter	Halter_42	1	21	37	677	6
Halter	Halter_42	1	22	26	691	3
Halter	Halter_42	1	23	121	566	33
Halter	Halter_42	2	0	212	485	23
Halter	Halter_42	2	1	259	443	18
Halter	Halter_42	2	2	256	457	7
Halter	Halter_42	2	3	18	697	5
Halter	Halter_42	2	4	19	701	0
Halter	Halter_42	2	5	19	699	2
Halter	Halter_42	2	6	15	705	0
Halter	Halter_42	2	7	46	669	5
Halter	Halter_42	2	8	19	700	1
Halter	Halter_42	2	9	482	222	16
Halter	Halter_42	2	10	521	155	44
Halter	Halter_42	2	11	479	208	33
Halter	Halter_42	2	12	272	434	14
Halter	Halter_42	2	13	572	104	44
Halter	Halter_42	2	14	586	104	30
Halter	Halter_42	2	15	600	79	41
Halter	Halter_42	2	16	562	102	56
Halter	Halter_42	2	17	522	154	44
Halter	Halter_42	2	18	91	600	29
Halter	Halter_42	2	19	20	695	5
Halter	Halter_42	2	20	16	702	2

Halter	Halter_42	2	21	358	311	51
Halter	Halter_42	2	22	8	710	2
Halter	Halter_42	2	23	128	567	25
Halter	Halter_42	3	0	38	672	10
Halter	Halter_42	3	1	15	702	3
Halter	Halter_42	3	2	38	680	2
Halter	Halter_42	3	3	70	643	7
Halter	Halter_42	3	4	21	698	1
Halter	Halter_42	3	5	24	690	6
Halter	Halter_42	3	6	20	698	2
Halter	Halter_42	3	7	12	707	1
Halter	Halter_42	3	8	120	552	48
Halter	Halter_42	3	9	575	78	67
Halter	Halter_42	3	10	590	81	49
Halter	Halter_42	3	11	552	118	50
Halter	Halter_42	3	12	632	62	26
Halter	Halter_42	3	13	609	77	34
Halter	Halter_42	3	14	592	88	40
Halter	Halter_42	3	15	491	153	76
Halter	Halter_42	3	16	390	229	101
Halter	Halter_42	3	17	435	170	115
Halter	Halter_42	3	18	52	638	30
Halter	Halter_42	3	19	170	520	30
Halter	Halter_42	3	20	19	697	4
Halter	Halter_42	3	21	18	701	1
Halter	Halter_42	3	22	294	378	48
Halter	Halter_42	3	23	393	262	65
Harness	Harness_19	1	0	34	686	0
Harness	Harness_19	1	1	49	669	2
Harness	Harness_19	1	2	13	704	3
Harness	Harness_19	1	3	13	707	0
Harness	Harness_19	1	4	1	719	0
Harness	Harness_19	1	5	5	714	1
Harness	Harness_19	1	6	35	681	4
Harness	Harness_19	1	7	27	686	7
Harness	Harness_19	1	8	37	681	2
Harness	Harness_19	1	9	32	687	1
Harness	Harness_19	1	10	55	664	1
Harness	Harness_19	1	11	154	561	5
Harness	Harness_19	1	12	102	613	5
Harness	Harness_19	1	13	83	635	2
Harness	Harness_19	1	14	88	630	2
Harness	Harness_19	1	15	84	634	2

Harness	Harness_19	1	16	58	662	0
Harness	Harness_19	1	17	100	610	10
Harness	Harness_19	1	18	109	609	2
Harness	Harness_19	1	19	31	689	0
Harness	Harness_19	1	20	22	696	2
Harness	Harness_19	1	21	21	699	0
Harness	Harness_19	1	22	8	711	1
Harness	Harness_19	1	23	70	648	2
Harness	Harness_19	2	0	38	679	3
Harness	Harness_19	2	1	7	712	1
Harness	Harness_19	2	2	2	713	5
Harness	Harness_19	2	3	2	712	6
Harness	Harness_19	2	4	10	709	1
Harness	Harness_19	2	5	4	716	0
Harness	Harness_19	2	6	11	708	1
Harness	Harness_19	2	7	3	717	0
Harness	Harness_19	2	8	31	686	3
Harness	Harness_19	2	9	47	667	6
Harness	Harness_19	2	10	99	617	4
Harness	Harness_19	2	11	157	555	8
Harness	Harness_19	2	12	24	694	2
Harness	Harness_19	2	13	38	681	1
Harness	Harness_19	2	14	51	668	1
Harness	Harness_19	2	15	63	657	0
Harness	Harness_19	2	16	91	626	3
Harness	Harness_19	2	17	122	595	3
Harness	Harness_19	2	18	12	708	0
Harness	Harness_19	2	19	4	716	0
Harness	Harness_19	2	20	7	713	0
Harness	Harness_19	2	21	8	712	0
Harness	Harness_19	2	22	1	718	1
Harness	Harness_19	2	23	21	698	1
Harness	Harness_19	3	0	46	673	1
Harness	Harness_19	3	1	54	664	2
Harness	Harness_19	3	2	2	718	0
Harness	Harness_19	3	3	5	715	0
Harness	Harness_19	3	4	4	716	0
Harness	Harness_19	3	5	15	704	1
Harness	Harness_19	3	6	5	715	0
Harness	Harness_19	3	7	5	714	1
Harness	Harness_19	3	8	108	606	6
Harness	Harness_19	3	9	109	608	3
Harness	Harness_19	3	10	91	626	3

Harness	Harness_19	3	11	41	678	1
Harness	Harness_19	3	12	83	634	3
Harness	Harness_19	3	13	47	673	0
Harness	Harness_19	3	14	75	641	4
Harness	Harness_19	3	15	61	659	0
Harness	Harness_19	3	16	131	588	1
Harness	Harness_19	3	17	94	621	5
Harness	Harness_19	3	18	18	698	4
Harness	Harness_19	3	19	0	720	0
Harness	Harness_19	3	20	8	712	0
Harness	Harness_19	3	21	14	706	0
Harness	Harness_19	3	22	9	708	3
Harness	Harness_19	3	23	35	684	1
Harness	Harness_21	1	0	57	663	0
Harness	Harness_21	1	1	32	688	0
Harness	Harness_21	1	2	8	711	1
Harness	Harness_21	1	3	56	663	1
Harness	Harness_21	1	4	0	720	0
Harness	Harness_21	1	5	7	713	0
Harness	Harness_21	1	6	1	719	0
Harness	Harness_21	1	7	72	647	1
Harness	Harness_21	1	8	71	647	2
Harness	Harness_21	1	9	68	649	3
Harness	Harness_21	1	10	50	661	9
Harness	Harness_21	1	11	220	493	7
Harness	Harness_21	1	12	185	531	4
Harness	Harness_21	1	13	112	608	0
Harness	Harness_21	1	14	135	581	4
Harness	Harness_21	1	15	116	603	1
Harness	Harness_21	1	16	141	576	3
Harness	Harness_21	1	17	120	599	1
Harness	Harness_21	1	18	67	652	1
Harness	Harness_21	1	19	18	701	1
Harness	Harness_21	1	20	6	714	0
Harness	Harness_21	1	21	11	706	3
Harness	Harness_21	1	22	7	713	0
Harness	Harness_21	1	23	61	659	0
Harness	Harness_21	2	0	7	711	2
Harness	Harness_21	2	1	14	706	0
Harness	Harness_21	2	2	5	713	2
Harness	Harness_21	2	3	4	713	3
Harness	Harness_21	2	4	12	706	2
Harness	Harness_21	2	5	30	688	2

Harness	Harness_21	2	6	25	694	1
Harness	Harness_21	2	7	10	710	0
Harness	Harness_21	2	8	9	710	1
Harness	Harness_21	2	9	20	697	3
Harness	Harness_21	2	10	91	626	3
Harness	Harness_21	2	11	107	612	1
Harness	Harness_21	2	12	95	625	0
Harness	Harness_21	2	13	92	627	1
Harness	Harness_21	2	14	113	604	3
Harness	Harness_21	2	15	52	667	1
Harness	Harness_21	2	16	123	596	1
Harness	Harness_21	2	17	128	587	5
Harness	Harness_21	2	18	28	692	0
Harness	Harness_21	2	19	13	707	0
Harness	Harness_21	2	20	6	712	2
Harness	Harness_21	2	21	17	703	0
Harness	Harness_21	2	22	30	689	1
Harness	Harness_21	2	23	44	674	2
Harness	Harness_21	3	0	100	619	1
Harness	Harness_21	3	1	4	716	0
Harness	Harness_21	3	2	0	720	0
Harness	Harness_21	3	3	27	692	1
Harness	Harness_21	3	4	6	714	0
Harness	Harness_21	3	5	1	719	0
Harness	Harness_21	3	6	3	717	0
Harness	Harness_21	3	7	12	706	2
Harness	Harness_21	3	8	77	635	8
Harness	Harness_21	3	9	178	540	2
Harness	Harness_21	3	10	137	580	3
Harness	Harness_21	3	11	59	661	0
Harness	Harness_21	3	12	110	604	6
Harness	Harness_21	3	13	16	702	2
Harness	Harness_21	3	14	130	589	1
Harness	Harness_21	3	15	155	564	1
Harness	Harness_21	3	16	98	622	0
Harness	Harness_21	3	17	123	590	7
Harness	Harness_21	3	18	58	662	0
Harness	Harness_21	3	19	10	710	0
Harness	Harness_21	3	20	5	715	0
Harness	Harness_21	3	21	42	677	1
Harness	Harness_21	3	22	4	716	0
Harness	Harness_21	3	23	29	689	2
Harness	Harness_24	1	0	103	614	3

Harness	Harness_24	1	1	58	657	5
Harness	Harness_24	1	2	38	677	5
Harness	Harness_24	1	3	7	713	0
Harness	Harness_24	1	4	30	687	3
Harness	Harness_24	1	5	20	699	1
Harness	Harness_24	1	6	6	713	1
Harness	Harness_24	1	7	0	720	0
Harness	Harness_24	1	8	75	640	5
Harness	Harness_24	1	9	66	653	1
Harness	Harness_24	1	10	65	652	3
Harness	Harness_24	1	11	237	468	15
Harness	Harness_24	1	12	162	549	9
Harness	Harness_24	1	13	205	509	6
Harness	Harness_24	1	14	141	573	6
Harness	Harness_24	1	15	130	582	8
Harness	Harness_24	1	16	114	604	2
Harness	Harness_24	1	17	92	621	7
Harness	Harness_24	1	18	100	615	5
Harness	Harness_24	1	19	9	709	2
Harness	Harness_24	1	20	2	718	0
Harness	Harness_24	1	21	48	671	1
Harness	Harness_24	1	22	12	708	0
Harness	Harness_24	1	23	35	684	1
Harness	Harness_24	2	0	0	717	3
Harness	Harness_24	2	1	12	703	5
Harness	Harness_24	2	2	6	711	3
Harness	Harness_24	2	3	10	704	6
Harness	Harness_24	2	4	2	715	3
Harness	Harness_24	2	5	2	718	0
Harness	Harness_24	2	6	1	719	0
Harness	Harness_24	2	7	1	719	0
Harness	Harness_24	2	8	67	643	10
Harness	Harness_24	2	9	62	651	7
Harness	Harness_24	2	10	10	710	0
Harness	Harness_24	2	11	100	613	7
Harness	Harness_24	2	12	100	617	3
Harness	Harness_24	2	13	19	700	1
Harness	Harness_24	2	14	97	620	3
Harness	Harness_24	2	15	105	614	1
Harness	Harness_24	2	16	138	576	6
Harness	Harness_24	2	17	154	556	10
Harness	Harness_24	2	18	63	654	3
Harness	Harness_24	2	19	1	719	0

Harness	Harness_24	2	20	25	693	2
Harness	Harness_24	2	21	14	705	1
Harness	Harness_24	2	22	3	716	1
Harness	Harness_24	2	23	13	705	2
Harness	Harness_24	3	0	23	696	1
Harness	Harness_24	3	1	13	705	2
Harness	Harness_24	3	2	12	702	6
Harness	Harness_24	3	3	9	710	1
Harness	Harness_24	3	4	0	720	0
Harness	Harness_24	3	5	6	714	0
Harness	Harness_24	3	6	7	712	1
Harness	Harness_24	3	7	1	719	0
Harness	Harness_24	3	8	86	624	10
Harness	Harness_24	3	9	201	511	8
Harness	Harness_24	3	10	104	614	2
Harness	Harness_24	3	11	78	641	1
Harness	Harness_24	3	12	112	601	7
Harness	Harness_24	3	13	144	569	7
Harness	Harness_24	3	14	169	547	4
Harness	Harness_24	3	15	181	536	3
Harness	Harness_24	3	16	131	588	1
Harness	Harness_24	3	17	161	534	25
Harness	Harness_24	3	18	38	678	4
Harness	Harness_24	3	19	0	720	0
Harness	Harness_24	3	20	9	710	1
Harness	Harness_24	3	21	7	713	0
Harness	Harness_24	3	22	10	709	1
Harness	Harness_24	3	23	5	715	0
Harness	Harness_28	1	0	102	617	1
Harness	Harness_28	1	1	52	667	1
Harness	Harness_28	1	2	16	703	1
Harness	Harness_28	1	3	4	716	0
Harness	Harness_28	1	4	12	706	2
Harness	Harness_28	1	5	4	716	0
Harness	Harness_28	1	6	14	706	0
Harness	Harness_28	1	7	7	713	0
Harness	Harness_28	1	8	130	587	3
Harness	Harness_28	1	9	82	637	1
Harness	Harness_28	1	10	111	607	2
Harness	Harness_28	1	11	221	477	22
Harness	Harness_28	1	12	159	554	7
Harness	Harness_28	1	13	159	551	10
Harness	Harness_28	1	14	84	634	2

Harness	Harness_28	1	15	104	616	0
Harness	Harness_28	1	16	158	557	5
Harness	Harness_28	1	17	126	582	12
Harness	Harness_28	1	18	68	645	7
Harness	Harness_28	1	19	6	714	0
Harness	Harness_28	1	20	28	691	1
Harness	Harness_28	1	21	8	711	1
Harness	Harness_28	1	22	5	714	1
Harness	Harness_28	1	23	78	639	3
Harness	Harness_28	2	0	91	625	4
Harness	Harness_28	2	1	42	676	2
Harness	Harness_28	2	2	7	711	2
Harness	Harness_28	2	3	37	679	4
Harness	Harness_28	2	4	16	702	2
Harness	Harness_28	2	5	0	720	0
Harness	Harness_28	2	6	8	711	1
Harness	Harness_28	2	7	1	719	0
Harness	Harness_28	2	8	54	665	1
Harness	Harness_28	2	9	70	647	3
Harness	Harness_28	2	10	27	691	2
Harness	Harness_28	2	11	118	601	1
Harness	Harness_28	2	12	98	620	2
Harness	Harness_28	2	13	119	597	4
Harness	Harness_28	2	14	100	618	2
Harness	Harness_28	2	15	101	615	4
Harness	Harness_28	2	16	96	621	3
Harness	Harness_28	2	17	102	615	3
Harness	Harness_28	2	18	100	619	1
Harness	Harness_28	2	19	0	720	0
Harness	Harness_28	2	20	12	708	0
Harness	Harness_28	2	21	5	715	0
Harness	Harness_28	2	22	5	714	1
Harness	Harness_28	2	23	2	717	1
Harness	Harness_28	3	0	9	711	0
Harness	Harness_28	3	1	7	713	0
Harness	Harness_28	3	2	87	629	4
Harness	Harness_28	3	3	40	678	2
Harness	Harness_28	3	4	6	714	0
Harness	Harness_28	3	5	2	717	1
Harness	Harness_28	3	6	5	715	0
Harness	Harness_28	3	7	2	718	0
Harness	Harness_28	3	8	109	597	14
Harness	Harness_28	3	9	259	447	14

Harness	Harness_28	3	10	170	542	8
Harness	Harness_28	3	11	103	613	4
Harness	Harness_28	3	12	160	556	4
Harness	Harness_28	3	13	124	594	2
Harness	Harness_28	3	14	104	613	3
Harness	Harness_28	3	15	192	521	7
Harness	Harness_28	3	16	116	600	4
Harness	Harness_28	3	17	127	570	23
Harness	Harness_28	3	18	65	655	0
Harness	Harness_28	3	19	8	712	0
Harness	Harness_28	3	20	6	714	0
Harness	Harness_28	3	21	0	720	0
Harness	Harness_28	3	22	38	681	1
Harness	Harness_28	3	23	82	637	1
Harness	Harness_30	1	0	119	598	3
Harness	Harness_30	1	1	80	639	1
Harness	Harness_30	1	2	42	677	1
Harness	Harness_30	1	3	28	690	2
Harness	Harness_30	1	4	0	720	0
Harness	Harness_30	1	5	12	708	0
Harness	Harness_30	1	6	5	715	0
Harness	Harness_30	1	7	18	702	0
Harness	Harness_30	1	8	51	665	4
Harness	Harness_30	1	9	72	647	1
Harness	Harness_30	1	10	56	659	5
Harness	Harness_30	1	11	296	406	18
Harness	Harness_30	1	12	277	421	22
Harness	Harness_30	1	13	288	422	10
Harness	Harness_30	1	14	239	474	7
Harness	Harness_30	1	15	207	506	7
Harness	Harness_30	1	16	177	533	10
Harness	Harness_30	1	17	154	554	12
Harness	Harness_30	1	18	152	559	9
Harness	Harness_30	1	19	85	632	3
Harness	Harness_30	1	20	11	707	2
Harness	Harness_30	1	21	53	666	1
Harness	Harness_30	1	22	9	711	0
Harness	Harness_30	1	23	82	636	2
Harness	Harness_30	2	0	48	669	3
Harness	Harness_30	2	1	24	694	2
Harness	Harness_30	2	2	13	706	1
Harness	Harness_30	2	3	0	720	0
Harness	Harness_30	2	4	33	682	5

Harness	Harness_30	2	5	25	694	1
Harness	Harness_30	2	6	0	720	0
Harness	Harness_30	2	7	5	715	0
Harness	Harness_30	2	8	6	713	1
Harness	Harness_30	2	9	105	612	3
Harness	Harness_30	2	10	101	615	4
Harness	Harness_30	2	11	151	563	6
Harness	Harness_30	2	12	147	573	0
Harness	Harness_30	2	13	144	572	4
Harness	Harness_30	2	14	126	592	2
Harness	Harness_30	2	15	130	583	7
Harness	Harness_30	2	16	129	589	2
Harness	Harness_30	2	17	151	565	4
Harness	Harness_30	2	18	91	626	3
Harness	Harness_30	2	19	1	719	0
Harness	Harness_30	2	20	39	679	2
Harness	Harness_30	2	21	7	712	1
Harness	Harness_30	2	22	52	666	2
Harness	Harness_30	2	23	43	674	3
Harness	Harness_30	3	0	51	666	3
Harness	Harness_30	3	1	33	686	1
Harness	Harness_30	3	2	0	720	0
Harness	Harness_30	3	3	7	713	0
Harness	Harness_30	3	4	12	708	0
Harness	Harness_30	3	5	1	718	1
Harness	Harness_30	3	6	5	715	0
Harness	Harness_30	3	7	4	715	1
Harness	Harness_30	3	8	113	586	21
Harness	Harness_30	3	9	261	445	14
Harness	Harness_30	3	10	218	491	11
Harness	Harness_30	3	11	169	545	6
Harness	Harness_30	3	12	210	499	11
Harness	Harness_30	3	13	56	661	3
Harness	Harness_30	3	14	129	586	5
Harness	Harness_30	3	15	134	579	7
Harness	Harness_30	3	16	120	595	5
Harness	Harness_30	3	17	153	552	15
Harness	Harness_30	3	18	64	656	0
Harness	Harness_30	3	19	9	711	0
Harness	Harness_30	3	20	19	699	2
Harness	Harness_30	3	21	3	717	0
Harness	Harness_30	3	22	82	635	3
Harness	Harness_30	3	23	62	657	1

Harness	Harness_35	1	0	53	665	2
Harness	Harness_35	1	1	26	693	1
Harness	Harness_35	1	2	5	715	0
Harness	Harness_35	1	3	12	708	0
Harness	Harness_35	1	4	19	701	0
Harness	Harness_35	1	5	7	713	0
Harness	Harness_35	1	6	0	720	0
Harness	Harness_35	1	7	13	705	2
Harness	Harness_35	1	8	29	690	1
Harness	Harness_35	1	9	8	711	1
Harness	Harness_35	1	10	58	660	2
Harness	Harness_35	1	11	159	545	16
Harness	Harness_35	1	12	56	654	10
Harness	Harness_35	1	13	65	655	0
Harness	Harness_35	1	14	106	607	7
Harness	Harness_35	1	15	44	675	1
Harness	Harness_35	1	16	57	661	2
Harness	Harness_35	1	17	80	635	5
Harness	Harness_35	1	18	127	584	9
Harness	Harness_35	1	19	34	685	1
Harness	Harness_35	1	20	18	701	1
Harness	Harness_35	1	21	30	689	1
Harness	Harness_35	1	22	9	711	0
Harness	Harness_35	1	23	52	665	3
Harness	Harness_35	2	0	4	715	1
Harness	Harness_35	2	1	12	706	2
Harness	Harness_35	2	2	5	713	2
Harness	Harness_35	2	3	8	711	1
Harness	Harness_35	2	4	0	720	0
Harness	Harness_35	2	5	4	715	1
Harness	Harness_35	2	6	1	719	0
Harness	Harness_35	2	7	15	704	1
Harness	Harness_35	2	8	19	700	1
Harness	Harness_35	2	9	55	662	3
Harness	Harness_35	2	10	99	619	2
Harness	Harness_35	2	11	85	635	0
Harness	Harness_35	2	12	31	688	1
Harness	Harness_35	2	13	29	690	1
Harness	Harness_35	2	14	39	680	1
Harness	Harness_35	2	15	83	633	4
Harness	Harness_35	2	16	64	655	1
Harness	Harness_35	2	17	89	629	2
Harness	Harness_35	2	18	68	647	5

Harness	Harness_35	2	19	9	710	1
Harness	Harness_35	2	20	7	713	0
Harness	Harness_35	2	21	39	680	1
Harness	Harness_35	2	22	3	717	0
Harness	Harness_35	2	23	3	714	3
Harness	Harness_35	3	0	30	688	2
Harness	Harness_35	3	1	32	686	2
Harness	Harness_35	3	2	0	720	0
Harness	Harness_35	3	3	5	715	0
Harness	Harness_35	3	4	5	714	1
Harness	Harness_35	3	5	9	711	0
Harness	Harness_35	3	6	2	717	1
Harness	Harness_35	3	7	7	712	1
Harness	Harness_35	3	8	45	669	6
Harness	Harness_35	3	9	121	593	6
Harness	Harness_35	3	10	76	642	2
Harness	Harness_35	3	11	53	665	2
Harness	Harness_35	3	12	67	643	10
Harness	Harness_35	3	13	70	646	4
Harness	Harness_35	3	14	98	618	4
Harness	Harness_35	3	15	150	565	5
Harness	Harness_35	3	16	132	573	15
Harness	Harness_35	3	17	109	591	20
Harness	Harness_35	3	18	9	711	0
Harness	Harness_35	3	19	1	719	0
Harness	Harness_35	3	20	4	716	0
Harness	Harness_35	3	21	2	718	0
Harness	Harness_35	3	22	6	714	0
Harness	Harness_35	3	23	6	713	1
Harness	Harness_40	1	0	82	634	4
Harness	Harness_40	1	1	8	712	0
Harness	Harness_40	1	2	7	713	0
Harness	Harness_40	1	3	9	710	1
Harness	Harness_40	1	4	12	708	0
Harness	Harness_40	1	5	0	720	0
Harness	Harness_40	1	6	5	715	0
Harness	Harness_40	1	7	1	719	0
Harness	Harness_40	1	8	23	697	0
Harness	Harness_40	1	9	45	675	0
Harness	Harness_40	1	10	111	608	1
Harness	Harness_40	1	11	169	546	5
Harness	Harness_40	1	12	126	592	2
Harness	Harness_40	1	13	72	645	3

Harness	Harness_40	1	14	87	633	0
Harness	Harness_40	1	15	98	621	1
Harness	Harness_40	1	16	99	616	5
Harness	Harness_40	1	17	89	625	6
Harness	Harness_40	1	18	44	672	4
Harness	Harness_40	1	19	7	713	0
Harness	Harness_40	1	20	15	705	0
Harness	Harness_40	1	21	52	667	1
Harness	Harness_40	1	22	14	704	2
Harness	Harness_40	1	23	35	684	1
Harness	Harness_40	2	0	4	715	1
Harness	Harness_40	2	1	14	705	1
Harness	Harness_40	2	2	27	690	3
Harness	Harness_40	2	3	17	699	4
Harness	Harness_40	2	4	4	716	0
Harness	Harness_40	2	5	0	720	0
Harness	Harness_40	2	6	13	706	1
Harness	Harness_40	2	7	17	702	1
Harness	Harness_40	2	8	56	660	4
Harness	Harness_40	2	9	60	658	2
Harness	Harness_40	2	10	81	639	0
Harness	Harness_40	2	11	91	626	3
Harness	Harness_40	2	12	114	602	4
Harness	Harness_40	2	13	90	627	3
Harness	Harness_40	2	14	95	623	2
Harness	Harness_40	2	15	84	635	1
Harness	Harness_40	2	16	101	619	0
Harness	Harness_40	2	17	73	642	5
Harness	Harness_40	2	18	50	668	2
Harness	Harness_40	2	19	0	720	0
Harness	Harness_40	2	20	5	715	0
Harness	Harness_40	2	21	15	705	0
Harness	Harness_40	2	22	28	690	2
Harness	Harness_40	2	23	4	716	0
Harness	Harness_40	3	0	81	637	2
Harness	Harness_40	3	1	90	626	4
Harness	Harness_40	3	2	0	720	0
Harness	Harness_40	3	3	12	707	1
Harness	Harness_40	3	4	7	713	0
Harness	Harness_40	3	5	0	720	0
Harness	Harness_40	3	6	2	718	0
Harness	Harness_40	3	7	7	713	0
Harness	Harness_40	3	8	118	593	9

Harness	Harness_40	3	9	163	555	2
Harness	Harness_40	3	10	142	574	4
Harness	Harness_40	3	11	42	678	0
Harness	Harness_40	3	12	88	628	4
Harness	Harness_40	3	13	101	617	2
Harness	Harness_40	3	14	71	649	0
Harness	Harness_40	3	15	145	574	1
Harness	Harness_40	3	16	136	581	3
Harness	Harness_40	3	17	101	613	6
Harness	Harness_40	3	18	10	710	0
Harness	Harness_40	3	19	16	703	1
Harness	Harness_40	3	20	1	719	0
Harness	Harness_40	3	21	8	712	0
Harness	Harness_40	3	22	9	711	0
Harness	Harness_40	3	23	30	688	2
Harness	Harness_41	1	0	48	672	0
Harness	Harness_41	1	1	11	709	0
Harness	Harness_41	1	2	4	715	1
Harness	Harness_41	1	3	11	709	0
Harness	Harness_41	1	4	7	712	1
Harness	Harness_41	1	5	5	715	0
Harness	Harness_41	1	6	13	707	0
Harness	Harness_41	1	7	6	714	0
Harness	Harness_41	1	8	20	700	0
Harness	Harness_41	1	9	37	681	2
Harness	Harness_41	1	10	69	649	2
Harness	Harness_41	1	11	179	534	7
Harness	Harness_41	1	12	69	651	0
Harness	Harness_41	1	13	111	605	4
Harness	Harness_41	1	14	97	623	0
Harness	Harness_41	1	15	74	641	5
Harness	Harness_41	1	16	70	650	0
Harness	Harness_41	1	17	97	615	8
Harness	Harness_41	1	18	72	641	7
Harness	Harness_41	1	19	17	703	0
Harness	Harness_41	1	20	13	707	0
Harness	Harness_41	1	21	12	708	0
Harness	Harness_41	1	22	39	679	2
Harness	Harness_41	1	23	69	648	3
Harness	Harness_41	2	0	33	687	0
Harness	Harness_41	2	1	7	712	1
Harness	Harness_41	2	2	1	719	0
Harness	Harness_41	2	3	6	714	0

Harness	Harness_41	2	4	12	708	0
Harness	Harness_41	2	5	0	720	0
Harness	Harness_41	2	6	8	711	1
Harness	Harness_41	2	7	0	720	0
Harness	Harness_41	2	8	43	676	1
Harness	Harness_41	2	9	72	644	4
Harness	Harness_41	2	10	63	652	5
Harness	Harness_41	2	11	51	668	1
Harness	Harness_41	2	12	71	648	1
Harness	Harness_41	2	13	36	683	1
Harness	Harness_41	2	14	52	667	1
Harness	Harness_41	2	15	73	646	1
Harness	Harness_41	2	16	70	650	0
Harness	Harness_41	2	17	86	628	6
Harness	Harness_41	2	18	12	708	0
Harness	Harness_41	2	19	3	717	0
Harness	Harness_41	2	20	9	711	0
Harness	Harness_41	2	21	6	714	0
Harness	Harness_41	2	22	1	719	0
Harness	Harness_41	2	23	20	699	1
Harness	Harness_41	3	0	40	680	0
Harness	Harness_41	3	1	33	687	0
Harness	Harness_41	3	2	3	717	0
Harness	Harness_41	3	3	3	716	1
Harness	Harness_41	3	4	5	715	0
Harness	Harness_41	3	5	5	715	0
Harness	Harness_41	3	6	6	713	1
Harness	Harness_41	3	7	3	717	0
Harness	Harness_41	3	8	80	635	5
Harness	Harness_41	3	9	135	584	1
Harness	Harness_41	3	10	112	607	1
Harness	Harness_41	3	11	71	648	1
Harness	Harness_41	3	12	90	629	1
Harness	Harness_41	3	13	106	612	2
Harness	Harness_41	3	14	73	646	1
Harness	Harness_41	3	15	109	611	0
Harness	Harness_41	3	16	84	634	2
Harness	Harness_41	3	17	94	619	7
Harness	Harness_41	3	18	11	708	1
Harness	Harness_41	3	19	4	716	0
Harness	Harness_41	3	20	11	708	1
Harness	Harness_41	3	21	2	717	1
Harness	Harness_41	3	22	19	701	0

Harness	Harness_41	3	23	20	700	0
Harness	Harness_42	1	0	61	659	0
Harness	Harness_42	1	1	54	665	1
Harness	Harness_42	1	2	20	699	1
Harness	Harness_42	1	3	32	687	1
Harness	Harness_42	1	4	3	717	0
Harness	Harness_42	1	5	6	714	0
Harness	Harness_42	1	6	22	696	2
Harness	Harness_42	1	7	38	680	2
Harness	Harness_42	1	8	43	676	1
Harness	Harness_42	1	9	75	642	3
Harness	Harness_42	1	10	101	617	2
Harness	Harness_42	1	11	224	481	15
Harness	Harness_42	1	12	164	549	7
Harness	Harness_42	1	13	110	609	1
Harness	Harness_42	1	14	114	600	6
Harness	Harness_42	1	15	93	625	2
Harness	Harness_42	1	16	144	572	4
Harness	Harness_42	1	17	125	592	3
Harness	Harness_42	1	18	119	597	4
Harness	Harness_42	1	19	43	676	1
Harness	Harness_42	1	20	29	691	0
Harness	Harness_42	1	21	26	691	3
Harness	Harness_42	1	22	13	705	2
Harness	Harness_42	1	23	86	632	2
Harness	Harness_42	2	0	29	689	2
Harness	Harness_42	2	1	50	668	2
Harness	Harness_42	2	2	22	697	1
Harness	Harness_42	2	3	4	713	3
Harness	Harness_42	2	4	4	716	0
Harness	Harness_42	2	5	4	716	0
Harness	Harness_42	2	6	0	720	0
Harness	Harness_42	2	7	14	703	3
Harness	Harness_42	2	8	4	716	0
Harness	Harness_42	2	9	48	670	2
Harness	Harness_42	2	10	108	611	1
Harness	Harness_42	2	11	83	632	5
Harness	Harness_42	2	12	51	669	0
Harness	Harness_42	2	13	90	630	0
Harness	Harness_42	2	14	81	638	1
Harness	Harness_42	2	15	92	623	5
Harness	Harness_42	2	16	101	615	4
Harness	Harness_42	2	17	105	613	2

Harness	Harness_42	2	18	54	664	2
Harness	Harness_42	2	19	9	710	1
Harness	Harness_42	2	20	6	714	0
Harness	Harness_42	2	21	90	629	1
Harness	Harness_42	2	22	2	718	0
Harness	Harness_42	2	23	39	678	3
Harness	Harness_42	3	0	20	698	2
Harness	Harness_42	3	1	5	715	0
Harness	Harness_42	3	2	5	714	1
Harness	Harness_42	3	3	20	700	0
Harness	Harness_42	3	4	2	717	1
Harness	Harness_42	3	5	13	705	2
Harness	Harness_42	3	6	9	711	0
Harness	Harness_42	3	7	8	711	1
Harness	Harness_42	3	8	97	615	8
Harness	Harness_42	3	9	247	473	0
Harness	Harness_42	3	10	161	556	3
Harness	Harness_42	3	11	147	571	2
Harness	Harness_42	3	12	91	628	1
Harness	Harness_42	3	13	105	612	3
Harness	Harness_42	3	14	132	582	6
Harness	Harness_42	3	15	126	591	3
Harness	Harness_42	3	16	99	619	2
Harness	Harness_42	3	17	172	540	8
Harness	Harness_42	3	18	36	683	1
Harness	Harness_42	3	19	46	673	1
Harness	Harness_42	3	20	5	714	1
Harness	Harness_42	3	21	4	716	0
Harness	Harness_42	3	22	77	640	3
Harness	Harness_42	3	23	54	665	1

Appendix 5. Supplementary material for Chapter 5

Appendix 5-1 R Script for preparation of GPS data and calculation of distance travelled

```
---
This describes R Script for preparing GPS data. Caution: Not the tidiest script you have seen
---
#READ THE DAILY GPS POSITION DATA AND
COMPILE THEM


#setwd("H:/seer/Data/position_data/raw_data")

#install.packages("plyr"); install.packages("lubridate");install.packages("sp");
install.packages("rgdal")#install the package, Only needs to be done once
```{r setup, include=FALSE}

library(lubridate);library(sp); library(rgdal);library(reshape2);library(tidyverse)#GRAB DATA
#Grab all the csv file names in THIS working directoryfiles <-
list.files(getwd(),pattern="*.CSV")
meta<-read.csv('../../meta-data/palmerston_metadata_1-8-2018.csv')

#CREATE FUNCTIONS NEEDED
first_day_of_month_wday <- function(dx) { day(dx) <- 1; wday(dx)}
select2<-function(x) x:(x+2)
tonum<-function(x) as.numeric(as.character(x))

#CREATE OBJECTS NEEDED
alldata<-c()
empty<-c()
date_time_NA<-c()
#in the loop:
diff_datetime<-c()
rptd_rownames<-c()
abnrml_records<-c()
lat_long_NA<-c()

# Create a list of dataframes and rename them
l<-lapply(setNames(files, make.names(gsub("CARTER", "GPS",gsub("*.CSV$", "",
files)))), read.csv)
length(l);length(files)

#k<-which(names(l)=="GPS9_9_Jan_18")

#REMOVE POTENTIAL EMPTY DATASETS AND KEEP TRACK OF THEM
if(sum(sapply(l, nrow)==0)>0){ empty<-paste(foldername,names(which(sapply(l,
nrow)==0)), sep=" / ")
                                             l<- l[-which(sapply(l, nrow)==0)] }
#BEFORE REMOVING ROWS: ADD a row_ID (unique for each folder) to be able to look at row
numbers in original files
```
```

```
addID<-function(x) cbind(x,row_ID=2:(nrow(x)+1))#create a function doing that (and
reordering columns)
l<-lapply(l,addID)#apply the function to all elements of your list#REMOVE
ALL ROWS WHERE LAT-LONG OR SAT ARE 0
rm0<-function(x) if(sum(x$lat==0|x$long==0|x$sats==0)>0){x<-x[-
which(x$lat==0|x$long==0|x$sats==0),]} else{x<-x}
l<-lapply(l,rm0)
#THEN remove first 2 rows of ACTUAL LOGGING DATA and NA generated columns ("X0" or
"X1")
rm2rows<-function(x) x[-c(1:2),!names(x)%in%c("X0","X1","X2")]l<-
lapply(l,rm2rows)

#Make a loop to go in each of the elements of the l list (dataframes):#tidy up
strange outputs in each row
#Grab the GPS number and append it as a new column,
```

```
#Tidy up data/time and convert to NZ time,
#Convert lat/long to NZTM.
for(k in 1:length(l)) #for each element of the list from 1 to the length of l
{
    store_different_dtformat<-c()
    store_rptd_rownames<-c()
    store_abnrml_records<-c()
    store_lat_long_NA<-c()
    #REMOVE REPEATED ROWNAMES (AND NEXT 2 ROWS)
    if(sum(is.na(as.numeric(as.character(l[[k]]$sats))))>0)
   {store_rptd_rownames<- paste(names(l[k]),sum(is.na(as.numeric(as.character(l[[k]]$sats)))),sep=" /
")
    l[[k]]<-l[[k]][-
  as.vector(sapply(which(is.na(as.numeric(as.character(l[[k]]$sats)))),select2)),]}#REMOVE
    ABNORMAL ROWS WHERE DATETIME STARTS WITH //
    if(length(grep("//",l[[k]][,1] ))!=0){store_abnrml_records<-
paste(names(l[k]),length(grep("//",l[[k]][,1] )),sep=" / ")
    l[[k]]<-l[[k]][-grep("//",l[[k]][,1] ),]}#TURN
    NUMERIVS BACK TO NUMERICS
    l[[k]][,-1]<-apply(l[[k]][,-1],2,tonum); #CONVERT
    THE FISRT COLUMN TO A CHARACTER STRING
    x<-as.character(l[[k]][,1])
    #the format of datetime is not conventional and not always the same, hence: #as.POSIXlt(x,
    tz="GMT", tryFormats = c('%d/%m/%y %H:%M:%S','%Y-%m-%d %H:%M:%S'))

   if(is.na(strptime(x,format='%Y-%m-%d %H:%M:%S')[1]) &
is.na(strptime(x,format='%d/%m/%y %H:%M:%S')[1]))
      {datetime<-as.POSIXct(x, format ='%d/%m/%Y %H:%M:%S',tz="GMT");
store_different_dtformat<- names(l[k])} else if(is.na(strptime(x,format='%d/%m/%y
%H:%M:%S')[1]))
      {datetime<-as.POSIXct(x, format ='%Y-%m-%d
%H:%M:%S',tz="GMT");store_different_dtformat<- names(l[k])} else
      {datetime<-as.POSIXct(x, format ='%d/%m/%y %H:%M:%S',tz="GMT")} #set what was the
original time zone upon recording

    attributes(datetime)$tzone <- "NZ"   #convert to NZ time zone
    l[[k]] <- l[[k]][,-1] #remove the first column of the dataframe (old datetime) l[[k]]<-
    cbind(datetime, l[[k]] )#add the new datetime instead (actually handled in R
as date-time)

    #check and store lat-long that are NA (not in the right format to be imported in R):
       if(sum(is.na(l[[k]][, c("long", "lat")]))>0)
   {store_lat_long_NA<-paste(names(l[k])," / row ", l[[k]][which(is.na(l[[k]][,c("long",
"lat")])),"row_ID"])
    l[[k]] <-l[[k]] [- which(is.na(l[[k]][, c("long", "lat")])),]   }

   coords.ll <- SpatialPoints(l[[k]][, c("long",
"lat")],proj4string=CRS("+init=epsg:4326") )
```

```
    coords.nztm <-spTransform(coords.ll, CRS("+init=epsg:2193"))
    l[[k]]<-data.frame(l[[k]][, !names(l[[k]])%in%c("long",
"lat")],coords.ll,coords.nztm)
   colnames(l[[k]])[(length(colnames(l[[k]]))-1):length(colnames(l[[k]]))]<-
c("NZTM_E","NZTM_S")

    diff_datetime<-c(diff_datetime,store_different_dtformat)
    rptd_rownames<-c(rptd_rownames,store_rptd_rownames)
    abnrml_records<-c(abnrml_records,store_abnrml_records)
    lat_long_NA<-c( lat_long_NA, store_lat_long_NA)

}

#Make a concatenated dataframe with ALL the data of all GPS for that sub-folder long<-ldply(l,
rbind)#note how this function actually uses the dataframe names (GPS
number_week) as a unique ID appended as a new column, to uniquely identify each subsetof the big
dataframe
names<-colsplit(string=long$.id   , pattern="_", names=c("GPS_ID", "week_ID"))
```

```
long<-cbind(names, long)
check<-
unique(paste(long$GPS_ID[is.na(long$datetime)],long$week_ID[is.na(long$datetime)]))
;check
long<-long[,-grep("X",names(long))]
names(long)[names(long)==".id"]<-"week_GPS_ID"
#CREATE UNIQUE ID OVER ALL THE DATA:
long$unique_ID<-seq(1:nrow(long))
long$week_GPS_ID<-
factor(long$week_GPS_ID)

#STORE DATA for which date-time could not be properly converted
date_time_NA<-ddply(long[is.na(long$datetime),],.(GPS_ID,week_ID),nrow)
colnames(date_time_NA)[grep("V1",colnames(date_time_NA))]<-"nb_rows"

#BRING METATDATA AND CONVERT DATETIMES
meta$obs_start<-as.POSIXct(meta$obs_start,format="%d/%m/%y %H:%M")
meta$obs_end<-as.POSIXct(meta$obs_end,format="%d/%m/%y %H:%M")
meta$date_last_drench<-as.POSIXct(meta$date_last_drench,format="%d_%b_%y")
meta$week_GPS_ID<-paste(meta$GPS_ID,meta$week_id,sep="_")


#MERGE WITH LONG
long<- merge(long,meta[,grep("obs|week_GPS_ID|date_last_drench|fec|weight|group",names(meta))]
  )

long %>% filter(sats < 3) %>% nrow()
#CREATE A VAIABLE TIME POST
DRENCH
long$tp_drench <-round(difftime(long$datetime,long$date_last_drench, units =
"days"),0)

#FLAG AND KEEP ONLY OBSERVATIONS WITHIN THE OBSERVATION TIME
keep_rec<-rep(0,nrow(long))
keep_rec[long$datetime>long$obs_start & long$datetime<long$obs_end]<-1
long<-long[keep_rec%in%1,]
rm(keep_rec);nrow(long)# 611238

#CALCULATE 24HRS
BLOCKS #CALCUATE
TIME SINCE START
long$days_from_start<-difftime(long$datetime,long$obs_start,units="days")max<-
ddply(long,.(week_GPS_ID), summarize, maxtime=max(days_from_start))
long<-merge(long,max,by.x="week_GPS_ID",by.y="week_GPS_ID",all.x=TRUE,all.y=FALSE)

#KEEP FULL 24 HOURS BLOCKS FOR THE LAST DAT OF THE WEEK
lastday<-which(floor(long$days_from_start)==floor(long$maxtime))
```

```
nearly_full<-lastday[lastday%in%which(long$maxtime-floor(long$maxtime)>=0.99)]
few_extras<-lastday[lastday%in%which(long$maxtime-floor(long$maxtime)<0.0)]
tokeep<-rep(1,nrow(long))
tokeep[lastday]<-0
tokeep[nearly_full]<-1
tokeep[few_extras]<-1
check<-lastday[lastday%in%which(long$maxtime-floor(long$maxtime)
<0.99)];length(check);nrow(long)-length(check)

long<-long[tokeep==1,]

#WHICH 24HRS BLOCKS DOES THIS VALUE BELONG TO? (USE ROUND 1 DIGITS AS
THE CRITERIA,i.e.0.95->2 and 1.04->1)
# long$block24_obs<-
ceiling(round(difftime(long$datetime,long$obs_start,units="days"),1))#
long$block24_obs[long$block24_obs==0]<-1

long$block24_obs<-ceiling(long$days_from_start)
long$maxtime

#IN THE MIDDLE
```

```
  long %>% group_by(week_GPS_ID,block24_obs)
     %>% summarize(n=n(),
     max=first(floor(maxtime)+1),
  last=last(obs_start),first=first(obs_start), last=last(datetime),first=first(datetime),
                 diff=difftime(last(datetime),first(datetime))) %>%
     filter(diff<24*0.95) %>%mutate(diffday=max-block24_obs) %>%filter(diffday>0)%>%ungroup()
     %>%  summarise(n=sum(n))

#LAST DAY
  long %>% group_by(week_GPS_ID,block24_obs)
     %>% summarize(n=n(),
     max=first(floor(maxtime)+1),
  last=last(obs_start),first=first(obs_start), last=last(datetime),first=first(datetime),
                 diff=difftime(last(datetime),first(datetime))) %>%
     filter(diff<24*0.95) %>%mutate(diffday=max-block24_obs) %>%filter(diffday<=0)%>%
     ungroup() %>%  summarise(n=sum(n))
#EVERYTHING
  long %>% group_by(week_GPS_ID,block24_obs)
     %>% summarize(n=n(),
     max=first(floor(maxtime)+1),
  last=last(obs_start),first=first(obs_start), last=last(datetime),first=first(datetime),
                 diff=difftime(last(datetime),first(datetime))) %>%
     filter(diff<24*0.95) %>%mutate(diffday=max-block24_obs) %>%
     ungroup() %>%  summarise(n=sum(n))

#TEST
short<-long %>% group_by(week_GPS_ID,block24_obs) %>%
summarize(n=n(), last=last(datetime),first=first(datetime),
diff=difftime(last(datetime),first(datetime))) %>%
filter(diff<24*0.95) #%>%ungroup() %>%   summarise(n=sum(n))

long %>% merge(.,short,by = c("week_GPS_ID","block24_obs"),all.x=FALSE,all.y=TRUE)
%>%nrow()

     filter(week_GPS_ID%in%short$week_GPS_ID & block24_obs%in%short$block24_obs)
     %>%filter(week_GPS_ID=="GPS10_13_Mar_18")

long %>% filter(week_GPS_ID=="GPS10_13_Mar_18"|block24_obs =="3")
GPS10_13_Mar_18 3


  short<-long %>% group_by(week_GPS_ID,block24_obs) %>%
     summarize(n=n(), last=last(datetime),first=first(datetime),
                 diff=difftime(last(datetime),first(datetime))) %>%
     filter(diff<24*0.95) %>% ungroup()%>% summarise(n=sum(n))

long %>% filter(week_GPS_ID%in%short$week_GPS_ID & block24_obs%in%short$block24_obs)
%>% nrow()
```

```
long %>% filter(week_GPS_ID%in%short$week_GPS_ID & block24_obs%in%short$block24_obs)
%>%

#CREATE A SUMMARY OF MAXTIMES BY GPS_WEEK TO FIND THE INCOMPLETE
BLOCKS
#ROUND TO ONE DIGIT AS THE PRECISION OF HOW WE WANT TO KEEP THE
OBSERVATIONS (0.95->2and 1.04->1)
max<-ddply(long,.(week_GPS_ID), summarize, maxtime_r=round(max(days_from_start),1))
long<-
merge(long,max,by.x="week_GPS_ID",by.y="week_GPS_ID",all.x=TRUE,all.y=FALSE)

#CREATE A CEILING OF THIS VARIABLE (BLOCK 24HRS THAT THE MAX BELONGS TO)
long$block24_max<-ceiling(long$maxtime_r)
long$block24_max[long$block24_max==0]<-1

#CREATE A FLAG FOR MAXTIMES THAT ARE NOT IN A FULL BLOCK BY COMPARING
WITH PRECISE(ROUNDED) VALUE
flag1<-rep(0,nrow(long));flag1[long$maxtime_r!=long$block24_max]<-1
#THEN A FLG WITHIN THIS FOR OBSERVATIONS IN THAT LAST
BLOCK
```

````
flag2<-rep(0,nrow(long));flag2[flag1==1 &long$block24_obs==long$block24_max]<-1
#REMOVE THE FLAGGED ROWS
old<-long[!flag2==1,]
nrow(old)
#long<-long[!flag2==1,]
long[setdiff(old$row_ID,new$row_ID),]

#REMOVE THE COLUMN MAXROUNDED
long<-long[,!names(long)%in%"maxtime_r"]
nrow(long)#585029


#CALCULATE DISTANCE
library(moveHMM)
install.packages("moveHMM")
help(moveHMM)
#THE ID TO BCALCULATE THE TRAJECTORY IS THE SHEEP_DAY
long$ID<-factor(paste(long$week_GPS_ID,long$block24_obs,sep="_"))

 long<-prepData(long, type = c("LL"),
    coordNames = c("long", "lat"),
    LLangle = TRUE)

#rename x and y as lat and long
long <- dplyr::rename(long, Latitude=y, Longitude=x)

```

## R Markdown
````
````

Appendix 5-2 Data table used for analysis of distance travelled in Chapter 5.2

Sheep ID	Calendar week	Day	Group	Study Week	Week post treatment	Distance travelled	Period	Season	Co_grazing lambs
35	9_Jan_18	1	B	3	3	2.32	1	Summer	yes
30	9_Jan_18	2	B	3	3	2.81	1	Summer	yes
30	9_Jan_18	1	B	3	3	3.32	1	Summer	yes
24	9_Jan_18	1	B	3	3	1.71	1	Summer	yes
24	9_Jan_18	2	B	3	3	1.73	1	Summer	yes
36	9_Jan_18	1	B	3	3	2.23	1	Summer	yes
36	9_Jan_18	2	B	3	3	2.05	1	Summer	yes
21	9_Jan_18	2	B	3	3	2.33	1	Summer	yes
21	9_Jan_18	1	B	3	3	2.49	1	Summer	yes
19	9_Jan_18	1	B	3	3	2.27	1	Summer	yes
19	9_Jan_18	2	B	3	3	2.11	1	Summer	yes
40	9_Jan_18	1	B	3	3	2.27	1	Summer	yes
40	9_Jan_18	2	B	3	3	2.66	1	Summer	yes
41	9_Jan_18	1	B	3	3	2.20	1	Summer	yes
42	9_Jan_18	1	B	3	3	2.18	1	Summer	yes
42	9_Jan_18	2	B	3	3	1.70	1	Summer	yes
25	16_Jan_18	2	A	4	1	2.24	1	Summer	yes
25	16_Jan_18	1	A	4	1	1.80	1	Summer	yes
35	16_Jan_18	1	B	4	4	2.14	1	Summer	yes
34	16_Jan_18	1	A	4	1	2.29	1	Summer	yes
34	16_Jan_18	2	A	4	1	2.24	1	Summer	yes
39	16_Jan_18	1	A	4	1	2.01	1	Summer	yes
28	16_Jan_18	1	B	4	4	2.39	1	Summer	yes
24	16_Jan_18	2	B	4	4	1.84	1	Summer	yes
24	16_Jan_18	1	B	4	4	1.90	1	Summer	yes
33	16_Jan_18	1	B	4	4	1.72	1	Summer	yes
33	16_Jan_18	2	B	4	4	2.23	1	Summer	yes
29	16_Jan_18	1	A	4	1	2.63	1	Summer	yes
29	16_Jan_18	2	A	4	1	2.58	1	Summer	yes
21	16_Jan_18	1	B	4	4	2.09	1	Summer	yes
21	16_Jan_18	2	B	4	4	2.43	1	Summer	yes
32	16_Jan_18	2	A	4	1	2.17	1	Summer	yes
32	16_Jan_18	1	A	4	1	1.88	1	Summer	yes
37	16_Jan_18	1	A	4	1	1.74	1	Summer	yes
19	16_Jan_18	1	B	4	4	2.32	1	Summer	yes
19	16_Jan_18	2	B	4	4	2.89	1	Summer	yes
40	16_Jan_18	2	B	4	4	2.65	1	Summer	yes
40	16_Jan_18	1	B	4	4	1.87	1	Summer	yes
23	16_Jan_18	2	A	4	1	2.39	1	Summer	yes

23	16_Jan_18	1	A	4	1	1.95	1	Summer	yes
31	16_Jan_18	1	A	4	1	1.90	1	Summer	yes
31	16_Jan_18	2	A	4	1	2.88	1	Summer	yes
41	16_Jan_18	1	B	4	4	2.43	1	Summer	yes
27	16_Jan_18	2	A	4	1	2.17	1	Summer	yes
27	16_Jan_18	1	A	4	1	2.11	1	Summer	yes
42	16_Jan_18	1	B	4	4	2.17	1	Summer	yes
42	16_Jan_18	2	B	4	4	2.14	1	Summer	yes
25	23_Jan_18	1	A	5	2	1.62	1	Summer	yes
35	23_Jan_18	2	B	5	5	1.79	1	Summer	yes
35	23_Jan_18	1	B	5	5	1.41	1	Summer	yes
26	23_Jan_18	2	A	5	2	1.61	1	Summer	yes
26	23_Jan_18	1	A	5	2	1.80	1	Summer	yes
30	23_Jan_18	1	B	5	5	1.62	1	Summer	yes
34	23_Jan_18	1	A	5	2	1.67	1	Summer	yes
34	23_Jan_18	2	A	5	2	1.82	1	Summer	yes
39	23_Jan_18	2	A	5	2	2.06	1	Summer	yes
39	23_Jan_18	1	A	5	2	1.45	1	Summer	yes
28	23_Jan_18	2	B	5	5	1.78	1	Summer	yes
28	23_Jan_18	1	B	5	5	1.59	1	Summer	yes
24	23_Jan_18	1	B	5	5	1.11	1	Summer	yes
24	23_Jan_18	2	B	5	5	1.50	1	Summer	yes
33	23_Jan_18	2	B	5	5	2.17	1	Summer	yes
33	23_Jan_18	1	B	5	5	1.47	1	Summer	yes
29	23_Jan_18	2	A	5	2	2.68	1	Summer	yes
29	23_Jan_18	1	A	5	2	2.06	1	Summer	yes
36	23_Jan_18	2	B	5	5	1.90	1	Summer	yes
36	23_Jan_18	1	B	5	5	1.59	1	Summer	yes
21	23_Jan_18	2	B	5	5	1.94	1	Summer	yes
21	23_Jan_18	1	B	5	5	1.40	1	Summer	yes
32	23_Jan_18	1	A	5	2	1.54	1	Summer	yes
32	23_Jan_18	2	A	5	2	1.70	1	Summer	yes
37	23_Jan_18	2	A	5	2	1.62	1	Summer	yes
37	23_Jan_18	1	A	5	2	1.21	1	Summer	yes
19	23_Jan_18	2	B	5	5	2.22	1	Summer	yes
19	23_Jan_18	1	B	5	5	1.45	1	Summer	yes
40	23_Jan_18	1	B	5	5	1.85	1	Summer	yes
40	23_Jan_18	2	B	5	5	1.88	1	Summer	yes
23	23_Jan_18	1	A	5	2	1.54	1	Summer	yes
23	23_Jan_18	2	A	5	2	1.97	1	Summer	yes
31	23_Jan_18	1	A	5	2	1.91	1	Summer	yes
31	23_Jan_18	2	A	5	2	2.38	1	Summer	yes
41	23_Jan_18	2	B	5	5	1.94	1	Summer	yes

41	23_Jan_18	1	B	5	5	1.62	1	Summer	yes
27	23_Jan_18	1	A	5	2	1.63	1	Summer	yes
27	23_Jan_18	2	A	5	2	1.98	1	Summer	yes
25	30_Jan_18	2	A	6	3	2.04	1	Summer	yes
25	30_Jan_18	1	A	6	3	1.51	1	Summer	yes
26	30_Jan_18	1	A	6	3	1.50	1	Summer	yes
26	30_Jan_18	2	A	6	3	1.53	1	Summer	yes
34	30_Jan_18	1	A	6	3	1.79	1	Summer	yes
34	30_Jan_18	2	A	6	3	2.07	1	Summer	yes
39	30_Jan_18	1	A	6	3	1.57	1	Summer	yes
39	30_Jan_18	2	A	6	3	1.43	1	Summer	yes
29	30_Jan_18	1	A	6	3	1.97	1	Summer	yes
32	30_Jan_18	2	A	6	3	1.57	1	Summer	yes
32	30_Jan_18	1	A	6	3	1.35	1	Summer	yes
38	30_Jan_18	2	A	6	3	2.05	1	Summer	yes
38	30_Jan_18	1	A	6	3	1.52	1	Summer	yes
37	30_Jan_18	2	A	6	3	1.49	1	Summer	yes
37	30_Jan_18	1	A	6	3	1.33	1	Summer	yes
23	30_Jan_18	1	A	6	3	1.71	1	Summer	yes
31	30_Jan_18	2	A	6	3	1.75	1	Summer	yes
31	30_Jan_18	1	A	6	3	1.09	1	Summer	yes
27	30_Jan_18	2	A	6	3	1.81	1	Summer	yes
27	30_Jan_18	1	A	6	3	1.39	1	Summer	yes
25	6_Feb_18	1	A	7	4	1.84	1	Summer	yes
25	6_Feb_18	2	A	7	4	2.09	1	Summer	yes
35	6_Feb_18	1	B	7	1	1.86	1	Summer	yes
35	6_Feb_18	2	B	7	1	2.03	1	Summer	yes
26	6_Feb_18	2	A	7	4	1.57	1	Summer	yes
26	6_Feb_18	1	A	7	4	1.17	1	Summer	yes
30	6_Feb_18	2	B	7	1	2.19	1	Summer	yes
30	6_Feb_18	1	B	7	1	1.82	1	Summer	yes
34	6_Feb_18	2	A	7	4	2.12	1	Summer	yes
34	6_Feb_18	1	A	7	4	2.00	1	Summer	yes
28	6_Feb_18	1	B	7	1	2.41	1	Summer	yes
28	6_Feb_18	2	B	7	1	3.00	1	Summer	yes
24	6_Feb_18	1	B	7	1	0.99	1	Summer	yes
24	6_Feb_18	2	B	7	1	1.62	1	Summer	yes
33	6_Feb_18	2	B	7	1	2.00	1	Summer	yes
33	6_Feb_18	1	B	7	1	1.89	1	Summer	yes
29	6_Feb_18	1	A	7	4	1.84	1	Summer	yes
29	6_Feb_18	2	A	7	4	1.73	1	Summer	yes
36	6_Feb_18	2	B	7	1	2.24	1	Summer	yes
36	6_Feb_18	1	B	7	1	1.84	1	Summer	yes

21	6_Feb_18	2	B	7	1	1.90	1	Summer	yes
21	6_Feb_18	1	B	7	1	2.00	1	Summer	yes
32	6_Feb_18	2	A	7	4	1.67	1	Summer	yes
32	6_Feb_18	1	A	7	4	1.30	1	Summer	yes
37	6_Feb_18	1	A	7	4	1.55	1	Summer	yes
37	6_Feb_18	2	A	7	4	1.82	1	Summer	yes
19	6_Feb_18	1	B	7	1	1.72	1	Summer	yes
19	6_Feb_18	2	B	7	1	2.05	1	Summer	yes
40	6_Feb_18	1	B	7	1	1.68	1	Summer	yes
40	6_Feb_18	2	B	7	1	2.09	1	Summer	yes
23	6_Feb_18	2	A	7	4	2.09	1	Summer	yes
23	6_Feb_18	1	A	7	4	1.60	1	Summer	yes
31	6_Feb_18	2	A	7	4	2.45	1	Summer	yes
31	6_Feb_18	1	A	7	4	1.76	1	Summer	yes
39	6_Feb_18	2	A	7	4	1.80	1	Summer	yes
39	6_Feb_18	1	A	7	4	1.37	1	Summer	yes
41	6_Feb_18	2	B	7	1	2.01	1	Summer	yes
41	6_Feb_18	1	B	7	1	1.95	1	Summer	yes
27	6_Feb_18	2	A	7	4	1.79	1	Summer	yes
27	6_Feb_18	1	A	7	4	1.45	1	Summer	yes
42	6_Feb_18	2	B	7	1	2.15	1	Summer	yes
42	6_Feb_18	1	B	7	1	1.73	1	Summer	yes
25	13_Feb_18	1	A	8	5	1.60	1	Summer	yes
25	13_Feb_18	2	A	8	5	1.42	1	Summer	yes
35	13_Feb_18	2	B	8	2	1.06	1	Summer	yes
35	13_Feb_18	1	B	8	2	1.27	1	Summer	yes
26	13_Feb_18	1	A	8	5	1.05	1	Summer	yes
26	13_Feb_18	2	A	8	5	0.73	1	Summer	yes
30	13_Feb_18	2	B	8	2	2.68	1	Summer	yes
30	13_Feb_18	1	B	8	2	1.60	1	Summer	yes
34	13_Feb_18	2	A	8	5	1.24	1	Summer	yes
34	13_Feb_18	1	A	8	5	1.27	1	Summer	yes
28	13_Feb_18	2	B	8	2	1.54	1	Summer	yes
28	13_Feb_18	1	B	8	2	1.68	1	Summer	yes
24	13_Feb_18	2	B	8	2	0.76	1	Summer	yes
24	13_Feb_18	1	B	8	2	0.99	1	Summer	yes
33	13_Feb_18	1	B	8	2	1.28	1	Summer	yes
33	13_Feb_18	2	B	8	2	1.26	1	Summer	yes
29	13_Feb_18	1	A	8	5	1.68	1	Summer	yes
29	13_Feb_18	2	A	8	5	2.44	1	Summer	yes
36	13_Feb_18	2	B	8	2	1.18	1	Summer	yes
36	13_Feb_18	1	B	8	2	1.24	1	Summer	yes
38	13_Feb_18	2	A	8	5	1.05	1	Summer	yes

38	13_Feb_18	1	A	8	5	1.38	1	Summer	yes
21	13_Feb_18	2	B	8	2	2.01	1	Summer	yes
21	13_Feb_18	1	B	8	2	1.42	1	Summer	yes
32	13_Feb_18	2	A	8	5	1.44	1	Summer	yes
32	13_Feb_18	1	A	8	5	1.01	1	Summer	yes
37	13_Feb_18	2	A	8	5	1.04	1	Summer	yes
37	13_Feb_18	1	A	8	5	1.19	1	Summer	yes
19	13_Feb_18	1	B	8	2	1.32	1	Summer	yes
19	13_Feb_18	2	B	8	2	1.06	1	Summer	yes
40	13_Feb_18	2	B	8	2	1.32	1	Summer	yes
40	13_Feb_18	1	B	8	2	1.32	1	Summer	yes
23	13_Feb_18	2	A	8	5	1.08	1	Summer	yes
23	13_Feb_18	1	A	8	5	1.31	1	Summer	yes
31	13_Feb_18	2	A	8	5	1.12	1	Summer	yes
31	13_Feb_18	1	A	8	5	1.74	1	Summer	yes
39	13_Feb_18	2	A	8	5	1.23	1	Summer	yes
39	13_Feb_18	1	A	8	5	1.19	1	Summer	yes
41	13_Feb_18	2	B	8	2	1.07	1	Summer	yes
41	13_Feb_18	1	B	8	2	1.33	1	Summer	yes
27	13_Feb_18	1	A	8	5	1.22	1	Summer	yes
27	13_Feb_18	2	A	8	5	1.08	1	Summer	yes
42	13_Feb_18	2	B	8	2	1.23	1	Summer	yes
42	13_Feb_18	1	B	8	2	1.70	1	Summer	yes
39	10_April_18	2	A	16	4	1.16	2	Autumn	yes
39	10_April_18	1	A	16	4	1.68	2	Autumn	yes
35	10_April_18	2	B	16	1	1.40	2	Autumn	yes
35	10_April_18	1	B	16	1	1.64	2	Autumn	yes
26	10_April_18	2	A	16	4	1.19	2	Autumn	yes
26	10_April_18	1	A	16	4	1.67	2	Autumn	yes
30	10_April_18	2	B	16	1	1.86	2	Autumn	yes
30	10_April_18	1	B	16	1	2.39	2	Autumn	yes
41	10_April_18	1	B	16	1	1.53	2	Autumn	yes
41	10_April_18	2	B	16	1	1.32	2	Autumn	yes
33	10_April_18	2	B	16	1	1.51	2	Autumn	yes
33	10_April_18	1	B	16	1	1.66	2	Autumn	yes
36	10_April_18	1	B	16	1	1.51	2	Autumn	yes
36	10_April_18	2	B	16	1	1.60	2	Autumn	yes
40	10_April_18	2	B	16	1	1.65	2	Autumn	yes
40	10_April_18	1	B	16	1	1.93	2	Autumn	yes
21	10_April_18	2	B	16	1	1.66	2	Autumn	yes
21	10_April_18	1	B	16	1	1.67	2	Autumn	yes
32	10_April_18	1	A	16	4	2.08	2	Autumn	yes
32	10_April_18	2	A	16	4	1.23	2	Autumn	yes

28	10_April_18	1	B	16	1	1.26	2	Autumn	yes
37	10_April_18	1	A	16	4	1.78	2	Autumn	yes
37	10_April_18	2	A	16	4	1.13	2	Autumn	yes
19	10_April_18	1	B	16	1	1.67	2	Autumn	yes
19	10_April_18	2	B	16	1	1.31	2	Autumn	yes
24	10_April_18	2	B	16	1	1.21	2	Autumn	yes
24	10_April_18	1	B	16	1	1.71	2	Autumn	yes
23	10_April_18	2	A	16	4	1.63	2	Autumn	yes
23	10_April_18	1	A	16	4	2.02	2	Autumn	yes
31	10_April_18	1	A	16	4	1.88	2	Autumn	yes
31	10_April_18	2	A	16	4	1.57	2	Autumn	yes
38	10_April_18	1	A	16	4	1.79	2	Autumn	yes
38	10_April_18	2	A	16	4	1.50	2	Autumn	yes
34	10_April_18	2	A	16	4	1.56	2	Autumn	yes
34	10_April_18	1	A	16	4	1.62	2	Autumn	yes
27	10_April_18	1	A	16	4	1.43	2	Autumn	yes
27	10_April_18	2	A	16	4	1.24	2	Autumn	yes
42	10_April_18	2	B	16	1	1.42	2	Autumn	yes
42	10_April_18	1	B	16	1	1.42	2	Autumn	yes
39	17_April_18	1	A	17	5	1.71	2	Autumn	yes
39	17_April_18	2	A	17	5	1.99	2	Autumn	yes
35	17_April_18	2	B	17	2	1.80	2	Autumn	yes
35	17_April_18	1	B	17	2	1.20	2	Autumn	yes
26	17_April_18	1	A	17	5	1.12	2	Autumn	yes
26	17_April_18	2	A	17	5	1.53	2	Autumn	yes
29	17_April_18	2	A	17	5	2.76	2	Autumn	yes
29	17_April_18	1	A	17	5	2.06	2	Autumn	yes
30	17_April_18	1	B	17	2	1.98	2	Autumn	yes
30	17_April_18	2	B	17	2	2.49	2	Autumn	yes
41	17_April_18	2	B	17	2	1.73	2	Autumn	yes
41	17_April_18	1	B	17	2	1.53	2	Autumn	yes
40	17_April_18	1	B	17	2	1.45	2	Autumn	yes
40	17_April_18	2	B	17	2	1.76	2	Autumn	yes
21	17_April_18	1	B	17	2	1.55	2	Autumn	yes
21	17_April_18	2	B	17	2	1.87	2	Autumn	yes
32	17_April_18	2	A	17	5	1.35	2	Autumn	yes
32	17_April_18	1	A	17	5	1.23	2	Autumn	yes
28	17_April_18	1	B	17	2	1.89	2	Autumn	yes
28	17_April_18	2	B	17	2	2.02	2	Autumn	yes
37	17_April_18	1	A	17	5	1.17	2	Autumn	yes
37	17_April_18	2	A	17	5	1.61	2	Autumn	yes
19	17_April_18	1	B	17	2	1.40	2	Autumn	yes
19	17_April_18	2	B	17	2	2.08	2	Autumn	yes

23	17_April_18	2	A	17	5	2.17	2	Autumn	yes
23	17_April_18	1	A	17	5	1.55	2	Autumn	yes
31	17_April_18	2	A	17	5	1.79	2	Autumn	yes
31	17_April_18	1	A	17	5	1.57	2	Autumn	yes
38	17_April_18	2	A	17	5	2.36	2	Autumn	yes
38	17_April_18	1	A	17	5	1.70	2	Autumn	yes
34	17_April_18	1	A	17	5	2.00	2	Autumn	yes
34	17_April_18	2	A	17	5	2.24	2	Autumn	yes
42	17_April_18	1	B	17	2	1.31	2	Autumn	yes
42	17_April_18	2	B	17	2	1.87	2	Autumn	yes
27	17_April_18	2	A	17	5	1.62	2	Autumn	yes
27	17_April_18	1	A	17	5	1.31	2	Autumn	yes
39	4_May_18	2	A	19	1	1.63	2	Autumn	yes
39	4_May_18	1	A	19	1	1.24	2	Autumn	yes
35	4_May_18	1	B	19	4	1.13	2	Autumn	yes
35	4_May_18	2	B	19	4	1.35	2	Autumn	yes
26	4_May_18	1	A	19	1	1.13	2	Autumn	yes
26	4_May_18	2	A	19	1	1.25	2	Autumn	yes
30	4_May_18	2	B	19	4	1.88	2	Autumn	yes
30	4_May_18	1	B	19	4	1.63	2	Autumn	yes
33	4_May_18	2	B	19	4	1.57	2	Autumn	yes
33	4_May_18	1	B	19	4	1.19	2	Autumn	yes
41	4_May_18	1	B	19	4	1.16	2	Autumn	yes
41	4_May_18	2	B	19	4	1.44	2	Autumn	yes
29	4_May_18	1	A	19	1	1.66	2	Autumn	yes
29	4_May_18	2	A	19	1	2.30	2	Autumn	yes
40	4_May_18	1	B	19	4	1.24	2	Autumn	yes
40	4_May_18	2	B	19	4	1.58	2	Autumn	yes
21	4_May_18	1	B	19	4	0.69	2	Autumn	yes
21	4_May_18	2	B	19	4	2.19	2	Autumn	yes
32	4_May_18	1	A	19	1	1.43	2	Autumn	yes
32	4_May_18	2	A	19	1	1.11	2	Autumn	yes
28	4_May_18	2	B	19	4	1.82	2	Autumn	yes
28	4_May_18	1	B	19	4	1.32	2	Autumn	yes
37	4_May_18	1	A	19	1	0.84	2	Autumn	yes
37	4_May_18	2	A	19	1	1.22	2	Autumn	yes
19	4_May_18	2	B	19	4	1.17	2	Autumn	yes
19	4_May_18	1	B	19	4	1.06	2	Autumn	yes
24	4_May_18	1	B	19	4	0.96	2	Autumn	yes
24	4_May_18	2	B	19	4	1.36	2	Autumn	yes
31	4_May_18	2	A	19	1	2.30	2	Autumn	yes
31	4_May_18	1	A	19	1	1.60	2	Autumn	yes
38	4_May_18	2	A	19	1	2.13	2	Autumn	yes

38	4_May_18	1	A	19	1	1.50	2	Autumn	yes
34	4_May_18	1	A	19	1	1.54	2	Autumn	yes
34	4_May_18	2	A	19	1	2.12	2	Autumn	yes
42	4_May_18	1	B	19	4	1.48	2	Autumn	yes
42	4_May_18	2	B	19	4	1.94	2	Autumn	yes
27	4_May_18	1	A	19	1	1.31	2	Autumn	yes
27	4_May_18	2	A	19	1	1.63	2	Autumn	yes
23	4_May_18	1	A	19	1	1.27	2	Autumn	yes
23	4_May_18	2	A	19	1	1.71	2	Autumn	yes
39	8_May_18	1	A	20	2	1.65	2	Autumn	yes
39	8_May_18	2	A	20	2	1.44	2	Autumn	yes
35	8_May_18	2	B	20	5	1.13	2	Autumn	yes
35	8_May_18	1	B	20	5	1.21	2	Autumn	yes
26	8_May_18	1	A	20	2	1.00	2	Autumn	yes
26	8_May_18	2	A	20	2	1.00	2	Autumn	yes
30	8_May_18	1	B	20	5	1.40	2	Autumn	yes
30	8_May_18	2	B	20	5	1.33	2	Autumn	yes
33	8_May_18	2	B	20	5	1.26	2	Autumn	yes
33	8_May_18	1	B	20	5	1.48	2	Autumn	yes
41	8_May_18	1	B	20	5	1.39	2	Autumn	yes
41	8_May_18	2	B	20	5	1.39	2	Autumn	yes
29	8_May_18	1	A	20	2	2.30	2	Autumn	yes
29	8_May_18	2	A	20	2	1.85	2	Autumn	yes
40	8_May_18	2	B	20	5	1.44	2	Autumn	yes
40	8_May_18	1	B	20	5	1.80	2	Autumn	yes
36	8_May_18	1	B	20	5	1.58	2	Autumn	yes
36	8_May_18	2	B	20	5	1.14	2	Autumn	yes
21	8_May_18	2	B	20	5	1.76	2	Autumn	yes
21	8_May_18	1	B	20	5	2.18	2	Autumn	yes
32	8_May_18	2	A	20	2	1.47	2	Autumn	yes
32	8_May_18	1	A	20	2	1.52	2	Autumn	yes
28	8_May_18	2	B	20	5	1.51	2	Autumn	yes
28	8_May_18	1	B	20	5	1.90	2	Autumn	yes
37	8_May_18	1	A	20	2	1.24	2	Autumn	yes
37	8_May_18	2	A	20	2	1.13	2	Autumn	yes
19	8_May_18	1	B	20	5	1.18	2	Autumn	yes
19	8_May_18	2	B	20	5	1.09	2	Autumn	yes
24	8_May_18	1	B	20	5	1.27	2	Autumn	yes
24	8_May_18	2	B	20	5	1.28	2	Autumn	yes
31	8_May_18	1	A	20	2	2.13	2	Autumn	yes
31	8_May_18	2	A	20	2	1.80	2	Autumn	yes
38	8_May_18	1	A	20	2	1.76	2	Autumn	yes
38	8_May_18	2	A	20	2	1.51	2	Autumn	yes

34	8_May_18	2	A	20	2	1.64	2	Autumn	yes
34	8_May_18	1	A	20	2	2.06	2	Autumn	yes
42	8_May_18	1	B	20	5	1.29	2	Autumn	yes
42	8_May_18	2	B	20	5	1.32	2	Autumn	yes
27	8_May_18	2	A	20	2	1.45	2	Autumn	yes
27	8_May_18	1	A	20	2	1.86	2	Autumn	yes
23	8_May_18	1	A	20	2	1.66	2	Autumn	yes
23	8_May_18	2	A	20	2	1.62	2	Autumn	yes
39	15_May_18	2	A	21	3	1.31	3	Autumn	no
39	15_May_18	1	A	21	3	1.24	3	Autumn	no
26	15_May_18	1	A	21	3	0.87	3	Autumn	no
26	15_May_18	2	A	21	3	1.02	3	Autumn	no
29	15_May_18	2	A	21	3	2.47	3	Autumn	no
29	15_May_18	1	A	21	3	2.24	3	Autumn	no
32	15_May_18	1	A	21	3	1.12	3	Autumn	no
32	15_May_18	2	A	21	3	1.22	3	Autumn	no
37	15_May_18	1	A	21	3	0.94	3	Autumn	no
37	15_May_18	2	A	21	3	0.97	3	Autumn	no
31	15_May_18	2	A	21	3	1.70	3	Autumn	no
31	15_May_18	1	A	21	3	2.02	3	Autumn	no
38	15_May_18	2	A	21	3	1.60	3	Autumn	no
38	15_May_18	1	A	21	3	1.47	3	Autumn	no
34	15_May_18	2	A	21	3	1.45	3	Autumn	no
34	15_May_18	1	A	21	3	1.74	3	Autumn	no
27	15_May_18	1	A	21	3	1.74	3	Autumn	no
27	15_May_18	2	A	21	3	1.77	3	Autumn	no
23	15_May_18	1	A	21	3	1.41	3	Autumn	no
23	15_May_18	2	A	21	3	1.46	3	Autumn	no
39	22_May_18	1	A	22	4	1.21	3	Autumn	no
35	22_May_18	1	B	22	1	1.20	3	Autumn	no
26	22_May_18	1	A	22	4	1.01	3	Autumn	no
30	22_May_18	1	B	22	1	1.69	3	Autumn	no
41	22_May_18	1	B	22	1	1.51	3	Autumn	no
29	22_May_18	1	A	22	4	1.33	3	Autumn	no
29	22_May_18	2	A	22	4	1.14	3	Autumn	no
40	22_May_18	1	B	22	1	1.61	3	Autumn	no
36	22_May_18	1	B	22	1	1.55	3	Autumn	no
33	22_May_18	1	B	22	1	1.41	3	Autumn	no
21	22_May_18	1	B	22	1	1.73	3	Autumn	no
32	22_May_18	1	A	22	4	1.07	3	Autumn	no
28	22_May_18	1	B	22	1	1.63	3	Autumn	no
37	22_May_18	1	A	22	4	1.14	3	Autumn	no
19	22_May_18	1	B	22	1	1.15	3	Autumn	no

24	22_May_18	1	B	22	1	1.08	3	Autumn	no
31	22_May_18	1	A	22	4	2.17	3	Autumn	no
38	22_May_18	1	A	22	4	1.29	3	Autumn	no
34	22_May_18	1	A	22	4	1.38	3	Autumn	no
42	22_May_18	1	B	22	1	1.24	3	Autumn	no
27	22_May_18	1	A	22	4	1.55	3	Autumn	no
23	22_May_18	1	A	22	4	1.72	3	Autumn	no
39	29_May_18	2	A	23	5	0.95	3	Autumn	no
39	29_May_18	1	A	23	5	1.37	3	Autumn	no
35	29_May_18	2	B	23	2	1.30	3	Autumn	no
35	29_May_18	1	B	23	2	1.52	3	Autumn	no
26	29_May_18	1	A	23	5	1.21	3	Autumn	no
26	29_May_18	2	A	23	5	0.94	3	Autumn	no
30	29_May_18	1	B	23	2	2.67	3	Autumn	no
30	29_May_18	2	B	23	2	2.05	3	Autumn	no
41	29_May_18	2	B	23	2	1.15	3	Autumn	no
41	29_May_18	1	B	23	2	1.72	3	Autumn	no
29	29_May_18	1	A	23	5	0.98	3	Autumn	no
29	29_May_18	2	A	23	5	0.88	3	Autumn	no
40	29_May_18	2	B	23	2	1.56	3	Autumn	no
40	29_May_18	1	B	23	2	2.24	3	Autumn	no
36	29_May_18	1	B	23	2	1.87	3	Autumn	no
36	29_May_18	2	B	23	2	1.43	3	Autumn	no
33	29_May_18	2	B	23	2	1.47	3	Autumn	no
33	29_May_18	1	B	23	2	1.49	3	Autumn	no
21	29_May_18	2	B	23	2	1.41	3	Autumn	no
21	29_May_18	1	B	23	2	2.17	3	Autumn	no
32	29_May_18	1	A	23	5	1.39	3	Autumn	no
32	29_May_18	2	A	23	5	1.15	3	Autumn	no
28	29_May_18	1	B	23	2	2.14	3	Autumn	no
28	29_May_18	2	B	23	2	1.56	3	Autumn	no
37	29_May_18	2	A	23	5	0.69	3	Autumn	no
37	29_May_18	1	A	23	5	1.19	3	Autumn	no
19	29_May_18	2	B	23	2	1.22	3	Autumn	no
19	29_May_18	1	B	23	2	1.71	3	Autumn	no
24	29_May_18	2	B	23	2	1.12	3	Autumn	no
24	29_May_18	1	B	23	2	1.37	3	Autumn	no
31	29_May_18	2	A	23	5	1.89	3	Autumn	no
31	29_May_18	1	A	23	5	2.39	3	Autumn	no
38	29_May_18	1	A	23	5	1.97	3	Autumn	no
38	29_May_18	2	A	23	5	1.71	3	Autumn	no
34	29_May_18	2	A	23	5	1.25	3	Autumn	no
34	29_May_18	1	A	23	5	1.84	3	Autumn	no

42	29_May_18	2	B	23	2	1.45	3	Autumn	no
42	29_May_18	1	B	23	2	1.99	3	Autumn	no
27	29_May_18	1	A	23	5	1.78	3	Autumn	no
27	29_May_18	2	A	23	5	1.18	3	Autumn	no
23	29_May_18	1	A	23	5	1.84	3	Autumn	no
23	29_May_18	2	A	23	5	1.25	3	Autumn	no
35	5_Jun_18	2	B	24	3	1.84	3	Winter	no
35	5_Jun_18	1	B	24	3	1.54	3	Winter	no
30	5_Jun_18	1	B	24	3	2.03	3	Winter	no
30	5_Jun_18	2	B	24	3	2.32	3	Winter	no
41	5_Jun_18	1	B	24	3	1.80	3	Winter	no
41	5_Jun_18	2	B	24	3	1.71	3	Winter	no
40	5_Jun_18	2	B	24	3	1.85	3	Winter	no
40	5_Jun_18	1	B	24	3	1.96	3	Winter	no
36	5_Jun_18	2	B	24	3	2.12	3	Winter	no
36	5_Jun_18	1	B	24	3	1.89	3	Winter	no
33	5_Jun_18	1	B	24	3	1.60	3	Winter	no
33	5_Jun_18	2	B	24	3	1.97	3	Winter	no
21	5_Jun_18	1	B	24	3	1.36	3	Winter	no
21	5_Jun_18	2	B	24	3	1.42	3	Winter	no
28	5_Jun_18	1	B	24	3	2.08	3	Winter	no
28	5_Jun_18	2	B	24	3	2.26	3	Winter	no
19	5_Jun_18	2	B	24	3	1.71	3	Winter	no
19	5_Jun_18	1	B	24	3	1.94	3	Winter	no
24	5_Jun_18	2	B	24	3	1.38	3	Winter	no
24	5_Jun_18	1	B	24	3	1.41	3	Winter	no
42	5_Jun_18	2	B	24	3	1.85	3	Winter	no
42	5_Jun_18	1	B	24	3	1.88	3	Winter	no
39	12_Jun_18	2	A	25	1	1.73	3	Winter	no
39	12_Jun_18	1	A	25	1	1.65	3	Winter	no
35	12_Jun_18	2	B	25	4	1.75	3	Winter	no
35	12_Jun_18	1	B	25	4	1.41	3	Winter	no
26	12_Jun_18	1	A	25	1	1.15	3	Winter	no
26	12_Jun_18	2	A	25	1	1.41	3	Winter	no
30	12_Jun_18	2	B	25	4	2.45	3	Winter	no
30	12_Jun_18	1	B	25	4	2.05	3	Winter	no
29	12_Jun_18	2	A	25	1	2.08	3	Winter	no
29	12_Jun_18	1	A	25	1	2.01	3	Winter	no
41	12_Jun_18	1	B	25	4	1.74	3	Winter	no
41	12_Jun_18	2	B	25	4	1.98	3	Winter	no
40	12_Jun_18	1	B	25	4	2.02	3	Winter	no
40	12_Jun_18	2	B	25	4	2.08	3	Winter	no
36	12_Jun_18	2	B	25	4	1.83	3	Winter	no

36	12_Jun_18	1	B	25	4	1.46	3	Winter	no
33	12_Jun_18	2	B	25	4	1.94	3	Winter	no
33	12_Jun_18	1	B	25	4	1.56	3	Winter	no
21	12_Jun_18	1	B	25	4	1.43	3	Winter	no
21	12_Jun_18	2	B	25	4	1.68	3	Winter	no
32	12_Jun_18	2	A	25	1	1.30	3	Winter	no
32	12_Jun_18	1	A	25	1	1.14	3	Winter	no
28	12_Jun_18	1	B	25	4	1.89	3	Winter	no
28	12_Jun_18	2	B	25	4	2.26	3	Winter	no
37	12_Jun_18	2	A	25	1	1.53	3	Winter	no
37	12_Jun_18	1	A	25	1	1.12	3	Winter	no
19	12_Jun_18	1	B	25	4	1.54	3	Winter	no
19	12_Jun_18	2	B	25	4	1.72	3	Winter	no
24	12_Jun_18	1	B	25	4	1.71	3	Winter	no
24	12_Jun_18	2	B	25	4	1.68	3	Winter	no
31	12_Jun_18	1	A	25	1	2.09	3	Winter	no
31	12_Jun_18	2	A	25	1	2.81	3	Winter	no
38	12_Jun_18	2	A	25	1	2.32	3	Winter	no
38	12_Jun_18	1	A	25	1	2.01	3	Winter	no
34	12_Jun_18	1	A	25	1	1.62	3	Winter	no
34	12_Jun_18	2	A	25	1	1.86	3	Winter	no
42	12_Jun_18	1	B	25	4	1.70	3	Winter	no
42	12_Jun_18	2	B	25	4	2.14	3	Winter	no
27	12_Jun_18	1	A	25	1	1.77	3	Winter	no
27	12_Jun_18	2	A	25	1	2.04	3	Winter	no
23	12_Jun_18	2	A	25	1	1.91	3	Winter	no
23	12_Jun_18	1	A	25	1	1.91	3	Winter	no
39	19_Jun_18	2	A	26	2	1.75	3	Winter	no
39	19_Jun_18	1	A	26	2	1.59	3	Winter	no
35	19_Jun_18	2	B	26	5	1.79	3	Winter	no
35	19_Jun_18	1	B	26	5	1.46	3	Winter	no
26	19_Jun_18	1	A	26	2	1.44	3	Winter	no
26	19_Jun_18	2	A	26	2	1.48	3	Winter	no
30	19_Jun_18	1	B	26	5	2.22	3	Winter	no
30	19_Jun_18	2	B	26	5	2.53	3	Winter	no
29	19_Jun_18	2	A	26	2	1.25	3	Winter	no
29	19_Jun_18	1	A	26	2	1.66	3	Winter	no
41	19_Jun_18	2	B	26	5	1.81	3	Winter	no
41	19_Jun_18	1	B	26	5	1.73	3	Winter	no
40	19_Jun_18	2	B	26	5	2.06	3	Winter	no
40	19_Jun_18	1	B	26	5	1.79	3	Winter	no
36	19_Jun_18	2	B	26	5	1.37	3	Winter	no
36	19_Jun_18	1	B	26	5	1.58	3	Winter	no

33	19_Jun_18	2	B	26	5	1.75	3	Winter	no
33	19_Jun_18	1	B	26	5	1.44	3	Winter	no
21	19_Jun_18	1	B	26	5	1.49	3	Winter	no
21	19_Jun_18	2	B	26	5	1.27	3	Winter	no
32	19_Jun_18	1	A	26	2	1.08	3	Winter	no
32	19_Jun_18	2	A	26	2	1.26	3	Winter	no
28	19_Jun_18	1	B	26	5	1.81	3	Winter	no
28	19_Jun_18	2	B	26	5	1.45	3	Winter	no
37	19_Jun_18	2	A	26	2	1.01	3	Winter	no
37	19_Jun_18	1	A	26	2	0.96	3	Winter	no
19	19_Jun_18	1	B	26	5	1.36	3	Winter	no
19	19_Jun_18	2	B	26	5	1.73	3	Winter	no
24	19_Jun_18	1	B	26	5	1.15	3	Winter	no
24	19_Jun_18	2	B	26	5	1.36	3	Winter	no
31	19_Jun_18	1	A	26	2	1.64	3	Winter	no
31	19_Jun_18	2	A	26	2	1.70	3	Winter	no
38	19_Jun_18	1	A	26	2	1.83	3	Winter	no
38	19_Jun_18	2	A	26	2	1.67	3	Winter	no
34	19_Jun_18	1	A	26	2	1.54	3	Winter	no
34	19_Jun_18	2	A	26	2	1.33	3	Winter	no
42	19_Jun_18	1	B	26	5	1.52	3	Winter	no
42	19_Jun_18	2	B	26	5	1.69	3	Winter	no
27	19_Jun_18	2	A	26	2	1.54	3	Winter	no
27	19_Jun_18	1	A	26	2	1.67	3	Winter	no
23	19_Jun_18	2	A	26	2	2.24	3	Winter	no
23	19_Jun_18	1	A	26	2	1.74	3	Winter	no
39	26_Jun_18	2	A	27	3	1.36	4	Winter	no
39	26_Jun_18	1	A	27	3	1.24	4	Winter	no
26	26_Jun_18	1	A	27	3	1.01	4	Winter	no
26	26_Jun_18	2	A	27	3	1.06	4	Winter	no
29	26_Jun_18	2	A	27	3	1.54	4	Winter	no
29	26_Jun_18	1	A	27	3	1.50	4	Winter	no
32	26_Jun_18	2	A	27	3	1.42	4	Winter	no
32	26_Jun_18	1	A	27	3	1.56	4	Winter	no
37	26_Jun_18	1	A	27	3	0.96	4	Winter	no
37	26_Jun_18	2	A	27	3	1.10	4	Winter	no
31	26_Jun_18	1	A	27	3	1.87	4	Winter	no
31	26_Jun_18	2	A	27	3	1.70	4	Winter	no
38	26_Jun_18	2	A	27	3	1.15	4	Winter	no
38	26_Jun_18	1	A	27	3	1.36	4	Winter	no
34	26_Jun_18	1	A	27	3	1.51	4	Winter	no
34	26_Jun_18	2	A	27	3	1.42	4	Winter	no
27	26_Jun_18	1	A	27	3	1.84	4	Winter	no

27	26_Jun_18	2	A	27	3	1.37	4	Winter	no
23	26_Jun_18	1	A	27	3	1.85	4	Winter	no
23	26_Jun_18	2	A	27	3	1.76	4	Winter	no
39	3_Jul_18	2	A	28	4	3.31	4	Winter	no
39	3_Jul_18	1	A	28	4	2.27	4	Winter	no
35	3_Jul_18	1	B	28	1	1.70	4	Winter	no
35	3_Jul_18	2	B	28	1	2.92	4	Winter	no
26	3_Jul_18	2	A	28	4	2.63	4	Winter	no
26	3_Jul_18	1	A	28	4	2.27	4	Winter	no
30	3_Jul_18	2	B	28	1	3.90	4	Winter	no
30	3_Jul_18	1	B	28	1	2.35	4	Winter	no
29	3_Jul_18	1	A	28	4	2.10	4	Winter	no
29	3_Jul_18	2	A	28	4	3.53	4	Winter	no
41	3_Jul_18	2	B	28	1	3.25	4	Winter	no
41	3_Jul_18	1	B	28	1	2.18	4	Winter	no
40	3_Jul_18	1	B	28	1	2.23	4	Winter	no
40	3_Jul_18	2	B	28	1	2.98	4	Winter	no
36	3_Jul_18	2	B	28	1	3.66	4	Winter	no
36	3_Jul_18	1	B	28	1	1.90	4	Winter	no
28	3_Jul_18	2	B	28	1	3.52	4	Winter	no
28	3_Jul_18	1	B	28	1	2.57	4	Winter	no
21	3_Jul_18	2	B	28	1	0.97	4	Winter	no
21	3_Jul_18	1	B	28	1	1.43	4	Winter	no
32	3_Jul_18	1	A	28	4	1.86	4	Winter	no
32	3_Jul_18	2	A	28	4	3.08	4	Winter	no
37	3_Jul_18	2	A	28	4	2.34	4	Winter	no
37	3_Jul_18	1	A	28	4	1.60	4	Winter	no
19	3_Jul_18	1	B	28	1	2.07	4	Winter	no
19	3_Jul_18	2	B	28	1	3.26	4	Winter	no
24	3_Jul_18	2	B	28	1	2.66	4	Winter	no
24	3_Jul_18	1	B	28	1	1.87	4	Winter	no
31	3_Jul_18	2	A	28	4	2.98	4	Winter	no
31	3_Jul_18	1	A	28	4	2.34	4	Winter	no
38	3_Jul_18	1	A	28	4	1.97	4	Winter	no
38	3_Jul_18	2	A	28	4	2.76	4	Winter	no
34	3_Jul_18	1	A	28	4	2.34	4	Winter	no
34	3_Jul_18	2	A	28	4	2.83	4	Winter	no
42	3_Jul_18	1	B	28	1	1.51	4	Winter	no
42	3_Jul_18	2	B	28	1	2.76	4	Winter	no
27	3_Jul_18	2	A	28	4	3.04	4	Winter	no
27	3_Jul_18	1	A	28	4	1.99	4	Winter	no
23	3_Jul_18	2	A	28	4	3.36	4	Winter	no
23	3_Jul_18	1	A	28	4	2.07	4	Winter	no

39	10_Jul_18	2	A	29	5	1.96	4	Winter	no
39	10_Jul_18	1	A	29	5	1.38	4	Winter	no
35	10_Jul_18	1	B	29	2	1.16	4	Winter	no
35	10_Jul_18	2	B	29	2	1.41	4	Winter	no
26	10_Jul_18	2	A	29	5	1.46	4	Winter	no
26	10_Jul_18	1	A	29	5	1.41	4	Winter	no
30	10_Jul_18	1	B	29	2	2.06	4	Winter	no
30	10_Jul_18	2	B	29	2	2.49	4	Winter	no
29	10_Jul_18	1	A	29	5	1.25	4	Winter	no
29	10_Jul_18	2	A	29	5	1.89	4	Winter	no
41	10_Jul_18	2	B	29	2	NA	4	Winter	no
40	10_Jul_18	2	B	29	2	1.63	4	Winter	no
40	10_Jul_18	1	B	29	2	1.73	4	Winter	no
36	10_Jul_18	1	B	29	2	1.73	4	Winter	no
36	10_Jul_18	2	B	29	2	1.76	4	Winter	no
28	10_Jul_18	2	B	29	2	2.32	4	Winter	no
28	10_Jul_18	1	B	29	2	2.18	4	Winter	no
21	10_Jul_18	1	B	29	2	1.91	4	Winter	no
21	10_Jul_18	2	B	29	2	1.94	4	Winter	no
32	10_Jul_18	2	A	29	5	1.29	4	Winter	no
32	10_Jul_18	1	A	29	5	1.11	4	Winter	no
37	10_Jul_18	1	A	29	5	1.27	4	Winter	no
37	10_Jul_18	2	A	29	5	1.41	4	Winter	no
19	10_Jul_18	2	B	29	2	1.92	4	Winter	no
19	10_Jul_18	1	B	29	2	1.37	4	Winter	no
24	10_Jul_18	1	B	29	2	1.54	4	Winter	no
24	10_Jul_18	2	B	29	2	1.69	4	Winter	no
33	10_Jul_18	1	B	29	2	1.56	4	Winter	no
33	10_Jul_18	2	B	29	2	1.79	4	Winter	no
31	10_Jul_18	2	A	29	5	2.29	4	Winter	no
31	10_Jul_18	1	A	29	5	1.46	4	Winter	no
38	10_Jul_18	2	A	29	5	1.81	4	Winter	no
38	10_Jul_18	1	A	29	5	1.33	4	Winter	no
34	10_Jul_18	2	A	29	5	1.68	4	Winter	no
34	10_Jul_18	1	A	29	5	1.29	4	Winter	no
42	10_Jul_18	2	B	29	2	1.57	4	Winter	no
42	10_Jul_18	1	B	29	2	1.22	4	Winter	no
27	10_Jul_18	2	A	29	5	2.14	4	Winter	no
27	10_Jul_18	1	A	29	5	1.46	4	Winter	no
23	10_Jul_18	2	A	29	5	1.74	4	Winter	no
23	10_Jul_18	1	A	29	5	1.60	4	Winter	no
40	17_Jul_18	1	B	30	3	3.04	4	Winter	no
40	17_Jul_18	2	B	30	3	3.15	4	Winter	no

28	17_Jul_18	2	B	30	3	3.13	4	Winter	no
28	17_Jul_18	1	B	30	3	3.35	4	Winter	no
21	17_Jul_18	1	B	30	3	2.88	4	Winter	no
24	17_Jul_18	1	B	30	3	2.32	4	Winter	no
33	17_Jul_18	2	B	30	3	2.80	4	Winter	no
33	17_Jul_18	1	B	30	3	2.91	4	Winter	no
42	17_Jul_18	1	B	30	3	2.44	4	Winter	no
39	24_Jul_18	1	A	31	1	1.87	4	Winter	no
39	24_Jul_18	2	A	31	1	1.31	4	Winter	no
35	24_Jul_18	2	B	31	4	1.19	4	Winter	no
35	24_Jul_18	1	B	31	4	1.38	4	Winter	no
26	24_Jul_18	1	A	31	1	1.39	4	Winter	no
26	24_Jul_18	2	A	31	1	0.84	4	Winter	no
30	24_Jul_18	1	B	31	4	2.42	4	Winter	no
30	24_Jul_18	2	B	31	4	1.65	4	Winter	no
29	24_Jul_18	1	A	31	1	1.48	4	Winter	no
29	24_Jul_18	2	A	31	1	0.95	4	Winter	no
41	24_Jul_18	2	B	31	4	1.28	4	Winter	no
41	24_Jul_18	1	B	31	4	1.73	4	Winter	no
40	24_Jul_18	1	B	31	4	1.51	4	Winter	no
40	24_Jul_18	2	B	31	4	1.18	4	Winter	no
36	24_Jul_18	1	B	31	4	2.03	4	Winter	no
36	24_Jul_18	2	B	31	4	1.49	4	Winter	no
28	24_Jul_18	1	B	31	4	2.15	4	Winter	no
28	24_Jul_18	2	B	31	4	1.64	4	Winter	no
21	24_Jul_18	2	B	31	4	1.10	4	Winter	no
21	24_Jul_18	1	B	31	4	1.56	4	Winter	no
32	24_Jul_18	1	A	31	1	1.67	4	Winter	no
32	24_Jul_18	2	A	31	1	0.92	4	Winter	no
37	24_Jul_18	2	A	31	1	1.88	4	Winter	no
37	24_Jul_18	1	A	31	1	2.15	4	Winter	no
19	24_Jul_18	2	B	31	4	1.08	4	Winter	no
19	24_Jul_18	1	B	31	4	1.46	4	Winter	no
24	24_Jul_18	2	B	31	4	1.19	4	Winter	no
24	24_Jul_18	1	B	31	4	1.36	4	Winter	no
33	24_Jul_18	2	B	31	4	1.39	4	Winter	no
33	24_Jul_18	1	B	31	4	1.76	4	Winter	no
31	24_Jul_18	2	A	31	1	1.65	4	Winter	no
31	24_Jul_18	1	A	31	1	1.95	4	Winter	no
38	24_Jul_18	2	A	31	1	1.15	4	Winter	no
38	24_Jul_18	1	A	31	1	1.40	4	Winter	no
34	24_Jul_18	1	A	31	1	2.34	4	Winter	no
34	24_Jul_18	2	A	31	1	1.54	4	Winter	no

42	24_Jul_18	2	B	31	4	1.07	4	Winter	no
42	24_Jul_18	1	B	31	4	1.61	4	Winter	no
27	24_Jul_18	2	A	31	1	1.43	4	Winter	no
27	24_Jul_18	1	A	31	1	2.51	4	Winter	no
23	24_Jul_18	1	A	31	1	2.21	4	Winter	no
23	24_Jul_18	2	A	31	1	1.46	4	Winter	no
39	31_Jul_18	2	A	32	2	1.77	4	Winter	no
39	31_Jul_18	1	A	32	2	1.56	4	Winter	no
35	31_Jul_18	1	B	32	5	NA	4	Winter	no
35	31_Jul_18	2	B	32	5	NA	4	Winter	no
26	31_Jul_18	2	A	32	2	1.45	4	Winter	no
26	31_Jul_18	1	A	32	2	1.23	4	Winter	no
30	31_Jul_18	2	B	32	5	2.81	4	Winter	no
30	31_Jul_18	1	B	32	5	2.47	4	Winter	no
29	31_Jul_18	2	A	32	2	1.53	4	Winter	no
29	31_Jul_18	1	A	32	2	1.21	4	Winter	no
41	31_Jul_18	1	B	32	5	1.40	4	Winter	no
41	31_Jul_18	2	B	32	5	1.93	4	Winter	no
40	31_Jul_18	1	B	32	5	1.75	4	Winter	no
40	31_Jul_18	2	B	32	5	1.90	4	Winter	no
36	31_Jul_18	2	B	32	5	2.00	4	Winter	no
36	31_Jul_18	1	B	32	5	1.63	4	Winter	no
28	31_Jul_18	1	B	32	5	1.97	4	Winter	no
28	31_Jul_18	2	B	32	5	2.61	4	Winter	no
21	31_Jul_18	2	B	32	5	2.09	4	Winter	no
21	31_Jul_18	1	B	32	5	1.42	4	Winter	no
32	31_Jul_18	2	A	32	2	1.84	4	Winter	no
32	31_Jul_18	1	A	32	2	1.26	4	Winter	no
37	31_Jul_18	1	A	32	2	1.18	4	Winter	no
37	31_Jul_18	2	A	32	2	1.47	4	Winter	no
19	31_Jul_18	1	B	32	5	1.86	4	Winter	no
19	31_Jul_18	2	B	32	5	2.00	4	Winter	no
24	31_Jul_18	1	B	32	5	1.63	4	Winter	no
24	31_Jul_18	2	B	32	5	1.87	4	Winter	no
33	31_Jul_18	1	B	32	5	1.67	4	Winter	no
33	31_Jul_18	2	B	32	5	1.98	4	Winter	no
31	31_Jul_18	2	A	32	2	1.99	4	Winter	no
31	31_Jul_18	1	A	32	2	1.95	4	Winter	no
38	31_Jul_18	1	A	32	2	1.25	4	Winter	no
38	31_Jul_18	2	A	32	2	1.59	4	Winter	no
34	31_Jul_18	2	A	32	2	1.90	4	Winter	no
34	31_Jul_18	1	A	32	2	2.19	4	Winter	no
42	31_Jul_18	2	B	32	5	1.57	4	Winter	no

42	31_Jul_18	1	B	32	5	1.47	4	Winter	no
27	31_Jul_18	1	A	32	2	2.22	4	Winter	no
27	31_Jul_18	2	A	32	2	2.15	4	Winter	no
23	31_Jul_18	1	A	32	2	1.58	4	Winter	no
23	31_Jul_18	2	A	32	2	1.81	4	Winter	no

Appendix 5-3 Data table used for analysis of activity time budget of lambs

Group	Calendar week	Sheep ID	Day	LW	FEC	Period	Co-grazing	Grazing count	Resting count	Walking count	Week Post Treatment
B	09/01/2018	19	1	39.5	0	1	yes	7748	9357	175	3
B	09/01/2018	19	2	39.5	0	1	yes	7135	9942	203	3
B	09/01/2018	19	3	39.5	0	1	yes	7313	9819	148	3
B	09/01/2018	21	1	35	150	1	yes	6941	10225	114	3
B	09/01/2018	21	2	35	150	1	yes	5327	11792	161	3
B	09/01/2018	21	3	35	150	1	yes	6697	10398	185	3
B	09/01/2018	24	1	32	150	1	yes	5636	11480	164	3
B	09/01/2018	24	2	32	150	1	yes	6170	10910	200	3
B	09/01/2018	24	3	32	150	1	yes	6437	10610	233	3
B	09/01/2018	28	1	32	300	1	yes	7695	9451	134	3
B	09/01/2018	28	2	32	300	1	yes	8608	8480	192	3
B	09/01/2018	28	3	32	300	1	yes	7910	9235	135	3
B	09/01/2018	30	1	34.5	0	1	yes	8642	8479	159	3
B	09/01/2018	30	2	34.5	0	1	yes	7806	9325	149	3
B	09/01/2018	30	3	34.5	0	1	yes	9456	7581	243	3
B	09/01/2018	33	1	31	0	1	yes	7372	9658	250	3
B	09/01/2018	33	2	31	0	1	yes	5819	11301	160	3
B	09/01/2018	33	3	31	0	1	yes	6327	10781	172	3
B	09/01/2018	35	1	36	0	1	yes	8008	8936	336	3

B	09/01/2018	35	2	36	0	1	yes	7795	9208	277	3
B	09/01/2018	35	3	36	0	1	yes	7416	9577	287	3
B	09/01/2018	36	1	36.5	0	1	yes	8290	8764	226	3
B	09/01/2018	36	2	36.5	0	1	yes	7203	9906	171	3
B	09/01/2018	36	3	36.5	0	1	yes	8245	8754	281	3
B	09/01/2018	40	1	32.5	0	1	yes	7912	9251	117	3
B	09/01/2018	40	2	32.5	0	1	yes	7554	9591	135	3
B	09/01/2018	40	3	32.5	0	1	yes	8276	8897	107	3
B	09/01/2018	41	1	37	0	1	yes	5467	11682	131	3
B	09/01/2018	41	2	37	0	1	yes	4632	12547	101	3
B	09/01/2018	41	3	37	0	1	yes	4998	12079	203	3
B	09/01/2018	42	1	32.5	0	1	yes	8760	8134	386	3
B	09/01/2018	42	2	32.5	0	1	yes	8544	8444	292	3
B	09/01/2018	42	3	32.5	0	1	yes	9393	7574	313	3
A	16/01/2018	23	1	29.5	0	1	yes	4270	12884	126	1
A	16/01/2018	23	2	29.5	0	1	yes	5918	11105	257	1
A	16/01/2018	23	3	29.5	0	1	yes	7155	9883	242	1
A	16/01/2018	25	1	30	0	1	yes	4850	12235	195	1
A	16/01/2018	25	2	30	0	1	yes	4983	12026	271	1
A	16/01/2018	25	3	30	0	1	yes	5006	12014	260	1
A	16/01/2018	31	1	29	0	1	yes	5828	11289	163	1
A	16/01/2018	31	2	29	0	1	yes	6581	10474	225	1
A	16/01/2018	31	3	29	0	1	yes	7320	9670	290	1
A	16/01/2018	32	1	30	0	1	yes	5787	11382	111	1
A	16/01/2018	32	2	30	0	1	yes	4450	12590	240	1
A	16/01/2018	32	3	30	0	1	yes	4270	12699	311	1
A	16/01/2018	37	1	30.5	0	1	yes	4912	12220	148	1
A	16/01/2018	37	2	30.5	0	1	yes	5918	11101	261	1
A	16/01/2018	37	3	30.5	0	1	yes	5576	11467	237	1
A	16/01/2018	38	1	23.5	0	1	yes	4545	12637	98	1
A	16/01/2018	38	2	23.5	0	1	yes	2318	14803	159	1
A	16/01/2018	38	3	23.5	0	1	yes	5167	11916	197	1
A	16/01/2018	39	1	29	0	1	yes	4461	12692	127	1
A	16/01/2018	39	2	29	0	1	yes	5915	11182	183	1
A	16/01/2018	39	3	29	0	1	yes	6082	10943	255	1
B	16/01/2018	19	1	31	200	1	yes	4780	12299	201	4
B	16/01/2018	19	2	31	200	1	yes	5066	11780	434	4
B	16/01/2018	19	3	31	200	1	yes	5159	11759	362	4
B	16/01/2018	21	1	28	0	1	yes	4568	12617	95	4
B	16/01/2018	21	2	28	0	1	yes	4534	12592	154	4
B	16/01/2018	21	3	28	0	1	yes	4379	12677	224	4
B	16/01/2018	24	1	27.5	0	1	yes	6336	10820	124	4
B	16/01/2018	24	2	27.5	0	1	yes	4493	12593	194	4

B	16/01/2018	24	3	27.5	0	1	yes	4629	12392	259	4
B	16/01/2018	28	1	31.5	0	1	yes	5663	11450	167	4
B	16/01/2018	28	2	31.5	0	1	yes	5220	11840	220	4
B	16/01/2018	28	3	31.5	0	1	yes	6389	10486	405	4
B	16/01/2018	30	1	30	0	1	yes	7047	10045	188	4
B	16/01/2018	30	2	30	0	1	yes	6101	10888	291	4
B	16/01/2018	30	3	30	0	1	yes	6732	10245	303	4
B	16/01/2018	33	1	27.5	200	1	yes	4757	12432	91	4
B	16/01/2018	33	2	27.5	200	1	yes	4944	12043	293	4
B	16/01/2018	33	3	27.5	200	1	yes	5873	11192	215	4
B	16/01/2018	35	1	31	0	1	yes	6190	10954	136	4
B	16/01/2018	35	2	31	0	1	yes	6527	10507	246	4
B	16/01/2018	35	3	31	0	1	yes	7933	9109	238	4
B	16/01/2018	36	1	32	0	1	yes	5086	12099	95	4
B	16/01/2018	36	2	32	0	1	yes	5152	11947	181	4
B	16/01/2018	36	3	32	0	1	yes	5768	11356	156	4
B	16/01/2018	40	1	28.5	0	1	yes	4504	12703	73	4
B	16/01/2018	40	2	28.5	0	1	yes	4805	12272	203	4
B	16/01/2018	40	3	28.5	0	1	yes	6064	11059	157	4
B	16/01/2018	41	1	31	0	1	yes	6001	11055	224	4
B	16/01/2018	41	2	31	0	1	yes	6071	10928	281	4
B	16/01/2018	41	3	31	0	1	yes	6575	10195	510	4
B	16/01/2018	42	1	27.5	0	1	yes	5891	11184	205	4
B	16/01/2018	42	2	27.5	0	1	yes	4898	12103	279	4
B	16/01/2018	42	3	27.5	0	1	yes	4678	12399	203	4
A	23/01/2018	23	1	33	0	1	yes	6585	10533	162	2
A	23/01/2018	23	2	33	0	1	yes	6718	10423	139	2
A	23/01/2018	23	3	33	0	1	yes	6102	11111	67	2
A	23/01/2018	25	1	35	0	1	yes	6060	11037	183	2
A	23/01/2018	25	2	35	0	1	yes	7031	10016	233	2
A	23/01/2018	25	3	35	0	1	yes	7041	10051	188	2
A	23/01/2018	26	1	35	0	1	yes	7247	9618	415	2
A	23/01/2018	26	2	35	0	1	yes	6565	10280	435	2
A	23/01/2018	26	3	35	0	1	yes	4758	12104	418	2
A	23/01/2018	27	1	36.5	0	1	yes	6737	10049	494	2
A	23/01/2018	27	2	36.5	0	1	yes	7214	9526	540	2
A	23/01/2018	27	3	36.5	0	1	yes	7191	9802	287	2
A	23/01/2018	31	1	31.5	50	1	yes	7088	9970	222	2
A	23/01/2018	31	2	31.5	50	1	yes	7345	9675	260	2
A	23/01/2018	31	3	31.5	50	1	yes	7167	9877	236	2
A	23/01/2018	32	1	34.5	0	1	yes	6682	10426	172	2
A	23/01/2018	32	2	34.5	0	1	yes	5421	11684	175	2
A	23/01/2018	32	3	34.5	0	1	yes	5169	11762	349	2

A	23/01/2018	34	1	29	0	1	yes	7555	9518	207	2
A	23/01/2018	34	2	29	0	1	yes	7143	9910	227	2
A	23/01/2018	34	3	29	0	1	yes	7150	9813	317	2
A	23/01/2018	37	1	36	0	1	yes	5396	11786	98	2
A	23/01/2018	37	2	36	0	1	yes	6052	11095	133	2
A	23/01/2018	37	3	36	0	1	yes	7011	10133	136	2
A	23/01/2018	38	1	25.5	0	1	yes	5806	11250	224	2
A	23/01/2018	38	2	25.5	0	1	yes	6268	10728	284	2
A	23/01/2018	38	3	25.5	0	1	yes	6708	10342	230	2
A	23/01/2018	39	1	32.5	0	1	yes	6343	10770	167	2
A	23/01/2018	39	2	32.5	0	1	yes	7285	9785	210	2
A	23/01/2018	39	3	32.5	0	1	yes	7728	9412	140	2
B	23/01/2018	19	1	38	550	1	yes	5160	11953	167	5
B	23/01/2018	19	2	38	550	1	yes	6004	11062	214	5
B	23/01/2018	19	3	38	550	1	yes	7429	9606	245	5
B	23/01/2018	21	1	31	0	1	yes	5876	11331	73	5
B	23/01/2018	21	2	31	0	1	yes	6174	11028	78	5
B	23/01/2018	21	3	31	0	1	yes	7246	9941	93	5
B	23/01/2018	24	1	31	150	1	yes	5483	11646	151	5
B	23/01/2018	24	2	31	150	1	yes	6330	10788	162	5
B	23/01/2018	24	3	31	150	1	yes	6515	10637	128	5
B	23/01/2018	28	1	34	50	1	yes	5404	11661	215	5
B	23/01/2018	28	2	34	50	1	yes	6370	10499	411	5
B	23/01/2018	28	3	34	50	1	yes	7044	9964	272	5
B	23/01/2018	30	1	34.5	0	1	yes	6682	10387	211	5
B	23/01/2018	30	2	34.5	0	1	yes	8324	8771	185	5
B	23/01/2018	30	3	34.5	0	1	yes	6714	10398	168	5
B	23/01/2018	33	1	29.5	350	1	yes	6032	11075	173	5
B	23/01/2018	33	2	29.5	350	1	yes	8019	9054	207	5
B	23/01/2018	33	3	29.5	350	1	yes	7140	9875	265	5
B	23/01/2018	35	1	37	400	1	yes	6189	10857	234	5
B	23/01/2018	35	2	37	400	1	yes	7788	9317	175	5
B	23/01/2018	35	3	37	400	1	yes	7989	9162	129	5
B	23/01/2018	36	1	38.5	200	1	yes	6166	10961	153	5
B	23/01/2018	36	2	38.5	200	1	yes	6071	11101	108	5
B	23/01/2018	36	3	38.5	200	1	yes	5807	11427	46	5
B	23/01/2018	40	1	32	50	1	yes	6403	10699	178	5
B	23/01/2018	40	2	32	50	1	yes	6176	10988	116	5
B	23/01/2018	40	3	32	50	1	yes	6333	10898	49	5
B	23/01/2018	41	1	35.5	0	1	yes	5832	10962	486	5
B	23/01/2018	41	2	35.5	0	1	yes	5914	10746	620	5
B	23/01/2018	41	3	35.5	0	1	yes	6066	10850	364	5
B	23/01/2018	42	1	28.5	0	1	yes	5023	12070	187	5

B	23/01/2018	42	2	28.5	0	1	yes	7834	9229	217	5
B	23/01/2018	42	3	28.5	0	1	yes	7554	9518	208	5
A	30/01/2018	23	2	31	0	1	yes	7483	9669	128	3
A	30/01/2018	23	3	31	0	1	yes	6914	10211	155	3
A	30/01/2018	25	2	37.5	0	1	yes	6553	10534	193	3
A	30/01/2018	25	3	37.5	0	1	yes	6771	10284	225	3
A	30/01/2018	26	2	38.5	0	1	yes	6850	10177	253	3
A	30/01/2018	26	3	38.5	0	1	yes	6054	11045	181	3
A	30/01/2018	27	2	34	50	1	yes	7387	9372	521	3
A	30/01/2018	27	3	34	50	1	yes	7092	9914	274	3
A	30/01/2018	29	2	44	0	1	yes	8019	9068	193	3
A	30/01/2018	29	3	44	0	1	yes	7230	9864	186	3
A	30/01/2018	31	2	34	0	1	yes	8109	8867	304	3
A	30/01/2018	31	3	34	0	1	yes	6193	10859	228	3
A	30/01/2018	32	2	36	0	1	yes	5272	11728	280	3
A	30/01/2018	32	3	36	0	1	yes	3977	13164	139	3
A	30/01/2018	34	2	30.5	0	1	yes	6601	9490	1189	3
A	30/01/2018	34	3	30.5	0	1	yes	6165	10282	833	3
A	30/01/2018	37	2	41	0	1	yes	7926	9180	174	3
A	30/01/2018	37	3	41	0	1	yes	6184	10959	137	3
A	30/01/2018	38	2	27	0	1	yes	7107	9953	220	3
A	30/01/2018	38	3	27	0	1	yes	5824	11226	230	3
A	30/01/2018	39	2	33.5	0	1	yes	6518	10575	187	3
A	30/01/2018	39	3	33.5	0	1	yes	5844	11165	271	3
A	06/02/2018	23	1	34.5	0	1	yes	7095	10079	106	4
A	06/02/2018	23	2	34.5	0	1	yes	7671	9473	136	4
A	06/02/2018	25	1	36.5	0	1	yes	6338	10699	243	4
A	06/02/2018	25	2	36.5	0	1	yes	8698	8283	299	4
A	06/02/2018	26	1	35	0	1	yes	7007	10074	199	4
A	06/02/2018	26	2	35	0	1	yes	8518	8551	211	4
A	06/02/2018	29	1	43.5	0	1	yes	7006	10198	76	4
A	06/02/2018	29	2	43.5	0	1	yes	8041	9065	174	4
A	06/02/2018	31	1	31	50	1	yes	7093	9991	196	4
A	06/02/2018	31	2	31	50	1	yes	7664	9351	265	4
A	06/02/2018	32	1	35	0	1	yes	6553	10455	272	4
A	06/02/2018	32	2	35	0	1	yes	8696	8028	556	4
A	06/02/2018	34	1	30.5	200	1	yes	5915	10757	608	4
A	06/02/2018	34	2	30.5	200	1	yes	6549	9954	777	4
A	06/02/2018	37	1	36.5	50	1	yes	7430	9654	196	4
A	06/02/2018	37	2	36.5	50	1	yes	7598	9434	248	4
A	06/02/2018	38	1	26	50	1	yes	6579	10493	208	4
A	06/02/2018	38	2	26	50	1	yes	8381	8600	299	4
B	06/02/2018	19	1	43	0	1	yes	6144	10881	255	1

B	06/02/2018	19	2	43	0	1	yes	6802	10161	317	1
B	06/02/2018	21	1	35	0	1	yes	6976	10226	78	1
B	06/02/2018	21	2	35	0	1	yes	7773	9367	140	1
B	06/02/2018	24	1	31.5	0	1	yes	6812	10276	192	1
B	06/02/2018	24	2	31.5	0	1	yes	7555	9429	296	1
B	06/02/2018	28	1	36.5	0	1	yes	6712	10309	259	1
B	06/02/2018	28	2	36.5	0	1	yes	7408	9374	498	1
B	06/02/2018	30	1	35.5	0	1	yes	8077	8934	269	1
B	06/02/2018	30	2	35.5	0	1	yes	8691	8163	426	1
B	06/02/2018	33	1	31.5	0	1	yes	6749	10100	431	1
B	06/02/2018	33	2	31.5	0	1	yes	7696	9124	460	1
B	06/02/2018	35	1	38.5	0	1	yes	7543	9567	170	1
B	06/02/2018	35	2	38.5	0	1	yes	7910	9136	234	1
B	06/02/2018	36	1	36	0	1	yes	7301	9833	146	1
B	06/02/2018	36	2	36	0	1	yes	7552	9546	182	1
B	06/02/2018	40	1	33.5	0	1	yes	7095	10105	80	1
B	06/02/2018	40	2	33.5	0	1	yes	7975	9157	148	1
B	06/02/2018	41	1	36.5	0	1	yes	7049	9754	477	1
B	06/02/2018	41	2	36.5	0	1	yes	7190	9509	581	1
B	06/02/2018	42	1	32	0	1	yes	7221	9786	273	1
B	06/02/2018	42	2	32	0	1	yes	7933	8983	364	1
A	13/02/2018	23	1	33.5	150	1	yes	7636	9532	112	5
A	13/02/2018	23	2	33.5	150	1	yes	6738	10458	84	5
A	13/02/2018	23	3	33.5	150	1	yes	7285	9922	72	5
A	13/02/2018	25	1	33.5	0	1	yes	7245	9685	350	5
A	13/02/2018	25	2	33.5	0	1	yes	7979	9045	256	5
A	13/02/2018	25	3	33.5	0	1	yes	7687	9312	280	5
A	13/02/2018	26	1	38.5	150	1	yes	7053	10095	132	5
A	13/02/2018	26	2	38.5	150	1	yes	5717	11462	101	5
A	13/02/2018	26	3	38.5	150	1	yes	6463	10683	133	5
A	13/02/2018	27	1	37	1100	1	yes	6338	10783	159	5
A	13/02/2018	27	2	37	1100	1	yes	6721	10426	133	5
A	13/02/2018	27	3	37	1100	1	yes	7076	10070	133	5
A	13/02/2018	29	1	42	400	1	yes	6554	10614	112	5
A	13/02/2018	29	2	42	400	1	yes	8295	8701	284	5
A	13/02/2018	29	3	42	400	1	yes	6199	10979	101	5
A	13/02/2018	31	1	33.5	250	1	yes	8556	8616	108	5
A	13/02/2018	31	2	33.5	250	1	yes	6980	10182	118	5
A	13/02/2018	31	3	33.5	250	1	yes	8222	8890	167	5
A	13/02/2018	32	1	32.5	1700	1	yes	6154	11047	79	5
A	13/02/2018	32	2	32.5	1700	1	yes	6695	10432	153	5
A	13/02/2018	32	3	32.5	1700	1	yes	5309	11884	86	5
A	13/02/2018	34	1	30	0	1	yes	6717	10332	231	5

A	13/02/2018	34	2	30	0	1	yes	6694	10341	245	5
A	13/02/2018	34	3	30	0	1	yes	6697	10312	270	5
A	13/02/2018	37	1	37.5	200	1	yes	8626	8562	92	5
A	13/02/2018	37	2	37.5	200	1	yes	7133	10016	131	5
A	13/02/2018	37	3	37.5	200	1	yes	8382	8794	103	5
A	13/02/2018	38	1	28.5	0	1	yes	6879	10320	81	5
A	13/02/2018	38	2	28.5	0	1	yes	7181	10024	75	5
A	13/02/2018	38	3	28.5	0	1	yes	6972	10235	72	5
A	13/02/2018	39	1	36	300	1	yes	7346	9886	48	5
A	13/02/2018	39	2	36	300	1	yes	7256	9959	65	5
A	13/02/2018	39	3	36	300	1	yes	8129	9090	60	5
B	13/02/2018	19	1	38	0	1	yes	5426	11597	257	2
B	13/02/2018	19	2	38	0	1	yes	5659	11469	152	2
B	13/02/2018	19	3	38	0	1	yes	5826	11310	143	2
B	13/02/2018	21	1	36	0	1	yes	6150	11076	54	2
B	13/02/2018	21	2	36	0	1	yes	8161	9012	107	2
B	13/02/2018	21	3	36	0	1	yes	7808	9400	71	2
B	13/02/2018	24	1	33.5	0	1	yes	6171	11024	85	2
B	13/02/2018	24	2	33.5	0	1	yes	6908	10314	58	2
B	13/02/2018	24	3	33.5	0	1	yes	7362	9795	122	2
B	13/02/2018	28	1	36.5	0	1	yes	6546	10598	136	2
B	13/02/2018	28	2	36.5	0	1	yes	7080	10007	193	2
B	13/02/2018	28	3	36.5	0	1	yes	7306	9732	241	2
B	13/02/2018	30	1	35.5	0	1	yes	7860	9220	200	2
B	13/02/2018	30	2	35.5	0	1	yes	8852	7988	440	2
B	13/02/2018	30	3	35.5	0	1	yes	5997	10963	319	2
B	13/02/2018	33	1	33	0	1	yes	7446	9648	186	2
B	13/02/2018	33	2	33	0	1	yes	7235	9880	165	2
B	13/02/2018	33	3	33	0	1	yes	8616	8359	304	2
B	13/02/2018	35	1	38.5	0	1	yes	7661	9527	92	2
B	13/02/2018	35	2	38.5	0	1	yes	7721	9415	144	2
B	13/02/2018	35	3	38.5	0	1	yes	8934	8210	135	2
B	13/02/2018	36	1	40	0	1	yes	7116	10063	101	2
B	13/02/2018	36	2	40	0	1	yes	6973	10219	88	2
B	13/02/2018	36	3	40	0	1	yes	7698	9475	106	2
B	13/02/2018	40	1	36.5	0	1	yes	7802	9430	48	2
B	13/02/2018	40	2	36.5	0	1	yes	7566	9654	60	2
B	13/02/2018	40	3	36.5	0	1	yes	7661	9561	57	2
B	13/02/2018	41	1	36.5	0	1	yes	7320	9807	153	2
B	13/02/2018	41	2	36.5	0	1	yes	7194	9980	106	2
B	13/02/2018	41	3	36.5	0	1	yes	7105	10032	142	2
B	13/02/2018	42	1	32.5	0	1	yes	8163	8977	140	2
B	13/02/2018	42	2	32.5	0	1	yes	7593	9553	134	2

B	13/02/2018	42	3	32.5	0	1	yes	8328	8847	104	2
A	10/04/2018	23	1	39.5	150	2	yes	7255	9880	145	4
A	10/04/2018	23	2	39.5	150	2	yes	7498	9662	120	4
A	10/04/2018	23	3	39.5	150	2	yes	8495	8630	154	4
A	10/04/2018	26	1	40	0	2	yes	7015	10051	214	4
A	10/04/2018	26	2	40	0	2	yes	7677	9358	245	4
A	10/04/2018	26	3	40	0	2	yes	8927	8143	209	4
A	10/04/2018	27	1	40.5	100	2	yes	7843	9344	93	4
A	10/04/2018	27	2	40.5	100	2	yes	7380	9748	152	4
A	10/04/2018	27	3	40.5	100	2	yes	8528	8644	107	4
A	10/04/2018	29	1	48	0	2	yes	6495	10629	156	4
A	10/04/2018	29	2	48	0	2	yes	6621	10395	264	4
A	10/04/2018	29	3	48	0	2	yes	8864	8280	135	4
A	10/04/2018	31	1	38.5	100	2	yes	6678	10438	164	4
A	10/04/2018	31	2	38.5	100	2	yes	7008	10159	113	4
A	10/04/2018	31	3	38.5	100	2	yes	7807	9349	123	4
A	10/04/2018	32	1	38.5	0	2	yes	5940	11125	215	4
A	10/04/2018	32	2	38.5	0	2	yes	6565	10492	223	4
A	10/04/2018	32	3	38.5	0	2	yes	8145	8951	183	4
A	10/04/2018	34	1	34	0	2	yes	6290	10881	109	4
A	10/04/2018	34	2	34	0	2	yes	7481	9703	96	4
A	10/04/2018	34	3	34	0	2	yes	8805	8388	86	4
A	10/04/2018	37	1	46.5	0	2	yes	6238	10925	117	4
A	10/04/2018	37	2	46.5	0	2	yes	5927	11274	79	4
A	10/04/2018	37	3	46.5	0	2	yes	6888	10274	117	4
A	10/04/2018	38	1	28.5	0	2	yes	6771	10329	180	4
A	10/04/2018	38	2	28.5	0	2	yes	8302	8868	110	4
A	10/04/2018	38	3	28.5	0	2	yes	7885	9237	157	4
A	10/04/2018	39	1	37	0	2	yes	6180	10873	227	4
A	10/04/2018	39	2	37	0	2	yes	6902	10159	219	4
A	10/04/2018	39	3	37	0	2	yes	7628	9506	145	4
B	10/04/2018	19	1	42.5	0	2	yes	7341	9720	219	1
B	10/04/2018	19	2	42.5	0	2	yes	7590	9455	235	1
B	10/04/2018	19	3	42.5	0	2	yes	8278	8860	141	1
B	10/04/2018	21	1	36	0	2	yes	6271	10894	115	1
B	10/04/2018	21	2	36	0	2	yes	6881	10282	117	1
B	10/04/2018	21	3	36	0	2	yes	7623	9522	134	1
B	10/04/2018	24	1	33.5	0	2	yes	5650	11489	141	1
B	10/04/2018	24	2	33.5	0	2	yes	6605	10568	107	1
B	10/04/2018	24	3	33.5	0	2	yes	7794	9357	128	1
B	10/04/2018	28	1	39.5	0	2	yes	7913	9081	286	1
B	10/04/2018	28	2	39.5	0	2	yes	8370	8731	179	1
B	10/04/2018	28	3	39.5	0	2	yes	9382	7744	153	1

B	10/04/2018	30	1	36	0	2	yes	9527	7509	244	1
B	10/04/2018	30	2	36	0	2	yes	8467	8627	186	1
B	10/04/2018	30	3	36	0	2	yes	9479	7579	221	1
B	10/04/2018	33	1	37.5	0	2	yes	6803	10299	178	1
B	10/04/2018	33	2	37.5	0	2	yes	7624	9535	121	1
B	10/04/2018	33	3	37.5	0	2	yes	8258	8911	110	1
B	10/04/2018	35	1	40.5	0	2	yes	7502	9556	222	1
B	10/04/2018	35	2	40.5	0	2	yes	6696	10405	179	1
B	10/04/2018	35	3	40.5	0	2	yes	9027	8078	174	1
B	10/04/2018	36	1	43	0	2	yes	6880	10280	120	1
B	10/04/2018	36	2	43	0	2	yes	7031	10147	102	1
B	10/04/2018	36	3	43	0	2	yes	9076	8093	110	1
B	10/04/2018	40	1	36	0	2	yes	8015	9110	155	1
B	10/04/2018	40	2	36	0	2	yes	7289	9871	120	1
B	10/04/2018	40	3	36	0	2	yes	8367	8748	164	1
B	10/04/2018	41	1	46.5	0	2	yes	8003	9153	124	1
B	10/04/2018	41	2	46.5	0	2	yes	6898	10197	185	1
B	10/04/2018	41	3	46.5	0	2	yes	6702	10419	158	1
B	10/04/2018	42	1	36.5	0	2	yes	7798	9226	256	1
B	10/04/2018	42	2	36.5	0	2	yes	7908	9193	179	1
B	10/04/2018	42	3	36.5	0	2	yes	9267	7865	147	1
A	17/04/2018	23	1	38	900	2	yes	6104	10959	217	5
A	17/04/2018	23	2	38	900	2	yes	6867	10196	217	5
A	17/04/2018	23	3	38	900	2	yes	7266	9730	284	5
A	17/04/2018	26	1	39.5	0	2	yes	7165	9865	250	5
A	17/04/2018	26	2	39.5	0	2	yes	6864	10193	223	5
A	17/04/2018	26	3	39.5	0	2	yes	7347	9654	279	5
A	17/04/2018	27	1	39	1100	2	yes	6521	10668	91	5
A	17/04/2018	27	2	39	1100	2	yes	6747	10430	103	5
A	17/04/2018	27	3	39	1100	2	yes	8009	9149	122	5
A	17/04/2018	31	1	38	550	2	yes	7507	9590	183	5
A	17/04/2018	31	2	38	550	2	yes	6327	10759	194	5
A	17/04/2018	31	3	38	550	2	yes	7208	9703	369	5
A	17/04/2018	32	1	37	50	2	yes	7571	9577	132	5
A	17/04/2018	32	2	37	50	2	yes	6032	11043	205	5
A	17/04/2018	32	3	37	50	2	yes	9122	7953	205	5
A	17/04/2018	34	1	33.5	550	2	yes	8415	8743	122	5
A	17/04/2018	34	2	33.5	550	2	yes	8233	8899	148	5
A	17/04/2018	34	3	33.5	550	2	yes	8755	8356	169	5
A	17/04/2018	37	1	45.5	1100	2	yes	5240	11953	87	5
A	17/04/2018	37	2	45.5	1100	2	yes	5384	11769	127	5
A	17/04/2018	37	3	45.5	1100	2	yes	6110	10997	173	5
A	17/04/2018	38	1	27	0	2	yes	6603	10527	150	5

A	17/04/2018	38	2	27	0	2	yes	6693	10409	178	5
A	17/04/2018	38	3	27	0	2	yes	6850	10226	204	5
A	17/04/2018	39	1	37	0	2	yes	5340	11715	225	5
A	17/04/2018	39	2	37	0	2	yes	4979	12000	301	5
A	17/04/2018	39	3	37	0	2	yes	6012	10988	280	5
B	17/04/2018	19	1	44	0	2	yes	7630	9438	212	2
B	17/04/2018	19	2	44	0	2	yes	7476	9492	312	2
B	17/04/2018	19	3	44	0	2	yes	8559	8328	393	2
B	17/04/2018	21	1	38.5	0	2	yes	6204	10974	102	2
B	17/04/2018	21	2	38.5	0	2	yes	6163	10981	136	2
B	17/04/2018	21	3	38.5	0	2	yes	7318	9803	159	2
B	17/04/2018	24	1	32.5	0	2	yes	6322	10838	120	2
B	17/04/2018	24	2	32.5	0	2	yes	6008	11144	128	2
B	17/04/2018	24	3	32.5	0	2	yes	7671	9427	182	2
B	17/04/2018	28	1	38.5	0	2	yes	7217	9913	150	2
B	17/04/2018	28	2	38.5	0	2	yes	7242	9869	169	2
B	17/04/2018	28	3	38.5	0	2	yes	7054	10003	223	2
B	17/04/2018	30	1	35	0	2	yes	7292	9716	272	2
B	17/04/2018	30	2	35	0	2	yes	7494	9509	277	2
B	17/04/2018	30	3	35	0	2	yes	8374	8489	417	2
B	17/04/2018	33	1	38	0	2	yes	6632	10530	118	2
B	17/04/2018	33	2	38	0	2	yes	7037	10116	127	2
B	17/04/2018	33	3	38	0	2	yes	7865	9269	146	2
B	17/04/2018	35	1	39.5	0	2	yes	6144	11008	128	2
B	17/04/2018	35	2	39.5	0	2	yes	6044	11038	198	2
B	17/04/2018	35	3	39.5	0	2	yes	7326	9706	248	2
B	17/04/2018	36	1	42.5	0	2	yes	7335	9827	118	2
B	17/04/2018	36	2	42.5	0	2	yes	6849	10245	186	2
B	17/04/2018	36	3	42.5	0	2	yes	8165	8849	266	2
B	17/04/2018	40	1	36.5	0	2	yes	7057	10103	120	2
B	17/04/2018	40	2	36.5	0	2	yes	7325	9815	140	2
B	17/04/2018	40	3	36.5	0	2	yes	8126	9004	150	2
B	17/04/2018	41	1	43	0	2	yes	7931	9239	110	2
B	17/04/2018	41	2	43	0	2	yes	7371	9752	157	2
B	17/04/2018	41	3	43	0	2	yes	6854	10272	154	2
B	17/04/2018	42	1	36	0	2	yes	7713	9332	235	2
B	17/04/2018	42	2	36	0	2	yes	7921	9132	227	2
B	17/04/2018	42	3	36	0	2	yes	8579	8504	197	2
A	04/05/2018	23	1	38	0	2	yes	6740	10391	149	1
A	04/05/2018	23	2	38	0	2	yes	8295	8808	177	1
A	04/05/2018	23	3	38	0	2	yes	5922	11160	197	1
A	04/05/2018	26	1	40.5	0	2	yes	6990	10093	197	1
A	04/05/2018	26	2	40.5	0	2	yes	10029	6999	252	1

A	04/05/2018	26	3	40.5	0	2	yes	6753	10328	198	1
A	04/05/2018	27	1	40.5	0	2	yes	7453	9698	129	1
A	04/05/2018	27	2	40.5	0	2	yes	9007	8173	100	1
A	04/05/2018	27	3	40.5	0	2	yes	6914	10267	98	1
A	04/05/2018	29	1	47.5	0	2	yes	5810	11270	200	1
A	04/05/2018	29	2	47.5	0	2	yes	8320	8685	275	1
A	04/05/2018	29	3	47.5	0	2	yes	6834	10181	264	1
A	04/05/2018	31	1	37.5	0	2	yes	8306	8856	118	1
A	04/05/2018	31	2	37.5	0	2	yes	10167	6921	192	1
A	04/05/2018	31	3	37.5	0	2	yes	7228	9940	111	1
A	04/05/2018	32	1	36.5	0	2	yes	6810	10337	133	1
A	04/05/2018	32	2	36.5	0	2	yes	7098	10027	155	1
A	04/05/2018	32	3	36.5	0	2	yes	5074	12057	148	1
A	04/05/2018	34	1	33.5	0	2	yes	8720	8484	76	1
A	04/05/2018	34	2	33.5	0	2	yes	10811	6323	146	1
A	04/05/2018	34	3	33.5	0	2	yes	7549	9546	184	1
A	04/05/2018	37	1	45	0	2	yes	7331	9855	94	1
A	04/05/2018	37	2	45	0	2	yes	8948	8207	125	1
A	04/05/2018	37	3	45	0	2	yes	6374	10784	121	1
A	04/05/2018	38	1	29.5	0	2	yes	5068	12119	93	1
A	04/05/2018	38	2	29.5	0	2	yes	6272	10856	152	1
A	04/05/2018	38	3	29.5	0	2	yes	4693	12484	102	1
A	04/05/2018	39	1	36.5	0	2	yes	6745	10351	184	1
A	04/05/2018	39	2	36.5	0	2	yes	8392	8622	266	1
A	04/05/2018	39	3	36.5	0	2	yes	6440	10627	212	1
B	04/05/2018	21	1	39	1500	2	yes	5347	11828	105	4
B	04/05/2018	21	2	39	1500	2	yes	6498	10654	128	4
B	04/05/2018	21	3	39	1500	2	yes	4450	12718	111	4
B	04/05/2018	24	1	33	350	2	yes	4111	13097	72	4
B	04/05/2018	24	2	33	350	2	yes	5163	12013	104	4
B	04/05/2018	24	3	33	350	2	yes	3539	13659	81	4
B	04/05/2018	28	1	39	850	2	yes	7230	9964	86	4
B	04/05/2018	28	2	39	850	2	yes	9367	7788	125	4
B	04/05/2018	28	3	39	850	2	yes	7287	9904	88	4
B	04/05/2018	30	1	36	700	2	yes	7136	10018	126	4
B	04/05/2018	30	2	36	700	2	yes	8358	8768	154	4
B	04/05/2018	30	3	36	700	2	yes	6309	10760	210	4
B	04/05/2018	33	1	37.5	450	2	yes	4766	12441	73	4
B	04/05/2018	33	2	37.5	450	2	yes	5643	11507	130	4
B	04/05/2018	33	3	37.5	450	2	yes	4338	12824	117	4
B	04/05/2018	35	1	39.5	350	2	yes	4951	12180	149	4
B	04/05/2018	35	2	39.5	350	2	yes	7166	9942	172	4
B	04/05/2018	35	3	39.5	350	2	yes	5431	11718	130	4

B	04/05/2018	40	1	38	400	2	yes	5282	11920	78	4
B	04/05/2018	40	2	38	400	2	yes	6866	10331	83	4
B	04/05/2018	40	3	38	400	2	yes	4753	12422	104	4
B	04/05/2018	41	1	43	100	2	yes	4858	12331	91	4
B	04/05/2018	41	2	43	100	2	yes	5485	11716	79	4
B	04/05/2018	41	3	43	100	2	yes	4542	12659	78	4
B	04/05/2018	42	1	36.5	100	2	yes	7929	9144	207	4
B	04/05/2018	42	2	36.5	100	2	yes	9279	7740	261	4
B	04/05/2018	42	3	36.5	100	2	yes	7876	9202	201	4
A	08/05/2018	23	1	38	0	2	yes	7592	9557	131	2
A	08/05/2018	23	2	38	0	2	yes	7402	9767	111	2
A	08/05/2018	26	1	40	0	2	yes	8014	9050	216	2
A	08/05/2018	26	2	40	0	2	yes	5724	11356	200	2
A	08/05/2018	27	1	41.5	0	2	yes	8093	9048	139	2
A	08/05/2018	27	2	41.5	0	2	yes	7556	9627	97	2
A	08/05/2018	29	1	46.5	0	2	yes	6093	10943	244	2
A	08/05/2018	29	2	46.5	0	2	yes	5839	11297	144	2
A	08/05/2018	31	1	37.5	0	2	yes	8229	8891	160	2
A	08/05/2018	31	2	37.5	0	2	yes	7837	9349	94	2
A	08/05/2018	32	1	37	0	2	yes	9592	7597	91	2
A	08/05/2018	32	2	37	0	2	yes	5876	11143	261	2
A	08/05/2018	34	1	33.5	0	2	yes	9165	8038	77	2
A	08/05/2018	34	2	33.5	0	2	yes	6918	10317	45	2
A	08/05/2018	37	1	44	0	2	yes	6368	10782	130	2
A	08/05/2018	37	2	44	0	2	yes	4952	12247	81	2
A	08/05/2018	38	1	29.5	0	2	yes	7447	9701	132	2
A	08/05/2018	38	2	29.5	0	2	yes	6386	10770	124	2
A	08/05/2018	39	1	37	0	2	yes	7754	9344	182	2
A	08/05/2018	39	2	37	0	2	yes	6105	11041	134	2
B	08/05/2018	19	1	39.5	3300	2	yes	6424	10775	81	5
B	08/05/2018	19	2	39.5	3300	2	yes	4796	12410	74	5
B	08/05/2018	24	1	33.5	850	2	yes	5520	11683	77	5
B	08/05/2018	24	2	33.5	850	2	yes	4537	12634	109	5
B	08/05/2018	28	1	38.5	3450	2	yes	7975	9195	110	5
B	08/05/2018	28	2	38.5	3450	2	yes	6446	10746	88	5
B	08/05/2018	30	1	35	900	2	yes	6095	11097	88	5
B	08/05/2018	30	2	35	900	2	yes	6155	10942	183	5
B	08/05/2018	33	1	37	1100	2	yes	3629	13566	85	5
B	08/05/2018	33	2	37	1100	2	yes	2693	14529	58	5
B	08/05/2018	36	1	41.5	850	2	yes	6753	10383	144	5
B	08/05/2018	36	2	41.5	850	2	yes	5899	11275	106	5
B	08/05/2018	40	1	37	1800	2	yes	7404	9768	108	5
B	08/05/2018	40	2	37	1800	2	yes	7063	10106	111	5

B	08/05/2018	42	1	36.5	1200	2	yes	8664	8498	118	5
B	08/05/2018	42	2	36.5	1200	2	yes	7644	9492	144	5
A	15/05/2018	23	1	37	0	2	no	7009	10100	171	3
A	15/05/2018	23	2	37	0	2	no	6861	10290	129	3
A	15/05/2018	23	3	37	0	2	no	5779	11414	87	3
A	15/05/2018	26	1	39	0	2	no	5219	11956	105	3
A	15/05/2018	26	2	39	0	2	no	6970	10152	158	3
A	15/05/2018	26	3	39	0	2	no	7807	9216	257	3
A	15/05/2018	27	1	41.5	0	2	no	7126	10107	47	3
A	15/05/2018	27	2	41.5	0	2	no	7795	9393	92	3
A	15/05/2018	27	3	41.5	0	2	no	7032	10085	163	3
A	15/05/2018	29	1	46.5	0	2	no	4721	12363	196	3
A	15/05/2018	29	2	46.5	0	2	no	5504	11580	196	3
A	15/05/2018	29	3	46.5	0	2	no	5799	11171	310	3
A	15/05/2018	31	1	38.5	0	2	no	7432	9746	102	3
A	15/05/2018	31	2	38.5	0	2	no	7097	10046	137	3
A	15/05/2018	31	3	38.5	0	2	no	7536	9633	111	3
A	15/05/2018	32	1	37.5	0	2	no	5406	11794	80	3
A	15/05/2018	32	2	37.5	0	2	no	7514	9610	156	3
A	15/05/2018	32	3	37.5	0	2	no	7589	9544	147	3
A	15/05/2018	34	1	34	0	2	no	7340	9859	81	3
A	15/05/2018	34	2	34	0	2	no	8283	8916	81	3
A	15/05/2018	34	3	34	0	2	no	8268	8891	121	3
A	15/05/2018	37	1	44.5	0	2	no	4578	12617	85	3
A	15/05/2018	37	2	44.5	0	2	no	6906	10333	41	3
A	15/05/2018	37	3	44.5	0	2	no	5856	11320	104	3
A	15/05/2018	38	1	29.5	0	2	no	3769	13448	63	3
A	15/05/2018	38	2	29.5	0	2	no	4946	12228	106	3
A	15/05/2018	38	3	29.5	0	2	no	5711	11438	131	3
A	15/05/2018	39	1	36	0	2	no	4902	12215	163	3
A	15/05/2018	39	2	36	0	2	no	6806	10264	210	3
A	15/05/2018	39	3	36	0	2	no	6465	10628	187	3
A	22/05/2018	23	1	38	100	3	no	7858	9252	170	4
A	22/05/2018	23	2	38	100	3	no	6786	10402	92	4
A	22/05/2018	26	1	38	50	3	no	7123	9984	173	4
A	22/05/2018	26	2	38	50	3	no	6375	10758	147	4
A	22/05/2018	27	1	39.5	200	3	no	7270	9899	111	4
A	22/05/2018	27	2	39.5	200	3	no	6117	11101	62	4
A	22/05/2018	29	1	46.5	0	3	no	4719	12438	123	4
A	22/05/2018	29	2	46.5	0	3	no	3867	13306	107	4
A	22/05/2018	31	1	37.5	50	3	no	8129	9043	108	4
A	22/05/2018	31	2	37.5	50	3	no	7396	9786	98	4
A	22/05/2018	32	1	34.5	0	3	no	6881	10325	74	4

A	22/05/2018	32	2	34.5	0	3	no	5195	11938	147	4
A	22/05/2018	34	1	32.5	50	3	no	5949	11270	61	4
A	22/05/2018	34	2	32.5	50	3	no	3847	13353	80	4
A	22/05/2018	37	1	46	250	3	no	4382	12818	80	4
A	22/05/2018	37	2	46	250	3	no	3311	13910	59	4
A	22/05/2018	38	1	28.5	50	3	no	4952	12219	109	4
A	22/05/2018	38	2	28.5	50	3	no	3878	13320	82	4
A	22/05/2018	39	1	35	0	3	no	6932	10205	143	4
A	22/05/2018	39	2	35	0	3	no	5762	11390	128	4
B	22/05/2018	19	1	43	0	3	no	8628	8527	125	1
B	22/05/2018	19	2	43	0	3	no	6916	10252	112	1
B	22/05/2018	21	1	39	0	3	no	2745	14422	113	1
B	22/05/2018	21	2	39	0	3	no	2319	14872	89	1
B	22/05/2018	24	1	32	0	3	no	5514	11718	48	1
B	22/05/2018	24	2	32	0	3	no	4378	12829	73	1
B	22/05/2018	28	1	37	0	3	no	7900	9300	80	1
B	22/05/2018	28	2	37	0	3	no	7652	9536	92	1
B	22/05/2018	30	1	36.5	0	3	no	7578	9591	111	1
B	22/05/2018	30	2	36.5	0	3	no	6562	10617	101	1
B	22/05/2018	33	1	38.5	0	3	no	4990	12188	102	1
B	22/05/2018	33	2	38.5	0	3	no	4807	12385	88	1
B	22/05/2018	35	1	39	0	3	no	3861	13310	109	1
B	22/05/2018	35	2	39	0	3	no	4531	12683	66	1
B	22/05/2018	36	1	40	0	3	no	7788	9357	135	1
B	22/05/2018	36	2	40	0	3	no	6596	10580	104	1
B	22/05/2018	40	1	34.5	0	3	no	7161	10064	55	1
B	22/05/2018	40	2	34.5	0	3	no	6233	10997	50	1
B	22/05/2018	41	1	42.5	0	3	no	5867	11358	55	1
B	22/05/2018	41	2	42.5	0	3	no	4491	12744	45	1
B	22/05/2018	42	1	35.5	0	3	no	7473	9683	124	1
B	22/05/2018	42	2	35.5	0	3	no	7147	9973	160	1
A	29/05/2018	23	1	36.5	350	3	no	5736	11418	126	5
A	29/05/2018	23	2	36.5	350	3	no	5561	11600	119	5
A	29/05/2018	23	3	36.5	350	3	no	5021	12083	176	5
A	29/05/2018	26	1	39	300	3	no	7920	9199	161	5
A	29/05/2018	26	2	39	300	3	no	7104	9914	262	5
A	29/05/2018	26	3	39	300	3	no	6449	10594	237	5
A	29/05/2018	27	1	40	1000	3	no	6897	10285	98	5
A	29/05/2018	27	2	40	1000	3	no	6882	10273	125	5
A	29/05/2018	27	3	40	1000	3	no	6260	10902	118	5
A	29/05/2018	29	1	44.5	200	3	no	5252	11918	110	5
A	29/05/2018	29	2	44.5	200	3	no	4369	12807	104	5
A	29/05/2018	29	3	44.5	200	3	no	4872	12323	85	5

A	29/05/2018	31	1	38	50	3	no	7983	9170	127	5
A	29/05/2018	31	2	38	50	3	no	6548	10595	137	5
A	29/05/2018	31	3	38	50	3	no	6225	10940	115	5
A	29/05/2018	32	1	36.5	450	3	no	8046	9098	136	5
A	29/05/2018	32	2	36.5	450	3	no	6795	10350	135	5
A	29/05/2018	32	3	36.5	450	3	no	5907	11049	324	5
A	29/05/2018	34	1	33	900	3	no	7407	9775	98	5
A	29/05/2018	34	2	33	900	3	no	6185	10993	102	5
A	29/05/2018	34	3	33	900	3	no	7070	10095	115	5
A	29/05/2018	37	1	43.5	1550	3	no	3811	13384	85	5
A	29/05/2018	37	2	43.5	1550	3	no	2903	14286	91	5
A	29/05/2018	37	3	43.5	1550	3	no	3318	13868	94	5
A	29/05/2018	38	1	29.5	850	3	no	6677	10521	82	5
A	29/05/2018	38	2	29.5	850	3	no	7659	9419	202	5
A	29/05/2018	38	3	29.5	850	3	no	6917	10161	202	5
A	29/05/2018	39	1	36	1300	3	no	5190	11926	164	5
A	29/05/2018	39	2	36	1300	3	no	5071	12020	189	5
A	29/05/2018	39	3	36	1300	3	no	4703	12418	159	5
B	29/05/2018	19	1	42.5	0	3	no	7713	9403	164	2
B	29/05/2018	19	2	42.5	0	3	no	7665	9391	224	2
B	29/05/2018	19	3	42.5	0	3	no	7950	9067	263	2
B	29/05/2018	21	1	39.5	0	3	no	3611	13570	99	2
B	29/05/2018	21	2	39.5	0	3	no	2565	14602	113	2
B	29/05/2018	21	3	39.5	0	3	no	2410	14759	111	2
B	29/05/2018	24	1	33	0	3	no	5462	11728	90	2
B	29/05/2018	24	2	33	0	3	no	5289	11872	119	2
B	29/05/2018	24	3	33	0	3	no	5174	11976	130	2
B	29/05/2018	28	1	38.5	0	3	no	7157	10011	112	2
B	29/05/2018	28	2	38.5	0	3	no	7123	10032	125	2
B	29/05/2018	28	3	38.5	0	3	no	7049	10114	117	2
B	29/05/2018	30	1	37.5	0	3	no	7777	9323	180	2
B	29/05/2018	30	2	37.5	0	3	no	8033	9008	239	2
B	29/05/2018	30	3	37.5	0	3	no	7289	9683	308	2
B	29/05/2018	33	1	38	0	3	no	5546	11594	140	2
B	29/05/2018	33	2	38	0	3	no	6646	10452	182	2
B	29/05/2018	33	3	38	0	3	no	6943	10167	170	2
B	29/05/2018	35	1	40.5	0	3	no	5058	12120	102	2
B	29/05/2018	35	2	40.5	0	3	no	4162	12950	168	2
B	29/05/2018	35	3	40.5	0	3	no	5242	11830	208	2
B	29/05/2018	36	1	40.5	0	3	no	6826	10352	102	2
B	29/05/2018	36	2	40.5	0	3	no	6278	10843	159	2
B	29/05/2018	36	3	40.5	0	3	no	6236	10870	174	2
B	29/05/2018	40	1	37.5	0	3	no	6557	10657	66	2

B	29/05/2018	40	2	37.5	0	3	no	6929	10281	70	2
B	29/05/2018	40	3	37.5	0	3	no	6200	11002	78	2
B	29/05/2018	41	1	42	0	3	no	6810	10310	160	2
B	29/05/2018	41	2	42	0	3	no	7068	10075	137	2
B	29/05/2018	41	3	42	0	3	no	6945	10061	274	2
B	29/05/2018	42	1	36.5	0	3	no	7890	9252	138	2
B	29/05/2018	42	2	36.5	0	3	no	7928	9149	203	2
B	29/05/2018	42	3	36.5	0	3	no	7847	9171	262	2
B	05/06/2018	19	1	44.5	0	3	no	6807	10349	124	3
B	05/06/2018	19	2	44.5	0	3	no	6506	10467	307	3
B	05/06/2018	19	3	44.5	0	3	no	7969	9184	127	3
B	05/06/2018	21	1	39	0	3	no	4382	12797	101	3
B	05/06/2018	21	2	39	0	3	no	4384	12768	128	3
B	05/06/2018	21	3	39	0	3	no	4310	12875	95	3
B	05/06/2018	24	1	33.5	0	3	no	6047	11132	101	3
B	05/06/2018	24	2	33.5	0	3	no	6517	10603	160	3
B	05/06/2018	24	3	33.5	0	3	no	7124	10068	88	3
B	05/06/2018	28	1	39	0	3	no	7045	10124	111	3
B	05/06/2018	28	2	39	0	3	no	8284	8738	258	3
B	05/06/2018	28	3	39	0	3	no	8102	9058	120	3
B	05/06/2018	30	1	38.5	0	3	no	7537	9596	147	3
B	05/06/2018	30	2	38.5	0	3	no	8904	8172	204	3
B	05/06/2018	30	3	38.5	0	3	no	8333	8724	223	3
B	05/06/2018	33	1	38	0	3	no	4358	12805	117	3
B	05/06/2018	33	2	38	0	3	no	4282	12693	305	3
B	05/06/2018	33	3	38	0	3	no	4418	12724	138	3
B	05/06/2018	35	1	40	0	3	no	6026	11112	142	3
B	05/06/2018	35	2	40	0	3	no	5832	11202	246	3
B	05/06/2018	35	3	40	0	3	no	6390	10756	134	3
B	05/06/2018	36	1	42	0	3	no	5804	11356	120	3
B	05/06/2018	36	2	42	0	3	no	6211	10770	299	3
B	05/06/2018	36	3	42	0	3	no	7103	9982	195	3
B	05/06/2018	40	1	40	0	3	no	6474	10734	72	3
B	05/06/2018	40	2	40	0	3	no	6965	10158	157	3
B	05/06/2018	40	3	40	0	3	no	7645	9532	103	3
B	05/06/2018	41	1	43.5	0	3	no	6872	10260	148	3
B	05/06/2018	41	2	43.5	0	3	no	6707	10300	273	3
B	05/06/2018	41	3	43.5	0	3	no	8465	8634	181	3
B	05/06/2018	42	1	38	0	3	no	7401	9687	192	3
B	05/06/2018	42	2	38	0	3	no	7961	9017	302	3
B	05/06/2018	42	3	38	0	3	no	8494	8598	188	3
A	12/06/2018	23	1	39.5	0	3	no	6328	10809	143	1
A	12/06/2018	23	2	39.5	0	3	no	6021	11046	213	1

A	12/06/2018	23	3	39.5	0	3	no	5560	11491	229	1
A	12/06/2018	26	1	40.5	0	3	no	6464	10726	90	1
A	12/06/2018	26	2	40.5	0	3	no	6367	10799	114	1
A	12/06/2018	26	3	40.5	0	3	no	6074	10978	228	1
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A	12/06/2018	29	2	48	0	3	no	4821	12302	157	1
A	12/06/2018	29	3	48	0	3	no	5568	11504	208	1
A	12/06/2018	31	1	41	0	3	no	7349	9784	147	1
A	12/06/2018	31	2	41	0	3	no	8015	9025	240	1
A	12/06/2018	31	3	41	0	3	no	7482	9598	200	1
A	12/06/2018	32	1	37	0	3	no	5528	11666	86	1
A	12/06/2018	32	2	37	0	3	no	5577	11507	196	1
A	12/06/2018	32	3	37	0	3	no	6752	10260	268	1
A	12/06/2018	34	1	36	0	3	no	5923	11276	81	1
A	12/06/2018	34	2	36	0	3	no	7545	9635	100	1
A	12/06/2018	34	3	36	0	3	no	7771	9344	165	1
A	12/06/2018	38	1	32	0	3	no	6244	10943	93	1
A	12/06/2018	38	2	32	0	3	no	7237	9911	132	1
A	12/06/2018	38	3	32	0	3	no	7875	9211	194	1
A	12/06/2018	39	1	37.5	0	3	no	5406	11720	154	1
A	12/06/2018	39	2	37.5	0	3	no	6123	10970	187	1
A	12/06/2018	39	3	37.5	0	3	no	6489	10514	277	1
B	12/06/2018	19	1	45.5	100	3	no	8131	9039	110	4
B	12/06/2018	19	2	45.5	100	3	no	7493	9635	152	4
B	12/06/2018	19	3	45.5	100	3	no	8012	8957	311	4
B	12/06/2018	21	1	41.5	0	3	no	6411	10808	61	4
B	12/06/2018	21	2	41.5	0	3	no	6959	10258	63	4
B	12/06/2018	21	3	41.5	0	3	no	5839	11322	119	4
B	12/06/2018	24	1	36.5	50	3	no	3714	13477	89	4
B	12/06/2018	24	2	36.5	50	3	no	3828	13342	110	4
B	12/06/2018	24	3	36.5	50	3	no	4138	13040	102	4
B	12/06/2018	28	1	40.5	250	3	no	6921	10242	117	4
B	12/06/2018	28	2	40.5	250	3	no	8620	8468	192	4
B	12/06/2018	28	3	40.5	250	3	no	6666	10449	165	4
B	12/06/2018	30	1	39.5	150	3	no	7377	9772	131	4
B	12/06/2018	30	2	39.5	150	3	no	8922	8219	139	4
B	12/06/2018	30	3	39.5	150	3	no	7613	9536	131	4
B	12/06/2018	33	1	38	0	3	no	1958	15280	42	4
B	12/06/2018	33	2	38	0	3	no	2539	14680	61	4
B	12/06/2018	33	3	38	0	3	no	1876	15366	38	4
B	12/06/2018	35	1	41.5	0	3	no	5705	11453	122	4
B	12/06/2018	35	2	41.5	0	3	no	7213	9878	189	4
B	12/06/2018	35	3	41.5	0	3	no	5088	11937	255	4

B	12/06/2018	36	1	43	0	3	no	6388	10770	122	4
B	12/06/2018	36	2	43	0	3	no	7482	9641	157	4
B	12/06/2018	36	3	43	0	3	no	6151	10966	163	4
B	12/06/2018	41	1	45	100	3	no	7049	10149	82	4
B	12/06/2018	41	2	45	100	3	no	7780	9375	125	4
B	12/06/2018	41	3	45	100	3	no	7891	9147	242	4
B	12/06/2018	42	1	41	0	3	no	8371	8756	153	4
B	12/06/2018	42	2	41	0	3	no	8888	8140	252	4
B	12/06/2018	42	3	41	0	3	no	7754	9289	237	4
A	19/06/2018	23	1	38.5	0	3	no	6715	10273	292	2
A	19/06/2018	23	2	38.5	0	3	no	6674	10229	377	2
A	19/06/2018	23	3	38.5	0	3	no	7203	9815	261	2
A	19/06/2018	26	1	39.5	0	3	no	6686	10261	333	2
A	19/06/2018	26	2	39.5	0	3	no	7468	9538	274	2
A	19/06/2018	26	3	39.5	0	3	no	6064	10978	237	2
A	19/06/2018	27	1	43	0	3	no	6959	10185	136	2
A	19/06/2018	27	2	43	0	3	no	6328	10811	141	2
A	19/06/2018	27	3	43	0	3	no	6267	10890	122	2
A	19/06/2018	29	1	48.5	0	3	no	6234	10769	277	2
A	19/06/2018	29	2	48.5	0	3	no	5154	11809	317	2
A	19/06/2018	29	3	48.5	0	3	no	6726	10382	171	2
A	19/06/2018	32	1	37.5	0	3	no	7005	10142	133	2
A	19/06/2018	32	2	37.5	0	3	no	6482	10554	244	2
A	19/06/2018	32	3	37.5	0	3	no	5522	11246	511	2
A	19/06/2018	34	1	34.5	0	3	no	7951	9180	149	2
A	19/06/2018	34	2	34.5	0	3	no	8459	8609	212	2
A	19/06/2018	34	3	34.5	0	3	no	7141	10023	115	2
A	19/06/2018	37	1	43.5	0	3	no	2980	14156	144	2
A	19/06/2018	37	2	43.5	0	3	no	2898	14246	136	2
A	19/06/2018	37	3	43.5	0	3	no	3372	13801	106	2
A	19/06/2018	38	1	31.5	0	3	no	6732	10385	163	2
A	19/06/2018	38	2	31.5	0	3	no	5741	11424	115	2
A	19/06/2018	38	3	31.5	0	3	no	5350	11786	143	2
B	19/06/2018	19	1	45	650	3	no	7250	9861	169	5
B	19/06/2018	19	2	45	650	3	no	6922	10038	320	5
B	19/06/2018	19	3	45	650	3	no	6830	10193	256	5
B	19/06/2018	21	1	41.5	100	3	no	6197	10930	153	5
B	19/06/2018	21	2	41.5	100	3	no	5011	12113	156	5
B	19/06/2018	21	3	41.5	100	3	no	5108	12028	143	5
B	19/06/2018	28	1	41.5	1100	3	no	7434	9571	275	5
B	19/06/2018	28	2	41.5	1100	3	no	8011	8963	306	5
B	19/06/2018	28	3	41.5	1100	3	no	7766	9301	212	5
B	19/06/2018	30	1	40	150	3	no	7077	9905	298	5

B	19/06/2018	30	2	40	150	3	no	7654	9332	294	5
B	19/06/2018	30	3	40	150	3	no	7955	9110	214	5
B	19/06/2018	33	1	39.5	50	3	no	2884	14344	52	5
B	19/06/2018	33	2	39.5	50	3	no	3271	13911	98	5
B	19/06/2018	33	3	39.5	50	3	no	3515	13694	70	5
B	19/06/2018	35	1	41.5	200	3	no	6921	10118	241	5
B	19/06/2018	35	2	41.5	200	3	no	6808	10189	283	5
B	19/06/2018	35	3	41.5	200	3	no	6993	10003	283	5
B	19/06/2018	36	1	42.5	0	3	no	7070	10014	196	5
B	19/06/2018	36	2	42.5	0	3	no	7001	10067	212	5
B	19/06/2018	36	3	42.5	0	3	no	7278	9778	223	5
B	19/06/2018	40	1	41.5	1500	3	no	7503	9625	152	5
B	19/06/2018	40	2	41.5	1500	3	no	7022	10130	128	5
B	19/06/2018	40	3	41.5	1500	3	no	7832	9320	127	5
B	19/06/2018	41	1	45.5	1350	3	no	8329	8823	128	5
B	19/06/2018	41	2	45.5	1350	3	no	7989	9057	234	5
B	19/06/2018	41	3	45.5	1350	3	no	7955	9160	164	5
A	26/06/2018	23	1	40.5	0	3	no	6745	10317	218	3
A	26/06/2018	23	2	40.5	0	3	no	6064	10994	222	3
A	26/06/2018	23	3	40.5	0	3	no	6059	10819	401	3
A	26/06/2018	27	1	44.5	0	3	no	7139	9939	202	3
A	26/06/2018	27	2	44.5	0	3	no	6303	10874	103	3
A	26/06/2018	27	3	44.5	0	3	no	6283	10844	152	3
A	26/06/2018	29	1	48.5	0	3	no	6940	10125	215	3
A	26/06/2018	29	2	48.5	0	3	no	6245	10879	156	3
A	26/06/2018	29	3	48.5	0	3	no	5919	11058	302	3
A	26/06/2018	32	1	39.5	0	3	no	7619	9498	163	3
A	26/06/2018	32	2	39.5	0	3	no	6820	10303	157	3
A	26/06/2018	32	3	39.5	0	3	no	6595	10286	398	3
A	26/06/2018	34	1	35.5	0	3	no	8188	8958	134	3
A	26/06/2018	34	2	35.5	0	3	no	8016	9137	127	3
A	26/06/2018	34	3	35.5	0	3	no	7384	9729	166	3
A	26/06/2018	37	1	44.5	0	3	no	5785	11403	92	3
A	26/06/2018	37	2	44.5	0	3	no	6177	10938	165	3
A	26/06/2018	37	3	44.5	0	3	no	6647	10471	161	3
A	26/06/2018	38	1	32	50	3	no	5641	11516	123	3
A	26/06/2018	38	2	32	50	3	no	6387	10821	72	3
A	26/06/2018	38	3	32	50	3	no	5311	11859	109	3
A	26/06/2018	39	1	38.5	0	3	no	5882	11148	250	3
A	26/06/2018	39	2	38.5	0	3	no	5362	11705	213	3
A	26/06/2018	39	3	38.5	0	3	no	5699	11262	318	3
A	03/07/2018	23	1	42	0	4	no	5778	11318	184	4
A	03/07/2018	23	2	42	0	4	no	6277	10685	318	4

A	03/07/2018	23	3	42	0	4	no	5860	11184	235	4
A	03/07/2018	27	1	46	0	4	no	5571	11504	205	4
A	03/07/2018	27	2	46	0	4	no	5940	11077	263	4
A	03/07/2018	27	3	46	0	4	no	5697	11331	251	4
A	03/07/2018	29	1	49	0	4	no	6510	10517	253	4
A	03/07/2018	29	2	49	0	4	no	6474	10437	369	4
A	03/07/2018	29	3	49	0	4	no	6005	11022	252	4
A	03/07/2018	34	1	36.5	0	4	no	7127	9911	242	4
A	03/07/2018	34	2	36.5	0	4	no	7287	9687	306	4
A	03/07/2018	34	3	36.5	0	4	no	7181	9854	244	4
A	03/07/2018	37	1	44.5	0	4	no	3811	13384	85	4
A	03/07/2018	37	2	44.5	0	4	no	4667	12448	165	4
A	03/07/2018	37	3	44.5	0	4	no	3951	13201	127	4
A	03/07/2018	38	1	33	0	4	no	4878	12282	120	4
A	03/07/2018	38	2	33	0	4	no	6473	10586	221	4
A	03/07/2018	38	3	33	0	4	no	6021	11113	145	4
A	03/07/2018	39	1	39	0	4	no	5543	11471	266	4
A	03/07/2018	39	2	39	0	4	no	5765	11097	418	4
A	03/07/2018	39	3	39	0	4	no	5644	11342	293	4
B	03/07/2018	21	1	43.5	0	4	no	4998	12176	106	1
B	03/07/2018	21	2	43.5	0	4	no	5551	11514	215	1
B	03/07/2018	21	3	43.5	0	4	no	5455	11664	160	1
B	03/07/2018	24	1	38	0	4	no	6519	10622	139	1
B	03/07/2018	24	2	38	0	4	no	6257	10807	216	1
B	03/07/2018	24	3	38	0	4	no	6354	10790	135	1
B	03/07/2018	28	1	44	0	4	no	7768	9249	263	1
B	03/07/2018	28	2	44	0	4	no	7526	9361	393	1
B	03/07/2018	28	3	44	0	4	no	7785	9169	325	1
B	03/07/2018	30	1	42.5	0	4	no	7407	9566	307	1
B	03/07/2018	30	2	42.5	0	4	no	8191	8581	508	1
B	03/07/2018	30	3	42.5	0	4	no	7611	9336	332	1
B	03/07/2018	33	1	41	0	4	no	3529	13647	104	1
B	03/07/2018	33	2	41	0	4	no	3425	13605	250	1
B	03/07/2018	33	3	41	0	4	no	3711	13429	139	1
B	03/07/2018	35	1	49	0	4	no	7068	10015	197	1
B	03/07/2018	35	2	49	0	4	no	7682	9211	387	1
B	03/07/2018	35	3	49	0	4	no	7024	9916	339	1
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B	03/07/2018	36	2	45.5	0	4	no	6821	10115	344	1
B	03/07/2018	36	3	45.5	0	4	no	6390	10577	312	1
B	03/07/2018	40	1	45.5	0	4	no	8249	8892	139	1
B	03/07/2018	40	2	45.5	0	4	no	7235	9801	244	1
B	03/07/2018	40	3	45.5	0	4	no	7126	10006	147	1

B	03/07/2018	41	1	48.5	0	4	no	7705	9330	245	1
B	03/07/2018	41	2	48.5	0	4	no	8006	9000	274	1
B	03/07/2018	41	3	48.5	0	4	no	7476	9596	207	1
B	03/07/2018	42	1	44.5	0	4	no	6547	10611	122	1
B	03/07/2018	42	2	44.5	0	4	no	7647	9386	247	1
B	03/07/2018	42	3	44.5	0	4	no	6928	10173	178	1
A	10/07/2018	23	1	40.5	0	4	no	6110	10767	403	5
A	10/07/2018	23	2	40.5	0	4	no	5271	11686	323	5
A	10/07/2018	23	3	40.5	0	4	no	6872	9918	489	5
A	10/07/2018	26	1	41	0	4	no	6906	10040	334	5
A	10/07/2018	26	2	41	0	4	no	6149	10845	286	5
A	10/07/2018	26	3	41	0	4	no	6713	10048	518	5
A	10/07/2018	27	1	45.5	0	4	no	6769	10306	205	5
A	10/07/2018	27	2	45.5	0	4	no	5815	11265	200	5
A	10/07/2018	27	3	45.5	0	4	no	6612	10281	386	5
A	10/07/2018	29	1	49	50	4	no	5503	11630	147	5
A	10/07/2018	29	2	49	50	4	no	5197	11934	149	5
A	10/07/2018	29	3	49	50	4	no	6639	10346	294	5
A	10/07/2018	32	1	39.5	0	4	no	7393	9663	224	5
A	10/07/2018	32	2	39.5	0	4	no	5324	11644	312	5
A	10/07/2018	32	3	39.5	0	4	no	7481	9525	273	5
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A	10/07/2018	37	2	46	0	4	no	5645	11379	256	5
A	10/07/2018	37	3	46	0	4	no	7384	9725	170	5
A	10/07/2018	38	1	32	0	4	no	6133	10720	427	5
A	10/07/2018	38	2	32	0	4	no	6609	10297	374	5
A	10/07/2018	38	3	32	0	4	no	6942	9809	528	5
A	10/07/2018	39	1	38.5	50	4	no	7860	9243	177	5
A	10/07/2018	39	2	38.5	50	4	no	6961	10096	223	5
A	10/07/2018	39	3	38.5	50	4	no	7553	9557	169	5
B	10/07/2018	19	1	48	0	4	no	8729	8262	289	2
B	10/07/2018	19	2	48	0	4	no	8004	8963	313	2
B	10/07/2018	19	3	48	0	4	no	8812	7936	531	2
B	10/07/2018	21	1	41.5	0	4	no	5022	12090	168	2
B	10/07/2018	21	2	41.5	0	4	no	5220	11859	201	2
B	10/07/2018	21	3	41.5	0	4	no	6325	10626	328	2
B	10/07/2018	24	1	37.5	0	4	no	6914	10138	228	2
B	10/07/2018	24	2	37.5	0	4	no	6260	10723	297	2
B	10/07/2018	24	3	37.5	0	4	no	6784	10181	314	2
B	10/07/2018	28	1	45.5	0	4	no	7594	9454	232	2
B	10/07/2018	28	2	45.5	0	4	no	7681	9319	280	2
B	10/07/2018	28	3	45.5	0	4	no	7911	9082	286	2
B	10/07/2018	33	1	42	0	4	no	3309	13874	97	2

B	10/07/2018	33	2	42	0	4	no	3271	13892	117	2
B	10/07/2018	33	3	42	0	4	no	3905	13065	309	2
B	10/07/2018	35	1	44	0	4	no	6807	10174	299	2
B	10/07/2018	35	2	44	0	4	no	8116	8810	354	2
B	10/07/2018	35	3	44	0	4	no	7413	9412	454	2
B	10/07/2018	36	1	45	0	4	no	8047	8952	281	2
B	10/07/2018	36	2	45	0	4	no	6062	10984	234	2
B	10/07/2018	36	3	45	0	4	no	7307	9551	421	2
B	10/07/2018	40	1	44	0	4	no	7425	9692	163	2
B	10/07/2018	40	2	44	0	4	no	6133	10986	161	2
B	10/07/2018	40	3	44	0	4	no	7953	9121	205	2
B	10/07/2018	41	1	48.5	0	4	no	5261	11888	131	2
B	10/07/2018	41	2	48.5	0	4	no	5504	11628	148	2
B	10/07/2018	41	3	48.5	0	4	no	5703	11329	247	2
B	10/07/2018	42	1	43	0	4	no	7397	9597	286	2
B	10/07/2018	42	2	43	0	4	no	8102	8947	231	2
B	10/07/2018	42	3	43	0	4	no	8435	8586	258	2
B	17/07/2018	19	1	50.5	0	4	no	8601	8270	409	3
B	17/07/2018	19	2	50.5	0	4	no	7578	9178	524	3
B	17/07/2018	21	1	44	0	4	no	5925	11110	245	3
B	17/07/2018	21	2	44	0	4	no	5330	11677	273	3
B	17/07/2018	24	1	39	0	4	no	6169	10905	206	3
B	17/07/2018	24	2	39	0	4	no	5652	11358	270	3
B	17/07/2018	28	1	45	0	4	no	7611	9268	401	3
B	17/07/2018	28	2	45	0	4	no	8031	8831	418	3
B	17/07/2018	30	1	42.5	0	4	no	7767	8978	535	3
B	17/07/2018	30	2	42.5	0	4	no	7363	9380	537	3
B	17/07/2018	33	1	41.5	0	4	no	4445	12687	148	3
B	17/07/2018	33	2	41.5	0	4	no	3841	13184	255	3
B	17/07/2018	35	1	44.5	0	4	no	7729	9146	405	3
B	17/07/2018	35	2	44.5	0	4	no	6998	9777	505	3
B	17/07/2018	36	1	45	0	4	no	6533	10371	376	3
B	17/07/2018	36	2	45	0	4	no	6084	10739	457	3
B	17/07/2018	40	1	43.5	0	4	no	7500	9582	198	3
B	17/07/2018	40	2	43.5	0	4	no	6405	10694	181	3
B	17/07/2018	41	1	49	0	4	no	8103	8748	429	3
B	17/07/2018	41	2	49	0	4	no	7617	9302	361	3
B	17/07/2018	42	1	44	0	4	no	8478	8582	220	3
B	17/07/2018	42	2	44	0	4	no	6836	10207	237	3
A	31/07/2018	23	1	40.5	0	4	no	6096	10896	288	2
A	31/07/2018	23	2	40.5	0	4	no	5691	11107	482	2
A	31/07/2018	23	3	40.5	0	4	no	6513	10151	616	2
A	31/07/2018	26	1	41	0	4	no	8439	8426	415	2

A	31/07/2018	26	2	41	0	4	no	6076	10553	651	2
A	31/07/2018	26	3	41	0	4	no	8091	8672	517	2
A	31/07/2018	27	1	46	0	4	no	7534	9383	363	2
A	31/07/2018	27	2	46	0	4	no	6610	10227	443	2
A	31/07/2018	27	3	46	0	4	no	7645	9225	410	2
A	31/07/2018	29	1	48.5	0	4	no	5408	11640	232	2
A	31/07/2018	29	2	48.5	0	4	no	5054	12040	186	2
A	31/07/2018	29	3	48.5	0	4	no	5545	11201	534	2
A	31/07/2018	31	1	43	0	4	no	8268	8673	339	2
A	31/07/2018	31	2	43	0	4	no	8024	8903	353	2
A	31/07/2018	31	3	43	0	4	no	7621	9103	556	2
A	31/07/2018	32	1	41	0	4	no	7343	9803	134	2
A	31/07/2018	32	2	41	0	4	no	5815	11273	192	2
A	31/07/2018	32	3	41	0	4	no	8018	8900	362	2
A	31/07/2018	34	1	37	0	4	no	8438	8518	324	2
A	31/07/2018	34	2	37	0	4	no	7126	9810	344	2
A	31/07/2018	34	3	37	0	4	no	8391	8416	473	2
A	31/07/2018	37	1	44.5	0	4	no	3886	13251	143	2
A	31/07/2018	37	2	44.5	0	4	no	3640	13344	296	2
A	31/07/2018	37	3	44.5	0	4	no	5371	11617	292	2
A	31/07/2018	38	1	33	0	4	no	6166	10974	140	2
A	31/07/2018	38	2	33	0	4	no	5389	11625	266	2
A	31/07/2018	38	3	33	0	4	no	6459	10373	448	2
A	31/07/2018	39	1	40.5	0	4	no	7053	9736	491	2
A	31/07/2018	39	2	40.5	0	4	no	6151	10640	489	2
A	31/07/2018	39	3	40.5	0	4	no	7488	9243	549	2
B	31/07/2018	19	1	49.5	0	4	no	7919	8875	486	5
B	31/07/2018	19	2	49.5	0	4	no	7409	9381	490	5
B	31/07/2018	19	3	49.5	0	4	no	8134	8389	757	5
B	31/07/2018	21	1	44	0	4	no	5940	11102	238	5
B	31/07/2018	21	2	44	0	4	no	5831	11222	227	5
B	31/07/2018	21	3	44	0	4	no	6789	10181	310	5
B	31/07/2018	24	1	38.5	0	4	no	7962	8996	322	5
B	31/07/2018	24	2	38.5	0	4	no	6873	10082	325	5
B	31/07/2018	24	3	38.5	0	4	no	7788	9090	402	5
B	31/07/2018	28	1	46	50	4	no	7574	9531	175	5
B	31/07/2018	28	2	46	50	4	no	7232	9820	228	5
B	31/07/2018	28	3	46	50	4	no	8146	8779	355	5
B	31/07/2018	30	1	41.5	0	4	no	8046	8811	423	5
B	31/07/2018	30	2	41.5	0	4	no	8145	8715	420	5
B	31/07/2018	30	3	41.5	0	4	no	7912	8644	724	5
B	31/07/2018	33	1	42	0	4	no	5313	11734	233	5
B	31/07/2018	33	2	42	0	4	no	4603	12338	339	5

B	31/07/2018	33	3	42	0	4	no	5166	11703	411	5
B	31/07/2018	35	1	44.5	50	4	no	6800	10227	253	5
B	31/07/2018	35	2	44.5	50	4	no	99	17147	34	5
B	31/07/2018	35	3	44.5	50	4	no	5	17270	5	5
B	31/07/2018	36	1	45	50	4	no	6998	10059	223	5
B	31/07/2018	36	2	45	50	4	no	6917	10025	338	5
B	31/07/2018	36	3	45	50	4	no	7597	9255	428	5
B	31/07/2018	40	1	43.5	0	4	no	6892	10131	257	5
B	31/07/2018	40	2	43.5	0	4	no	6020	11069	191	5
B	31/07/2018	40	3	43.5	0	4	no	7153	9696	431	5
B	31/07/2018	41	1	49	0	4	no	8502	8551	227	5
B	31/07/2018	41	2	49	0	4	no	7037	9904	339	5
B	31/07/2018	41	3	49	0	4	no	8536	8383	361	5
B	31/07/2018	42	1	44.5	0	4	no	7682	9350	248	5
B	31/07/2018	42	2	44.5	0	4	no	6953	10001	326	5
B	31/07/2018	42	3	44.5	0	4	no	7784	9171	325	5

Keys:

Appendix 5-4 Data table used for analysis of activity vector magnitudes (VeDBA)

Calendar week	Sheep ID	Day	Activity	Group	LW	FEC	LWG	Study week	Period	WPT	Co-Grazing	VeDBA
09/01/2018	19	1	Walking	B	39.5	0	0.405	3	1	3	yes	0.713
09/01/2018	19	2	Walking	B	39.5	0	0.405	3	1	3	yes	0.813
09/01/2018	19	3	Walking	B	39.5	0	0.405	3	1	3	yes	0.583
09/01/2018	21	1	Walking	B	35	150	0.238	3	1	3	yes	0.465
09/01/2018	21	2	Walking	B	35	150	0.238	3	1	3	yes	0.661
09/01/2018	21	3	Walking	B	35	150	0.238	3	1	3	yes	0.636
09/01/2018	24	1	Walking	B	32	150	0.190	3	1	3	yes	0.666
09/01/2018	24	2	Walking	B	32	150	0.190	3	1	3	yes	0.738
09/01/2018	24	3	Walking	B	32	150	0.190	3	1	3	yes	0.948
09/01/2018	28	1	Walking	B	32	300	-0.071	3	1	3	yes	0.631
09/01/2018	28	2	Walking	B	32	300	-0.071	3	1	3	yes	0.846
09/01/2018	28	3	Walking	B	32	300	-0.071	3	1	3	yes	0.512
09/01/2018	30	1	Walking	B	34.5	0	0.119	3	1	3	yes	0.624
09/01/2018	30	2	Walking	B	34.5	0	0.119	3	1	3	yes	0.590
09/01/2018	30	3	Walking	B	34.5	0	0.119	3	1	3	yes	0.921
09/01/2018	33	1	Walking	B	31	0	0.500	3	1	3	yes	0.877
09/01/2018	33	2	Walking	B	31	0	0.500	3	1	3	yes	0.727
09/01/2018	33	3	Walking	B	31	0	0.500	3	1	3	yes	0.602
09/01/2018	35	1	Walking	B	36	0	0.262	3	1	3	yes	1.448
09/01/2018	35	2	Walking	B	36	0	0.262	3	1	3	yes	1.137
09/01/2018	35	3	Walking	B	36	0	0.262	3	1	3	yes	1.115
09/01/2018	36	1	Walking	B	36.5	0	0.214	3	1	3	yes	1.050
09/01/2018	36	2	Walking	B	36.5	0	0.214	3	1	3	yes	0.790
09/01/2018	36	3	Walking	B	36.5	0	0.214	3	1	3	yes	1.140
09/01/2018	40	1	Walking	B	32.5	0	0.095	3	1	3	yes	0.510
09/01/2018	40	2	Walking	B	32.5	0	0.095	3	1	3	yes	0.548
09/01/2018	40	3	Walking	B	32.5	0	0.095	3	1	3	yes	0.373
09/01/2018	41	1	Walking	B	37	0	0.095	3	1	3	yes	0.525
09/01/2018	41	2	Walking	B	37	0	0.095	3	1	3	yes	0.394
09/01/2018	41	3	Walking	B	37	0	0.095	3	1	3	yes	0.778
09/01/2018	42	1	Walking	B	32.5	0	0.310	3	1	3	yes	1.443
09/01/2018	42	2	Walking	B	32.5	0	0.310	3	1	3	yes	1.220
09/01/2018	42	3	Walking	B	32.5	0	0.310	3	1	3	yes	1.134
16/01/2018	19	1	Walking	B	31	200	0.000	4	1	4	yes	0.848
16/01/2018	19	2	Walking	B	31	200	0.000	4	1	4	yes	2.253
16/01/2018	19	3	Walking	B	31	200	0.000	4	1	4	yes	1.659
16/01/2018	21	1	Walking	B	28	0	-0.071	4	1	4	yes	0.343
16/01/2018	21	2	Walking	B	28	0	-0.071	4	1	4	yes	0.865
16/01/2018	21	3	Walking	B	28	0	-0.071	4	1	4	yes	1.019
16/01/2018	23	1	Walking	A	29.5	0	-0.214	4	1	1	yes	0.446
16/01/2018	23	2	Walking	A	29.5	0	-0.214	4	1	1	yes	1.195
16/01/2018	23	3	Walking	A	29.5	0	-0.214	4	1	1	yes	1.043
16/01/2018	24	1	Walking	B	27.5	0	-0.018	4	1	4	yes	0.400

16/01/2018	24	2	Walking	B	27.5	0	-0.018	4	1	4	yes	0.895
16/01/2018	24	3	Walking	B	27.5	0	-0.018	4	1	4	yes	1.109
16/01/2018	25	1	Walking	A	30	0	-0.214	4	1	1	yes	0.678
16/01/2018	25	2	Walking	A	30	0	-0.214	4	1	1	yes	1.144
16/01/2018	25	3	Walking	A	30	0	-0.214	4	1	1	yes	0.939
16/01/2018	26	1	Walking	A	30	0	NA	4	1	1	yes	0.534
16/01/2018	26	2	Walking	A	30	0	NA	4	1	1	yes	0.814
16/01/2018	26	3	Walking	A	30	0	NA	4	1	1	yes	1.107
16/01/2018	27	1	Walking	A	30	0	NA	4	1	1	yes	0.488
16/01/2018	27	2	Walking	A	30	0	NA	4	1	1	yes	1.091
16/01/2018	27	3	Walking	A	30	0	NA	4	1	1	yes	1.213
16/01/2018	28	1	Walking	B	31.5	0	-0.071	4	1	4	yes	0.497
16/01/2018	28	2	Walking	B	31.5	0	-0.071	4	1	4	yes	0.932
16/01/2018	28	3	Walking	B	31.5	0	-0.071	4	1	4	yes	1.268
16/01/2018	30	1	Walking	B	30	0	-0.071	4	1	4	yes	0.732
16/01/2018	30	2	Walking	B	30	0	-0.071	4	1	4	yes	1.703
16/01/2018	30	3	Walking	B	30	0	-0.071	4	1	4	yes	1.337
16/01/2018	31	1	Walking	A	29	0	-0.643	4	1	1	yes	0.556
16/01/2018	31	2	Walking	A	29	0	-0.643	4	1	1	yes	0.972
16/01/2018	31	3	Walking	A	29	0	-0.643	4	1	1	yes	0.961
16/01/2018	32	1	Walking	A	30	0	-1.000	4	1	1	yes	0.441
16/01/2018	32	2	Walking	A	30	0	-1.000	4	1	1	yes	1.573
16/01/2018	32	3	Walking	A	30	0	-1.000	4	1	1	yes	1.478
16/01/2018	33	1	Walking	B	27.5	200	0.250	4	1	4	yes	0.305
16/01/2018	33	2	Walking	B	27.5	200	0.250	4	1	4	yes	1.543
16/01/2018	33	3	Walking	B	27.5	200	0.250	4	1	4	yes	0.964
16/01/2018	34	1	Walking	A	25	0	NA	4	1	1	yes	0.565
16/01/2018	34	2	Walking	A	25	0	NA	4	1	1	yes	0.774
16/01/2018	34	3	Walking	A	25	0	NA	4	1	1	yes	0.833
16/01/2018	35	1	Walking	B	31	0	-0.232	4	1	4	yes	0.519
16/01/2018	35	2	Walking	B	31	0	-0.232	4	1	4	yes	1.087
16/01/2018	35	3	Walking	B	31	0	-0.232	4	1	4	yes	0.920
16/01/2018	36	1	Walking	B	32	0	0.000	4	1	4	yes	0.355
16/01/2018	36	2	Walking	B	32	0	0.000	4	1	4	yes	0.887
16/01/2018	36	3	Walking	B	32	0	0.000	4	1	4	yes	0.629
16/01/2018	37	1	Walking	A	30.5	0	-0.714	4	1	1	yes	0.582
16/01/2018	37	2	Walking	A	30.5	0	-0.714	4	1	1	yes	1.373
16/01/2018	37	3	Walking	A	30.5	0	-0.714	4	1	1	yes	1.086
16/01/2018	38	1	Walking	A	23.5	0	0.071	4	1	1	yes	0.316
16/01/2018	38	2	Walking	A	23.5	0	0.071	4	1	1	yes	0.776
16/01/2018	38	3	Walking	A	23.5	0	0.071	4	1	1	yes	0.797
16/01/2018	39	1	Walking	A	29	0	-0.714	4	1	1	yes	0.464
16/01/2018	39	2	Walking	A	29	0	-0.714	4	1	1	yes	0.862
16/01/2018	39	3	Walking	A	29	0	-0.714	4	1	1	yes	0.919
16/01/2018	40	1	Walking	B	28.5	0	-0.071	4	1	4	yes	0.200
16/01/2018	40	2	Walking	B	28.5	0	-0.071	4	1	4	yes	0.958

16/01/2018	40	3	Walking	B	28.5	0	-0.071	4	1	4	yes	0.609
16/01/2018	41	1	Walking	B	31	0	-0.143	4	1	4	yes	0.692
16/01/2018	41	2	Walking	B	31	0	-0.143	4	1	4	yes	1.088
16/01/2018	41	3	Walking	B	31	0	-0.143	4	1	4	yes	1.479
16/01/2018	42	1	Walking	B	27.5	0	0.054	4	1	4	yes	0.815
16/01/2018	42	2	Walking	B	27.5	0	0.054	4	1	4	yes	1.618
16/01/2018	42	3	Walking	B	27.5	0	0.054	4	1	4	yes	1.018
23/01/2018	19	1	Walking	B	38	550	0.200	5	1	5	yes	0.541
23/01/2018	19	2	Walking	B	38	550	0.200	5	1	5	yes	0.784
23/01/2018	19	3	Walking	B	38	550	0.200	5	1	5	yes	0.784
23/01/2018	21	1	Walking	B	31	0	0.029	5	1	5	yes	0.234
23/01/2018	21	2	Walking	B	31	0	0.029	5	1	5	yes	0.291
23/01/2018	21	3	Walking	B	31	0	0.029	5	1	5	yes	0.285
23/01/2018	23	1	Walking	A	33	0	0.143	5	1	2	yes	0.520
23/01/2018	23	2	Walking	A	33	0	0.143	5	1	2	yes	0.493
23/01/2018	23	3	Walking	A	33	0	0.143	5	1	2	yes	0.207
23/01/2018	24	1	Walking	B	31	150	0.086	5	1	5	yes	0.427
23/01/2018	24	2	Walking	B	31	150	0.086	5	1	5	yes	0.536
23/01/2018	24	3	Walking	B	31	150	0.086	5	1	5	yes	0.325
23/01/2018	25	1	Walking	A	35	0	0.036	5	1	2	yes	0.578
23/01/2018	25	2	Walking	A	35	0	0.036	5	1	2	yes	0.793
23/01/2018	25	3	Walking	A	35	0	0.036	5	1	2	yes	0.590
23/01/2018	26	1	Walking	A	35	0	-0.071	5	1	2	yes	1.395
23/01/2018	26	2	Walking	A	35	0	-0.071	5	1	2	yes	1.535
23/01/2018	26	3	Walking	A	35	0	-0.071	5	1	2	yes	1.380
23/01/2018	27	1	Walking	A	36.5	0	0.071	5	1	2	yes	1.244
23/01/2018	27	2	Walking	A	36.5	0	0.071	5	1	2	yes	1.613
23/01/2018	27	3	Walking	A	36.5	0	0.071	5	1	2	yes	0.757
23/01/2018	28	1	Walking	B	34	50	0.014	5	1	5	yes	0.559
23/01/2018	28	2	Walking	B	34	50	0.014	5	1	5	yes	1.207
23/01/2018	28	3	Walking	B	34	50	0.014	5	1	5	yes	0.734
23/01/2018	29	1	Walking	A	36.5	0	NA	5	1	2	yes	0.870
23/01/2018	29	2	Walking	A	36.5	0	NA	5	1	2	yes	1.102
23/01/2018	29	3	Walking	A	36.5	0	NA	5	1	2	yes	0.511
23/01/2018	30	1	Walking	B	34.5	0	0.071	5	1	5	yes	0.612
23/01/2018	30	2	Walking	B	34.5	0	0.071	5	1	5	yes	0.654
23/01/2018	30	3	Walking	B	34.5	0	0.071	5	1	5	yes	0.502
23/01/2018	31	1	Walking	A	31.5	50	-0.143	5	1	2	yes	0.622
23/01/2018	31	2	Walking	A	31.5	50	-0.143	5	1	2	yes	0.810
23/01/2018	31	3	Walking	A	31.5	50	-0.143	5	1	2	yes	0.675
23/01/2018	32	1	Walking	A	34.5	0	-0.179	5	1	2	yes	0.613
23/01/2018	32	2	Walking	A	34.5	0	-0.179	5	1	2	yes	0.656
23/01/2018	32	3	Walking	A	34.5	0	-0.179	5	1	2	yes	1.099
23/01/2018	33	1	Walking	B	29.5	350	0.257	5	1	5	yes	0.511
23/01/2018	33	2	Walking	B	29.5	350	0.257	5	1	5	yes	0.718
23/01/2018	33	3	Walking	B	29.5	350	0.257	5	1	5	yes	0.783

23/01/2018	34	1	Walking	A	29	0	0.000	5	1	2	yes	0.515
23/01/2018	34	2	Walking	A	29	0	0.000	5	1	2	yes	0.656
23/01/2018	34	3	Walking	A	29	0	0.000	5	1	2	yes	0.826
23/01/2018	35	1	Walking	B	37	400	-0.014	5	1	5	yes	0.690
23/01/2018	35	2	Walking	B	37	400	-0.014	5	1	5	yes	0.528
23/01/2018	35	3	Walking	B	37	400	-0.014	5	1	5	yes	0.408
23/01/2018	36	1	Walking	B	38.5	200	0.186	5	1	5	yes	0.491
23/01/2018	36	2	Walking	B	38.5	200	0.186	5	1	5	yes	0.388
23/01/2018	36	3	Walking	B	38.5	200	0.186	5	1	5	yes	0.138
23/01/2018	37	1	Walking	A	36	0	0.036	5	1	2	yes	0.341
23/01/2018	37	2	Walking	A	36	0	0.036	5	1	2	yes	0.536
23/01/2018	37	3	Walking	A	36	0	0.036	5	1	2	yes	0.491
23/01/2018	38	1	Walking	A	25.5	0	0.179	5	1	2	yes	0.567
23/01/2018	38	2	Walking	A	25.5	0	0.179	5	1	2	yes	0.809
23/01/2018	38	3	Walking	A	25.5	0	0.179	5	1	2	yes	0.553
23/01/2018	39	1	Walking	A	32.5	0	-0.107	5	1	2	yes	0.486
23/01/2018	39	2	Walking	A	32.5	0	-0.107	5	1	2	yes	0.697
23/01/2018	39	3	Walking	A	32.5	0	-0.107	5	1	2	yes	0.388
23/01/2018	40	1	Walking	B	32	50	0.043	5	1	5	yes	0.499
23/01/2018	40	2	Walking	B	32	50	0.043	5	1	5	yes	0.352
23/01/2018	40	3	Walking	B	32	50	0.043	5	1	5	yes	0.139
23/01/2018	41	1	Walking	B	35.5	0	0.014	5	1	5	yes	1.281
23/01/2018	41	2	Walking	B	35.5	0	0.014	5	1	5	yes	1.649
23/01/2018	41	3	Walking	B	35.5	0	0.014	5	1	5	yes	0.975
23/01/2018	42	1	Walking	B	28.5	0	0.071	5	1	5	yes	0.540
23/01/2018	42	2	Walking	B	28.5	0	0.071	5	1	5	yes	0.712
23/01/2018	42	3	Walking	B	28.5	0	0.071	5	1	5	yes	0.549
30/01/2018	23	2	Walking	A	31	0	0.000	6	1	3	yes	0.476
30/01/2018	23	3	Walking	A	31	0	0.000	6	1	3	yes	0.542
30/01/2018	25	2	Walking	A	37.5	0	0.143	6	1	3	yes	0.663
30/01/2018	25	3	Walking	A	37.5	0	0.143	6	1	3	yes	0.791
30/01/2018	26	2	Walking	A	38.5	0	0.119	6	1	3	yes	0.853
30/01/2018	26	3	Walking	A	38.5	0	0.119	6	1	3	yes	0.649
30/01/2018	27	2	Walking	A	34	50	-0.071	6	1	3	yes	1.424
30/01/2018	27	3	Walking	A	34	50	-0.071	6	1	3	yes	0.826
30/01/2018	29	2	Walking	A	44	0	0.000	6	1	3	yes	0.754
30/01/2018	29	3	Walking	A	44	0	0.000	6	1	3	yes	0.736
30/01/2018	31	2	Walking	A	34	0	0.024	6	1	3	yes	1.019
30/01/2018	31	3	Walking	A	34	0	0.024	6	1	3	yes	0.782
30/01/2018	32	2	Walking	A	36	0	-0.048	6	1	3	yes	0.926
30/01/2018	32	3	Walking	A	36	0	-0.048	6	1	3	yes	0.551
30/01/2018	34	2	Walking	A	30.5	0	0.071	6	1	3	yes	2.917
30/01/2018	34	3	Walking	A	30.5	0	0.071	6	1	3	yes	2.047
30/01/2018	37	2	Walking	A	41	0	0.262	6	1	3	yes	0.585
30/01/2018	37	3	Walking	A	41	0	0.262	6	1	3	yes	0.461
30/01/2018	38	2	Walking	A	27	0	0.190	6	1	3	yes	0.579

30/01/2018	38	3	Walking	A	27	0	0.190	6	1	3	yes	0.646
30/01/2018	39	2	Walking	A	33.5	0	-0.024	6	1	3	yes	0.541
30/01/2018	39	3	Walking	A	33.5	0	-0.024	6	1	3	yes	0.804
06/02/2018	19	1	Walking	B	43	0	0.786	7	1	1	yes	0.960
06/02/2018	19	2	Walking	B	43	0	0.786	7	1	1	yes	1.361
06/02/2018	21	1	Walking	B	35	0	0.143	7	1	1	yes	0.235
06/02/2018	21	2	Walking	B	35	0	0.143	7	1	1	yes	0.564
06/02/2018	23	1	Walking	A	34.5	0	0.125	7	1	4	yes	0.352
06/02/2018	23	2	Walking	A	34.5	0	0.125	7	1	4	yes	0.541
06/02/2018	24	1	Walking	B	31.5	0	-0.214	7	1	1	yes	0.523
06/02/2018	24	2	Walking	B	31.5	0	-0.214	7	1	1	yes	0.915
06/02/2018	25	1	Walking	A	36.5	0	0.071	7	1	4	yes	0.834
06/02/2018	25	2	Walking	A	36.5	0	0.071	7	1	4	yes	1.082
06/02/2018	26	1	Walking	A	35	0	-0.036	7	1	4	yes	0.736
06/02/2018	26	2	Walking	A	35	0	-0.036	7	1	4	yes	0.886
06/02/2018	27	1	Walking	A	44	200	NA	7	1	4	yes	0.653
06/02/2018	27	2	Walking	A	44	200	NA	7	1	4	yes	0.997
06/02/2018	28	1	Walking	B	36.5	0	0.214	7	1	1	yes	0.792
06/02/2018	28	2	Walking	B	36.5	0	0.214	7	1	1	yes	1.527
06/02/2018	29	1	Walking	A	43.5	0	-0.018	7	1	4	yes	0.304
06/02/2018	29	2	Walking	A	43.5	0	-0.018	7	1	4	yes	0.773
06/02/2018	30	1	Walking	B	35.5	0	-0.071	7	1	1	yes	0.851
06/02/2018	30	2	Walking	B	35.5	0	-0.071	7	1	1	yes	1.445
06/02/2018	31	1	Walking	A	31	50	-0.089	7	1	4	yes	0.569
06/02/2018	31	2	Walking	A	31	50	-0.089	7	1	4	yes	0.930
06/02/2018	32	1	Walking	A	35	0	-0.071	7	1	4	yes	0.853
06/02/2018	32	2	Walking	A	35	0	-0.071	7	1	4	yes	1.639
06/02/2018	33	1	Walking	B	31.5	0	0.143	7	1	1	yes	1.250
06/02/2018	33	2	Walking	B	31.5	0	0.143	7	1	1	yes	1.402
06/02/2018	34	1	Walking	A	30.5	200	0.054	7	1	4	yes	1.483
06/02/2018	34	2	Walking	A	30.5	200	0.054	7	1	4	yes	2.093
06/02/2018	35	1	Walking	B	38.5	0	-0.143	7	1	1	yes	0.543
06/02/2018	35	2	Walking	B	38.5	0	-0.143	7	1	1	yes	0.955
06/02/2018	36	1	Walking	B	36	0	-0.214	7	1	1	yes	0.518
06/02/2018	36	2	Walking	B	36	0	-0.214	7	1	1	yes	0.807
06/02/2018	37	1	Walking	A	36.5	50	0.036	7	1	4	yes	0.619
06/02/2018	37	2	Walking	A	36.5	50	0.036	7	1	4	yes	0.949
06/02/2018	38	1	Walking	A	26	50	0.107	7	1	4	yes	0.524
06/02/2018	38	2	Walking	A	26	50	0.107	7	1	4	yes	0.897
06/02/2018	40	1	Walking	B	33.5	0	-0.143	7	1	1	yes	0.249
06/02/2018	40	2	Walking	B	33.5	0	-0.143	7	1	1	yes	0.610
06/02/2018	41	1	Walking	B	36.5	0	-0.429	7	1	1	yes	1.363
06/02/2018	41	2	Walking	B	36.5	0	-0.429	7	1	1	yes	1.664
06/02/2018	42	1	Walking	B	32	0	0.286	7	1	1	yes	0.821
06/02/2018	42	2	Walking	B	32	0	0.286	7	1	1	yes	1.147
13/02/2018	19	1	Walking	B	38	0	0.036	8	1	2	yes	0.981

13/02/2018	19	2	Walking	B	38	0	0.036	8	1	2	yes	0.544
13/02/2018	19	3	Walking	B	38	0	0.036	8	1	2	yes	0.524
13/02/2018	21	1	Walking	B	36	0	0.143	8	1	2	yes	0.165
13/02/2018	21	2	Walking	B	36	0	0.143	8	1	2	yes	0.340
13/02/2018	21	3	Walking	B	36	0	0.143	8	1	2	yes	0.211
13/02/2018	23	1	Walking	A	33.5	150	0.071	8	1	5	yes	0.452
13/02/2018	23	2	Walking	A	33.5	150	0.071	8	1	5	yes	0.357
13/02/2018	23	3	Walking	A	33.5	150	0.071	8	1	5	yes	0.264
13/02/2018	24	1	Walking	B	33.5	0	0.036	8	1	2	yes	0.303
13/02/2018	24	2	Walking	B	33.5	0	0.036	8	1	2	yes	0.186
13/02/2018	24	3	Walking	B	33.5	0	0.036	8	1	2	yes	0.347
13/02/2018	25	1	Walking	A	33.5	0	-0.029	8	1	5	yes	1.223
13/02/2018	25	2	Walking	A	33.5	0	-0.029	8	1	5	yes	0.960
13/02/2018	25	3	Walking	A	33.5	0	-0.029	8	1	5	yes	1.072
13/02/2018	26	1	Walking	A	38.5	150	0.071	8	1	5	yes	0.498
13/02/2018	26	2	Walking	A	38.5	150	0.071	8	1	5	yes	0.346
13/02/2018	26	3	Walking	A	38.5	150	0.071	8	1	5	yes	0.484
13/02/2018	27	1	Walking	A	37	1100	0.043	8	1	5	yes	0.407
13/02/2018	27	2	Walking	A	37	1100	0.043	8	1	5	yes	0.341
13/02/2018	27	3	Walking	A	37	1100	0.043	8	1	5	yes	0.418
13/02/2018	28	1	Walking	B	36.5	0	0.107	8	1	2	yes	0.381
13/02/2018	28	2	Walking	B	36.5	0	0.107	8	1	2	yes	0.539
13/02/2018	28	3	Walking	B	36.5	0	0.107	8	1	2	yes	0.690
13/02/2018	29	1	Walking	A	42	400	-0.057	8	1	5	yes	0.386
13/02/2018	29	2	Walking	A	42	400	-0.057	8	1	5	yes	1.068
13/02/2018	29	3	Walking	A	42	400	-0.057	8	1	5	yes	0.351
13/02/2018	30	1	Walking	B	35.5	0	-0.036	8	1	2	yes	0.629
13/02/2018	30	2	Walking	B	35.5	0	-0.036	8	1	2	yes	1.491
13/02/2018	30	3	Walking	B	35.5	0	-0.036	8	1	2	yes	0.975
13/02/2018	31	1	Walking	A	33.5	250	0.000	8	1	5	yes	0.325
13/02/2018	31	2	Walking	A	33.5	250	0.000	8	1	5	yes	0.371
13/02/2018	31	3	Walking	A	33.5	250	0.000	8	1	5	yes	0.514
13/02/2018	32	1	Walking	A	32.5	1700	-0.129	8	1	5	yes	0.266
13/02/2018	32	2	Walking	A	32.5	1700	-0.129	8	1	5	yes	0.542
13/02/2018	32	3	Walking	A	32.5	1700	-0.129	8	1	5	yes	0.300
13/02/2018	33	1	Walking	B	33	0	0.179	8	1	2	yes	0.533
13/02/2018	33	2	Walking	B	33	0	0.179	8	1	2	yes	0.468
13/02/2018	33	3	Walking	B	33	0	0.179	8	1	2	yes	0.961
13/02/2018	34	1	Walking	A	30	0	0.029	8	1	5	yes	0.622
13/02/2018	34	2	Walking	A	30	0	0.029	8	1	5	yes	0.637
13/02/2018	34	3	Walking	A	30	0	0.029	8	1	5	yes	0.723
13/02/2018	35	1	Walking	B	38.5	0	-0.071	8	1	2	yes	0.350
13/02/2018	35	2	Walking	B	38.5	0	-0.071	8	1	2	yes	0.454
13/02/2018	35	3	Walking	B	38.5	0	-0.071	8	1	2	yes	0.458
13/02/2018	36	1	Walking	B	40	0	0.179	8	1	2	yes	0.351
13/02/2018	36	2	Walking	B	40	0	0.179	8	1	2	yes	0.278

13/02/2018	36	3	Walking	B	40	0	0.179	8	1	2	yes	0.418
13/02/2018	37	1	Walking	A	37.5	200	0.057	8	1	5	yes	0.298
13/02/2018	37	2	Walking	A	37.5	200	0.057	8	1	5	yes	0.446
13/02/2018	37	3	Walking	A	37.5	200	0.057	8	1	5	yes	0.338
13/02/2018	38	1	Walking	A	28.5	0	0.157	8	1	5	yes	0.228
13/02/2018	38	2	Walking	A	28.5	0	0.157	8	1	5	yes	0.246
13/02/2018	38	3	Walking	A	28.5	0	0.157	8	1	5	yes	0.194
13/02/2018	39	1	Walking	A	36	300	0.057	8	1	5	yes	0.138
13/02/2018	39	2	Walking	A	36	300	0.057	8	1	5	yes	0.197
13/02/2018	39	3	Walking	A	36	300	0.057	8	1	5	yes	0.190
13/02/2018	40	1	Walking	B	36.5	0	0.143	8	1	2	yes	NA
13/02/2018	40	2	Walking	B	36.5	0	0.143	8	1	2	yes	0.183
13/02/2018	40	3	Walking	B	36.5	0	0.143	8	1	2	yes	0.185
13/02/2018	41	1	Walking	B	36.5	0	-0.214	8	1	2	yes	0.496
13/02/2018	41	2	Walking	B	36.5	0	-0.214	8	1	2	yes	0.354
13/02/2018	41	3	Walking	B	36.5	0	-0.214	8	1	2	yes	0.492
13/02/2018	42	1	Walking	B	32.5	0	0.179	8	1	2	yes	0.474
13/02/2018	42	2	Walking	B	32.5	0	0.179	8	1	2	yes	0.460
13/02/2018	42	3	Walking	B	32.5	0	0.179	8	1	2	yes	0.371
10/04/2018	19	1	Walking	B	42.5	0	0.357	16	2	1	yes	1.056
10/04/2018	19	2	Walking	B	42.5	0	0.357	16	2	1	yes	1.098
10/04/2018	19	3	Walking	B	42.5	0	0.357	16	2	1	yes	0.626
10/04/2018	21	1	Walking	B	36	0	-0.143	16	2	1	yes	0.556
10/04/2018	21	2	Walking	B	36	0	-0.143	16	2	1	yes	0.478
10/04/2018	21	3	Walking	B	36	0	-0.143	16	2	1	yes	0.626
10/04/2018	23	1	Walking	A	39.5	150	0.179	16	2	4	yes	0.710
10/04/2018	23	2	Walking	A	39.5	150	0.179	16	2	4	yes	0.567
10/04/2018	23	3	Walking	A	39.5	150	0.179	16	2	4	yes	0.851
10/04/2018	24	1	Walking	B	33.5	0	0.214	16	2	1	yes	0.627
10/04/2018	24	2	Walking	B	33.5	0	0.214	16	2	1	yes	0.595
10/04/2018	24	3	Walking	B	33.5	0	0.214	16	2	1	yes	0.656
10/04/2018	26	1	Walking	A	40	0	0.071	16	2	4	yes	1.049
10/04/2018	26	2	Walking	A	40	0	0.071	16	2	4	yes	1.094
10/04/2018	26	3	Walking	A	40	0	0.071	16	2	4	yes	0.915
10/04/2018	27	1	Walking	A	40.5	100	0.196	16	2	4	yes	0.450
10/04/2018	27	2	Walking	A	40.5	100	0.196	16	2	4	yes	0.631
10/04/2018	27	3	Walking	A	40.5	100	0.196	16	2	4	yes	0.488
10/04/2018	28	1	Walking	B	39.5	0	0.429	16	2	1	yes	1.553
10/04/2018	28	2	Walking	B	39.5	0	0.429	16	2	1	yes	0.808
10/04/2018	28	3	Walking	B	39.5	0	0.429	16	2	1	yes	0.695
10/04/2018	29	1	Walking	A	48	0	0.125	16	2	4	yes	0.871
10/04/2018	29	2	Walking	A	48	0	0.125	16	2	4	yes	1.120
10/04/2018	29	3	Walking	A	48	0	0.125	16	2	4	yes	0.593
10/04/2018	30	1	Walking	B	36	0	0.357	16	2	1	yes	1.100
10/04/2018	30	2	Walking	B	36	0	0.357	16	2	1	yes	0.800
10/04/2018	30	3	Walking	B	36	0	0.357	16	2	1	yes	0.971

10/04/2018	31	1	Walking	A	38.5	100	0.071	16	2	4	yes	0.737
10/04/2018	31	2	Walking	A	38.5	100	0.071	16	2	4	yes	0.446
10/04/2018	31	3	Walking	A	38.5	100	0.071	16	2	4	yes	0.512
10/04/2018	32	1	Walking	A	38.5	0	0.179	16	2	4	yes	1.040
10/04/2018	32	2	Walking	A	38.5	0	0.179	16	2	4	yes	0.997
10/04/2018	32	3	Walking	A	38.5	0	0.179	16	2	4	yes	0.887
10/04/2018	33	1	Walking	B	37.5	0	0.143	16	2	1	yes	0.864
10/04/2018	33	2	Walking	B	37.5	0	0.143	16	2	1	yes	0.479
10/04/2018	33	3	Walking	B	37.5	0	0.143	16	2	1	yes	0.483
10/04/2018	34	1	Walking	A	34	0	0.143	16	2	4	yes	0.490
10/04/2018	34	2	Walking	A	34	0	0.143	16	2	4	yes	0.375
10/04/2018	34	3	Walking	A	34	0	0.143	16	2	4	yes	0.357
10/04/2018	35	1	Walking	B	40.5	0	0.571	16	2	1	yes	1.135
10/04/2018	35	2	Walking	B	40.5	0	0.571	16	2	1	yes	0.927
10/04/2018	35	3	Walking	B	40.5	0	0.571	16	2	1	yes	0.856
10/04/2018	36	1	Walking	B	43	0	0.429	16	2	1	yes	0.527
10/04/2018	36	2	Walking	B	43	0	0.429	16	2	1	yes	0.397
10/04/2018	36	3	Walking	B	43	0	0.429	16	2	1	yes	0.487
10/04/2018	37	1	Walking	A	46.5	0	0.179	16	2	4	yes	0.583
10/04/2018	37	2	Walking	A	46.5	0	0.179	16	2	4	yes	0.309
10/04/2018	37	3	Walking	A	46.5	0	0.179	16	2	4	yes	0.497
10/04/2018	38	1	Walking	A	28.5	0	0.000	16	2	4	yes	0.864
10/04/2018	38	2	Walking	A	28.5	0	0.000	16	2	4	yes	0.471
10/04/2018	38	3	Walking	A	28.5	0	0.000	16	2	4	yes	0.732
10/04/2018	39	1	Walking	A	37	0	0.107	16	2	4	yes	1.029
10/04/2018	39	2	Walking	A	37	0	0.107	16	2	4	yes	0.954
10/04/2018	39	3	Walking	A	37	0	0.107	16	2	4	yes	0.617
10/04/2018	40	1	Walking	B	36	0	0.357	16	2	1	yes	0.844
10/04/2018	40	2	Walking	B	36	0	0.357	16	2	1	yes	0.648
10/04/2018	40	3	Walking	B	36	0	0.357	16	2	1	yes	0.826
10/04/2018	41	1	Walking	B	46.5	0	0.643	16	2	1	yes	0.608
10/04/2018	41	2	Walking	B	46.5	0	0.643	16	2	1	yes	0.798
10/04/2018	41	3	Walking	B	46.5	0	0.643	16	2	1	yes	0.727
10/04/2018	42	1	Walking	B	36.5	0	0.429	16	2	1	yes	1.249
10/04/2018	42	2	Walking	B	36.5	0	0.429	16	2	1	yes	0.876
10/04/2018	42	3	Walking	B	36.5	0	0.429	16	2	1	yes	0.715
17/04/2018	19	1	Walking	B	44	0	0.286	17	2	2	yes	0.842
17/04/2018	19	2	Walking	B	44	0	0.286	17	2	2	yes	1.363
17/04/2018	19	3	Walking	B	44	0	0.286	17	2	2	yes	1.556
17/04/2018	21	1	Walking	B	38.5	0	0.107	17	2	2	yes	0.425
17/04/2018	21	2	Walking	B	38.5	0	0.107	17	2	2	yes	0.550
17/04/2018	21	3	Walking	B	38.5	0	0.107	17	2	2	yes	0.659
17/04/2018	23	1	Walking	A	38	900	0.100	17	2	5	yes	1.056
17/04/2018	23	2	Walking	A	38	900	0.100	17	2	5	yes	1.101
17/04/2018	23	3	Walking	A	38	900	0.100	17	2	5	yes	1.340
17/04/2018	24	1	Walking	B	32.5	0	0.036	17	2	2	yes	0.559

17/04/2018	24	2	Walking	B	32.5	0	0.036	17	2	2	yes	0.680
17/04/2018	24	3	Walking	B	32.5	0	0.036	17	2	2	yes	0.889
17/04/2018	26	1	Walking	A	39.5	0	0.043	17	2	5	yes	1.056
17/04/2018	26	2	Walking	A	39.5	0	0.043	17	2	5	yes	0.995
17/04/2018	26	3	Walking	A	39.5	0	0.043	17	2	5	yes	1.334
17/04/2018	27	1	Walking	A	39	1100	0.114	17	2	5	yes	0.370
17/04/2018	27	2	Walking	A	39	1100	0.114	17	2	5	yes	0.436
17/04/2018	27	3	Walking	A	39	1100	0.114	17	2	5	yes	0.539
17/04/2018	28	1	Walking	B	38.5	0	0.143	17	2	2	yes	0.606
17/04/2018	28	2	Walking	B	38.5	0	0.143	17	2	2	yes	0.758
17/04/2018	28	3	Walking	B	38.5	0	0.143	17	2	2	yes	1.030
17/04/2018	29	1	Walking	A	45.5	NA	0.029	17	2	5	yes	1.194
17/04/2018	29	2	Walking	A	45.5	NA	0.029	17	2	5	yes	1.209
17/04/2018	29	3	Walking	A	45.5	NA	0.029	17	2	5	yes	1.970
17/04/2018	30	1	Walking	B	35	0	0.107	17	2	2	yes	1.209
17/04/2018	30	2	Walking	B	35	0	0.107	17	2	2	yes	1.155
17/04/2018	30	3	Walking	B	35	0	0.107	17	2	2	yes	1.938
17/04/2018	31	1	Walking	A	38	550	0.043	17	2	5	yes	0.746
17/04/2018	31	2	Walking	A	38	550	0.043	17	2	5	yes	0.843
17/04/2018	31	3	Walking	A	38	550	0.043	17	2	5	yes	1.737
17/04/2018	32	1	Walking	A	37	50	0.100	17	2	5	yes	0.515
17/04/2018	32	2	Walking	A	37	50	0.100	17	2	5	yes	0.832
17/04/2018	32	3	Walking	A	37	50	0.100	17	2	5	yes	0.881
17/04/2018	33	1	Walking	B	38	0	0.107	17	2	2	yes	0.448
17/04/2018	33	2	Walking	B	38	0	0.107	17	2	2	yes	0.588
17/04/2018	33	3	Walking	B	38	0	0.107	17	2	2	yes	0.664
17/04/2018	34	1	Walking	A	33.5	550	0.100	17	2	5	yes	0.432
17/04/2018	34	2	Walking	A	33.5	550	0.100	17	2	5	yes	0.479
17/04/2018	34	3	Walking	A	33.5	550	0.100	17	2	5	yes	0.642
17/04/2018	35	1	Walking	B	39.5	0	0.214	17	2	2	yes	0.639
17/04/2018	35	2	Walking	B	39.5	0	0.214	17	2	2	yes	0.943
17/04/2018	35	3	Walking	B	39.5	0	0.214	17	2	2	yes	1.165
17/04/2018	36	1	Walking	B	42.5	0	0.179	17	2	2	yes	0.489
17/04/2018	36	2	Walking	B	42.5	0	0.179	17	2	2	yes	0.797
17/04/2018	36	3	Walking	B	42.5	0	0.179	17	2	2	yes	1.204
17/04/2018	37	1	Walking	A	45.5	1100	0.114	17	2	5	yes	0.321
17/04/2018	37	2	Walking	A	45.5	1100	0.114	17	2	5	yes	0.477
17/04/2018	37	3	Walking	A	45.5	1100	0.114	17	2	5	yes	0.704
17/04/2018	38	1	Walking	A	27	0	-0.043	17	2	5	yes	0.678
17/04/2018	38	2	Walking	A	27	0	-0.043	17	2	5	yes	0.832
17/04/2018	38	3	Walking	A	27	0	-0.043	17	2	5	yes	0.998
17/04/2018	39	1	Walking	A	37	0	0.086	17	2	5	yes	0.898
17/04/2018	39	2	Walking	A	37	0	0.086	17	2	5	yes	1.252
17/04/2018	39	3	Walking	A	37	0	0.086	17	2	5	yes	1.150
17/04/2018	40	1	Walking	B	36.5	0	0.214	17	2	2	yes	0.684
17/04/2018	40	2	Walking	B	36.5	0	0.214	17	2	2	yes	0.763

17/04/2018	40	3	Walking	B	36.5	0	0.214	17	2	2	yes	0.898
17/04/2018	41	1	Walking	B	43	0	0.071	17	2	2	yes	0.473
17/04/2018	41	2	Walking	B	43	0	0.071	17	2	2	yes	0.761
17/04/2018	41	3	Walking	B	43	0	0.071	17	2	2	yes	0.840
17/04/2018	42	1	Walking	B	36	0	0.179	17	2	2	yes	1.080
17/04/2018	42	2	Walking	B	36	0	0.179	17	2	2	yes	1.007
17/04/2018	42	3	Walking	B	36	0	0.179	17	2	2	yes	1.018
04/05/2018	21	1	Walking	B	39	1500	0.071	19	2	4	yes	0.380
04/05/2018	21	2	Walking	B	39	1500	0.071	19	2	4	yes	0.526
04/05/2018	21	3	Walking	B	39	1500	0.071	19	2	4	yes	0.437
04/05/2018	23	1	Walking	A	38	0	0.000	19	2	1	yes	0.663
04/05/2018	23	2	Walking	A	38	0	0.000	19	2	1	yes	0.840
04/05/2018	23	3	Walking	A	38	0	0.000	19	2	1	yes	0.995
04/05/2018	24	1	Walking	B	33	350	0.036	19	2	4	yes	0.333
04/05/2018	24	2	Walking	B	33	350	0.036	19	2	4	yes	0.453
04/05/2018	24	3	Walking	B	33	350	0.036	19	2	4	yes	0.414
04/05/2018	26	1	Walking	A	40.5	0	0.214	19	2	1	yes	0.812
04/05/2018	26	2	Walking	A	40.5	0	0.214	19	2	1	yes	1.119
04/05/2018	26	3	Walking	A	40.5	0	0.214	19	2	1	yes	0.911
04/05/2018	27	1	Walking	A	40.5	0	0.429	19	2	1	yes	0.472
04/05/2018	27	2	Walking	A	40.5	0	0.429	19	2	1	yes	0.422
04/05/2018	27	3	Walking	A	40.5	0	0.429	19	2	1	yes	0.357
04/05/2018	28	1	Walking	B	39	850	0.089	19	2	4	yes	0.431
04/05/2018	28	2	Walking	B	39	850	0.089	19	2	4	yes	0.546
04/05/2018	28	3	Walking	B	39	850	0.089	19	2	4	yes	0.364
04/05/2018	29	1	Walking	A	47.5	0	0.357	19	2	1	yes	0.807
04/05/2018	29	2	Walking	A	47.5	0	0.357	19	2	1	yes	1.101
04/05/2018	29	3	Walking	A	47.5	0	0.357	19	2	1	yes	1.133
04/05/2018	30	1	Walking	B	36	700	0.089	19	2	4	yes	0.523
04/05/2018	30	2	Walking	B	36	700	0.089	19	2	4	yes	0.695
04/05/2018	30	3	Walking	B	36	700	0.089	19	2	4	yes	0.875
04/05/2018	31	1	Walking	A	37.5	0	0.286	19	2	1	yes	0.470
04/05/2018	31	2	Walking	A	37.5	0	0.286	19	2	1	yes	0.788
04/05/2018	31	3	Walking	A	37.5	0	0.286	19	2	1	yes	0.510
04/05/2018	32	1	Walking	A	36.5	0	-0.071	19	2	1	yes	0.568
04/05/2018	32	2	Walking	A	36.5	0	-0.071	19	2	1	yes	0.679
04/05/2018	32	3	Walking	A	36.5	0	-0.071	19	2	1	yes	0.597
04/05/2018	33	1	Walking	B	37.5	450	0.036	19	2	4	yes	0.267
04/05/2018	33	2	Walking	B	37.5	450	0.036	19	2	4	yes	0.569
04/05/2018	33	3	Walking	B	37.5	450	0.036	19	2	4	yes	0.614
04/05/2018	34	1	Walking	A	33.5	0	0.143	19	2	1	yes	0.262
04/05/2018	34	2	Walking	A	33.5	0	0.143	19	2	1	yes	0.594
04/05/2018	34	3	Walking	A	33.5	0	0.143	19	2	1	yes	0.650
04/05/2018	35	1	Walking	B	39.5	350	0.107	19	2	4	yes	0.632
04/05/2018	35	2	Walking	B	39.5	350	0.107	19	2	4	yes	0.771
04/05/2018	35	3	Walking	B	39.5	350	0.107	19	2	4	yes	0.634

04/05/2018	36	1	Walking	B	42	NA	0.071	19	2	4	yes	0.533
04/05/2018	36	2	Walking	B	42	NA	0.071	19	2	4	yes	0.885
04/05/2018	36	3	Walking	B	42	NA	0.071	19	2	4	yes	0.761
04/05/2018	37	1	Walking	A	45	0	0.714	19	2	1	yes	0.351
04/05/2018	37	2	Walking	A	45	0	0.714	19	2	1	yes	0.516
04/05/2018	37	3	Walking	A	45	0	0.714	19	2	1	yes	0.480
04/05/2018	38	1	Walking	A	29.5	0	0.357	19	2	1	yes	0.412
04/05/2018	38	2	Walking	A	29.5	0	0.357	19	2	1	yes	0.702
04/05/2018	38	3	Walking	A	29.5	0	0.357	19	2	1	yes	0.438
04/05/2018	39	1	Walking	A	36.5	0	0.071	19	2	1	yes	0.733
04/05/2018	39	2	Walking	A	36.5	0	0.071	19	2	1	yes	1.059
04/05/2018	39	3	Walking	A	36.5	0	0.071	19	2	1	yes	0.880
04/05/2018	40	1	Walking	B	38	400	0.161	19	2	4	yes	0.379
04/05/2018	40	2	Walking	B	38	400	0.161	19	2	4	yes	0.448
04/05/2018	40	3	Walking	B	38	400	0.161	19	2	4	yes	0.452
04/05/2018	41	1	Walking	B	43	100	0.036	19	2	4	yes	0.486
04/05/2018	41	2	Walking	B	43	100	0.036	19	2	4	yes	0.364
04/05/2018	41	3	Walking	B	43	100	0.036	19	2	4	yes	0.405
04/05/2018	42	1	Walking	B	36.5	100	0.107	19	2	4	yes	0.995
04/05/2018	42	2	Walking	B	36.5	100	0.107	19	2	4	yes	1.182
04/05/2018	42	3	Walking	B	36.5	100	0.107	19	2	4	yes	0.882
08/05/2018	19	1	Walking	B	39.5	NA	-0.014	20	2	5	yes	0.315
08/05/2018	19	2	Walking	B	39.5	NA	-0.014	20	2	5	yes	0.302
08/05/2018	21	1	Walking	B	39	NA	0.057	20	2	5	yes	0.403
08/05/2018	21	2	Walking	B	39	NA	0.057	20	2	5	yes	0.383
08/05/2018	23	1	Walking	A	38	0	0.000	20	2	2	yes	0.613
08/05/2018	23	2	Walking	A	38	0	0.000	20	2	2	yes	0.530
08/05/2018	24	1	Walking	B	33.5	850	0.043	20	2	5	yes	0.429
08/05/2018	24	2	Walking	B	33.5	850	0.043	20	2	5	yes	0.515
08/05/2018	26	1	Walking	A	40	0	0.071	20	2	2	yes	1.033
08/05/2018	26	2	Walking	A	40	0	0.071	20	2	2	yes	0.938
08/05/2018	27	1	Walking	A	41.5	0	0.286	20	2	2	yes	0.500
08/05/2018	27	2	Walking	A	41.5	0	0.286	20	2	2	yes	0.363
08/05/2018	28	1	Walking	B	38.5	NA	0.057	20	2	5	yes	0.467
08/05/2018	28	2	Walking	B	38.5	NA	0.057	20	2	5	yes	0.414
08/05/2018	29	1	Walking	A	46.5	0	0.107	20	2	2	yes	0.999
08/05/2018	29	2	Walking	A	46.5	0	0.107	20	2	2	yes	0.571
08/05/2018	30	1	Walking	B	35	900	0.043	20	2	5	yes	0.367
08/05/2018	30	2	Walking	B	35	900	0.043	20	2	5	yes	0.770
08/05/2018	31	1	Walking	A	37.5	0	0.143	20	2	2	yes	0.628
08/05/2018	31	2	Walking	A	37.5	0	0.143	20	2	2	yes	0.379
08/05/2018	32	1	Walking	A	37	0	0.000	20	2	2	yes	0.391
08/05/2018	32	2	Walking	A	37	0	0.000	20	2	2	yes	1.154
08/05/2018	33	1	Walking	B	37	1100	0.014	20	2	5	yes	0.317
08/05/2018	33	2	Walking	B	37	1100	0.014	20	2	5	yes	0.189
08/05/2018	34	1	Walking	A	33.5	0	0.071	20	2	2	yes	0.272

08/05/2018	34	2	Walking	A	33.5	0	0.071	20	2	2	yes	0.147
08/05/2018	35	1	Walking	B	37	NA	0.014	20	2	5	yes	0.658
08/05/2018	35	2	Walking	B	37	NA	0.014	20	2	5	yes	0.388
08/05/2018	36	1	Walking	B	41.5	850	0.043	20	2	5	yes	0.567
08/05/2018	36	2	Walking	B	41.5	850	0.043	20	2	5	yes	0.385
08/05/2018	37	1	Walking	A	44	0	0.286	20	2	2	yes	0.531
08/05/2018	37	2	Walking	A	44	0	0.286	20	2	2	yes	0.301
08/05/2018	38	1	Walking	A	29.5	0	0.179	20	2	2	yes	0.671
08/05/2018	38	2	Walking	A	29.5	0	0.179	20	2	2	yes	0.588
08/05/2018	39	1	Walking	A	37	0	0.071	20	2	2	yes	0.739
08/05/2018	39	2	Walking	A	37	0	0.071	20	2	2	yes	0.533
08/05/2018	40	1	Walking	B	37	1800	0.100	20	2	5	yes	0.521
08/05/2018	40	2	Walking	B	37	1800	0.100	20	2	5	yes	0.617
08/05/2018	41	1	Walking	B	42	NA	0.000	20	2	5	yes	0.458
08/05/2018	41	2	Walking	B	42	NA	0.000	20	2	5	yes	0.426
08/05/2018	42	1	Walking	B	36.5	1200	0.086	20	2	5	yes	0.588
08/05/2018	42	2	Walking	B	36.5	1200	0.086	20	2	5	yes	0.646
15/05/2018	23	1	Walking	A	37	0	-0.048	21	2	3	no	0.708
15/05/2018	23	2	Walking	A	37	0	-0.048	21	2	3	no	0.560
15/05/2018	23	3	Walking	A	37	0	-0.048	21	2	3	no	0.369
15/05/2018	26	1	Walking	A	39	0	0.000	21	2	3	no	0.437
15/05/2018	26	2	Walking	A	39	0	0.000	21	2	3	no	0.644
15/05/2018	26	3	Walking	A	39	0	0.000	21	2	3	no	1.035
15/05/2018	27	1	Walking	A	41.5	0	0.190	21	2	3	no	0.173
15/05/2018	27	2	Walking	A	41.5	0	0.190	21	2	3	no	0.326
15/05/2018	27	3	Walking	A	41.5	0	0.190	21	2	3	no	0.751
15/05/2018	29	1	Walking	A	46.5	0	0.071	21	2	3	no	0.770
15/05/2018	29	2	Walking	A	46.5	0	0.071	21	2	3	no	0.870
15/05/2018	29	3	Walking	A	46.5	0	0.071	21	2	3	no	1.438
15/05/2018	31	1	Walking	A	38.5	0	0.143	21	2	3	no	0.356
15/05/2018	31	2	Walking	A	38.5	0	0.143	21	2	3	no	0.494
15/05/2018	31	3	Walking	A	38.5	0	0.143	21	2	3	no	0.389
15/05/2018	32	1	Walking	A	37.5	0	0.024	21	2	3	no	0.351
15/05/2018	32	2	Walking	A	37.5	0	0.024	21	2	3	no	0.662
15/05/2018	32	3	Walking	A	37.5	0	0.024	21	2	3	no	0.682
15/05/2018	34	1	Walking	A	34	0	0.071	21	2	3	no	0.288
15/05/2018	34	2	Walking	A	34	0	0.071	21	2	3	no	0.275
15/05/2018	34	3	Walking	A	34	0	0.071	21	2	3	no	0.420
15/05/2018	37	1	Walking	A	44.5	0	0.214	21	2	3	no	0.344
15/05/2018	37	2	Walking	A	44.5	0	0.214	21	2	3	no	0.147
15/05/2018	37	3	Walking	A	44.5	0	0.214	21	2	3	no	0.416
15/05/2018	38	1	Walking	A	29.5	0	0.119	21	2	3	no	0.306
15/05/2018	38	2	Walking	A	29.5	0	0.119	21	2	3	no	0.444
15/05/2018	38	3	Walking	A	29.5	0	0.119	21	2	3	no	0.599
15/05/2018	39	1	Walking	A	36	0	0.000	21	2	3	no	0.624
15/05/2018	39	2	Walking	A	36	0	0.000	21	2	3	no	0.824

15/05/2018	39	3	Walking	A	36	0	0.000	21	2	3	no	0.750
22/05/2018	19	1	Walking	B	43	0	0.000	22	3	1	no	0.582
22/05/2018	19	2	Walking	B	43	0	0.000	22	3	1	no	0.472
22/05/2018	21	1	Walking	B	39	0	-0.143	22	3	1	no	0.463
22/05/2018	21	2	Walking	B	39	0	-0.143	22	3	1	no	0.402
22/05/2018	23	1	Walking	A	38	100	0.000	22	3	4	no	0.725
22/05/2018	23	2	Walking	A	38	100	0.000	22	3	4	no	0.313
22/05/2018	24	1	Walking	B	32	0	-0.214	22	3	1	no	0.157
22/05/2018	24	2	Walking	B	32	0	-0.214	22	3	1	no	0.363
22/05/2018	26	1	Walking	A	38	50	-0.036	22	3	4	no	0.706
22/05/2018	26	2	Walking	A	38	50	-0.036	22	3	4	no	0.570
22/05/2018	27	1	Walking	A	39.5	200	0.071	22	3	4	no	0.427
22/05/2018	27	2	Walking	A	39.5	200	0.071	22	3	4	no	0.219
22/05/2018	28	1	Walking	B	37	0	-0.214	22	3	1	no	0.351
22/05/2018	28	2	Walking	B	37	0	-0.214	22	3	1	no	0.357
22/05/2018	29	1	Walking	A	46.5	0	0.054	22	3	4	no	0.455
22/05/2018	29	2	Walking	A	46.5	0	0.054	22	3	4	no	0.468
22/05/2018	30	1	Walking	B	36.5	0	-0.071	22	3	1	no	0.435
22/05/2018	30	2	Walking	B	36.5	0	-0.071	22	3	1	no	0.359
22/05/2018	31	1	Walking	A	37.5	50	0.071	22	3	4	no	0.458
22/05/2018	31	2	Walking	A	37.5	50	0.071	22	3	4	no	0.374
22/05/2018	32	1	Walking	A	34.5	0	-0.089	22	3	4	no	0.339
22/05/2018	32	2	Walking	A	34.5	0	-0.089	22	3	4	no	0.603
22/05/2018	33	1	Walking	B	38.5	0	0.000	22	3	1	no	0.466
22/05/2018	33	2	Walking	B	38.5	0	0.000	22	3	1	no	0.330
22/05/2018	34	1	Walking	A	32.5	50	0.000	22	3	4	no	0.220
22/05/2018	34	2	Walking	A	32.5	50	0.000	22	3	4	no	0.241
22/05/2018	35	1	Walking	B	39	0	0.000	22	3	1	no	0.413
22/05/2018	35	2	Walking	B	39	0	0.000	22	3	1	no	0.238
22/05/2018	36	1	Walking	B	40	0	-0.071	22	3	1	no	0.561
22/05/2018	36	2	Walking	B	40	0	-0.071	22	3	1	no	0.404
22/05/2018	37	1	Walking	A	46	250	0.214	22	3	4	no	0.279
22/05/2018	37	2	Walking	A	46	250	0.214	22	3	4	no	0.185
22/05/2018	38	1	Walking	A	28.5	50	0.054	22	3	4	no	0.505
22/05/2018	38	2	Walking	A	28.5	50	0.054	22	3	4	no	0.390
22/05/2018	39	1	Walking	A	35	0	-0.036	22	3	4	no	0.570
22/05/2018	39	2	Walking	A	35	0	-0.036	22	3	4	no	0.463
22/05/2018	40	1	Walking	B	34.5	0	-0.286	22	3	1	no	0.248
22/05/2018	40	2	Walking	B	34.5	0	-0.286	22	3	1	no	0.229
22/05/2018	41	1	Walking	B	42.5	0	0.000	22	3	1	no	0.235
22/05/2018	41	2	Walking	B	42.5	0	0.000	22	3	1	no	0.191
22/05/2018	42	1	Walking	B	35.5	0	-0.286	22	3	1	no	0.579
22/05/2018	42	2	Walking	B	35.5	0	-0.286	22	3	1	no	0.713
29/05/2018	19	1	Walking	B	42.5	0	-0.036	23	3	2	no	0.660
29/05/2018	19	2	Walking	B	42.5	0	-0.036	23	3	2	no	0.964
29/05/2018	19	3	Walking	B	42.5	0	-0.036	23	3	2	no	1.329

29/05/2018	21	1	Walking	B	39.5	0	-0.036	23	3	2	no	0.457
29/05/2018	21	2	Walking	B	39.5	0	-0.036	23	3	2	no	0.443
29/05/2018	21	3	Walking	B	39.5	0	-0.036	23	3	2	no	0.436
29/05/2018	23	1	Walking	A	36.5	350	-0.043	23	3	5	no	0.435
29/05/2018	23	2	Walking	A	36.5	350	-0.043	23	3	5	no	0.445
29/05/2018	23	3	Walking	A	36.5	350	-0.043	23	3	5	no	0.652
29/05/2018	24	1	Walking	B	33	0	-0.036	23	3	2	no	0.403
29/05/2018	24	2	Walking	B	33	0	-0.036	23	3	2	no	0.604
29/05/2018	24	3	Walking	B	33	0	-0.036	23	3	2	no	0.675
29/05/2018	26	1	Walking	A	39	300	0.000	23	3	5	no	0.634
29/05/2018	26	2	Walking	A	39	300	0.000	23	3	5	no	1.116
29/05/2018	26	3	Walking	A	39	300	0.000	23	3	5	no	0.944
29/05/2018	27	1	Walking	A	40	1000	0.071	23	3	5	no	0.343
29/05/2018	27	2	Walking	A	40	1000	0.071	23	3	5	no	0.445
29/05/2018	27	3	Walking	A	40	1000	0.071	23	3	5	no	0.447
29/05/2018	28	1	Walking	B	38.5	0	0.000	23	3	2	no	0.398
29/05/2018	28	2	Walking	B	38.5	0	0.000	23	3	2	no	0.521
29/05/2018	28	3	Walking	B	38.5	0	0.000	23	3	2	no	0.426
29/05/2018	29	1	Walking	A	44.5	200	-0.014	23	3	5	no	0.452
29/05/2018	29	2	Walking	A	44.5	200	-0.014	23	3	5	no	0.385
29/05/2018	29	3	Walking	A	44.5	200	-0.014	23	3	5	no	0.327
29/05/2018	30	1	Walking	B	37.5	0	0.036	23	3	2	no	0.652
29/05/2018	30	2	Walking	B	37.5	0	0.036	23	3	2	no	0.949
29/05/2018	30	3	Walking	B	37.5	0	0.036	23	3	2	no	1.164
29/05/2018	31	1	Walking	A	38	50	0.071	23	3	5	no	0.494
29/05/2018	31	2	Walking	A	38	50	0.071	23	3	5	no	0.568
29/05/2018	31	3	Walking	A	38	50	0.071	23	3	5	no	0.429
29/05/2018	32	1	Walking	A	36.5	450	-0.014	23	3	5	no	0.498
29/05/2018	32	2	Walking	A	36.5	450	-0.014	23	3	5	no	0.505
29/05/2018	32	3	Walking	A	36.5	450	-0.014	23	3	5	no	1.213
29/05/2018	33	1	Walking	B	38	0	-0.036	23	3	2	no	0.515
29/05/2018	33	2	Walking	B	38	0	-0.036	23	3	2	no	0.823
29/05/2018	33	3	Walking	B	38	0	-0.036	23	3	2	no	0.788
29/05/2018	34	1	Walking	A	33	900	0.014	23	3	5	no	0.334
29/05/2018	34	2	Walking	A	33	900	0.014	23	3	5	no	0.370
29/05/2018	34	3	Walking	A	33	900	0.014	23	3	5	no	0.399
29/05/2018	35	1	Walking	B	40.5	0	0.107	23	3	2	no	0.396
29/05/2018	35	2	Walking	B	40.5	0	0.107	23	3	2	no	0.662
29/05/2018	35	3	Walking	B	40.5	0	0.107	23	3	2	no	0.773
29/05/2018	36	1	Walking	B	40.5	0	0.000	23	3	2	no	0.424
29/05/2018	36	2	Walking	B	40.5	0	0.000	23	3	2	no	0.642
29/05/2018	36	3	Walking	B	40.5	0	0.000	23	3	2	no	0.742
29/05/2018	37	1	Walking	A	43.5	1550	0.100	23	3	5	no	0.318
29/05/2018	37	2	Walking	A	43.5	1550	0.100	23	3	5	no	0.357
29/05/2018	37	3	Walking	A	43.5	1550	0.100	23	3	5	no	0.351
29/05/2018	38	1	Walking	A	29.5	850	0.071	23	3	5	no	0.365

29/05/2018	38	2	Walking	A	29.5	850	0.071	23	3	5	no	0.904
29/05/2018	38	3	Walking	A	29.5	850	0.071	23	3	5	no	0.818
29/05/2018	39	1	Walking	A	36	1300	0.000	23	3	5	no	0.557
29/05/2018	39	2	Walking	A	36	1300	0.000	23	3	5	no	0.727
29/05/2018	39	3	Walking	A	36	1300	0.000	23	3	5	no	0.575
29/05/2018	40	1	Walking	B	37.5	0	0.071	23	3	2	no	0.211
29/05/2018	40	2	Walking	B	37.5	0	0.071	23	3	2	no	0.270
29/05/2018	40	3	Walking	B	37.5	0	0.071	23	3	2	no	0.317
29/05/2018	41	1	Walking	B	42	0	-0.036	23	3	2	no	0.653
29/05/2018	41	2	Walking	B	42	0	-0.036	23	3	2	no	0.574
29/05/2018	41	3	Walking	B	42	0	-0.036	23	3	2	no	1.266
29/05/2018	42	1	Walking	B	36.5	0	-0.071	23	3	2	no	0.556
29/05/2018	42	2	Walking	B	36.5	0	-0.071	23	3	2	no	0.837
29/05/2018	42	3	Walking	B	36.5	0	-0.071	23	3	2	no	1.192
05/06/2018	19	1	Walking	B	44.5	0	0.071	24	3	3	no	0.465
05/06/2018	19	2	Walking	B	44.5	0	0.071	24	3	3	no	1.619
05/06/2018	19	3	Walking	B	44.5	0	0.071	24	3	3	no	0.549
05/06/2018	21	1	Walking	B	39	0	-0.048	24	3	3	no	0.379
05/06/2018	21	2	Walking	B	39	0	-0.048	24	3	3	no	0.597
05/06/2018	21	3	Walking	B	39	0	-0.048	24	3	3	no	0.495
05/06/2018	24	1	Walking	B	33.5	0	0.000	24	3	3	no	0.487
05/06/2018	24	2	Walking	B	33.5	0	0.000	24	3	3	no	0.939
05/06/2018	24	3	Walking	B	33.5	0	0.000	24	3	3	no	0.392
05/06/2018	28	1	Walking	B	39	0	0.024	24	3	3	no	0.427
05/06/2018	28	2	Walking	B	39	0	0.024	24	3	3	no	1.358
05/06/2018	28	3	Walking	B	39	0	0.024	24	3	3	no	0.526
05/06/2018	30	1	Walking	B	38.5	0	0.071	24	3	3	no	0.541
05/06/2018	30	2	Walking	B	38.5	0	0.071	24	3	3	no	0.898
05/06/2018	30	3	Walking	B	38.5	0	0.071	24	3	3	no	0.983
05/06/2018	33	1	Walking	B	38	0	-0.024	24	3	3	no	0.473
05/06/2018	33	2	Walking	B	38	0	-0.024	24	3	3	no	1.797
05/06/2018	33	3	Walking	B	38	0	-0.024	24	3	3	no	0.598
05/06/2018	35	1	Walking	B	40	0	0.048	24	3	3	no	0.486
05/06/2018	35	2	Walking	B	40	0	0.048	24	3	3	no	1.159
05/06/2018	35	3	Walking	B	40	0	0.048	24	3	3	no	0.578
05/06/2018	36	1	Walking	B	42	0	0.071	24	3	3	no	0.450
05/06/2018	36	2	Walking	B	42	0	0.071	24	3	3	no	1.750
05/06/2018	36	3	Walking	B	42	0	0.071	24	3	3	no	0.894
05/06/2018	40	1	Walking	B	40	0	0.167	24	3	3	no	0.285
05/06/2018	40	2	Walking	B	40	0	0.167	24	3	3	no	0.794
05/06/2018	40	3	Walking	B	40	0	0.167	24	3	3	no	0.517
05/06/2018	41	1	Walking	B	43.5	0	0.048	24	3	3	no	0.529
05/06/2018	41	2	Walking	B	43.5	0	0.048	24	3	3	no	1.209
05/06/2018	41	3	Walking	B	43.5	0	0.048	24	3	3	no	0.844
05/06/2018	42	1	Walking	B	38	0	0.024	24	3	3	no	0.799
05/06/2018	42	2	Walking	B	38	0	0.024	24	3	3	no	1.561

05/06/2018	42	3	Walking	B	38	0	0.024	24	3	3	no	0.877
12/06/2018	19	1	Walking	B	45.5	100	0.089	25	3	4	no	0.686
12/06/2018	19	2	Walking	B	45.5	100	0.089	25	3	4	no	0.750
12/06/2018	19	3	Walking	B	45.5	100	0.089	25	3	4	no	1.505
12/06/2018	21	1	Walking	B	41.5	0	0.054	25	3	4	no	0.376
12/06/2018	21	2	Walking	B	41.5	0	0.054	25	3	4	no	0.375
12/06/2018	21	3	Walking	B	41.5	0	0.054	25	3	4	no	0.417
12/06/2018	23	1	Walking	A	39.5	0	0.286	25	3	1	no	0.650
12/06/2018	23	2	Walking	A	39.5	0	0.286	25	3	1	no	0.902
12/06/2018	23	3	Walking	A	39.5	0	0.286	25	3	1	no	0.795
12/06/2018	24	1	Walking	B	36.5	50	0.107	25	3	4	no	0.379
12/06/2018	24	2	Walking	B	36.5	50	0.107	25	3	4	no	0.414
12/06/2018	24	3	Walking	B	36.5	50	0.107	25	3	4	no	0.474
12/06/2018	26	1	Walking	A	40.5	0	0.143	25	3	1	no	0.355
12/06/2018	26	2	Walking	A	40.5	0	0.143	25	3	1	no	0.492
12/06/2018	26	3	Walking	A	40.5	0	0.143	25	3	1	no	0.808
12/06/2018	27	1	Walking	A	42.5	NA	0.429	25	3	1	no	0.745
12/06/2018	27	2	Walking	A	42.5	NA	0.429	25	3	1	no	0.750
12/06/2018	27	3	Walking	A	42.5	NA	0.429	25	3	1	no	0.532
12/06/2018	28	1	Walking	B	40.5	250	0.071	25	3	4	no	0.537
12/06/2018	28	2	Walking	B	40.5	250	0.071	25	3	4	no	0.908
12/06/2018	28	3	Walking	B	40.5	250	0.071	25	3	4	no	0.615
12/06/2018	29	1	Walking	A	48	0	0.357	25	3	1	no	0.680
12/06/2018	29	2	Walking	A	48	0	0.357	25	3	1	no	0.799
12/06/2018	29	3	Walking	A	48	0	0.357	25	3	1	no	0.894
12/06/2018	30	1	Walking	B	39.5	150	0.089	25	3	4	no	0.567
12/06/2018	30	2	Walking	B	39.5	150	0.089	25	3	4	no	0.556
12/06/2018	30	3	Walking	B	39.5	150	0.089	25	3	4	no	0.435
12/06/2018	31	1	Walking	A	41	0	0.429	25	3	1	no	0.800
12/06/2018	31	2	Walking	A	41	0	0.429	25	3	1	no	1.066
12/06/2018	31	3	Walking	A	41	0	0.429	25	3	1	no	0.690
12/06/2018	32	1	Walking	A	37	0	0.214	25	3	1	no	0.499
12/06/2018	32	2	Walking	A	37	0	0.214	25	3	1	no	1.136
12/06/2018	32	3	Walking	A	37	0	0.214	25	3	1	no	1.034
12/06/2018	33	1	Walking	B	38	0	-0.018	25	3	4	no	0.172
12/06/2018	33	2	Walking	B	38	0	-0.018	25	3	4	no	0.219
12/06/2018	33	3	Walking	B	38	0	-0.018	25	3	4	no	NA
12/06/2018	34	1	Walking	A	36	0	0.429	25	3	1	no	0.375
12/06/2018	34	2	Walking	A	36	0	0.429	25	3	1	no	0.442
12/06/2018	34	3	Walking	A	36	0	0.429	25	3	1	no	0.601
12/06/2018	35	1	Walking	B	41.5	0	0.089	25	3	4	no	0.591
12/06/2018	35	2	Walking	B	41.5	0	0.089	25	3	4	no	0.948
12/06/2018	35	3	Walking	B	41.5	0	0.089	25	3	4	no	1.125
12/06/2018	36	1	Walking	B	43	0	0.089	25	3	4	no	0.584
12/06/2018	36	2	Walking	B	43	0	0.089	25	3	4	no	0.699
12/06/2018	36	3	Walking	B	43	0	0.089	25	3	4	no	0.627

12/06/2018	37	1	Walking	A	45.5	NA	0.286	25	3	1	no	0.231
12/06/2018	37	2	Walking	A	45.5	NA	0.286	25	3	1	no	0.508
12/06/2018	37	3	Walking	A	45.5	NA	0.286	25	3	1	no	0.447
12/06/2018	38	1	Walking	A	32	0	0.286	25	3	1	no	0.618
12/06/2018	38	2	Walking	A	32	0	0.286	25	3	1	no	0.701
12/06/2018	38	3	Walking	A	32	0	0.286	25	3	1	no	0.844
12/06/2018	39	1	Walking	A	37.5	0	0.214	25	3	1	no	0.674
12/06/2018	39	2	Walking	A	37.5	0	0.214	25	3	1	no	0.767
12/06/2018	39	3	Walking	A	37.5	0	0.214	25	3	1	no	1.025
12/06/2018	40	1	Walking	B	41.5	NA	0.179	25	3	4	no	0.418
12/06/2018	40	2	Walking	B	41.5	NA	0.179	25	3	4	no	0.340
12/06/2018	40	3	Walking	B	41.5	NA	0.179	25	3	4	no	0.192
12/06/2018	41	1	Walking	B	45	100	0.089	25	3	4	no	0.490
12/06/2018	41	2	Walking	B	45	100	0.089	25	3	4	no	0.675
12/06/2018	41	3	Walking	B	45	100	0.089	25	3	4	no	0.970
12/06/2018	42	1	Walking	B	41	0	0.125	25	3	4	no	0.726
12/06/2018	42	2	Walking	B	41	0	0.125	25	3	4	no	1.099
12/06/2018	42	3	Walking	B	41	0	0.125	25	3	4	no	0.883
19/06/2018	19	1	Walking	B	45	650	0.057	26	3	5	no	0.757
19/06/2018	19	2	Walking	B	45	650	0.057	26	3	5	no	1.450
19/06/2018	19	3	Walking	B	45	650	0.057	26	3	5	no	1.082
19/06/2018	21	1	Walking	B	41.5	100	0.043	26	3	5	no	0.584
19/06/2018	21	2	Walking	B	41.5	100	0.043	26	3	5	no	0.683
19/06/2018	21	3	Walking	B	41.5	100	0.043	26	3	5	no	0.542
19/06/2018	23	1	Walking	A	38.5	0	0.071	26	3	2	no	1.124
19/06/2018	23	2	Walking	A	38.5	0	0.071	26	3	2	no	1.855
19/06/2018	23	3	Walking	A	38.5	0	0.071	26	3	2	no	1.050
19/06/2018	24	1	Walking	B	35.5	NA	0.057	26	3	5	no	0.414
19/06/2018	24	2	Walking	B	35.5	NA	0.057	26	3	5	no	0.658
19/06/2018	24	3	Walking	B	35.5	NA	0.057	26	3	5	no	0.574
19/06/2018	26	1	Walking	A	39.5	0	0.000	26	3	2	no	1.286
19/06/2018	26	2	Walking	A	39.5	0	0.000	26	3	2	no	1.098
19/06/2018	26	3	Walking	A	39.5	0	0.000	26	3	2	no	0.904
19/06/2018	27	1	Walking	A	43	0	0.250	26	3	2	no	0.461
19/06/2018	27	2	Walking	A	43	0	0.250	26	3	2	no	0.570
19/06/2018	27	3	Walking	A	43	0	0.250	26	3	2	no	0.415
19/06/2018	28	1	Walking	B	41.5	1100	0.086	26	3	5	no	1.095
19/06/2018	28	2	Walking	B	41.5	1100	0.086	26	3	5	no	1.401
19/06/2018	28	3	Walking	B	41.5	1100	0.086	26	3	5	no	0.899
19/06/2018	29	1	Walking	A	48.5	0	0.214	26	3	2	no	1.513
19/06/2018	29	2	Walking	A	48.5	0	0.214	26	3	2	no	2.047
19/06/2018	29	3	Walking	A	48.5	0	0.214	26	3	2	no	0.766
19/06/2018	30	1	Walking	B	40	150	0.086	26	3	5	no	1.164
19/06/2018	30	2	Walking	B	40	150	0.086	26	3	5	no	1.181
19/06/2018	30	3	Walking	B	40	150	0.086	26	3	5	no	0.908
19/06/2018	31	1	Walking	A	40	NA	0.143	26	3	2	no	0.929

19/06/2018	31	2	Walking	A	40	NA	0.143	26	3	2	no	0.885
19/06/2018	31	3	Walking	A	40	NA	0.143	26	3	2	no	0.506
19/06/2018	32	1	Walking	A	37.5	0	0.143	26	3	2	no	0.535
19/06/2018	32	2	Walking	A	37.5	0	0.143	26	3	2	no	0.968
19/06/2018	32	3	Walking	A	37.5	0	0.143	26	3	2	no	1.908
19/06/2018	33	1	Walking	B	39.5	50	0.029	26	3	5	no	0.202
19/06/2018	33	2	Walking	B	39.5	50	0.029	26	3	5	no	0.369
19/06/2018	33	3	Walking	B	39.5	50	0.029	26	3	5	no	0.276
19/06/2018	34	1	Walking	A	34.5	0	0.107	26	3	2	no	0.550
19/06/2018	34	2	Walking	A	34.5	0	0.107	26	3	2	no	0.781
19/06/2018	34	3	Walking	A	34.5	0	0.107	26	3	2	no	0.424
19/06/2018	35	1	Walking	B	41.5	200	0.071	26	3	5	no	0.932
19/06/2018	35	2	Walking	B	41.5	200	0.071	26	3	5	no	1.176
19/06/2018	35	3	Walking	B	41.5	200	0.071	26	3	5	no	1.074
19/06/2018	36	1	Walking	B	42.5	0	0.057	26	3	5	no	0.789
19/06/2018	36	2	Walking	B	42.5	0	0.057	26	3	5	no	0.928
19/06/2018	36	3	Walking	B	42.5	0	0.057	26	3	5	no	0.932
19/06/2018	37	1	Walking	A	43.5	0	0.000	26	3	2	no	0.504
19/06/2018	37	2	Walking	A	43.5	0	0.000	26	3	2	no	0.466
19/06/2018	37	3	Walking	A	43.5	0	0.000	26	3	2	no	0.321
19/06/2018	38	1	Walking	A	31.5	0	0.107	26	3	2	no	0.645
19/06/2018	38	2	Walking	A	31.5	0	0.107	26	3	2	no	0.373
19/06/2018	38	3	Walking	A	31.5	0	0.107	26	3	2	no	0.502
19/06/2018	39	1	Walking	A	37	NA	0.071	26	3	2	no	1.486
19/06/2018	39	2	Walking	A	37	NA	0.071	26	3	2	no	1.084
19/06/2018	39	3	Walking	A	37	NA	0.071	26	3	2	no	0.981
19/06/2018	40	1	Walking	B	41.5	1500	0.143	26	3	5	no	0.591
19/06/2018	40	2	Walking	B	41.5	1500	0.143	26	3	5	no	0.509
19/06/2018	40	3	Walking	B	41.5	1500	0.143	26	3	5	no	0.492
19/06/2018	41	1	Walking	B	45.5	1350	0.086	26	3	5	no	0.545
19/06/2018	41	2	Walking	B	45.5	1350	0.086	26	3	5	no	1.111
19/06/2018	41	3	Walking	B	45.5	1350	0.086	26	3	5	no	0.648
19/06/2018	42	1	Walking	B	40.5	NA	0.086	26	3	5	no	0.642
19/06/2018	42	2	Walking	B	40.5	NA	0.086	26	3	5	no	0.834
19/06/2018	42	3	Walking	B	40.5	NA	0.086	26	3	5	no	0.754
26/06/2018	1	1	Walking	C	40	0	0.000	27	3	1	yes	0.563
26/06/2018	1	2	Walking	C	40	0	0.000	27	3	1	yes	0.898
26/06/2018	1	3	Walking	C	40	0	0.000	27	3	1	yes	1.254
26/06/2018	2	1	Walking	C	38	0	0.000	27	3	1	yes	0.609
26/06/2018	2	2	Walking	C	38	0	0.000	27	3	1	yes	0.745
26/06/2018	2	3	Walking	C	38	0	0.000	27	3	1	yes	0.897
26/06/2018	3	1	Walking	C	34	0	0.000	27	3	1	yes	0.425
26/06/2018	3	2	Walking	C	34	0	0.000	27	3	1	yes	0.439
26/06/2018	3	3	Walking	C	34	0	0.000	27	3	1	yes	0.780
26/06/2018	4	1	Walking	C	45	0	0.000	27	3	1	yes	0.679
26/06/2018	4	2	Walking	C	45	0	0.000	27	3	1	yes	0.902

26/06/2018	4	3	Walking	C	45	0	0.000	27	3	1	yes	1.056
26/06/2018	5	1	Walking	C	37	0	0.000	27	3	1	yes	1.001
26/06/2018	5	2	Walking	C	37	0	0.000	27	3	1	yes	1.040
26/06/2018	5	3	Walking	C	37	0	0.000	27	3	1	yes	1.323
26/06/2018	6	1	Walking	C	40	0	0.000	27	3	1	yes	1.247
26/06/2018	6	2	Walking	C	40	0	0.000	27	3	1	yes	1.448
26/06/2018	6	3	Walking	C	40	0	0.000	27	3	1	yes	1.523
26/06/2018	23	1	Walking	A	40.5	0	0.143	27	3	3	no	0.848
26/06/2018	23	2	Walking	A	40.5	0	0.143	27	3	3	no	0.922
26/06/2018	23	3	Walking	A	40.5	0	0.143	27	3	3	no	1.978
26/06/2018	26	1	Walking	A	41	NA	0.071	27	3	3	no	1.303
26/06/2018	26	2	Walking	A	41	NA	0.071	27	3	3	no	1.012
26/06/2018	26	3	Walking	A	41	NA	0.071	27	3	3	no	1.435
26/06/2018	27	1	Walking	A	44.5	0	0.238	27	3	3	no	0.765
26/06/2018	27	2	Walking	A	44.5	0	0.238	27	3	3	no	0.388
26/06/2018	27	3	Walking	A	44.5	0	0.238	27	3	3	no	0.640
26/06/2018	29	1	Walking	A	48.5	0	0.143	27	3	3	no	1.185
26/06/2018	29	2	Walking	A	48.5	0	0.143	27	3	3	no	0.942
26/06/2018	29	3	Walking	A	48.5	0	0.143	27	3	3	no	2.083
26/06/2018	31	1	Walking	A	41.5	NA	0.167	27	3	3	no	0.497
26/06/2018	31	2	Walking	A	41.5	NA	0.167	27	3	3	no	0.301
26/06/2018	31	3	Walking	A	41.5	NA	0.167	27	3	3	no	0.535
26/06/2018	32	1	Walking	A	39.5	0	0.190	27	3	3	no	0.718
26/06/2018	32	2	Walking	A	39.5	0	0.190	27	3	3	no	0.611
26/06/2018	32	3	Walking	A	39.5	0	0.190	27	3	3	no	1.952
26/06/2018	34	1	Walking	A	35.5	0	0.119	27	3	3	no	0.492
26/06/2018	34	2	Walking	A	35.5	0	0.119	27	3	3	no	0.475
26/06/2018	34	3	Walking	A	35.5	0	0.119	27	3	3	no	0.607
26/06/2018	37	1	Walking	A	44.5	0	0.048	27	3	3	no	0.423
26/06/2018	37	2	Walking	A	44.5	0	0.048	27	3	3	no	0.718
26/06/2018	37	3	Walking	A	44.5	0	0.048	27	3	3	no	0.840
26/06/2018	38	1	Walking	A	32	50	0.095	27	3	3	no	0.512
26/06/2018	38	2	Walking	A	32	50	0.095	27	3	3	no	0.254
26/06/2018	38	3	Walking	A	32	50	0.095	27	3	3	no	0.364
26/06/2018	39	1	Walking	A	38.5	0	0.119	27	3	3	no	0.939
26/06/2018	39	2	Walking	A	38.5	0	0.119	27	3	3	no	0.789
26/06/2018	39	3	Walking	A	38.5	0	0.119	27	3	3	no	1.452
03/07/2018	1	1	Walking	C	41.5	0	0.214	28	3	1	yes	0.469
03/07/2018	1	2	Walking	C	41.5	0	0.214	28	3	1	yes	0.574
03/07/2018	1	3	Walking	C	41.5	0	0.214	28	3	1	yes	0.718
03/07/2018	2	1	Walking	C	39.5	0	0.214	28	3	1	yes	0.653
03/07/2018	2	2	Walking	C	39.5	0	0.214	28	3	1	yes	1.062
03/07/2018	2	3	Walking	C	39.5	0	0.214	28	3	1	yes	0.602
03/07/2018	3	1	Walking	C	36.5	0	0.357	28	3	1	yes	0.505
03/07/2018	3	2	Walking	C	36.5	0	0.357	28	3	1	yes	1.156
03/07/2018	3	3	Walking	C	36.5	0	0.357	28	3	1	yes	0.895

03/07/2018	4	1	Walking	C	46.5	0	0.214	28	3	1	yes	0.536
03/07/2018	4	2	Walking	C	46.5	0	0.214	28	3	1	yes	1.087
03/07/2018	4	3	Walking	C	46.5	0	0.214	28	3	1	yes	0.567
03/07/2018	5	1	Walking	C	40	0	0.429	28	3	1	yes	1.323
03/07/2018	5	2	Walking	C	40	0	0.429	28	3	1	yes	1.788
03/07/2018	5	3	Walking	C	40	0	0.429	28	3	1	yes	1.166
03/07/2018	6	1	Walking	C	41.5	0	0.214	28	3	1	yes	1.372
03/07/2018	6	2	Walking	C	41.5	0	0.214	28	3	1	yes	2.111
03/07/2018	6	3	Walking	C	41.5	0	0.214	28	3	1	yes	1.820
03/07/2018	19	1	Walking	B	42	0	NA	28	4	1	no	1.053
03/07/2018	19	2	Walking	B	42	0	NA	28	4	1	no	1.991
03/07/2018	19	3	Walking	B	42	0	NA	28	4	1	no	1.558
03/07/2018	21	1	Walking	B	43.5	0	0.143	28	4	1	no	0.372
03/07/2018	21	2	Walking	B	43.5	0	0.143	28	4	1	no	1.043
03/07/2018	21	3	Walking	B	43.5	0	0.143	28	4	1	no	0.588
03/07/2018	23	1	Walking	A	42	0	0.161	28	4	4	no	0.671
03/07/2018	23	2	Walking	A	42	0	0.161	28	4	4	no	1.394
03/07/2018	23	3	Walking	A	42	0	0.161	28	4	4	no	0.886
03/07/2018	24	1	Walking	B	38	0	0.214	28	4	1	no	0.541
03/07/2018	24	2	Walking	B	38	0	0.214	28	4	1	no	1.072
03/07/2018	24	3	Walking	B	38	0	0.214	28	4	1	no	0.517
03/07/2018	26	1	Walking	A	41.5	NA	0.071	28	4	4	no	1.067
03/07/2018	26	2	Walking	A	41.5	NA	0.071	28	4	4	no	1.481
03/07/2018	26	3	Walking	A	41.5	NA	0.071	28	4	4	no	0.959
03/07/2018	27	1	Walking	A	46	0	0.232	28	4	4	no	0.746
03/07/2018	27	2	Walking	A	46	0	0.232	28	4	4	no	1.154
03/07/2018	27	3	Walking	A	46	0	0.232	28	4	4	no	0.944
03/07/2018	28	1	Walking	B	44	0	0.143	28	4	1	no	1.038
03/07/2018	28	2	Walking	B	44	0	0.143	28	4	1	no	1.795
03/07/2018	28	3	Walking	B	44	0	0.143	28	4	1	no	1.209
03/07/2018	29	1	Walking	A	49	0	0.125	28	4	4	no	1.092
03/07/2018	29	2	Walking	A	49	0	0.125	28	4	4	no	1.889
03/07/2018	29	3	Walking	A	49	0	0.125	28	4	4	no	0.987
03/07/2018	30	1	Walking	B	42.5	0	0.643	28	4	1	no	1.197
03/07/2018	30	2	Walking	B	42.5	0	0.643	28	4	1	no	2.402
03/07/2018	30	3	Walking	B	42.5	0	0.643	28	4	1	no	1.296
03/07/2018	31	1	Walking	A	42	NA	0.143	28	4	4	no	0.836
03/07/2018	31	2	Walking	A	42	NA	0.143	28	4	4	no	1.130
03/07/2018	31	3	Walking	A	42	NA	0.143	28	4	4	no	0.602
03/07/2018	32	1	Walking	A	39.5	NA	0.143	28	4	4	no	0.692
03/07/2018	32	2	Walking	A	39.5	NA	0.143	28	4	4	no	1.710
03/07/2018	32	3	Walking	A	39.5	NA	0.143	28	4	4	no	0.835
03/07/2018	33	1	Walking	B	41	0	0.214	28	4	1	no	0.432
03/07/2018	33	2	Walking	B	41	0	0.214	28	4	1	no	1.492
03/07/2018	33	3	Walking	B	41	0	0.214	28	4	1	no	0.523
03/07/2018	34	1	Walking	A	36.5	0	0.125	28	4	4	no	0.942

03/07/2018	34	2	Walking	A	36.5	0	0.125	28	4	4	no	1.242
03/07/2018	34	3	Walking	A	36.5	0	0.125	28	4	4	no	0.923
03/07/2018	35	1	Walking	B	49	0	0.929	28	4	1	no	0.808
03/07/2018	35	2	Walking	B	49	0	0.929	28	4	1	no	1.781
03/07/2018	35	3	Walking	B	49	0	0.929	28	4	1	no	1.387
03/07/2018	36	1	Walking	B	45.5	0	0.214	28	4	1	no	0.577
03/07/2018	36	2	Walking	B	45.5	0	0.214	28	4	1	no	1.650
03/07/2018	36	3	Walking	B	45.5	0	0.214	28	4	1	no	1.271
03/07/2018	37	1	Walking	A	44.5	0	0.036	28	4	4	no	0.320
03/07/2018	37	2	Walking	A	44.5	0	0.036	28	4	4	no	0.831
03/07/2018	37	3	Walking	A	44.5	0	0.036	28	4	4	no	0.505
03/07/2018	38	1	Walking	A	33	0	0.107	28	4	4	no	0.427
03/07/2018	38	2	Walking	A	33	0	0.107	28	4	4	no	0.968
03/07/2018	38	3	Walking	A	33	0	0.107	28	4	4	no	0.506
03/07/2018	39	1	Walking	A	39	0	0.107	28	4	4	no	1.011
03/07/2018	39	2	Walking	A	39	0	0.107	28	4	4	no	1.868
03/07/2018	39	3	Walking	A	39	0	0.107	28	4	4	no	1.122
03/07/2018	40	1	Walking	B	45.5	0	0.500	28	4	1	no	0.546
03/07/2018	40	2	Walking	B	45.5	0	0.500	28	4	1	no	1.078
03/07/2018	40	3	Walking	B	45.5	0	0.500	28	4	1	no	0.545
03/07/2018	41	1	Walking	B	48.5	0	0.000	28	4	1	no	0.865
03/07/2018	41	2	Walking	B	48.5	0	0.000	28	4	1	no	1.250
03/07/2018	41	3	Walking	B	48.5	0	0.000	28	4	1	no	0.827
03/07/2018	42	1	Walking	B	44.5	0	0.429	28	4	1	no	0.508
03/07/2018	42	2	Walking	B	44.5	0	0.429	28	4	1	no	1.185
03/07/2018	42	3	Walking	B	44.5	0	0.429	28	4	1	no	0.627
10/07/2018	1	1	Walking	C	40.5	0	-0.143	29	4	1	yes	0.663
10/07/2018	1	2	Walking	C	40.5	0	-0.143	29	4	1	yes	0.825
10/07/2018	1	3	Walking	C	40.5	0	-0.143	29	4	1	yes	0.983
10/07/2018	2	1	Walking	C	40	0	0.071	29	4	1	yes	0.687
10/07/2018	2	2	Walking	C	40	0	0.071	29	4	1	yes	0.748
10/07/2018	2	3	Walking	C	40	0	0.071	29	4	1	yes	1.132
10/07/2018	3	1	Walking	C	36	0	-0.071	29	4	1	yes	0.636
10/07/2018	3	2	Walking	C	36	0	-0.071	29	4	1	yes	0.550
10/07/2018	3	3	Walking	C	36	0	-0.071	29	4	1	yes	1.111
10/07/2018	4	1	Walking	C	45.5	0	-0.143	29	4	1	yes	1.222
10/07/2018	4	2	Walking	C	45.5	0	-0.143	29	4	1	yes	1.463
10/07/2018	4	3	Walking	C	45.5	0	-0.143	29	4	1	yes	1.925
10/07/2018	5	1	Walking	C	40.5	0	0.071	29	4	1	yes	1.178
10/07/2018	5	2	Walking	C	40.5	0	0.071	29	4	1	yes	1.583
10/07/2018	5	3	Walking	C	40.5	0	0.071	29	4	1	yes	1.221
10/07/2018	6	1	Walking	C	41.5	NA	0.000	29	4	1	yes	1.028
10/07/2018	6	2	Walking	C	41.5	NA	0.000	29	4	1	yes	1.365
10/07/2018	6	3	Walking	C	41.5	NA	0.000	29	4	1	yes	2.020
10/07/2018	19	1	Walking	B	48	0	0.071	29	4	2	no	1.321
10/07/2018	19	2	Walking	B	48	0	0.071	29	4	2	no	1.392

10/07/2018	19	3	Walking	B	48	0	0.071	29	4	2	no	2.639
10/07/2018	21	1	Walking	B	41.5	0	-0.071	29	4	2	no	0.634
10/07/2018	21	2	Walking	B	41.5	0	-0.071	29	4	2	no	0.884
10/07/2018	21	3	Walking	B	41.5	0	-0.071	29	4	2	no	1.543
10/07/2018	23	1	Walking	A	40.5	0	0.086	29	4	5	no	1.703
10/07/2018	23	2	Walking	A	40.5	0	0.086	29	4	5	no	1.310
10/07/2018	23	3	Walking	A	40.5	0	0.086	29	4	5	no	2.525
10/07/2018	24	1	Walking	B	37.5	0	0.071	29	4	2	no	0.951
10/07/2018	24	2	Walking	B	37.5	0	0.071	29	4	2	no	1.140
10/07/2018	24	3	Walking	B	37.5	0	0.071	29	4	2	no	1.618
10/07/2018	26	1	Walking	A	41	0	0.043	29	4	5	no	1.248
10/07/2018	26	2	Walking	A	41	0	0.043	29	4	5	no	1.076
10/07/2018	26	3	Walking	A	41	0	0.043	29	4	5	no	2.396
10/07/2018	27	1	Walking	A	45.5	0	0.171	29	4	5	no	0.773
10/07/2018	27	2	Walking	A	45.5	0	0.171	29	4	5	no	0.793
10/07/2018	27	3	Walking	A	45.5	0	0.171	29	4	5	no	1.874
10/07/2018	28	1	Walking	B	45.5	0	0.179	29	4	2	no	0.956
10/07/2018	28	2	Walking	B	45.5	0	0.179	29	4	2	no	1.141
10/07/2018	28	3	Walking	B	45.5	0	0.179	29	4	2	no	1.495
10/07/2018	29	1	Walking	A	49	50	0.100	29	4	5	no	0.729
10/07/2018	29	2	Walking	A	49	50	0.100	29	4	5	no	0.699
10/07/2018	29	3	Walking	A	49	50	0.100	29	4	5	no	1.576
10/07/2018	30	1	Walking	B	41.5	NA	0.250	29	4	2	no	1.842
10/07/2018	30	2	Walking	B	41.5	NA	0.250	29	4	2	no	1.463
10/07/2018	30	3	Walking	B	41.5	NA	0.250	29	4	2	no	2.356
10/07/2018	31	1	Walking	A	42	NA	0.114	29	4	5	no	0.873
10/07/2018	31	2	Walking	A	42	NA	0.114	29	4	5	no	0.808
10/07/2018	31	3	Walking	A	42	NA	0.114	29	4	5	no	1.415
10/07/2018	32	1	Walking	A	39.5	0	0.114	29	4	5	no	0.947
10/07/2018	32	2	Walking	A	39.5	0	0.114	29	4	5	no	1.288
10/07/2018	32	3	Walking	A	39.5	0	0.114	29	4	5	no	1.295
10/07/2018	33	1	Walking	B	42	0	0.179	29	4	2	no	0.375
10/07/2018	33	2	Walking	B	42	0	0.179	29	4	2	no	0.498
10/07/2018	33	3	Walking	B	42	0	0.179	29	4	2	no	1.966
10/07/2018	34	1	Walking	A	36.5	NA	0.100	29	4	5	no	0.698
10/07/2018	34	2	Walking	A	36.5	NA	0.100	29	4	5	no	0.782
10/07/2018	34	3	Walking	A	36.5	NA	0.100	29	4	5	no	1.301
10/07/2018	35	1	Walking	B	44	0	0.107	29	4	2	no	1.189
10/07/2018	35	2	Walking	B	44	0	0.107	29	4	2	no	1.349
10/07/2018	35	3	Walking	B	44	0	0.107	29	4	2	no	2.332
10/07/2018	36	1	Walking	B	45	0	0.071	29	4	2	no	1.178
10/07/2018	36	2	Walking	B	45	0	0.071	29	4	2	no	1.020
10/07/2018	36	3	Walking	B	45	0	0.071	29	4	2	no	2.394
10/07/2018	37	1	Walking	A	46	0	0.071	29	4	5	no	0.754
10/07/2018	37	2	Walking	A	46	0	0.071	29	4	5	no	1.018
10/07/2018	37	3	Walking	A	46	0	0.071	29	4	5	no	0.756

10/07/2018	38	1	Walking	A	32	0	0.057	29	4	5	no	1.606
10/07/2018	38	2	Walking	A	32	0	0.057	29	4	5	no	1.616
10/07/2018	38	3	Walking	A	32	0	0.057	29	4	5	no	2.428
10/07/2018	39	1	Walking	A	38.5	50	0.071	29	4	5	no	0.713
10/07/2018	39	2	Walking	A	38.5	50	0.071	29	4	5	no	1.001
10/07/2018	39	3	Walking	A	38.5	50	0.071	29	4	5	no	0.837
10/07/2018	40	1	Walking	B	44	0	0.143	29	4	2	no	0.660
10/07/2018	40	2	Walking	B	44	0	0.143	29	4	2	no	0.659
10/07/2018	40	3	Walking	B	44	0	0.143	29	4	2	no	0.938
10/07/2018	41	1	Walking	B	48.5	0	0.000	29	4	2	no	0.545
10/07/2018	41	2	Walking	B	48.5	0	0.000	29	4	2	no	0.684
10/07/2018	41	3	Walking	B	48.5	0	0.000	29	4	2	no	1.258
10/07/2018	42	1	Walking	B	43	0	0.107	29	4	2	no	1.132
10/07/2018	42	2	Walking	B	43	0	0.107	29	4	2	no	0.926
10/07/2018	42	3	Walking	B	43	0	0.107	29	4	2	no	1.377
17/07/2018	1	1	Walking	C	42	0	0.214	30	4	1	yes	1.037
17/07/2018	1	2	Walking	C	42	0	0.214	30	4	1	yes	1.058
17/07/2018	2	1	Walking	C	41.5	0	0.214	30	4	1	yes	1.476
17/07/2018	2	2	Walking	C	41.5	0	0.214	30	4	1	yes	1.780
17/07/2018	3	1	Walking	C	39	0	0.429	30	4	1	yes	1.142
17/07/2018	3	2	Walking	C	39	0	0.429	30	4	1	yes	1.363
17/07/2018	4	1	Walking	C	48.5	0	0.429	30	4	1	yes	0.866
17/07/2018	4	2	Walking	C	48.5	0	0.429	30	4	1	yes	1.584
17/07/2018	5	1	Walking	C	42	0	0.214	30	4	1	yes	1.514
17/07/2018	5	2	Walking	C	42	0	0.214	30	4	1	yes	1.642
17/07/2018	6	1	Walking	C	42.5	NA	0.143	30	4	1	yes	1.912
17/07/2018	6	2	Walking	C	42.5	NA	0.143	30	4	1	yes	2.604
17/07/2018	19	1	Walking	B	50.5	0	0.167	30	4	3	no	1.708
17/07/2018	19	2	Walking	B	50.5	0	0.167	30	4	3	no	2.843
17/07/2018	21	1	Walking	B	44	0	0.071	30	4	3	no	0.945
17/07/2018	21	2	Walking	B	44	0	0.071	30	4	3	no	1.419
17/07/2018	24	1	Walking	B	39	0	0.119	30	4	3	no	0.814
17/07/2018	24	2	Walking	B	39	0	0.119	30	4	3	no	1.375
17/07/2018	28	1	Walking	B	45	0	0.095	30	4	3	no	1.638
17/07/2018	28	2	Walking	B	45	0	0.095	30	4	3	no	2.030
17/07/2018	30	1	Walking	B	42.5	0	0.214	30	4	3	no	2.223
17/07/2018	30	2	Walking	B	42.5	0	0.214	30	4	3	no	2.505
17/07/2018	33	1	Walking	B	41.5	0	0.095	30	4	3	no	0.666
17/07/2018	33	2	Walking	B	41.5	0	0.095	30	4	3	no	1.475
17/07/2018	35	1	Walking	B	44.5	0	0.095	30	4	3	no	1.603
17/07/2018	35	2	Walking	B	44.5	0	0.095	30	4	3	no	2.720
17/07/2018	36	1	Walking	B	45	0	0.048	30	4	3	no	1.505
17/07/2018	36	2	Walking	B	45	0	0.048	30	4	3	no	2.286
17/07/2018	40	1	Walking	B	43.5	0	0.071	30	4	3	no	0.846
17/07/2018	40	2	Walking	B	43.5	0	0.071	30	4	3	no	0.846
17/07/2018	41	1	Walking	B	49	0	0.024	30	4	3	no	1.760

17/07/2018	41	2	Walking	B	49	0	0.024	30	4	3	no	1.772
17/07/2018	42	1	Walking	B	44	0	0.119	30	4	3	no	0.965
17/07/2018	42	2	Walking	B	44	0	0.119	30	4	3	no	1.179
31/07/2018	1	1	Walking	C	42.5	0	0.214	32	4	1	yes	0.577
31/07/2018	1	2	Walking	C	42.5	0	0.214	32	4	1	yes	0.916
31/07/2018	1	3	Walking	C	42.5	0	0.214	32	4	1	yes	1.413
31/07/2018	2	1	Walking	C	41.5	0	0.143	32	4	1	yes	1.095
31/07/2018	2	2	Walking	C	41.5	0	0.143	32	4	1	yes	0.926
31/07/2018	2	3	Walking	C	41.5	0	0.143	32	4	1	yes	2.632
31/07/2018	3	1	Walking	C	40	0	0.429	32	4	1	yes	0.509
31/07/2018	3	2	Walking	C	40	0	0.429	32	4	1	yes	0.840
31/07/2018	3	3	Walking	C	40	0	0.429	32	4	1	yes	1.567
31/07/2018	4	1	Walking	C	47.5	0	0.214	32	4	1	yes	0.611
31/07/2018	4	2	Walking	C	47.5	0	0.214	32	4	1	yes	0.968
31/07/2018	4	3	Walking	C	47.5	0	0.214	32	4	1	yes	1.546
31/07/2018	5	1	Walking	C	43	0	0.071	32	4	1	yes	1.108
31/07/2018	5	2	Walking	C	43	0	0.071	32	4	1	yes	1.445
31/07/2018	5	3	Walking	C	43	0	0.071	32	4	1	yes	1.668
31/07/2018	6	1	Walking	C	44	0	0.214	32	4	1	yes	1.269
31/07/2018	6	2	Walking	C	44	0	0.214	32	4	1	yes	1.729
31/07/2018	6	3	Walking	C	44	0	0.214	32	4	1	yes	2.920
31/07/2018	19	1	Walking	B	49.5	0	0.071	32	4	5	no	1.956
31/07/2018	19	2	Walking	B	49.5	0	0.071	32	4	5	no	2.108
31/07/2018	19	3	Walking	B	49.5	0	0.071	32	4	5	no	3.434
31/07/2018	21	1	Walking	B	44	0	0.043	32	4	5	no	0.865
31/07/2018	21	2	Walking	B	44	0	0.043	32	4	5	no	0.951
31/07/2018	21	3	Walking	B	44	0	0.043	32	4	5	no	1.323
31/07/2018	23	1	Walking	A	40.5	0	-0.107	32	4	2	no	1.121
31/07/2018	23	2	Walking	A	40.5	0	-0.107	32	4	2	no	2.122
31/07/2018	23	3	Walking	A	40.5	0	-0.107	32	4	2	no	2.858
31/07/2018	24	1	Walking	B	38.5	0	0.057	32	4	5	no	1.313
31/07/2018	24	2	Walking	B	38.5	0	0.057	32	4	5	no	1.457
31/07/2018	24	3	Walking	B	38.5	0	0.057	32	4	5	no	1.791
31/07/2018	26	1	Walking	A	41	0	-0.107	32	4	2	no	1.653
31/07/2018	26	2	Walking	A	41	0	-0.107	32	4	2	no	2.741
31/07/2018	26	3	Walking	A	41	0	-0.107	32	4	2	no	2.534
31/07/2018	27	1	Walking	A	46	0	-0.036	32	4	2	no	1.521
31/07/2018	27	2	Walking	A	46	0	-0.036	32	4	2	no	2.245
31/07/2018	27	3	Walking	A	46	0	-0.036	32	4	2	no	1.922
31/07/2018	28	1	Walking	B	46	50	0.086	32	4	5	no	0.674
31/07/2018	28	2	Walking	B	46	50	0.086	32	4	5	no	0.990
31/07/2018	28	3	Walking	B	46	50	0.086	32	4	5	no	1.780
31/07/2018	29	1	Walking	A	48.5	0	-0.143	32	4	2	no	0.997
31/07/2018	29	2	Walking	A	48.5	0	-0.143	32	4	2	no	0.976
31/07/2018	29	3	Walking	A	48.5	0	-0.143	32	4	2	no	3.351
31/07/2018	30	1	Walking	B	41.5	0	0.100	32	4	5	no	1.654

31/07/2018	30	2	Walking	B	41.5	0	0.100	32	4	5	no	1.863
31/07/2018	30	3	Walking	B	41.5	0	0.100	32	4	5	no	3.278
31/07/2018	31	1	Walking	A	43	0	0.000	32	4	2	no	1.397
31/07/2018	31	2	Walking	A	43	0	0.000	32	4	2	no	1.679
31/07/2018	31	3	Walking	A	43	0	0.000	32	4	2	no	2.657
31/07/2018	32	1	Walking	A	41	0	0.143	32	4	2	no	0.490
31/07/2018	32	2	Walking	A	41	0	0.143	32	4	2	no	0.824
31/07/2018	32	3	Walking	A	41	0	0.143	32	4	2	no	1.646
31/07/2018	33	1	Walking	B	42	0	0.071	32	4	5	no	0.840
31/07/2018	33	2	Walking	B	42	0	0.071	32	4	5	no	1.928
31/07/2018	33	3	Walking	B	42	0	0.071	32	4	5	no	2.194
31/07/2018	34	1	Walking	A	37	0	-0.036	32	4	2	no	1.175
31/07/2018	34	2	Walking	A	37	0	-0.036	32	4	2	no	1.404
31/07/2018	34	3	Walking	A	37	0	-0.036	32	4	2	no	2.119
31/07/2018	35	1	Walking	B	44.5	50	0.057	32	4	5	no	1.092
31/07/2018	35	2	Walking	B	44.5	50	0.057	32	4	5	no	NA
31/07/2018	35	3	Walking	B	44.5	50	0.057	32	4	5	no	NA
31/07/2018	36	1	Walking	B	45	50	0.029	32	4	5	no	0.939
31/07/2018	36	2	Walking	B	45	50	0.029	32	4	5	no	1.594
31/07/2018	36	3	Walking	B	45	50	0.029	32	4	5	no	2.221
31/07/2018	37	1	Walking	A	44.5	0	-0.071	32	4	2	no	0.536
31/07/2018	37	2	Walking	A	44.5	0	-0.071	32	4	2	no	1.288
31/07/2018	37	3	Walking	A	44.5	0	-0.071	32	4	2	no	1.413
31/07/2018	38	1	Walking	A	33	0	0.036	32	4	2	no	0.556
31/07/2018	38	2	Walking	A	33	0	0.036	32	4	2	no	1.063
31/07/2018	38	3	Walking	A	33	0	0.036	32	4	2	no	2.101
31/07/2018	39	1	Walking	A	40.5	0	0.500	32	4	2	no	1.935
31/07/2018	39	2	Walking	A	40.5	0	0.500	32	4	2	no	2.029
31/07/2018	39	3	Walking	A	40.5	0	0.500	32	4	2	no	2.420
31/07/2018	40	1	Walking	B	43.5	0	0.043	32	4	5	no	1.044
31/07/2018	40	2	Walking	B	43.5	0	0.043	32	4	5	no	0.810
31/07/2018	40	3	Walking	B	43.5	0	0.043	32	4	5	no	1.919
31/07/2018	41	1	Walking	B	49	0	0.014	32	4	5	no	0.954
31/07/2018	41	2	Walking	B	49	0	0.014	32	4	5	no	1.510
31/07/2018	41	3	Walking	B	49	0	0.014	32	4	5	no	1.754
31/07/2018	42	1	Walking	B	44.5	0	0.086	32	4	5	no	0.989
31/07/2018	42	2	Walking	B	44.5	0	0.086	32	4	5	no	1.326
31/07/2018	42	3	Walking	B	44.5	0	0.086	32	4	5	no	1.596
09/01/2018	19	1	Grazing	B	39.5	0	0.405	3	1	3	yes	7.098
09/01/2018	19	2	Grazing	B	39.5	0	0.405	3	1	3	yes	6.630
09/01/2018	19	3	Grazing	B	39.5	0	0.405	3	1	3	yes	6.685
09/01/2018	21	1	Grazing	B	35	150	0.238	3	1	3	yes	5.263
09/01/2018	21	2	Grazing	B	35	150	0.238	3	1	3	yes	4.142
09/01/2018	21	3	Grazing	B	35	150	0.238	3	1	3	yes	5.352
09/01/2018	24	1	Grazing	B	32	150	0.190	3	1	3	yes	4.915
09/01/2018	24	2	Grazing	B	32	150	0.190	3	1	3	yes	5.443

09/01/2018	24	3	Grazing	B	32	150	0.190	3	1	3	yes	6.425
09/01/2018	28	1	Grazing	B	32	300	-0.071	3	1	3	yes	9.807
09/01/2018	28	2	Grazing	B	32	300	-0.071	3	1	3	yes	10.438
09/01/2018	28	3	Grazing	B	32	300	-0.071	3	1	3	yes	9.631
09/01/2018	30	1	Grazing	B	34.5	0	0.119	3	1	3	yes	8.900
09/01/2018	30	2	Grazing	B	34.5	0	0.119	3	1	3	yes	8.728
09/01/2018	30	3	Grazing	B	34.5	0	0.119	3	1	3	yes	10.840
09/01/2018	33	1	Grazing	B	31	0	0.500	3	1	3	yes	7.074
09/01/2018	33	2	Grazing	B	31	0	0.500	3	1	3	yes	5.008
09/01/2018	33	3	Grazing	B	31	0	0.500	3	1	3	yes	5.601
09/01/2018	35	1	Grazing	B	36	0	0.262	3	1	3	yes	9.117
09/01/2018	35	2	Grazing	B	36	0	0.262	3	1	3	yes	8.487
09/01/2018	35	3	Grazing	B	36	0	0.262	3	1	3	yes	8.135
09/01/2018	36	1	Grazing	B	36.5	0	0.214	3	1	3	yes	8.186
09/01/2018	36	2	Grazing	B	36.5	0	0.214	3	1	3	yes	6.399
09/01/2018	36	3	Grazing	B	36.5	0	0.214	3	1	3	yes	7.855
09/01/2018	40	1	Grazing	B	32.5	0	0.095	3	1	3	yes	8.446
09/01/2018	40	2	Grazing	B	32.5	0	0.095	3	1	3	yes	7.668
09/01/2018	40	3	Grazing	B	32.5	0	0.095	3	1	3	yes	7.867
09/01/2018	41	1	Grazing	B	37	0	0.095	3	1	3	yes	4.228
09/01/2018	41	2	Grazing	B	37	0	0.095	3	1	3	yes	3.729
09/01/2018	41	3	Grazing	B	37	0	0.095	3	1	3	yes	4.385
09/01/2018	42	1	Grazing	B	32.5	0	0.310	3	1	3	yes	11.850
09/01/2018	42	2	Grazing	B	32.5	0	0.310	3	1	3	yes	10.632
09/01/2018	42	3	Grazing	B	32.5	0	0.310	3	1	3	yes	11.137
16/01/2018	19	1	Grazing	B	31	200	0.000	4	1	4	yes	5.803
16/01/2018	19	2	Grazing	B	31	200	0.000	4	1	4	yes	6.882
16/01/2018	19	3	Grazing	B	31	200	0.000	4	1	4	yes	7.557
16/01/2018	21	1	Grazing	B	28	0	-0.071	4	1	4	yes	4.438
16/01/2018	21	2	Grazing	B	28	0	-0.071	4	1	4	yes	4.339
16/01/2018	21	3	Grazing	B	28	0	-0.071	4	1	4	yes	4.545
16/01/2018	23	1	Grazing	A	29.5	0	-0.214	4	1	1	yes	4.267
16/01/2018	23	2	Grazing	A	29.5	0	-0.214	4	1	1	yes	5.564
16/01/2018	23	3	Grazing	A	29.5	0	-0.214	4	1	1	yes	7.498
16/01/2018	24	1	Grazing	B	27.5	0	-0.018	4	1	4	yes	7.653
16/01/2018	24	2	Grazing	B	27.5	0	-0.018	4	1	4	yes	5.206
16/01/2018	24	3	Grazing	B	27.5	0	-0.018	4	1	4	yes	6.034
16/01/2018	25	1	Grazing	A	30	0	-0.214	4	1	1	yes	6.285
16/01/2018	25	2	Grazing	A	30	0	-0.214	4	1	1	yes	6.251
16/01/2018	25	3	Grazing	A	30	0	-0.214	4	1	1	yes	6.751
16/01/2018	26	1	Grazing	A	30	0	NA	4	1	1	yes	5.786
16/01/2018	26	2	Grazing	A	30	0	NA	4	1	1	yes	5.671
16/01/2018	26	3	Grazing	A	30	0	NA	4	1	1	yes	7.018
16/01/2018	27	1	Grazing	A	30	0	NA	4	1	1	yes	7.611
16/01/2018	27	2	Grazing	A	30	0	NA	4	1	1	yes	6.894
16/01/2018	27	3	Grazing	A	30	0	NA	4	1	1	yes	8.391

16/01/2018	28	1	Grazing	B	31.5	0	-0.071	4	1	4	yes	7.224
16/01/2018	28	2	Grazing	B	31.5	0	-0.071	4	1	4	yes	6.110
16/01/2018	28	3	Grazing	B	31.5	0	-0.071	4	1	4	yes	8.719
16/01/2018	30	1	Grazing	B	30	0	-0.071	4	1	4	yes	9.519
16/01/2018	30	2	Grazing	B	30	0	-0.071	4	1	4	yes	7.875
16/01/2018	30	3	Grazing	B	30	0	-0.071	4	1	4	yes	10.657
16/01/2018	31	1	Grazing	A	29	0	-0.643	4	1	1	yes	7.130
16/01/2018	31	2	Grazing	A	29	0	-0.643	4	1	1	yes	8.146
16/01/2018	31	3	Grazing	A	29	0	-0.643	4	1	1	yes	9.733
16/01/2018	32	1	Grazing	A	30	0	-1.000	4	1	1	yes	6.949
16/01/2018	32	2	Grazing	A	30	0	-1.000	4	1	1	yes	5.503
16/01/2018	32	3	Grazing	A	30	0	-1.000	4	1	1	yes	6.183
16/01/2018	33	1	Grazing	B	27.5	200	0.250	4	1	4	yes	5.070
16/01/2018	33	2	Grazing	B	27.5	200	0.250	4	1	4	yes	5.524
16/01/2018	33	3	Grazing	B	27.5	200	0.250	4	1	4	yes	7.387
16/01/2018	34	1	Grazing	A	25	0	NA	4	1	1	yes	6.907
16/01/2018	34	2	Grazing	A	25	0	NA	4	1	1	yes	6.358
16/01/2018	34	3	Grazing	A	25	0	NA	4	1	1	yes	7.987
16/01/2018	35	1	Grazing	B	31	0	-0.232	4	1	4	yes	6.708
16/01/2018	35	2	Grazing	B	31	0	-0.232	4	1	4	yes	7.289
16/01/2018	35	3	Grazing	B	31	0	-0.232	4	1	4	yes	10.443
16/01/2018	36	1	Grazing	B	32	0	0.000	4	1	4	yes	4.616
16/01/2018	36	2	Grazing	B	32	0	0.000	4	1	4	yes	4.657
16/01/2018	36	3	Grazing	B	32	0	0.000	4	1	4	yes	5.035
16/01/2018	37	1	Grazing	A	30.5	0	-0.714	4	1	1	yes	5.293
16/01/2018	37	2	Grazing	A	30.5	0	-0.714	4	1	1	yes	5.928
16/01/2018	37	3	Grazing	A	30.5	0	-0.714	4	1	1	yes	6.408
16/01/2018	38	1	Grazing	A	23.5	0	0.071	4	1	1	yes	4.124
16/01/2018	38	2	Grazing	A	23.5	0	0.071	4	1	1	yes	1.885
16/01/2018	38	3	Grazing	A	23.5	0	0.071	4	1	1	yes	5.263
16/01/2018	39	1	Grazing	A	29	0	-0.714	4	1	1	yes	5.310
16/01/2018	39	2	Grazing	A	29	0	-0.714	4	1	1	yes	6.403
16/01/2018	39	3	Grazing	A	29	0	-0.714	4	1	1	yes	7.143
16/01/2018	40	1	Grazing	B	28.5	0	-0.071	4	1	4	yes	3.674
16/01/2018	40	2	Grazing	B	28.5	0	-0.071	4	1	4	yes	4.013
16/01/2018	40	3	Grazing	B	28.5	0	-0.071	4	1	4	yes	5.899
16/01/2018	41	1	Grazing	B	31	0	-0.143	4	1	4	yes	7.669
16/01/2018	41	2	Grazing	B	31	0	-0.143	4	1	4	yes	7.072
16/01/2018	41	3	Grazing	B	31	0	-0.143	4	1	4	yes	9.028
16/01/2018	42	1	Grazing	B	27.5	0	0.054	4	1	4	yes	6.992
16/01/2018	42	2	Grazing	B	27.5	0	0.054	4	1	4	yes	5.660
16/01/2018	42	3	Grazing	B	27.5	0	0.054	4	1	4	yes	5.360
23/01/2018	19	1	Grazing	B	38	550	0.200	5	1	5	yes	6.614
23/01/2018	19	2	Grazing	B	38	550	0.200	5	1	5	yes	7.900
23/01/2018	19	3	Grazing	B	38	550	0.200	5	1	5	yes	10.501
23/01/2018	21	1	Grazing	B	31	0	0.029	5	1	5	yes	5.357

23/01/2018	21	2	Grazing	B	31	0	0.029	5	1	5	yes	6.246
23/01/2018	21	3	Grazing	B	31	0	0.029	5	1	5	yes	7.307
23/01/2018	23	1	Grazing	A	33	0	0.143	5	1	2	yes	7.277
23/01/2018	23	2	Grazing	A	33	0	0.143	5	1	2	yes	6.937
23/01/2018	23	3	Grazing	A	33	0	0.143	5	1	2	yes	5.723
23/01/2018	24	1	Grazing	B	31	150	0.086	5	1	5	yes	7.268
23/01/2018	24	2	Grazing	B	31	150	0.086	5	1	5	yes	8.004
23/01/2018	24	3	Grazing	B	31	150	0.086	5	1	5	yes	8.203
23/01/2018	25	1	Grazing	A	35	0	0.036	5	1	2	yes	7.670
23/01/2018	25	2	Grazing	A	35	0	0.036	5	1	2	yes	8.852
23/01/2018	25	3	Grazing	A	35	0	0.036	5	1	2	yes	8.918
23/01/2018	26	1	Grazing	A	35	0	-0.071	5	1	2	yes	9.463
23/01/2018	26	2	Grazing	A	35	0	-0.071	5	1	2	yes	7.738
23/01/2018	26	3	Grazing	A	35	0	-0.071	5	1	2	yes	5.389
23/01/2018	27	1	Grazing	A	36.5	0	0.071	5	1	2	yes	9.963
23/01/2018	27	2	Grazing	A	36.5	0	0.071	5	1	2	yes	10.534
23/01/2018	27	3	Grazing	A	36.5	0	0.071	5	1	2	yes	9.417
23/01/2018	28	1	Grazing	B	34	50	0.014	5	1	5	yes	7.671
23/01/2018	28	2	Grazing	B	34	50	0.014	5	1	5	yes	9.135
23/01/2018	28	3	Grazing	B	34	50	0.014	5	1	5	yes	8.872
23/01/2018	29	1	Grazing	A	36.5	0	NA	5	1	2	yes	9.409
23/01/2018	29	2	Grazing	A	36.5	0	NA	5	1	2	yes	10.902
23/01/2018	29	3	Grazing	A	36.5	0	NA	5	1	2	yes	10.111
23/01/2018	30	1	Grazing	B	34.5	0	0.071	5	1	5	yes	9.678
23/01/2018	30	2	Grazing	B	34.5	0	0.071	5	1	5	yes	11.387
23/01/2018	30	3	Grazing	B	34.5	0	0.071	5	1	5	yes	9.372
23/01/2018	31	1	Grazing	A	31.5	50	-0.143	5	1	2	yes	8.844
23/01/2018	31	2	Grazing	A	31.5	50	-0.143	5	1	2	yes	10.053
23/01/2018	31	3	Grazing	A	31.5	50	-0.143	5	1	2	yes	10.056
23/01/2018	32	1	Grazing	A	34.5	0	-0.179	5	1	2	yes	9.908
23/01/2018	32	2	Grazing	A	34.5	0	-0.179	5	1	2	yes	7.692
23/01/2018	32	3	Grazing	A	34.5	0	-0.179	5	1	2	yes	8.147
23/01/2018	33	1	Grazing	B	29.5	350	0.257	5	1	5	yes	8.421
23/01/2018	33	2	Grazing	B	29.5	350	0.257	5	1	5	yes	10.151
23/01/2018	33	3	Grazing	B	29.5	350	0.257	5	1	5	yes	9.578
23/01/2018	34	1	Grazing	A	29	0	0.000	5	1	2	yes	9.539
23/01/2018	34	2	Grazing	A	29	0	0.000	5	1	2	yes	9.407
23/01/2018	34	3	Grazing	A	29	0	0.000	5	1	2	yes	10.346
23/01/2018	35	1	Grazing	B	37	400	-0.014	5	1	5	yes	8.699
23/01/2018	35	2	Grazing	B	37	400	-0.014	5	1	5	yes	9.415
23/01/2018	35	3	Grazing	B	37	400	-0.014	5	1	5	yes	9.488
23/01/2018	36	1	Grazing	B	38.5	200	0.186	5	1	5	yes	6.101
23/01/2018	36	2	Grazing	B	38.5	200	0.186	5	1	5	yes	5.915
23/01/2018	36	3	Grazing	B	38.5	200	0.186	5	1	5	yes	4.954
23/01/2018	37	1	Grazing	A	36	0	0.036	5	1	2	yes	5.655
23/01/2018	37	2	Grazing	A	36	0	0.036	5	1	2	yes	6.816

23/01/2018	37	3	Grazing	A	36	0	0.036	5	1	2	yes	7.785
23/01/2018	38	1	Grazing	A	25.5	0	0.179	5	1	2	yes	7.029
23/01/2018	38	2	Grazing	A	25.5	0	0.179	5	1	2	yes	7.653
23/01/2018	38	3	Grazing	A	25.5	0	0.179	5	1	2	yes	7.789
23/01/2018	39	1	Grazing	A	32.5	0	-0.107	5	1	2	yes	8.234
23/01/2018	39	2	Grazing	A	32.5	0	-0.107	5	1	2	yes	8.818
23/01/2018	39	3	Grazing	A	32.5	0	-0.107	5	1	2	yes	8.956
23/01/2018	40	1	Grazing	B	32	50	0.043	5	1	5	yes	6.963
23/01/2018	40	2	Grazing	B	32	50	0.043	5	1	5	yes	6.077
23/01/2018	40	3	Grazing	B	32	50	0.043	5	1	5	yes	6.108
23/01/2018	41	1	Grazing	B	35.5	0	0.014	5	1	5	yes	8.105
23/01/2018	41	2	Grazing	B	35.5	0	0.014	5	1	5	yes	8.279
23/01/2018	41	3	Grazing	B	35.5	0	0.014	5	1	5	yes	7.926
23/01/2018	42	1	Grazing	B	28.5	0	0.071	5	1	5	yes	6.449
23/01/2018	42	2	Grazing	B	28.5	0	0.071	5	1	5	yes	9.326
23/01/2018	42	3	Grazing	B	28.5	0	0.071	5	1	5	yes	8.906
30/01/2018	23	2	Grazing	A	31	0	0.000	6	1	3	yes	6.954
30/01/2018	23	3	Grazing	A	31	0	0.000	6	1	3	yes	5.905
30/01/2018	25	2	Grazing	A	37.5	0	0.143	6	1	3	yes	8.129
30/01/2018	25	3	Grazing	A	37.5	0	0.143	6	1	3	yes	8.535
30/01/2018	26	2	Grazing	A	38.5	0	0.119	6	1	3	yes	7.860
30/01/2018	26	3	Grazing	A	38.5	0	0.119	6	1	3	yes	6.130
30/01/2018	27	2	Grazing	A	34	50	-0.071	6	1	3	yes	10.196
30/01/2018	27	3	Grazing	A	34	50	-0.071	6	1	3	yes	9.136
30/01/2018	29	2	Grazing	A	44	0	0.000	6	1	3	yes	10.099
30/01/2018	29	3	Grazing	A	44	0	0.000	6	1	3	yes	8.795
30/01/2018	31	2	Grazing	A	34	0	0.024	6	1	3	yes	11.540
30/01/2018	31	3	Grazing	A	34	0	0.024	6	1	3	yes	9.039
30/01/2018	32	2	Grazing	A	36	0	-0.048	6	1	3	yes	7.209
30/01/2018	32	3	Grazing	A	36	0	-0.048	6	1	3	yes	5.102
30/01/2018	34	2	Grazing	A	30.5	0	0.071	6	1	3	yes	10.281
30/01/2018	34	3	Grazing	A	30.5	0	0.071	6	1	3	yes	9.189
30/01/2018	37	2	Grazing	A	41	0	0.262	6	1	3	yes	9.268
30/01/2018	37	3	Grazing	A	41	0	0.262	6	1	3	yes	6.779
30/01/2018	38	2	Grazing	A	27	0	0.190	6	1	3	yes	8.824
30/01/2018	38	3	Grazing	A	27	0	0.190	6	1	3	yes	7.169
30/01/2018	39	2	Grazing	A	33.5	0	-0.024	6	1	3	yes	7.940
30/01/2018	39	3	Grazing	A	33.5	0	-0.024	6	1	3	yes	7.485
06/02/2018	19	1	Grazing	B	43	0	0.786	7	1	1	yes	7.488
06/02/2018	19	2	Grazing	B	43	0	0.786	7	1	1	yes	8.798
06/02/2018	21	1	Grazing	B	35	0	0.143	7	1	1	yes	7.146
06/02/2018	21	2	Grazing	B	35	0	0.143	7	1	1	yes	8.328
06/02/2018	23	1	Grazing	A	34.5	0	0.125	7	1	4	yes	5.936
06/02/2018	23	2	Grazing	A	34.5	0	0.125	7	1	4	yes	6.480
06/02/2018	24	1	Grazing	B	31.5	0	-0.214	7	1	1	yes	8.926
06/02/2018	24	2	Grazing	B	31.5	0	-0.214	7	1	1	yes	10.510

06/02/2018	25	1	Grazing	A	36.5	0	0.071	7	1	4	yes	8.205
06/02/2018	25	2	Grazing	A	36.5	0	0.071	7	1	4	yes	11.662
06/02/2018	26	1	Grazing	A	35	0	-0.036	7	1	4	yes	7.586
06/02/2018	26	2	Grazing	A	35	0	-0.036	7	1	4	yes	9.224
06/02/2018	27	1	Grazing	A	44	200	NA	7	1	4	yes	7.756
06/02/2018	27	2	Grazing	A	44	200	NA	7	1	4	yes	10.097
06/02/2018	28	1	Grazing	B	36.5	0	0.214	7	1	1	yes	9.272
06/02/2018	28	2	Grazing	B	36.5	0	0.214	7	1	1	yes	10.392
06/02/2018	29	1	Grazing	A	43.5	0	-0.018	7	1	4	yes	6.737
06/02/2018	29	2	Grazing	A	43.5	0	-0.018	7	1	4	yes	7.987
06/02/2018	30	1	Grazing	B	35.5	0	-0.071	7	1	1	yes	11.600
06/02/2018	30	2	Grazing	B	35.5	0	-0.071	7	1	1	yes	12.386
06/02/2018	31	1	Grazing	A	31	50	-0.089	7	1	4	yes	9.558
06/02/2018	31	2	Grazing	A	31	50	-0.089	7	1	4	yes	10.565
06/02/2018	32	1	Grazing	A	35	0	-0.071	7	1	4	yes	9.076
06/02/2018	32	2	Grazing	A	35	0	-0.071	7	1	4	yes	12.182
06/02/2018	33	1	Grazing	B	31.5	0	0.143	7	1	1	yes	10.160
06/02/2018	33	2	Grazing	B	31.5	0	0.143	7	1	1	yes	11.122
06/02/2018	34	1	Grazing	A	30.5	200	0.054	7	1	4	yes	8.644
06/02/2018	34	2	Grazing	A	30.5	200	0.054	7	1	4	yes	10.858
06/02/2018	35	1	Grazing	B	38.5	0	-0.143	7	1	1	yes	9.628
06/02/2018	35	2	Grazing	B	38.5	0	-0.143	7	1	1	yes	10.375
06/02/2018	36	1	Grazing	B	36	0	-0.214	7	1	1	yes	6.299
06/02/2018	36	2	Grazing	B	36	0	-0.214	7	1	1	yes	7.142
06/02/2018	37	1	Grazing	A	36.5	50	0.036	7	1	4	yes	9.428
06/02/2018	37	2	Grazing	A	36.5	50	0.036	7	1	4	yes	9.584
06/02/2018	38	1	Grazing	A	26	50	0.107	7	1	4	yes	8.182
06/02/2018	38	2	Grazing	A	26	50	0.107	7	1	4	yes	10.646
06/02/2018	40	1	Grazing	B	33.5	0	-0.143	7	1	1	yes	9.482
06/02/2018	40	2	Grazing	B	33.5	0	-0.143	7	1	1	yes	10.874
06/02/2018	41	1	Grazing	B	36.5	0	-0.429	7	1	1	yes	9.151
06/02/2018	41	2	Grazing	B	36.5	0	-0.429	7	1	1	yes	9.893
06/02/2018	42	1	Grazing	B	32	0	0.286	7	1	1	yes	9.427
06/02/2018	42	2	Grazing	B	32	0	0.286	7	1	1	yes	10.389
13/02/2018	19	1	Grazing	B	38	0	0.036	8	1	2	yes	5.779
13/02/2018	19	2	Grazing	B	38	0	0.036	8	1	2	yes	5.887
13/02/2018	19	3	Grazing	B	38	0	0.036	8	1	2	yes	5.696
13/02/2018	21	1	Grazing	B	36	0	0.143	8	1	2	yes	4.275
13/02/2018	21	2	Grazing	B	36	0	0.143	8	1	2	yes	6.937
13/02/2018	21	3	Grazing	B	36	0	0.143	8	1	2	yes	6.120
13/02/2018	23	1	Grazing	A	33.5	150	0.071	8	1	5	yes	6.489
13/02/2018	23	2	Grazing	A	33.5	150	0.071	8	1	5	yes	5.085
13/02/2018	23	3	Grazing	A	33.5	150	0.071	8	1	5	yes	5.201
13/02/2018	24	1	Grazing	B	33.5	0	0.036	8	1	2	yes	6.673
13/02/2018	24	2	Grazing	B	33.5	0	0.036	8	1	2	yes	6.399
13/02/2018	24	3	Grazing	B	33.5	0	0.036	8	1	2	yes	7.065

13/02/2018	25	1	Grazing	A	33.5	0	-0.029	8	1	5	yes	10.156
13/02/2018	25	2	Grazing	A	33.5	0	-0.029	8	1	5	yes	10.042
13/02/2018	25	3	Grazing	A	33.5	0	-0.029	8	1	5	yes	10.138
13/02/2018	26	1	Grazing	A	38.5	150	0.071	8	1	5	yes	6.273
13/02/2018	26	2	Grazing	A	38.5	150	0.071	8	1	5	yes	4.844
13/02/2018	26	3	Grazing	A	38.5	150	0.071	8	1	5	yes	5.552
13/02/2018	27	1	Grazing	A	37	1100	0.043	8	1	5	yes	7.393
13/02/2018	27	2	Grazing	A	37	1100	0.043	8	1	5	yes	7.138
13/02/2018	27	3	Grazing	A	37	1100	0.043	8	1	5	yes	7.684
13/02/2018	28	1	Grazing	B	36.5	0	0.107	8	1	2	yes	8.274
13/02/2018	28	2	Grazing	B	36.5	0	0.107	8	1	2	yes	8.828
13/02/2018	28	3	Grazing	B	36.5	0	0.107	8	1	2	yes	9.027
13/02/2018	29	1	Grazing	A	42	400	-0.057	8	1	5	yes	5.752
13/02/2018	29	2	Grazing	A	42	400	-0.057	8	1	5	yes	7.999
13/02/2018	29	3	Grazing	A	42	400	-0.057	8	1	5	yes	4.994
13/02/2018	30	1	Grazing	B	35.5	0	-0.036	8	1	2	yes	11.121
13/02/2018	30	2	Grazing	B	35.5	0	-0.036	8	1	2	yes	13.105
13/02/2018	30	3	Grazing	B	35.5	0	-0.036	8	1	2	yes	8.892
13/02/2018	31	1	Grazing	A	33.5	250	0.000	8	1	5	yes	9.866
13/02/2018	31	2	Grazing	A	33.5	250	0.000	8	1	5	yes	7.553
13/02/2018	31	3	Grazing	A	33.5	250	0.000	8	1	5	yes	9.134
13/02/2018	32	1	Grazing	A	32.5	1700	-0.129	8	1	5	yes	6.650
13/02/2018	32	2	Grazing	A	32.5	1700	-0.129	8	1	5	yes	7.337
13/02/2018	32	3	Grazing	A	32.5	1700	-0.129	8	1	5	yes	5.520
13/02/2018	33	1	Grazing	B	33	0	0.179	8	1	2	yes	9.221
13/02/2018	33	2	Grazing	B	33	0	0.179	8	1	2	yes	8.756
13/02/2018	33	3	Grazing	B	33	0	0.179	8	1	2	yes	10.872
13/02/2018	34	1	Grazing	A	30	0	0.029	8	1	5	yes	9.422
13/02/2018	34	2	Grazing	A	30	0	0.029	8	1	5	yes	9.261
13/02/2018	34	3	Grazing	A	30	0	0.029	8	1	5	yes	9.823
13/02/2018	35	1	Grazing	B	38.5	0	-0.071	8	1	2	yes	9.014
13/02/2018	35	2	Grazing	B	38.5	0	-0.071	8	1	2	yes	8.350
13/02/2018	35	3	Grazing	B	38.5	0	-0.071	8	1	2	yes	10.030
13/02/2018	36	1	Grazing	B	40	0	0.179	8	1	2	yes	5.779
13/02/2018	36	2	Grazing	B	40	0	0.179	8	1	2	yes	5.353
13/02/2018	36	3	Grazing	B	40	0	0.179	8	1	2	yes	6.416
13/02/2018	37	1	Grazing	A	37.5	200	0.057	8	1	5	yes	9.074
13/02/2018	37	2	Grazing	A	37.5	200	0.057	8	1	5	yes	6.936
13/02/2018	37	3	Grazing	A	37.5	200	0.057	8	1	5	yes	8.188
13/02/2018	38	1	Grazing	A	28.5	0	0.157	8	1	5	yes	8.248
13/02/2018	38	2	Grazing	A	28.5	0	0.157	8	1	5	yes	7.929
13/02/2018	38	3	Grazing	A	28.5	0	0.157	8	1	5	yes	7.861
13/02/2018	39	1	Grazing	A	36	300	0.057	8	1	5	yes	8.127
13/02/2018	39	2	Grazing	A	36	300	0.057	8	1	5	yes	8.301
13/02/2018	39	3	Grazing	A	36	300	0.057	8	1	5	yes	9.179
13/02/2018	40	1	Grazing	B	36.5	0	0.143	8	1	2	yes	9.406

13/02/2018	40	2	Grazing	B	36.5	0	0.143	8	1	2	yes	9.527
13/02/2018	40	3	Grazing	B	36.5	0	0.143	8	1	2	yes	9.184
13/02/2018	41	1	Grazing	B	36.5	0	-0.214	8	1	2	yes	7.830
13/02/2018	41	2	Grazing	B	36.5	0	-0.214	8	1	2	yes	6.987
13/02/2018	41	3	Grazing	B	36.5	0	-0.214	8	1	2	yes	7.314
13/02/2018	42	1	Grazing	B	32.5	0	0.179	8	1	2	yes	9.476
13/02/2018	42	2	Grazing	B	32.5	0	0.179	8	1	2	yes	7.506
13/02/2018	42	3	Grazing	B	32.5	0	0.179	8	1	2	yes	8.546
10/04/2018	19	1	Grazing	B	42.5	0	0.357	16	2	1	yes	7.159
10/04/2018	19	2	Grazing	B	42.5	0	0.357	16	2	1	yes	7.054
10/04/2018	19	3	Grazing	B	42.5	0	0.357	16	2	1	yes	5.884
10/04/2018	21	1	Grazing	B	36	0	-0.143	16	2	1	yes	4.169
10/04/2018	21	2	Grazing	B	36	0	-0.143	16	2	1	yes	4.477
10/04/2018	21	3	Grazing	B	36	0	-0.143	16	2	1	yes	4.828
10/04/2018	23	1	Grazing	A	39.5	150	0.179	16	2	4	yes	5.165
10/04/2018	23	2	Grazing	A	39.5	150	0.179	16	2	4	yes	5.466
10/04/2018	23	3	Grazing	A	39.5	150	0.179	16	2	4	yes	5.870
10/04/2018	24	1	Grazing	B	33.5	0	0.214	16	2	1	yes	5.011
10/04/2018	24	2	Grazing	B	33.5	0	0.214	16	2	1	yes	5.586
10/04/2018	24	3	Grazing	B	33.5	0	0.214	16	2	1	yes	6.507
10/04/2018	26	1	Grazing	A	40	0	0.071	16	2	4	yes	7.981
10/04/2018	26	2	Grazing	A	40	0	0.071	16	2	4	yes	7.866
10/04/2018	26	3	Grazing	A	40	0	0.071	16	2	4	yes	8.212
10/04/2018	27	1	Grazing	A	40.5	100	0.196	16	2	4	yes	8.292
10/04/2018	27	2	Grazing	A	40.5	100	0.196	16	2	4	yes	8.086
10/04/2018	27	3	Grazing	A	40.5	100	0.196	16	2	4	yes	8.286
10/04/2018	28	1	Grazing	B	39.5	0	0.429	16	2	1	yes	8.763
10/04/2018	28	2	Grazing	B	39.5	0	0.429	16	2	1	yes	9.417
10/04/2018	28	3	Grazing	B	39.5	0	0.429	16	2	1	yes	9.917
10/04/2018	29	1	Grazing	A	48	0	0.125	16	2	4	yes	6.736
10/04/2018	29	2	Grazing	A	48	0	0.125	16	2	4	yes	7.058
10/04/2018	29	3	Grazing	A	48	0	0.125	16	2	4	yes	7.663
10/04/2018	30	1	Grazing	B	36	0	0.357	16	2	1	yes	8.429
10/04/2018	30	2	Grazing	B	36	0	0.357	16	2	1	yes	7.157
10/04/2018	30	3	Grazing	B	36	0	0.357	16	2	1	yes	8.044
10/04/2018	31	1	Grazing	A	38.5	100	0.071	16	2	4	yes	8.329
10/04/2018	31	2	Grazing	A	38.5	100	0.071	16	2	4	yes	7.932
10/04/2018	31	3	Grazing	A	38.5	100	0.071	16	2	4	yes	8.171
10/04/2018	32	1	Grazing	A	38.5	0	0.179	16	2	4	yes	6.457
10/04/2018	32	2	Grazing	A	38.5	0	0.179	16	2	4	yes	6.663
10/04/2018	32	3	Grazing	A	38.5	0	0.179	16	2	4	yes	7.425
10/04/2018	33	1	Grazing	B	37.5	0	0.143	16	2	1	yes	5.096
10/04/2018	33	2	Grazing	B	37.5	0	0.143	16	2	1	yes	5.396
10/04/2018	33	3	Grazing	B	37.5	0	0.143	16	2	1	yes	5.385
10/04/2018	34	1	Grazing	A	34	0	0.143	16	2	4	yes	7.224
10/04/2018	34	2	Grazing	A	34	0	0.143	16	2	4	yes	8.562

10/04/2018	34	3	Grazing	A	34	0	0.143	16	2	4	yes	10.247
10/04/2018	35	1	Grazing	B	40.5	0	0.571	16	2	1	yes	6.950
10/04/2018	35	2	Grazing	B	40.5	0	0.571	16	2	1	yes	6.125
10/04/2018	35	3	Grazing	B	40.5	0	0.571	16	2	1	yes	7.779
10/04/2018	36	1	Grazing	B	43	0	0.429	16	2	1	yes	5.604
10/04/2018	36	2	Grazing	B	43	0	0.429	16	2	1	yes	5.942
10/04/2018	36	3	Grazing	B	43	0	0.429	16	2	1	yes	6.679
10/04/2018	37	1	Grazing	A	46.5	0	0.179	16	2	4	yes	3.552
10/04/2018	37	2	Grazing	A	46.5	0	0.179	16	2	4	yes	3.630
10/04/2018	37	3	Grazing	A	46.5	0	0.179	16	2	4	yes	3.878
10/04/2018	38	1	Grazing	A	28.5	0	0.000	16	2	4	yes	6.184
10/04/2018	38	2	Grazing	A	28.5	0	0.000	16	2	4	yes	7.559
10/04/2018	38	3	Grazing	A	28.5	0	0.000	16	2	4	yes	7.572
10/04/2018	39	1	Grazing	A	37	0	0.107	16	2	4	yes	5.654
10/04/2018	39	2	Grazing	A	37	0	0.107	16	2	4	yes	6.393
10/04/2018	39	3	Grazing	A	37	0	0.107	16	2	4	yes	6.593
10/04/2018	40	1	Grazing	B	36	0	0.357	16	2	1	yes	7.567
10/04/2018	40	2	Grazing	B	36	0	0.357	16	2	1	yes	7.113
10/04/2018	40	3	Grazing	B	36	0	0.357	16	2	1	yes	8.018
10/04/2018	41	1	Grazing	B	46.5	0	0.643	16	2	1	yes	7.103
10/04/2018	41	2	Grazing	B	46.5	0	0.643	16	2	1	yes	6.579
10/04/2018	41	3	Grazing	B	46.5	0	0.643	16	2	1	yes	6.085
10/04/2018	42	1	Grazing	B	36.5	0	0.429	16	2	1	yes	8.553
10/04/2018	42	2	Grazing	B	36.5	0	0.429	16	2	1	yes	8.503
10/04/2018	42	3	Grazing	B	36.5	0	0.429	16	2	1	yes	9.159
17/04/2018	19	1	Grazing	B	44	0	0.286	17	2	2	yes	8.454
17/04/2018	19	2	Grazing	B	44	0	0.286	17	2	2	yes	8.208
17/04/2018	19	3	Grazing	B	44	0	0.286	17	2	2	yes	9.484
17/04/2018	21	1	Grazing	B	38.5	0	0.107	17	2	2	yes	3.812
17/04/2018	21	2	Grazing	B	38.5	0	0.107	17	2	2	yes	4.059
17/04/2018	21	3	Grazing	B	38.5	0	0.107	17	2	2	yes	5.129
17/04/2018	23	1	Grazing	A	38	900	0.100	17	2	5	yes	5.462
17/04/2018	23	2	Grazing	A	38	900	0.100	17	2	5	yes	5.834
17/04/2018	23	3	Grazing	A	38	900	0.100	17	2	5	yes	7.541
17/04/2018	24	1	Grazing	B	32.5	0	0.036	17	2	2	yes	5.236
17/04/2018	24	2	Grazing	B	32.5	0	0.036	17	2	2	yes	5.411
17/04/2018	24	3	Grazing	B	32.5	0	0.036	17	2	2	yes	6.621
17/04/2018	26	1	Grazing	A	39.5	0	0.043	17	2	5	yes	7.508
17/04/2018	26	2	Grazing	A	39.5	0	0.043	17	2	5	yes	7.400
17/04/2018	26	3	Grazing	A	39.5	0	0.043	17	2	5	yes	8.207
17/04/2018	27	1	Grazing	A	39	1100	0.114	17	2	5	yes	5.230
17/04/2018	27	2	Grazing	A	39	1100	0.114	17	2	5	yes	5.441
17/04/2018	27	3	Grazing	A	39	1100	0.114	17	2	5	yes	7.595
17/04/2018	28	1	Grazing	B	38.5	0	0.143	17	2	2	yes	8.427
17/04/2018	28	2	Grazing	B	38.5	0	0.143	17	2	2	yes	8.564
17/04/2018	28	3	Grazing	B	38.5	0	0.143	17	2	2	yes	9.059

17/04/2018	29	1	Grazing	A	45.5	NA	0.029	17	2	5	yes	8.085
17/04/2018	29	2	Grazing	A	45.5	NA	0.029	17	2	5	yes	8.761
17/04/2018	29	3	Grazing	A	45.5	NA	0.029	17	2	5	yes	10.263
17/04/2018	30	1	Grazing	B	35	0	0.107	17	2	2	yes	6.085
17/04/2018	30	2	Grazing	B	35	0	0.107	17	2	2	yes	6.143
17/04/2018	30	3	Grazing	B	35	0	0.107	17	2	2	yes	7.507
17/04/2018	31	1	Grazing	A	38	550	0.043	17	2	5	yes	7.886
17/04/2018	31	2	Grazing	A	38	550	0.043	17	2	5	yes	6.626
17/04/2018	31	3	Grazing	A	38	550	0.043	17	2	5	yes	7.331
17/04/2018	32	1	Grazing	A	37	50	0.100	17	2	5	yes	6.657
17/04/2018	32	2	Grazing	A	37	50	0.100	17	2	5	yes	5.408
17/04/2018	32	3	Grazing	A	37	50	0.100	17	2	5	yes	8.092
17/04/2018	33	1	Grazing	B	38	0	0.107	17	2	2	yes	5.684
17/04/2018	33	2	Grazing	B	38	0	0.107	17	2	2	yes	5.706
17/04/2018	33	3	Grazing	B	38	0	0.107	17	2	2	yes	6.385
17/04/2018	34	1	Grazing	A	33.5	550	0.100	17	2	5	yes	9.999
17/04/2018	34	2	Grazing	A	33.5	550	0.100	17	2	5	yes	9.388
17/04/2018	34	3	Grazing	A	33.5	550	0.100	17	2	5	yes	10.631
17/04/2018	35	1	Grazing	B	39.5	0	0.214	17	2	2	yes	4.583
17/04/2018	35	2	Grazing	B	39.5	0	0.214	17	2	2	yes	4.905
17/04/2018	35	3	Grazing	B	39.5	0	0.214	17	2	2	yes	5.789
17/04/2018	36	1	Grazing	B	42.5	0	0.179	17	2	2	yes	6.438
17/04/2018	36	2	Grazing	B	42.5	0	0.179	17	2	2	yes	6.426
17/04/2018	36	3	Grazing	B	42.5	0	0.179	17	2	2	yes	7.193
17/04/2018	37	1	Grazing	A	45.5	1100	0.114	17	2	5	yes	3.420
17/04/2018	37	2	Grazing	A	45.5	1100	0.114	17	2	5	yes	3.666
17/04/2018	37	3	Grazing	A	45.5	1100	0.114	17	2	5	yes	4.210
17/04/2018	38	1	Grazing	A	27	0	-0.043	17	2	5	yes	6.573
17/04/2018	38	2	Grazing	A	27	0	-0.043	17	2	5	yes	6.759
17/04/2018	38	3	Grazing	A	27	0	-0.043	17	2	5	yes	7.786
17/04/2018	39	1	Grazing	A	37	0	0.086	17	2	5	yes	4.705
17/04/2018	39	2	Grazing	A	37	0	0.086	17	2	5	yes	4.475
17/04/2018	39	3	Grazing	A	37	0	0.086	17	2	5	yes	5.996
17/04/2018	40	1	Grazing	B	36.5	0	0.214	17	2	2	yes	6.482
17/04/2018	40	2	Grazing	B	36.5	0	0.214	17	2	2	yes	6.681
17/04/2018	40	3	Grazing	B	36.5	0	0.214	17	2	2	yes	7.381
17/04/2018	41	1	Grazing	B	43	0	0.071	17	2	2	yes	6.985
17/04/2018	41	2	Grazing	B	43	0	0.071	17	2	2	yes	7.432
17/04/2018	41	3	Grazing	B	43	0	0.071	17	2	2	yes	7.121
17/04/2018	42	1	Grazing	B	36	0	0.179	17	2	2	yes	8.547
17/04/2018	42	2	Grazing	B	36	0	0.179	17	2	2	yes	8.891
17/04/2018	42	3	Grazing	B	36	0	0.179	17	2	2	yes	9.565
04/05/2018	21	1	Grazing	B	39	1500	0.071	19	2	4	yes	3.189
04/05/2018	21	2	Grazing	B	39	1500	0.071	19	2	4	yes	4.029
04/05/2018	21	3	Grazing	B	39	1500	0.071	19	2	4	yes	2.738
04/05/2018	23	1	Grazing	A	38	0	0.000	19	2	1	yes	4.735

04/05/2018	23	2	Grazing	A	38	0	0.000	19	2	1	yes	6.288
04/05/2018	23	3	Grazing	A	38	0	0.000	19	2	1	yes	4.575
04/05/2018	24	1	Grazing	B	33	350	0.036	19	2	4	yes	2.314
04/05/2018	24	2	Grazing	B	33	350	0.036	19	2	4	yes	3.144
04/05/2018	24	3	Grazing	B	33	350	0.036	19	2	4	yes	2.051
04/05/2018	26	1	Grazing	A	40.5	0	0.214	19	2	1	yes	6.608
04/05/2018	26	2	Grazing	A	40.5	0	0.214	19	2	1	yes	9.548
04/05/2018	26	3	Grazing	A	40.5	0	0.214	19	2	1	yes	6.468
04/05/2018	27	1	Grazing	A	40.5	0	0.429	19	2	1	yes	5.542
04/05/2018	27	2	Grazing	A	40.5	0	0.429	19	2	1	yes	7.185
04/05/2018	27	3	Grazing	A	40.5	0	0.429	19	2	1	yes	5.385
04/05/2018	28	1	Grazing	B	39	850	0.089	19	2	4	yes	7.380
04/05/2018	28	2	Grazing	B	39	850	0.089	19	2	4	yes	9.692
04/05/2018	28	3	Grazing	B	39	850	0.089	19	2	4	yes	7.542
04/05/2018	29	1	Grazing	A	47.5	0	0.357	19	2	1	yes	6.119
04/05/2018	29	2	Grazing	A	47.5	0	0.357	19	2	1	yes	8.443
04/05/2018	29	3	Grazing	A	47.5	0	0.357	19	2	1	yes	6.537
04/05/2018	30	1	Grazing	B	36	700	0.089	19	2	4	yes	5.108
04/05/2018	30	2	Grazing	B	36	700	0.089	19	2	4	yes	6.509
04/05/2018	30	3	Grazing	B	36	700	0.089	19	2	4	yes	5.008
04/05/2018	31	1	Grazing	A	37.5	0	0.286	19	2	1	yes	7.697
04/05/2018	31	2	Grazing	A	37.5	0	0.286	19	2	1	yes	10.225
04/05/2018	31	3	Grazing	A	37.5	0	0.286	19	2	1	yes	6.871
04/05/2018	32	1	Grazing	A	36.5	0	-0.071	19	2	1	yes	4.872
04/05/2018	32	2	Grazing	A	36.5	0	-0.071	19	2	1	yes	4.548
04/05/2018	32	3	Grazing	A	36.5	0	-0.071	19	2	1	yes	3.144
04/05/2018	33	1	Grazing	B	37.5	450	0.036	19	2	4	yes	2.900
04/05/2018	33	2	Grazing	B	37.5	450	0.036	19	2	4	yes	3.958
04/05/2018	33	3	Grazing	B	37.5	450	0.036	19	2	4	yes	2.696
04/05/2018	34	1	Grazing	A	33.5	0	0.143	19	2	1	yes	8.974
04/05/2018	34	2	Grazing	A	33.5	0	0.143	19	2	1	yes	11.128
04/05/2018	34	3	Grazing	A	33.5	0	0.143	19	2	1	yes	7.959
04/05/2018	35	1	Grazing	B	39.5	350	0.107	19	2	4	yes	3.622
04/05/2018	35	2	Grazing	B	39.5	350	0.107	19	2	4	yes	6.284
04/05/2018	35	3	Grazing	B	39.5	350	0.107	19	2	4	yes	4.660
04/05/2018	36	1	Grazing	B	42	NA	0.071	19	2	4	yes	5.387
04/05/2018	36	2	Grazing	B	42	NA	0.071	19	2	4	yes	7.154
04/05/2018	36	3	Grazing	B	42	NA	0.071	19	2	4	yes	4.695
04/05/2018	37	1	Grazing	A	45	0	0.714	19	2	1	yes	4.603
04/05/2018	37	2	Grazing	A	45	0	0.714	19	2	1	yes	6.040
04/05/2018	37	3	Grazing	A	45	0	0.714	19	2	1	yes	4.385
04/05/2018	38	1	Grazing	A	29.5	0	0.357	19	2	1	yes	2.999
04/05/2018	38	2	Grazing	A	29.5	0	0.357	19	2	1	yes	4.339
04/05/2018	38	3	Grazing	A	29.5	0	0.357	19	2	1	yes	3.039
04/05/2018	39	1	Grazing	A	36.5	0	0.071	19	2	1	yes	5.389
04/05/2018	39	2	Grazing	A	36.5	0	0.071	19	2	1	yes	7.178

04/05/2018	39	3	Grazing	A	36.5	0	0.071	19	2	1	yes	5.302
04/05/2018	40	1	Grazing	B	38	400	0.161	19	2	4	yes	3.039
04/05/2018	40	2	Grazing	B	38	400	0.161	19	2	4	yes	3.957
04/05/2018	40	3	Grazing	B	38	400	0.161	19	2	4	yes	2.882
04/05/2018	41	1	Grazing	B	43	100	0.036	19	2	4	yes	2.675
04/05/2018	41	2	Grazing	B	43	100	0.036	19	2	4	yes	3.558
04/05/2018	41	3	Grazing	B	43	100	0.036	19	2	4	yes	2.711
04/05/2018	42	1	Grazing	B	36.5	100	0.107	19	2	4	yes	8.819
04/05/2018	42	2	Grazing	B	36.5	100	0.107	19	2	4	yes	10.199
04/05/2018	42	3	Grazing	B	36.5	100	0.107	19	2	4	yes	8.157
08/05/2018	19	1	Grazing	B	39.5	NA	-0.014	20	2	5	yes	5.086
08/05/2018	19	2	Grazing	B	39.5	NA	-0.014	20	2	5	yes	3.468
08/05/2018	21	1	Grazing	B	39	NA	0.057	20	2	5	yes	2.158
08/05/2018	21	2	Grazing	B	39	NA	0.057	20	2	5	yes	1.486
08/05/2018	23	1	Grazing	A	38	0	0.000	20	2	2	yes	6.280
08/05/2018	23	2	Grazing	A	38	0	0.000	20	2	2	yes	5.362
08/05/2018	24	1	Grazing	B	33.5	850	0.043	20	2	5	yes	3.253
08/05/2018	24	2	Grazing	B	33.5	850	0.043	20	2	5	yes	2.970
08/05/2018	26	1	Grazing	A	40	0	0.071	20	2	2	yes	7.350
08/05/2018	26	2	Grazing	A	40	0	0.071	20	2	2	yes	5.895
08/05/2018	27	1	Grazing	A	41.5	0	0.286	20	2	2	yes	7.477
08/05/2018	27	2	Grazing	A	41.5	0	0.286	20	2	2	yes	6.539
08/05/2018	28	1	Grazing	B	38.5	NA	0.057	20	2	5	yes	9.181
08/05/2018	28	2	Grazing	B	38.5	NA	0.057	20	2	5	yes	7.174
08/05/2018	29	1	Grazing	A	46.5	0	0.107	20	2	2	yes	6.891
08/05/2018	29	2	Grazing	A	46.5	0	0.107	20	2	2	yes	6.374
08/05/2018	30	1	Grazing	B	35	900	0.043	20	2	5	yes	4.523
08/05/2018	30	2	Grazing	B	35	900	0.043	20	2	5	yes	4.790
08/05/2018	31	1	Grazing	A	37.5	0	0.143	20	2	2	yes	8.943
08/05/2018	31	2	Grazing	A	37.5	0	0.143	20	2	2	yes	7.691
08/05/2018	32	1	Grazing	A	37	0	0.000	20	2	2	yes	8.101
08/05/2018	32	2	Grazing	A	37	0	0.000	20	2	2	yes	5.805
08/05/2018	33	1	Grazing	B	37	1100	0.014	20	2	5	yes	2.316
08/05/2018	33	2	Grazing	B	37	1100	0.014	20	2	5	yes	1.811
08/05/2018	34	1	Grazing	A	33.5	0	0.071	20	2	2	yes	6.195
08/05/2018	34	2	Grazing	A	33.5	0	0.071	20	2	2	yes	4.533
08/05/2018	35	1	Grazing	B	37	NA	0.014	20	2	5	yes	5.091
08/05/2018	35	2	Grazing	B	37	NA	0.014	20	2	5	yes	4.030
08/05/2018	36	1	Grazing	B	41.5	850	0.043	20	2	5	yes	5.300
08/05/2018	36	2	Grazing	B	41.5	850	0.043	20	2	5	yes	4.208
08/05/2018	37	1	Grazing	A	44	0	0.286	20	2	2	yes	3.580
08/05/2018	37	2	Grazing	A	44	0	0.286	20	2	2	yes	2.935
08/05/2018	38	1	Grazing	A	29.5	0	0.179	20	2	2	yes	5.172
08/05/2018	38	2	Grazing	A	29.5	0	0.179	20	2	2	yes	4.062
08/05/2018	39	1	Grazing	A	37	0	0.071	20	2	2	yes	6.269
08/05/2018	39	2	Grazing	A	37	0	0.071	20	2	2	yes	4.936

08/05/2018	40	1	Grazing	B	37	1800	0.100	20	2	5	yes	6.536
08/05/2018	40	2	Grazing	B	37	1800	0.100	20	2	5	yes	6.088
08/05/2018	41	1	Grazing	B	42	NA	0.000	20	2	5	yes	5.022
08/05/2018	41	2	Grazing	B	42	NA	0.000	20	2	5	yes	4.659
08/05/2018	42	1	Grazing	B	36.5	1200	0.086	20	2	5	yes	9.254
08/05/2018	42	2	Grazing	B	36.5	1200	0.086	20	2	5	yes	7.667
15/05/2018	23	1	Grazing	A	37	0	-0.048	21	2	3	no	5.316
15/05/2018	23	2	Grazing	A	37	0	-0.048	21	2	3	no	5.005
15/05/2018	23	3	Grazing	A	37	0	-0.048	21	2	3	no	3.979
15/05/2018	26	1	Grazing	A	39	0	0.000	21	2	3	no	4.045
15/05/2018	26	2	Grazing	A	39	0	0.000	21	2	3	no	5.073
15/05/2018	26	3	Grazing	A	39	0	0.000	21	2	3	no	6.560
15/05/2018	27	1	Grazing	A	41.5	0	0.190	21	2	3	no	5.032
15/05/2018	27	2	Grazing	A	41.5	0	0.190	21	2	3	no	6.064
15/05/2018	27	3	Grazing	A	41.5	0	0.190	21	2	3	no	5.835
15/05/2018	29	1	Grazing	A	46.5	0	0.071	21	2	3	no	4.376
15/05/2018	29	2	Grazing	A	46.5	0	0.071	21	2	3	no	5.244
15/05/2018	29	3	Grazing	A	46.5	0	0.071	21	2	3	no	5.657
15/05/2018	31	1	Grazing	A	38.5	0	0.143	21	2	3	no	5.692
15/05/2018	31	2	Grazing	A	38.5	0	0.143	21	2	3	no	6.156
15/05/2018	31	3	Grazing	A	38.5	0	0.143	21	2	3	no	6.447
15/05/2018	32	1	Grazing	A	37.5	0	0.024	21	2	3	no	4.057
15/05/2018	32	2	Grazing	A	37.5	0	0.024	21	2	3	no	5.828
15/05/2018	32	3	Grazing	A	37.5	0	0.024	21	2	3	no	6.275
15/05/2018	34	1	Grazing	A	34	0	0.071	21	2	3	no	5.511
15/05/2018	34	2	Grazing	A	34	0	0.071	21	2	3	no	6.114
15/05/2018	34	3	Grazing	A	34	0	0.071	21	2	3	no	6.335
15/05/2018	37	1	Grazing	A	44.5	0	0.214	21	2	3	no	3.025
15/05/2018	37	2	Grazing	A	44.5	0	0.214	21	2	3	no	4.131
15/05/2018	37	3	Grazing	A	44.5	0	0.214	21	2	3	no	3.959
15/05/2018	38	1	Grazing	A	29.5	0	0.119	21	2	3	no	2.288
15/05/2018	38	2	Grazing	A	29.5	0	0.119	21	2	3	no	3.186
15/05/2018	38	3	Grazing	A	29.5	0	0.119	21	2	3	no	3.996
15/05/2018	39	1	Grazing	A	36	0	0.000	21	2	3	no	3.898
15/05/2018	39	2	Grazing	A	36	0	0.000	21	2	3	no	5.377
15/05/2018	39	3	Grazing	A	36	0	0.000	21	2	3	no	5.107
22/05/2018	19	1	Grazing	B	43	0	0.000	22	3	1	no	6.340
22/05/2018	19	2	Grazing	B	43	0	0.000	22	3	1	no	4.897
22/05/2018	21	1	Grazing	B	39	0	-0.143	22	3	1	no	2.310
22/05/2018	21	2	Grazing	B	39	0	-0.143	22	3	1	no	1.799
22/05/2018	23	1	Grazing	A	38	100	0.000	22	3	4	no	6.960
22/05/2018	23	2	Grazing	A	38	100	0.000	22	3	4	no	5.481
22/05/2018	24	1	Grazing	B	32	0	-0.214	22	3	1	no	3.041
22/05/2018	24	2	Grazing	B	32	0	-0.214	22	3	1	no	2.363
22/05/2018	26	1	Grazing	A	38	50	-0.036	22	3	4	no	5.157
22/05/2018	26	2	Grazing	A	38	50	-0.036	22	3	4	no	4.283

22/05/2018	27	1	Grazing	A	39.5	200	0.071	22	3	4	no	6.852
22/05/2018	27	2	Grazing	A	39.5	200	0.071	22	3	4	no	4.635
22/05/2018	28	1	Grazing	B	37	0	-0.214	22	3	1	no	7.693
22/05/2018	28	2	Grazing	B	37	0	-0.214	22	3	1	no	6.737
22/05/2018	29	1	Grazing	A	46.5	0	0.054	22	3	4	no	3.726
22/05/2018	29	2	Grazing	A	46.5	0	0.054	22	3	4	no	2.571
22/05/2018	30	1	Grazing	B	36.5	0	-0.071	22	3	1	no	5.438
22/05/2018	30	2	Grazing	B	36.5	0	-0.071	22	3	1	no	4.526
22/05/2018	31	1	Grazing	A	37.5	50	0.071	22	3	4	no	9.240
22/05/2018	31	2	Grazing	A	37.5	50	0.071	22	3	4	no	8.031
22/05/2018	32	1	Grazing	A	34.5	0	-0.089	22	3	4	no	4.767
22/05/2018	32	2	Grazing	A	34.5	0	-0.089	22	3	4	no	4.040
22/05/2018	33	1	Grazing	B	38.5	0	0.000	22	3	1	no	3.064
22/05/2018	33	2	Grazing	B	38.5	0	0.000	22	3	1	no	3.020
22/05/2018	34	1	Grazing	A	32.5	50	0.000	22	3	4	no	3.159
22/05/2018	34	2	Grazing	A	32.5	50	0.000	22	3	4	no	2.324
22/05/2018	35	1	Grazing	B	39	0	0.000	22	3	1	no	2.994
22/05/2018	35	2	Grazing	B	39	0	0.000	22	3	1	no	3.333
22/05/2018	36	1	Grazing	B	40	0	-0.071	22	3	1	no	7.844
22/05/2018	36	2	Grazing	B	40	0	-0.071	22	3	1	no	5.985
22/05/2018	37	1	Grazing	A	46	250	0.214	22	3	4	no	2.447
22/05/2018	37	2	Grazing	A	46	250	0.214	22	3	4	no	1.742
22/05/2018	38	1	Grazing	A	28.5	50	0.054	22	3	4	no	3.487
22/05/2018	38	2	Grazing	A	28.5	50	0.054	22	3	4	no	2.385
22/05/2018	39	1	Grazing	A	35	0	-0.036	22	3	4	no	5.696
22/05/2018	39	2	Grazing	A	35	0	-0.036	22	3	4	no	4.363
22/05/2018	40	1	Grazing	B	34.5	0	-0.286	22	3	1	no	5.364
22/05/2018	40	2	Grazing	B	34.5	0	-0.286	22	3	1	no	4.730
22/05/2018	41	1	Grazing	B	42.5	0	0.000	22	3	1	no	3.436
22/05/2018	41	2	Grazing	B	42.5	0	0.000	22	3	1	no	2.766
22/05/2018	42	1	Grazing	B	35.5	0	-0.286	22	3	1	no	8.335
22/05/2018	42	2	Grazing	B	35.5	0	-0.286	22	3	1	no	7.681
29/05/2018	19	1	Grazing	B	42.5	0	-0.036	23	3	2	no	8.000
29/05/2018	19	2	Grazing	B	42.5	0	-0.036	23	3	2	no	7.410
29/05/2018	19	3	Grazing	B	42.5	0	-0.036	23	3	2	no	7.583
29/05/2018	21	1	Grazing	B	39.5	0	-0.036	23	3	2	no	2.697
29/05/2018	21	2	Grazing	B	39.5	0	-0.036	23	3	2	no	1.967
29/05/2018	21	3	Grazing	B	39.5	0	-0.036	23	3	2	no	1.966
29/05/2018	23	1	Grazing	A	36.5	350	-0.043	23	3	5	no	4.025
29/05/2018	23	2	Grazing	A	36.5	350	-0.043	23	3	5	no	3.816
29/05/2018	23	3	Grazing	A	36.5	350	-0.043	23	3	5	no	3.912
29/05/2018	24	1	Grazing	B	33	0	-0.036	23	3	2	no	3.240
29/05/2018	24	2	Grazing	B	33	0	-0.036	23	3	2	no	3.264
29/05/2018	24	3	Grazing	B	33	0	-0.036	23	3	2	no	3.459
29/05/2018	26	1	Grazing	A	39	300	0.000	23	3	5	no	6.547
29/05/2018	26	2	Grazing	A	39	300	0.000	23	3	5	no	5.209

29/05/2018	26	3	Grazing	A	39	300	0.000	23	3	5	no	5.714
29/05/2018	27	1	Grazing	A	40	1000	0.071	23	3	5	no	5.609
29/05/2018	27	2	Grazing	A	40	1000	0.071	23	3	5	no	5.038
29/05/2018	27	3	Grazing	A	40	1000	0.071	23	3	5	no	4.940
29/05/2018	28	1	Grazing	B	38.5	0	0.000	23	3	2	no	5.414
29/05/2018	28	2	Grazing	B	38.5	0	0.000	23	3	2	no	5.078
29/05/2018	28	3	Grazing	B	38.5	0	0.000	23	3	2	no	5.635
29/05/2018	29	1	Grazing	A	44.5	200	-0.014	23	3	5	no	4.166
29/05/2018	29	2	Grazing	A	44.5	200	-0.014	23	3	5	no	3.056
29/05/2018	29	3	Grazing	A	44.5	200	-0.014	23	3	5	no	3.611
29/05/2018	30	1	Grazing	B	37.5	0	0.036	23	3	2	no	5.789
29/05/2018	30	2	Grazing	B	37.5	0	0.036	23	3	2	no	6.051
29/05/2018	30	3	Grazing	B	37.5	0	0.036	23	3	2	no	6.363
29/05/2018	31	1	Grazing	A	38	50	0.071	23	3	5	no	6.417
29/05/2018	31	2	Grazing	A	38	50	0.071	23	3	5	no	5.181
29/05/2018	31	3	Grazing	A	38	50	0.071	23	3	5	no	5.067
29/05/2018	32	1	Grazing	A	36.5	450	-0.014	23	3	5	no	6.394
29/05/2018	32	2	Grazing	A	36.5	450	-0.014	23	3	5	no	5.313
29/05/2018	32	3	Grazing	A	36.5	450	-0.014	23	3	5	no	4.271
29/05/2018	33	1	Grazing	B	38	0	-0.036	23	3	2	no	4.061
29/05/2018	33	2	Grazing	B	38	0	-0.036	23	3	2	no	4.382
29/05/2018	33	3	Grazing	B	38	0	-0.036	23	3	2	no	4.667
29/05/2018	34	1	Grazing	A	33	900	0.014	23	3	5	no	5.218
29/05/2018	34	2	Grazing	A	33	900	0.014	23	3	5	no	4.321
29/05/2018	34	3	Grazing	A	33	900	0.014	23	3	5	no	4.945
29/05/2018	35	1	Grazing	B	40.5	0	0.107	23	3	2	no	3.474
29/05/2018	35	2	Grazing	B	40.5	0	0.107	23	3	2	no	3.026
29/05/2018	35	3	Grazing	B	40.5	0	0.107	23	3	2	no	4.402
29/05/2018	36	1	Grazing	B	40.5	0	0.000	23	3	2	no	4.857
29/05/2018	36	2	Grazing	B	40.5	0	0.000	23	3	2	no	4.566
29/05/2018	36	3	Grazing	B	40.5	0	0.000	23	3	2	no	5.139
29/05/2018	37	1	Grazing	A	43.5	1550	0.100	23	3	5	no	2.029
29/05/2018	37	2	Grazing	A	43.5	1550	0.100	23	3	5	no	1.739
29/05/2018	37	3	Grazing	A	43.5	1550	0.100	23	3	5	no	2.318
29/05/2018	38	1	Grazing	A	29.5	850	0.071	23	3	5	no	6.639
29/05/2018	38	2	Grazing	A	29.5	850	0.071	23	3	5	no	6.629
29/05/2018	38	3	Grazing	A	29.5	850	0.071	23	3	5	no	6.468
29/05/2018	39	1	Grazing	A	36	1300	0.000	23	3	5	no	3.906
29/05/2018	39	2	Grazing	A	36	1300	0.000	23	3	5	no	3.758
29/05/2018	39	3	Grazing	A	36	1300	0.000	23	3	5	no	3.796
29/05/2018	40	1	Grazing	B	37.5	0	0.071	23	3	2	no	4.656
29/05/2018	40	2	Grazing	B	37.5	0	0.071	23	3	2	no	4.401
29/05/2018	40	3	Grazing	B	37.5	0	0.071	23	3	2	no	4.316
29/05/2018	41	1	Grazing	B	42	0	-0.036	23	3	2	no	5.462
29/05/2018	41	2	Grazing	B	42	0	-0.036	23	3	2	no	5.111
29/05/2018	41	3	Grazing	B	42	0	-0.036	23	3	2	no	6.013

29/05/2018	42	1	Grazing	B	36.5	0	-0.071	23	3	2	no	7.090
29/05/2018	42	2	Grazing	B	36.5	0	-0.071	23	3	2	no	6.638
29/05/2018	42	3	Grazing	B	36.5	0	-0.071	23	3	2	no	6.873
05/06/2018	19	1	Grazing	B	44.5	0	0.071	24	3	3	no	4.851
05/06/2018	19	2	Grazing	B	44.5	0	0.071	24	3	3	no	5.168
05/06/2018	19	3	Grazing	B	44.5	0	0.071	24	3	3	no	5.405
05/06/2018	21	1	Grazing	B	39	0	-0.048	24	3	3	no	2.617
05/06/2018	21	2	Grazing	B	39	0	-0.048	24	3	3	no	2.827
05/06/2018	21	3	Grazing	B	39	0	-0.048	24	3	3	no	2.361
05/06/2018	24	1	Grazing	B	33.5	0	0.000	24	3	3	no	4.501
05/06/2018	24	2	Grazing	B	33.5	0	0.000	24	3	3	no	5.291
05/06/2018	24	3	Grazing	B	33.5	0	0.000	24	3	3	no	4.800
05/06/2018	28	1	Grazing	B	39	0	0.024	24	3	3	no	7.410
05/06/2018	28	2	Grazing	B	39	0	0.024	24	3	3	no	7.958
05/06/2018	28	3	Grazing	B	39	0	0.024	24	3	3	no	7.995
05/06/2018	30	1	Grazing	B	38.5	0	0.071	24	3	3	no	8.039
05/06/2018	30	2	Grazing	B	38.5	0	0.071	24	3	3	no	8.688
05/06/2018	30	3	Grazing	B	38.5	0	0.071	24	3	3	no	8.352
05/06/2018	33	1	Grazing	B	38	0	-0.024	24	3	3	no	2.842
05/06/2018	33	2	Grazing	B	38	0	-0.024	24	3	3	no	3.471
05/06/2018	33	3	Grazing	B	38	0	-0.024	24	3	3	no	2.938
05/06/2018	35	1	Grazing	B	40	0	0.048	24	3	3	no	4.986
05/06/2018	35	2	Grazing	B	40	0	0.048	24	3	3	no	5.140
05/06/2018	35	3	Grazing	B	40	0	0.048	24	3	3	no	4.587
05/06/2018	36	1	Grazing	B	42	0	0.071	24	3	3	no	4.943
05/06/2018	36	2	Grazing	B	42	0	0.071	24	3	3	no	5.393
05/06/2018	36	3	Grazing	B	42	0	0.071	24	3	3	no	5.817
05/06/2018	40	1	Grazing	B	40	0	0.167	24	3	3	no	4.680
05/06/2018	40	2	Grazing	B	40	0	0.167	24	3	3	no	5.154
05/06/2018	40	3	Grazing	B	40	0	0.167	24	3	3	no	5.269
05/06/2018	41	1	Grazing	B	43.5	0	0.048	24	3	3	no	5.955
05/06/2018	41	2	Grazing	B	43.5	0	0.048	24	3	3	no	5.868
05/06/2018	41	3	Grazing	B	43.5	0	0.048	24	3	3	no	6.923
05/06/2018	42	1	Grazing	B	38	0	0.024	24	3	3	no	7.584
05/06/2018	42	2	Grazing	B	38	0	0.024	24	3	3	no	8.193
05/06/2018	42	3	Grazing	B	38	0	0.024	24	3	3	no	7.724
12/06/2018	19	1	Grazing	B	45.5	100	0.089	25	3	4	no	6.160
12/06/2018	19	2	Grazing	B	45.5	100	0.089	25	3	4	no	6.401
12/06/2018	19	3	Grazing	B	45.5	100	0.089	25	3	4	no	6.984
12/06/2018	21	1	Grazing	B	41.5	0	0.054	25	3	4	no	3.968
12/06/2018	21	2	Grazing	B	41.5	0	0.054	25	3	4	no	4.492
12/06/2018	21	3	Grazing	B	41.5	0	0.054	25	3	4	no	4.285
12/06/2018	23	1	Grazing	A	39.5	0	0.286	25	3	1	no	5.255
12/06/2018	23	2	Grazing	A	39.5	0	0.286	25	3	1	no	5.352
12/06/2018	23	3	Grazing	A	39.5	0	0.286	25	3	1	no	5.609
12/06/2018	24	1	Grazing	B	36.5	50	0.107	25	3	4	no	2.768

12/06/2018	24	2	Grazing	B	36.5	50	0.107	25	3	4	no	2.656
12/06/2018	24	3	Grazing	B	36.5	50	0.107	25	3	4	no	3.013
12/06/2018	26	1	Grazing	A	40.5	0	0.143	25	3	1	no	4.192
12/06/2018	26	2	Grazing	A	40.5	0	0.143	25	3	1	no	4.215
12/06/2018	26	3	Grazing	A	40.5	0	0.143	25	3	1	no	5.214
12/06/2018	27	1	Grazing	A	42.5	NA	0.429	25	3	1	no	5.569
12/06/2018	27	2	Grazing	A	42.5	NA	0.429	25	3	1	no	5.517
12/06/2018	27	3	Grazing	A	42.5	NA	0.429	25	3	1	no	5.203
12/06/2018	28	1	Grazing	B	40.5	250	0.071	25	3	4	no	6.821
12/06/2018	28	2	Grazing	B	40.5	250	0.071	25	3	4	no	8.605
12/06/2018	28	3	Grazing	B	40.5	250	0.071	25	3	4	no	7.682
12/06/2018	29	1	Grazing	A	48	0	0.357	25	3	1	no	4.337
12/06/2018	29	2	Grazing	A	48	0	0.357	25	3	1	no	4.454
12/06/2018	29	3	Grazing	A	48	0	0.357	25	3	1	no	4.785
12/06/2018	30	1	Grazing	B	39.5	150	0.089	25	3	4	no	5.368
12/06/2018	30	2	Grazing	B	39.5	150	0.089	25	3	4	no	7.006
12/06/2018	30	3	Grazing	B	39.5	150	0.089	25	3	4	no	6.666
12/06/2018	31	1	Grazing	A	41	0	0.429	25	3	1	no	7.636
12/06/2018	31	2	Grazing	A	41	0	0.429	25	3	1	no	8.294
12/06/2018	31	3	Grazing	A	41	0	0.429	25	3	1	no	8.236
12/06/2018	32	1	Grazing	A	37	0	0.214	25	3	1	no	5.036
12/06/2018	32	2	Grazing	A	37	0	0.214	25	3	1	no	4.976
12/06/2018	32	3	Grazing	A	37	0	0.214	25	3	1	no	5.912
12/06/2018	33	1	Grazing	B	38	0	-0.018	25	3	4	no	1.359
12/06/2018	33	2	Grazing	B	38	0	-0.018	25	3	4	no	1.939
12/06/2018	33	3	Grazing	B	38	0	-0.018	25	3	4	no	1.680
12/06/2018	34	1	Grazing	A	36	0	0.429	25	3	1	no	4.450
12/06/2018	34	2	Grazing	A	36	0	0.429	25	3	1	no	5.686
12/06/2018	34	3	Grazing	A	36	0	0.429	25	3	1	no	6.785
12/06/2018	35	1	Grazing	B	41.5	0	0.089	25	3	4	no	5.636
12/06/2018	35	2	Grazing	B	41.5	0	0.089	25	3	4	no	7.337
12/06/2018	35	3	Grazing	B	41.5	0	0.089	25	3	4	no	5.550
12/06/2018	36	1	Grazing	B	43	0	0.089	25	3	4	no	4.539
12/06/2018	36	2	Grazing	B	43	0	0.089	25	3	4	no	5.433
12/06/2018	36	3	Grazing	B	43	0	0.089	25	3	4	no	5.338
12/06/2018	37	1	Grazing	A	45.5	NA	0.286	25	3	1	no	2.196
12/06/2018	37	2	Grazing	A	45.5	NA	0.286	25	3	1	no	3.094
12/06/2018	37	3	Grazing	A	45.5	NA	0.286	25	3	1	no	3.185
12/06/2018	38	1	Grazing	A	32	0	0.286	25	3	1	no	5.828
12/06/2018	38	2	Grazing	A	32	0	0.286	25	3	1	no	6.748
12/06/2018	38	3	Grazing	A	32	0	0.286	25	3	1	no	8.052
12/06/2018	39	1	Grazing	A	37.5	0	0.214	25	3	1	no	4.197
12/06/2018	39	2	Grazing	A	37.5	0	0.214	25	3	1	no	4.884
12/06/2018	39	3	Grazing	A	37.5	0	0.214	25	3	1	no	5.891
12/06/2018	40	1	Grazing	B	41.5	NA	0.179	25	3	4	no	5.293
12/06/2018	40	2	Grazing	B	41.5	NA	0.179	25	3	4	no	5.906

12/06/2018	40	3	Grazing	B	41.5	NA	0.179	25	3	4	no	5.609
12/06/2018	41	1	Grazing	B	45	100	0.089	25	3	4	no	5.697
12/06/2018	41	2	Grazing	B	45	100	0.089	25	3	4	no	6.832
12/06/2018	41	3	Grazing	B	45	100	0.089	25	3	4	no	8.128
12/06/2018	42	1	Grazing	B	41	0	0.125	25	3	4	no	7.664
12/06/2018	42	2	Grazing	B	41	0	0.125	25	3	4	no	8.803
12/06/2018	42	3	Grazing	B	41	0	0.125	25	3	4	no	8.034
19/06/2018	19	1	Grazing	B	45	650	0.057	26	3	5	no	5.306
19/06/2018	19	2	Grazing	B	45	650	0.057	26	3	5	no	5.360
19/06/2018	19	3	Grazing	B	45	650	0.057	26	3	5	no	5.494
19/06/2018	21	1	Grazing	B	41.5	100	0.043	26	3	5	no	4.619
19/06/2018	21	2	Grazing	B	41.5	100	0.043	26	3	5	no	3.545
19/06/2018	21	3	Grazing	B	41.5	100	0.043	26	3	5	no	3.972
19/06/2018	23	1	Grazing	A	38.5	0	0.071	26	3	2	no	6.714
19/06/2018	23	2	Grazing	A	38.5	0	0.071	26	3	2	no	6.367
19/06/2018	23	3	Grazing	A	38.5	0	0.071	26	3	2	no	6.756
19/06/2018	24	1	Grazing	B	35.5	NA	0.057	26	3	5	no	4.719
19/06/2018	24	2	Grazing	B	35.5	NA	0.057	26	3	5	no	4.837
19/06/2018	24	3	Grazing	B	35.5	NA	0.057	26	3	5	no	6.192
19/06/2018	26	1	Grazing	A	39.5	0	0.000	26	3	2	no	6.970
19/06/2018	26	2	Grazing	A	39.5	0	0.000	26	3	2	no	7.182
19/06/2018	26	3	Grazing	A	39.5	0	0.000	26	3	2	no	6.112
19/06/2018	27	1	Grazing	A	43	0	0.250	26	3	2	no	5.710
19/06/2018	27	2	Grazing	A	43	0	0.250	26	3	2	no	4.924
19/06/2018	27	3	Grazing	A	43	0	0.250	26	3	2	no	4.673
19/06/2018	28	1	Grazing	B	41.5	1100	0.086	26	3	5	no	9.378
19/06/2018	28	2	Grazing	B	41.5	1100	0.086	26	3	5	no	9.335
19/06/2018	28	3	Grazing	B	41.5	1100	0.086	26	3	5	no	8.943
19/06/2018	29	1	Grazing	A	48.5	0	0.214	26	3	2	no	6.117
19/06/2018	29	2	Grazing	A	48.5	0	0.214	26	3	2	no	4.679
19/06/2018	29	3	Grazing	A	48.5	0	0.214	26	3	2	no	6.232
19/06/2018	30	1	Grazing	B	40	150	0.086	26	3	5	no	7.037
19/06/2018	30	2	Grazing	B	40	150	0.086	26	3	5	no	6.898
19/06/2018	30	3	Grazing	B	40	150	0.086	26	3	5	no	7.094
19/06/2018	31	1	Grazing	A	40	NA	0.143	26	3	2	no	6.495
19/06/2018	31	2	Grazing	A	40	NA	0.143	26	3	2	no	6.259
19/06/2018	31	3	Grazing	A	40	NA	0.143	26	3	2	no	6.224
19/06/2018	32	1	Grazing	A	37.5	0	0.143	26	3	2	no	5.935
19/06/2018	32	2	Grazing	A	37.5	0	0.143	26	3	2	no	4.889
19/06/2018	32	3	Grazing	A	37.5	0	0.143	26	3	2	no	4.633
19/06/2018	33	1	Grazing	B	39.5	50	0.029	26	3	5	no	2.092
19/06/2018	33	2	Grazing	B	39.5	50	0.029	26	3	5	no	2.619
19/06/2018	33	3	Grazing	B	39.5	50	0.029	26	3	5	no	2.578
19/06/2018	34	1	Grazing	A	34.5	0	0.107	26	3	2	no	7.673
19/06/2018	34	2	Grazing	A	34.5	0	0.107	26	3	2	no	7.747
19/06/2018	34	3	Grazing	A	34.5	0	0.107	26	3	2	no	6.209

19/06/2018	35	1	Grazing	B	41.5	200	0.071	26	3	5	no	7.109
19/06/2018	35	2	Grazing	B	41.5	200	0.071	26	3	5	no	6.614
19/06/2018	35	3	Grazing	B	41.5	200	0.071	26	3	5	no	7.482
19/06/2018	36	1	Grazing	B	42.5	0	0.057	26	3	5	no	7.604
19/06/2018	36	2	Grazing	B	42.5	0	0.057	26	3	5	no	6.858
19/06/2018	36	3	Grazing	B	42.5	0	0.057	26	3	5	no	7.805
19/06/2018	37	1	Grazing	A	43.5	0	0.000	26	3	2	no	2.159
19/06/2018	37	2	Grazing	A	43.5	0	0.000	26	3	2	no	2.085
19/06/2018	37	3	Grazing	A	43.5	0	0.000	26	3	2	no	2.294
19/06/2018	38	1	Grazing	A	31.5	0	0.107	26	3	2	no	5.411
19/06/2018	38	2	Grazing	A	31.5	0	0.107	26	3	2	no	4.460
19/06/2018	38	3	Grazing	A	31.5	0	0.107	26	3	2	no	4.707
19/06/2018	39	1	Grazing	A	37	NA	0.071	26	3	2	no	6.563
19/06/2018	39	2	Grazing	A	37	NA	0.071	26	3	2	no	5.261
19/06/2018	39	3	Grazing	A	37	NA	0.071	26	3	2	no	5.778
19/06/2018	40	1	Grazing	B	41.5	1500	0.143	26	3	5	no	6.997
19/06/2018	40	2	Grazing	B	41.5	1500	0.143	26	3	5	no	6.610
19/06/2018	40	3	Grazing	B	41.5	1500	0.143	26	3	5	no	7.017
19/06/2018	41	1	Grazing	B	45.5	1350	0.086	26	3	5	no	8.144
19/06/2018	41	2	Grazing	B	45.5	1350	0.086	26	3	5	no	7.503
19/06/2018	41	3	Grazing	B	45.5	1350	0.086	26	3	5	no	7.877
19/06/2018	42	1	Grazing	B	40.5	NA	0.086	26	3	5	no	6.030
19/06/2018	42	2	Grazing	B	40.5	NA	0.086	26	3	5	no	5.825
19/06/2018	42	3	Grazing	B	40.5	NA	0.086	26	3	5	no	6.349
26/06/2018	1	1	Grazing	C	40	0	0.000	27	3	1	yes	5.534
26/06/2018	1	2	Grazing	C	40	0	0.000	27	3	1	yes	4.883
26/06/2018	1	3	Grazing	C	40	0	0.000	27	3	1	yes	4.582
26/06/2018	2	1	Grazing	C	38	0	0.000	27	3	1	yes	4.447
26/06/2018	2	2	Grazing	C	38	0	0.000	27	3	1	yes	3.477
26/06/2018	2	3	Grazing	C	38	0	0.000	27	3	1	yes	3.749
26/06/2018	3	1	Grazing	C	34	0	0.000	27	3	1	yes	5.322
26/06/2018	3	2	Grazing	C	34	0	0.000	27	3	1	yes	4.560
26/06/2018	3	3	Grazing	C	34	0	0.000	27	3	1	yes	4.667
26/06/2018	4	1	Grazing	C	45	0	0.000	27	3	1	yes	5.311
26/06/2018	4	2	Grazing	C	45	0	0.000	27	3	1	yes	5.561
26/06/2018	4	3	Grazing	C	45	0	0.000	27	3	1	yes	5.264
26/06/2018	5	1	Grazing	C	37	0	0.000	27	3	1	yes	9.152
26/06/2018	5	2	Grazing	C	37	0	0.000	27	3	1	yes	7.684
26/06/2018	5	3	Grazing	C	37	0	0.000	27	3	1	yes	8.494
26/06/2018	6	1	Grazing	C	40	0	0.000	27	3	1	yes	8.680
26/06/2018	6	2	Grazing	C	40	0	0.000	27	3	1	yes	7.982
26/06/2018	6	3	Grazing	C	40	0	0.000	27	3	1	yes	8.023
26/06/2018	23	1	Grazing	A	40.5	0	0.143	27	3	3	no	5.626
26/06/2018	23	2	Grazing	A	40.5	0	0.143	27	3	3	no	4.443
26/06/2018	23	3	Grazing	A	40.5	0	0.143	27	3	3	no	5.011
26/06/2018	26	1	Grazing	A	41	NA	0.071	27	3	3	no	7.580

26/06/2018	26	2	Grazing	A	41	NA	0.071	27	3	3	no	7.128
26/06/2018	26	3	Grazing	A	41	NA	0.071	27	3	3	no	7.116
26/06/2018	27	1	Grazing	A	44.5	0	0.238	27	3	3	no	6.388
26/06/2018	27	2	Grazing	A	44.5	0	0.238	27	3	3	no	4.551
26/06/2018	27	3	Grazing	A	44.5	0	0.238	27	3	3	no	4.892
26/06/2018	29	1	Grazing	A	48.5	0	0.143	27	3	3	no	7.019
26/06/2018	29	2	Grazing	A	48.5	0	0.143	27	3	3	no	5.388
26/06/2018	29	3	Grazing	A	48.5	0	0.143	27	3	3	no	5.363
26/06/2018	31	1	Grazing	A	41.5	NA	0.167	27	3	3	no	4.257
26/06/2018	31	2	Grazing	A	41.5	NA	0.167	27	3	3	no	3.203
26/06/2018	31	3	Grazing	A	41.5	NA	0.167	27	3	3	no	3.409
26/06/2018	32	1	Grazing	A	39.5	0	0.190	27	3	3	no	6.803
26/06/2018	32	2	Grazing	A	39.5	0	0.190	27	3	3	no	6.454
26/06/2018	32	3	Grazing	A	39.5	0	0.190	27	3	3	no	7.168
26/06/2018	34	1	Grazing	A	35.5	0	0.119	27	3	3	no	8.478
26/06/2018	34	2	Grazing	A	35.5	0	0.119	27	3	3	no	7.335
26/06/2018	34	3	Grazing	A	35.5	0	0.119	27	3	3	no	7.131
26/06/2018	37	1	Grazing	A	44.5	0	0.048	27	3	3	no	4.831
26/06/2018	37	2	Grazing	A	44.5	0	0.048	27	3	3	no	4.862
26/06/2018	37	3	Grazing	A	44.5	0	0.048	27	3	3	no	5.247
26/06/2018	38	1	Grazing	A	32	50	0.095	27	3	3	no	4.672
26/06/2018	38	2	Grazing	A	32	50	0.095	27	3	3	no	3.937
26/06/2018	38	3	Grazing	A	32	50	0.095	27	3	3	no	3.977
26/06/2018	39	1	Grazing	A	38.5	0	0.119	27	3	3	no	5.191
26/06/2018	39	2	Grazing	A	38.5	0	0.119	27	3	3	no	4.046
26/06/2018	39	3	Grazing	A	38.5	0	0.119	27	3	3	no	4.667
03/07/2018	1	1	Grazing	C	41.5	0	0.214	28	3	1	yes	5.380
03/07/2018	1	2	Grazing	C	41.5	0	0.214	28	3	1	yes	5.421
03/07/2018	1	3	Grazing	C	41.5	0	0.214	28	3	1	yes	5.440
03/07/2018	2	1	Grazing	C	39.5	0	0.214	28	3	1	yes	4.544
03/07/2018	2	2	Grazing	C	39.5	0	0.214	28	3	1	yes	4.086
03/07/2018	2	3	Grazing	C	39.5	0	0.214	28	3	1	yes	4.218
03/07/2018	3	1	Grazing	C	36.5	0	0.357	28	3	1	yes	4.163
03/07/2018	3	2	Grazing	C	36.5	0	0.357	28	3	1	yes	5.208
03/07/2018	3	3	Grazing	C	36.5	0	0.357	28	3	1	yes	4.644
03/07/2018	4	1	Grazing	C	46.5	0	0.214	28	3	1	yes	5.131
03/07/2018	4	2	Grazing	C	46.5	0	0.214	28	3	1	yes	5.651
03/07/2018	4	3	Grazing	C	46.5	0	0.214	28	3	1	yes	5.628
03/07/2018	5	1	Grazing	C	40	0	0.429	28	3	1	yes	7.590
03/07/2018	5	2	Grazing	C	40	0	0.429	28	3	1	yes	8.489
03/07/2018	5	3	Grazing	C	40	0	0.429	28	3	1	yes	9.197
03/07/2018	6	1	Grazing	C	41.5	0	0.214	28	3	1	yes	7.372
03/07/2018	6	2	Grazing	C	41.5	0	0.214	28	3	1	yes	8.501
03/07/2018	6	3	Grazing	C	41.5	0	0.214	28	3	1	yes	7.944
03/07/2018	19	1	Grazing	B	42	0	NA	28	4	1	no	8.534
03/07/2018	19	2	Grazing	B	42	0	NA	28	4	1	no	8.653

03/07/2018	19	3	Grazing	B	42	0	NA	28	4	1	no	8.636
03/07/2018	21	1	Grazing	B	43.5	0	0.143	28	4	1	no	3.701
03/07/2018	21	2	Grazing	B	43.5	0	0.143	28	4	1	no	4.329
03/07/2018	21	3	Grazing	B	43.5	0	0.143	28	4	1	no	4.288
03/07/2018	23	1	Grazing	A	42	0	0.161	28	4	4	no	4.752
03/07/2018	23	2	Grazing	A	42	0	0.161	28	4	4	no	5.855
03/07/2018	23	3	Grazing	A	42	0	0.161	28	4	4	no	5.436
03/07/2018	24	1	Grazing	B	38	0	0.214	28	4	1	no	5.277
03/07/2018	24	2	Grazing	B	38	0	0.214	28	4	1	no	5.717
03/07/2018	24	3	Grazing	B	38	0	0.214	28	4	1	no	5.472
03/07/2018	26	1	Grazing	A	41.5	NA	0.071	28	4	4	no	6.673
03/07/2018	26	2	Grazing	A	41.5	NA	0.071	28	4	4	no	7.009
03/07/2018	26	3	Grazing	A	41.5	NA	0.071	28	4	4	no	7.159
03/07/2018	27	1	Grazing	A	46	0	0.232	28	4	4	no	4.356
03/07/2018	27	2	Grazing	A	46	0	0.232	28	4	4	no	5.181
03/07/2018	27	3	Grazing	A	46	0	0.232	28	4	4	no	5.203
03/07/2018	28	1	Grazing	B	44	0	0.143	28	4	1	no	7.773
03/07/2018	28	2	Grazing	B	44	0	0.143	28	4	1	no	8.094
03/07/2018	28	3	Grazing	B	44	0	0.143	28	4	1	no	8.081
03/07/2018	29	1	Grazing	A	49	0	0.125	28	4	4	no	6.323
03/07/2018	29	2	Grazing	A	49	0	0.125	28	4	4	no	6.921
03/07/2018	29	3	Grazing	A	49	0	0.125	28	4	4	no	6.007
03/07/2018	30	1	Grazing	B	42.5	0	0.643	28	4	1	no	7.354
03/07/2018	30	2	Grazing	B	42.5	0	0.643	28	4	1	no	8.212
03/07/2018	30	3	Grazing	B	42.5	0	0.643	28	4	1	no	7.597
03/07/2018	31	1	Grazing	A	42	NA	0.143	28	4	4	no	4.856
03/07/2018	31	2	Grazing	A	42	NA	0.143	28	4	4	no	5.868
03/07/2018	31	3	Grazing	A	42	NA	0.143	28	4	4	no	5.224
03/07/2018	32	1	Grazing	A	39.5	NA	0.143	28	4	4	no	6.437
03/07/2018	32	2	Grazing	A	39.5	NA	0.143	28	4	4	no	7.596
03/07/2018	32	3	Grazing	A	39.5	NA	0.143	28	4	4	no	6.837
03/07/2018	33	1	Grazing	B	41	0	0.214	28	4	1	no	2.813
03/07/2018	33	2	Grazing	B	41	0	0.214	28	4	1	no	3.367
03/07/2018	33	3	Grazing	B	41	0	0.214	28	4	1	no	3.169
03/07/2018	34	1	Grazing	A	36.5	0	0.125	28	4	4	no	6.039
03/07/2018	34	2	Grazing	A	36.5	0	0.125	28	4	4	no	6.757
03/07/2018	34	3	Grazing	A	36.5	0	0.125	28	4	4	no	6.435
03/07/2018	35	1	Grazing	B	49	0	0.929	28	4	1	no	6.744
03/07/2018	35	2	Grazing	B	49	0	0.929	28	4	1	no	7.632
03/07/2018	35	3	Grazing	B	49	0	0.929	28	4	1	no	7.290
03/07/2018	36	1	Grazing	B	45.5	0	0.214	28	4	1	no	5.538
03/07/2018	36	2	Grazing	B	45.5	0	0.214	28	4	1	no	7.194
03/07/2018	36	3	Grazing	B	45.5	0	0.214	28	4	1	no	7.011
03/07/2018	37	1	Grazing	A	44.5	0	0.036	28	4	4	no	2.490
03/07/2018	37	2	Grazing	A	44.5	0	0.036	28	4	4	no	3.363
03/07/2018	37	3	Grazing	A	44.5	0	0.036	28	4	4	no	2.941

03/07/2018	38	1	Grazing	A	33	0	0.107	28	4	4	no	4.199
03/07/2018	38	2	Grazing	A	33	0	0.107	28	4	4	no	5.874
03/07/2018	38	3	Grazing	A	33	0	0.107	28	4	4	no	5.319
03/07/2018	39	1	Grazing	A	39	0	0.107	28	4	4	no	5.315
03/07/2018	39	2	Grazing	A	39	0	0.107	28	4	4	no	6.137
03/07/2018	39	3	Grazing	A	39	0	0.107	28	4	4	no	5.807
03/07/2018	40	1	Grazing	B	45.5	0	0.500	28	4	1	no	7.575
03/07/2018	40	2	Grazing	B	45.5	0	0.500	28	4	1	no	7.725
03/07/2018	40	3	Grazing	B	45.5	0	0.500	28	4	1	no	7.665
03/07/2018	41	1	Grazing	B	48.5	0	0.000	28	4	1	no	6.663
03/07/2018	41	2	Grazing	B	48.5	0	0.000	28	4	1	no	7.123
03/07/2018	41	3	Grazing	B	48.5	0	0.000	28	4	1	no	6.789
03/07/2018	42	1	Grazing	B	44.5	0	0.429	28	4	1	no	4.858
03/07/2018	42	2	Grazing	B	44.5	0	0.429	28	4	1	no	6.036
03/07/2018	42	3	Grazing	B	44.5	0	0.429	28	4	1	no	5.550
10/07/2018	1	1	Grazing	C	40.5	0	-0.143	29	4	1	yes	5.347
10/07/2018	1	2	Grazing	C	40.5	0	-0.143	29	4	1	yes	4.895
10/07/2018	1	3	Grazing	C	40.5	0	-0.143	29	4	1	yes	6.584
10/07/2018	2	1	Grazing	C	40	0	0.071	29	4	1	yes	4.468
10/07/2018	2	2	Grazing	C	40	0	0.071	29	4	1	yes	4.957
10/07/2018	2	3	Grazing	C	40	0	0.071	29	4	1	yes	4.238
10/07/2018	3	1	Grazing	C	36	0	-0.071	29	4	1	yes	6.384
10/07/2018	3	2	Grazing	C	36	0	-0.071	29	4	1	yes	5.415
10/07/2018	3	3	Grazing	C	36	0	-0.071	29	4	1	yes	5.857
10/07/2018	4	1	Grazing	C	45.5	0	-0.143	29	4	1	yes	8.298
10/07/2018	4	2	Grazing	C	45.5	0	-0.143	29	4	1	yes	7.156
10/07/2018	4	3	Grazing	C	45.5	0	-0.143	29	4	1	yes	8.438
10/07/2018	5	1	Grazing	C	40.5	0	0.071	29	4	1	yes	9.508
10/07/2018	5	2	Grazing	C	40.5	0	0.071	29	4	1	yes	9.370
10/07/2018	5	3	Grazing	C	40.5	0	0.071	29	4	1	yes	10.079
10/07/2018	6	1	Grazing	C	41.5	NA	0.000	29	4	1	yes	5.652
10/07/2018	6	2	Grazing	C	41.5	NA	0.000	29	4	1	yes	5.520
10/07/2018	6	3	Grazing	C	41.5	NA	0.000	29	4	1	yes	5.553
10/07/2018	19	1	Grazing	B	48	0	0.071	29	4	2	no	9.271
10/07/2018	19	2	Grazing	B	48	0	0.071	29	4	2	no	8.053
10/07/2018	19	3	Grazing	B	48	0	0.071	29	4	2	no	9.528
10/07/2018	21	1	Grazing	B	41.5	0	-0.071	29	4	2	no	4.335
10/07/2018	21	2	Grazing	B	41.5	0	-0.071	29	4	2	no	3.779
10/07/2018	21	3	Grazing	B	41.5	0	-0.071	29	4	2	no	4.743
10/07/2018	23	1	Grazing	A	40.5	0	0.086	29	4	5	no	7.018
10/07/2018	23	2	Grazing	A	40.5	0	0.086	29	4	5	no	5.550
10/07/2018	23	3	Grazing	A	40.5	0	0.086	29	4	5	no	6.704
10/07/2018	24	1	Grazing	B	37.5	0	0.071	29	4	2	no	6.771
10/07/2018	24	2	Grazing	B	37.5	0	0.071	29	4	2	no	6.137
10/07/2018	24	3	Grazing	B	37.5	0	0.071	29	4	2	no	6.278
10/07/2018	26	1	Grazing	A	41	0	0.043	29	4	5	no	8.974

10/07/2018	26	2	Grazing	A	41	0	0.043	29	4	5	no	7.373
10/07/2018	26	3	Grazing	A	41	0	0.043	29	4	5	no	8.445
10/07/2018	27	1	Grazing	A	45.5	0	0.171	29	4	5	no	5.656
10/07/2018	27	2	Grazing	A	45.5	0	0.171	29	4	5	no	4.974
10/07/2018	27	3	Grazing	A	45.5	0	0.171	29	4	5	no	5.869
10/07/2018	28	1	Grazing	B	45.5	0	0.179	29	4	2	no	8.656
10/07/2018	28	2	Grazing	B	45.5	0	0.179	29	4	2	no	8.473
10/07/2018	28	3	Grazing	B	45.5	0	0.179	29	4	2	no	8.409
10/07/2018	29	1	Grazing	A	49	50	0.100	29	4	5	no	5.289
10/07/2018	29	2	Grazing	A	49	50	0.100	29	4	5	no	5.373
10/07/2018	29	3	Grazing	A	49	50	0.100	29	4	5	no	6.488
10/07/2018	30	1	Grazing	B	41.5	NA	0.250	29	4	2	no	8.345
10/07/2018	30	2	Grazing	B	41.5	NA	0.250	29	4	2	no	7.998
10/07/2018	30	3	Grazing	B	41.5	NA	0.250	29	4	2	no	7.814
10/07/2018	31	1	Grazing	A	42	NA	0.114	29	4	5	no	7.105
10/07/2018	31	2	Grazing	A	42	NA	0.114	29	4	5	no	6.654
10/07/2018	31	3	Grazing	A	42	NA	0.114	29	4	5	no	7.596
10/07/2018	32	1	Grazing	A	39.5	0	0.114	29	4	5	no	8.555
10/07/2018	32	2	Grazing	A	39.5	0	0.114	29	4	5	no	6.124
10/07/2018	32	3	Grazing	A	39.5	0	0.114	29	4	5	no	7.744
10/07/2018	33	1	Grazing	B	42	0	0.179	29	4	2	no	2.574
10/07/2018	33	2	Grazing	B	42	0	0.179	29	4	2	no	2.700
10/07/2018	33	3	Grazing	B	42	0	0.179	29	4	2	no	3.235
10/07/2018	34	1	Grazing	A	36.5	NA	0.100	29	4	5	no	8.174
10/07/2018	34	2	Grazing	A	36.5	NA	0.100	29	4	5	no	6.842
10/07/2018	34	3	Grazing	A	36.5	NA	0.100	29	4	5	no	8.907
10/07/2018	35	1	Grazing	B	44	0	0.107	29	4	2	no	7.187
10/07/2018	35	2	Grazing	B	44	0	0.107	29	4	2	no	8.328
10/07/2018	35	3	Grazing	B	44	0	0.107	29	4	2	no	7.855
10/07/2018	36	1	Grazing	B	45	0	0.071	29	4	2	no	9.377
10/07/2018	36	2	Grazing	B	45	0	0.071	29	4	2	no	6.680
10/07/2018	36	3	Grazing	B	45	0	0.071	29	4	2	no	7.749
10/07/2018	37	1	Grazing	A	46	0	0.071	29	4	5	no	6.479
10/07/2018	37	2	Grazing	A	46	0	0.071	29	4	5	no	4.919
10/07/2018	37	3	Grazing	A	46	0	0.071	29	4	5	no	5.917
10/07/2018	38	1	Grazing	A	32	0	0.057	29	4	5	no	5.981
10/07/2018	38	2	Grazing	A	32	0	0.057	29	4	5	no	5.474
10/07/2018	38	3	Grazing	A	32	0	0.057	29	4	5	no	6.260
10/07/2018	39	1	Grazing	A	38.5	50	0.071	29	4	5	no	7.642
10/07/2018	39	2	Grazing	A	38.5	50	0.071	29	4	5	no	6.530
10/07/2018	39	3	Grazing	A	38.5	50	0.071	29	4	5	no	6.959
10/07/2018	40	1	Grazing	B	44	0	0.143	29	4	2	no	7.722
10/07/2018	40	2	Grazing	B	44	0	0.143	29	4	2	no	6.124
10/07/2018	40	3	Grazing	B	44	0	0.143	29	4	2	no	7.355
10/07/2018	41	1	Grazing	B	48.5	0	0.000	29	4	2	no	4.367
10/07/2018	41	2	Grazing	B	48.5	0	0.000	29	4	2	no	3.810

10/07/2018	41	3	Grazing	B	48.5	0	0.000	29	4	2	no	4.670
10/07/2018	42	1	Grazing	B	43	0	0.107	29	4	2	no	9.054
10/07/2018	42	2	Grazing	B	43	0	0.107	29	4	2	no	9.143
10/07/2018	42	3	Grazing	B	43	0	0.107	29	4	2	no	9.721
17/07/2018	1	1	Grazing	C	42	0	0.214	30	4	1	yes	7.166
17/07/2018	1	2	Grazing	C	42	0	0.214	30	4	1	yes	6.389
17/07/2018	2	1	Grazing	C	41.5	0	0.214	30	4	1	yes	5.725
17/07/2018	2	2	Grazing	C	41.5	0	0.214	30	4	1	yes	4.664
17/07/2018	3	1	Grazing	C	39	0	0.429	30	4	1	yes	5.770
17/07/2018	3	2	Grazing	C	39	0	0.429	30	4	1	yes	5.303
17/07/2018	4	1	Grazing	C	48.5	0	0.429	30	4	1	yes	6.090
17/07/2018	4	2	Grazing	C	48.5	0	0.429	30	4	1	yes	4.938
17/07/2018	5	1	Grazing	C	42	0	0.214	30	4	1	yes	10.024
17/07/2018	5	2	Grazing	C	42	0	0.214	30	4	1	yes	9.414
17/07/2018	6	1	Grazing	C	42.5	NA	0.143	30	4	1	yes	6.742
17/07/2018	6	2	Grazing	C	42.5	NA	0.143	30	4	1	yes	6.176
17/07/2018	19	1	Grazing	B	50.5	0	0.167	30	4	3	no	8.852
17/07/2018	19	2	Grazing	B	50.5	0	0.167	30	4	3	no	7.672
17/07/2018	21	1	Grazing	B	44	0	0.071	30	4	3	no	4.902
17/07/2018	21	2	Grazing	B	44	0	0.071	30	4	3	no	4.698
17/07/2018	24	1	Grazing	B	39	0	0.119	30	4	3	no	5.318
17/07/2018	24	2	Grazing	B	39	0	0.119	30	4	3	no	4.702
17/07/2018	28	1	Grazing	B	45	0	0.095	30	4	3	no	9.829
17/07/2018	28	2	Grazing	B	45	0	0.095	30	4	3	no	9.756
17/07/2018	30	1	Grazing	B	42.5	0	0.214	30	4	3	no	9.325
17/07/2018	30	2	Grazing	B	42.5	0	0.214	30	4	3	no	8.231
17/07/2018	33	1	Grazing	B	41.5	0	0.095	30	4	3	no	4.058
17/07/2018	33	2	Grazing	B	41.5	0	0.095	30	4	3	no	3.655
17/07/2018	35	1	Grazing	B	44.5	0	0.095	30	4	3	no	7.552
17/07/2018	35	2	Grazing	B	44.5	0	0.095	30	4	3	no	7.292
17/07/2018	36	1	Grazing	B	45	0	0.048	30	4	3	no	6.478
17/07/2018	36	2	Grazing	B	45	0	0.048	30	4	3	no	5.520
17/07/2018	40	1	Grazing	B	43.5	0	0.071	30	4	3	no	6.684
17/07/2018	40	2	Grazing	B	43.5	0	0.071	30	4	3	no	5.536
17/07/2018	41	1	Grazing	B	49	0	0.024	30	4	3	no	8.501
17/07/2018	41	2	Grazing	B	49	0	0.024	30	4	3	no	7.651
17/07/2018	42	1	Grazing	B	44	0	0.119	30	4	3	no	7.055
17/07/2018	42	2	Grazing	B	44	0	0.119	30	4	3	no	5.825
31/07/2018	1	1	Grazing	C	42.5	0	0.214	32	4	1	yes	6.262
31/07/2018	1	2	Grazing	C	42.5	0	0.214	32	4	1	yes	5.846
31/07/2018	1	3	Grazing	C	42.5	0	0.214	32	4	1	yes	7.476
31/07/2018	2	1	Grazing	C	41.5	0	0.143	32	4	1	yes	4.418
31/07/2018	2	2	Grazing	C	41.5	0	0.143	32	4	1	yes	3.632
31/07/2018	2	3	Grazing	C	41.5	0	0.143	32	4	1	yes	5.869
31/07/2018	3	1	Grazing	C	40	0	0.429	32	4	1	yes	5.444
31/07/2018	3	2	Grazing	C	40	0	0.429	32	4	1	yes	4.805

31/07/2018	3	3	Grazing	C	40	0	0.429	32	4	1	yes	7.020
31/07/2018	4	1	Grazing	C	47.5	0	0.214	32	4	1	yes	5.929
31/07/2018	4	2	Grazing	C	47.5	0	0.214	32	4	1	yes	5.060
31/07/2018	4	3	Grazing	C	47.5	0	0.214	32	4	1	yes	6.372
31/07/2018	5	1	Grazing	C	43	0	0.071	32	4	1	yes	9.207
31/07/2018	5	2	Grazing	C	43	0	0.071	32	4	1	yes	9.021
31/07/2018	5	3	Grazing	C	43	0	0.071	32	4	1	yes	7.561
31/07/2018	6	1	Grazing	C	44	0	0.214	32	4	1	yes	8.442
31/07/2018	6	2	Grazing	C	44	0	0.214	32	4	1	yes	8.449
31/07/2018	6	3	Grazing	C	44	0	0.214	32	4	1	yes	9.948
31/07/2018	19	1	Grazing	B	49.5	0	0.071	32	4	5	no	9.791
31/07/2018	19	2	Grazing	B	49.5	0	0.071	32	4	5	no	8.845
31/07/2018	19	3	Grazing	B	49.5	0	0.071	32	4	5	no	9.939
31/07/2018	21	1	Grazing	B	44	0	0.043	32	4	5	no	4.207
31/07/2018	21	2	Grazing	B	44	0	0.043	32	4	5	no	4.014
31/07/2018	21	3	Grazing	B	44	0	0.043	32	4	5	no	5.372
31/07/2018	23	1	Grazing	A	40.5	0	-0.107	32	4	2	no	4.620
31/07/2018	23	2	Grazing	A	40.5	0	-0.107	32	4	2	no	5.065
31/07/2018	23	3	Grazing	A	40.5	0	-0.107	32	4	2	no	6.256
31/07/2018	24	1	Grazing	B	38.5	0	0.057	32	4	5	no	7.554
31/07/2018	24	2	Grazing	B	38.5	0	0.057	32	4	5	no	6.813
31/07/2018	24	3	Grazing	B	38.5	0	0.057	32	4	5	no	7.989
31/07/2018	26	1	Grazing	A	41	0	-0.107	32	4	2	no	6.318
31/07/2018	26	2	Grazing	A	41	0	-0.107	32	4	2	no	5.118
31/07/2018	26	3	Grazing	A	41	0	-0.107	32	4	2	no	7.113
31/07/2018	27	1	Grazing	A	46	0	-0.036	32	4	2	no	8.299
31/07/2018	27	2	Grazing	A	46	0	-0.036	32	4	2	no	6.333
31/07/2018	27	3	Grazing	A	46	0	-0.036	32	4	2	no	8.025
31/07/2018	28	1	Grazing	B	46	50	0.086	32	4	5	no	8.895
31/07/2018	28	2	Grazing	B	46	50	0.086	32	4	5	no	7.528
31/07/2018	28	3	Grazing	B	46	50	0.086	32	4	5	no	9.621
31/07/2018	29	1	Grazing	A	48.5	0	-0.143	32	4	2	no	4.242
31/07/2018	29	2	Grazing	A	48.5	0	-0.143	32	4	2	no	4.339
31/07/2018	29	3	Grazing	A	48.5	0	-0.143	32	4	2	no	5.696
31/07/2018	30	1	Grazing	B	41.5	0	0.100	32	4	5	no	8.157
31/07/2018	30	2	Grazing	B	41.5	0	0.100	32	4	5	no	7.098
31/07/2018	30	3	Grazing	B	41.5	0	0.100	32	4	5	no	8.888
31/07/2018	31	1	Grazing	A	43	0	0.000	32	4	2	no	7.254
31/07/2018	31	2	Grazing	A	43	0	0.000	32	4	2	no	6.775
31/07/2018	31	3	Grazing	A	43	0	0.000	32	4	2	no	8.247
31/07/2018	32	1	Grazing	A	41	0	0.143	32	4	2	no	6.189
31/07/2018	32	2	Grazing	A	41	0	0.143	32	4	2	no	5.208
31/07/2018	32	3	Grazing	A	41	0	0.143	32	4	2	no	7.923
31/07/2018	33	1	Grazing	B	42	0	0.071	32	4	5	no	4.126
31/07/2018	33	2	Grazing	B	42	0	0.071	32	4	5	no	3.362
31/07/2018	33	3	Grazing	B	42	0	0.071	32	4	5	no	4.864

31/07/2018	34	1	Grazing	A	37	0	-0.036	32	4	2	no	7.302
31/07/2018	34	2	Grazing	A	37	0	-0.036	32	4	2	no	6.346
31/07/2018	34	3	Grazing	A	37	0	-0.036	32	4	2	no	8.574
31/07/2018	35	1	Grazing	B	44.5	50	0.057	32	4	5	no	6.832
31/07/2018	35	2	Grazing	B	44.5	50	0.057	32	4	5	no	NA
31/07/2018	35	3	Grazing	B	44.5	50	0.057	32	4	5	no	NA
31/07/2018	36	1	Grazing	B	45	50	0.029	32	4	5	no	6.470
31/07/2018	36	2	Grazing	B	45	50	0.029	32	4	5	no	6.408
31/07/2018	36	3	Grazing	B	45	50	0.029	32	4	5	no	7.961
31/07/2018	37	1	Grazing	A	44.5	0	-0.071	32	4	2	no	2.861
31/07/2018	37	2	Grazing	A	44.5	0	-0.071	32	4	2	no	2.991
31/07/2018	37	3	Grazing	A	44.5	0	-0.071	32	4	2	no	4.923
31/07/2018	38	1	Grazing	A	33	0	0.036	32	4	2	no	4.934
31/07/2018	38	2	Grazing	A	33	0	0.036	32	4	2	no	4.321
31/07/2018	38	3	Grazing	A	33	0	0.036	32	4	2	no	6.338
31/07/2018	39	1	Grazing	A	40.5	0	0.500	32	4	2	no	7.069
31/07/2018	39	2	Grazing	A	40.5	0	0.500	32	4	2	no	6.011
31/07/2018	39	3	Grazing	A	40.5	0	0.500	32	4	2	no	7.884
31/07/2018	40	1	Grazing	B	43.5	0	0.043	32	4	5	no	5.407
31/07/2018	40	2	Grazing	B	43.5	0	0.043	32	4	5	no	4.612
31/07/2018	40	3	Grazing	B	43.5	0	0.043	32	4	5	no	6.106
31/07/2018	41	1	Grazing	B	49	0	0.014	32	4	5	no	7.649
31/07/2018	41	2	Grazing	B	49	0	0.014	32	4	5	no	6.950
31/07/2018	41	3	Grazing	B	49	0	0.014	32	4	5	no	8.378
31/07/2018	42	1	Grazing	B	44.5	0	0.086	32	4	5	no	5.594
31/07/2018	42	2	Grazing	B	44.5	0	0.086	32	4	5	no	5.018
31/07/2018	42	3	Grazing	B	44.5	0	0.086	32	4	5	no	6.305
09/01/2018	19	1	Resting	B	39.5	0	0.405	3	1	3	yes	0.755
09/01/2018	19	2	Resting	B	39.5	0	0.405	3	1	3	yes	0.885
09/01/2018	19	3	Resting	B	39.5	0	0.405	3	1	3	yes	0.772
09/01/2018	21	1	Resting	B	35	150	0.238	3	1	3	yes	1.099
09/01/2018	21	2	Resting	B	35	150	0.238	3	1	3	yes	1.258
09/01/2018	21	3	Resting	B	35	150	0.238	3	1	3	yes	0.997
09/01/2018	24	1	Resting	B	32	150	0.190	3	1	3	yes	0.799
09/01/2018	24	2	Resting	B	32	150	0.190	3	1	3	yes	0.794
09/01/2018	24	3	Resting	B	32	150	0.190	3	1	3	yes	0.747
09/01/2018	28	1	Resting	B	32	300	-0.071	3	1	3	yes	0.345
09/01/2018	28	2	Resting	B	32	300	-0.071	3	1	3	yes	0.395
09/01/2018	28	3	Resting	B	32	300	-0.071	3	1	3	yes	0.485
09/01/2018	30	1	Resting	B	34.5	0	0.119	3	1	3	yes	0.509
09/01/2018	30	2	Resting	B	34.5	0	0.119	3	1	3	yes	0.593
09/01/2018	30	3	Resting	B	34.5	0	0.119	3	1	3	yes	0.545
09/01/2018	33	1	Resting	B	31	0	0.500	3	1	3	yes	1.058
09/01/2018	33	2	Resting	B	31	0	0.500	3	1	3	yes	1.058
09/01/2018	33	3	Resting	B	31	0	0.500	3	1	3	yes	1.119
09/01/2018	35	1	Resting	B	36	0	0.262	3	1	3	yes	0.596

09/01/2018	35	2	Resting	B	36	0	0.262	3	1	3	yes	0.855
09/01/2018	35	3	Resting	B	36	0	0.262	3	1	3	yes	0.870
09/01/2018	36	1	Resting	B	36.5	0	0.214	3	1	3	yes	0.555
09/01/2018	36	2	Resting	B	36.5	0	0.214	3	1	3	yes	0.579
09/01/2018	36	3	Resting	B	36.5	0	0.214	3	1	3	yes	0.629
09/01/2018	40	1	Resting	B	32.5	0	0.095	3	1	3	yes	0.574
09/01/2018	40	2	Resting	B	32.5	0	0.095	3	1	3	yes	0.656
09/01/2018	40	3	Resting	B	32.5	0	0.095	3	1	3	yes	0.657
09/01/2018	41	1	Resting	B	37	0	0.095	3	1	3	yes	1.015
09/01/2018	41	2	Resting	B	37	0	0.095	3	1	3	yes	1.154
09/01/2018	41	3	Resting	B	37	0	0.095	3	1	3	yes	1.551
09/01/2018	42	1	Resting	B	32.5	0	0.310	3	1	3	yes	0.733
09/01/2018	42	2	Resting	B	32.5	0	0.310	3	1	3	yes	0.775
09/01/2018	42	3	Resting	B	32.5	0	0.310	3	1	3	yes	0.786
16/01/2018	19	1	Resting	B	31	200	0.000	4	1	4	yes	0.942
16/01/2018	19	2	Resting	B	31	200	0.000	4	1	4	yes	0.941
16/01/2018	19	3	Resting	B	31	200	0.000	4	1	4	yes	1.030
16/01/2018	21	1	Resting	B	28	0	-0.071	4	1	4	yes	1.388
16/01/2018	21	2	Resting	B	28	0	-0.071	4	1	4	yes	1.259
16/01/2018	21	3	Resting	B	28	0	-0.071	4	1	4	yes	1.268
16/01/2018	23	1	Resting	A	29.5	0	-0.214	4	1	1	yes	1.153
16/01/2018	23	2	Resting	A	29.5	0	-0.214	4	1	1	yes	1.013
16/01/2018	23	3	Resting	A	29.5	0	-0.214	4	1	1	yes	0.653
16/01/2018	24	1	Resting	B	27.5	0	-0.018	4	1	4	yes	0.707
16/01/2018	24	2	Resting	B	27.5	0	-0.018	4	1	4	yes	0.588
16/01/2018	24	3	Resting	B	27.5	0	-0.018	4	1	4	yes	0.669
16/01/2018	25	1	Resting	A	30	0	-0.214	4	1	1	yes	1.057
16/01/2018	25	2	Resting	A	30	0	-0.214	4	1	1	yes	1.181
16/01/2018	25	3	Resting	A	30	0	-0.214	4	1	1	yes	1.238
16/01/2018	26	1	Resting	A	30	0	NA	4	1	1	yes	0.816
16/01/2018	26	2	Resting	A	30	0	NA	4	1	1	yes	0.756
16/01/2018	26	3	Resting	A	30	0	NA	4	1	1	yes	0.944
16/01/2018	27	1	Resting	A	30	0	NA	4	1	1	yes	0.730
16/01/2018	27	2	Resting	A	30	0	NA	4	1	1	yes	0.753
16/01/2018	27	3	Resting	A	30	0	NA	4	1	1	yes	1.321
16/01/2018	28	1	Resting	B	31.5	0	-0.071	4	1	4	yes	0.844
16/01/2018	28	2	Resting	B	31.5	0	-0.071	4	1	4	yes	0.825
16/01/2018	28	3	Resting	B	31.5	0	-0.071	4	1	4	yes	1.771
16/01/2018	30	1	Resting	B	30	0	-0.071	4	1	4	yes	0.636
16/01/2018	30	2	Resting	B	30	0	-0.071	4	1	4	yes	0.695
16/01/2018	30	3	Resting	B	30	0	-0.071	4	1	4	yes	0.742
16/01/2018	31	1	Resting	A	29	0	-0.643	4	1	1	yes	0.734
16/01/2018	31	2	Resting	A	29	0	-0.643	4	1	1	yes	0.880
16/01/2018	31	3	Resting	A	29	0	-0.643	4	1	1	yes	0.942
16/01/2018	32	1	Resting	A	30	0	-1.000	4	1	1	yes	0.533
16/01/2018	32	2	Resting	A	30	0	-1.000	4	1	1	yes	0.798

16/01/2018	32	3	Resting	A	30	0	-1.000	4	1	1	yes	0.727
16/01/2018	33	1	Resting	B	27.5	200	0.250	4	1	4	yes	0.834
16/01/2018	33	2	Resting	B	27.5	200	0.250	4	1	4	yes	0.852
16/01/2018	33	3	Resting	B	27.5	200	0.250	4	1	4	yes	0.980
16/01/2018	34	1	Resting	A	25	0	NA	4	1	1	yes	1.125
16/01/2018	34	2	Resting	A	25	0	NA	4	1	1	yes	0.851
16/01/2018	34	3	Resting	A	25	0	NA	4	1	1	yes	1.320
16/01/2018	35	1	Resting	B	31	0	-0.232	4	1	4	yes	0.962
16/01/2018	35	2	Resting	B	31	0	-0.232	4	1	4	yes	1.088
16/01/2018	35	3	Resting	B	31	0	-0.232	4	1	4	yes	0.833
16/01/2018	36	1	Resting	B	32	0	0.000	4	1	4	yes	0.920
16/01/2018	36	2	Resting	B	32	0	0.000	4	1	4	yes	1.080
16/01/2018	36	3	Resting	B	32	0	0.000	4	1	4	yes	1.294
16/01/2018	37	1	Resting	A	30.5	0	-0.714	4	1	1	yes	0.955
16/01/2018	37	2	Resting	A	30.5	0	-0.714	4	1	1	yes	0.965
16/01/2018	37	3	Resting	A	30.5	0	-0.714	4	1	1	yes	0.890
16/01/2018	38	1	Resting	A	23.5	0	0.071	4	1	1	yes	1.207
16/01/2018	38	2	Resting	A	23.5	0	0.071	4	1	1	yes	0.987
16/01/2018	38	3	Resting	A	23.5	0	0.071	4	1	1	yes	0.936
16/01/2018	39	1	Resting	A	29	0	-0.714	4	1	1	yes	0.986
16/01/2018	39	2	Resting	A	29	0	-0.714	4	1	1	yes	1.043
16/01/2018	39	3	Resting	A	29	0	-0.714	4	1	1	yes	1.057
16/01/2018	40	1	Resting	B	28.5	0	-0.071	4	1	4	yes	1.122
16/01/2018	40	2	Resting	B	28.5	0	-0.071	4	1	4	yes	1.175
16/01/2018	40	3	Resting	B	28.5	0	-0.071	4	1	4	yes	0.898
16/01/2018	41	1	Resting	B	31	0	-0.143	4	1	4	yes	1.146
16/01/2018	41	2	Resting	B	31	0	-0.143	4	1	4	yes	1.190
16/01/2018	41	3	Resting	B	31	0	-0.143	4	1	4	yes	1.929
16/01/2018	42	1	Resting	B	27.5	0	0.054	4	1	4	yes	1.312
16/01/2018	42	2	Resting	B	27.5	0	0.054	4	1	4	yes	1.042
16/01/2018	42	3	Resting	B	27.5	0	0.054	4	1	4	yes	0.973
23/01/2018	19	1	Resting	B	38	550	0.200	5	1	5	yes	0.866
23/01/2018	19	2	Resting	B	38	550	0.200	5	1	5	yes	0.879
23/01/2018	19	3	Resting	B	38	550	0.200	5	1	5	yes	0.929
23/01/2018	21	1	Resting	B	31	0	0.029	5	1	5	yes	0.792
23/01/2018	21	2	Resting	B	31	0	0.029	5	1	5	yes	0.830
23/01/2018	21	3	Resting	B	31	0	0.029	5	1	5	yes	0.895
23/01/2018	23	1	Resting	A	33	0	0.143	5	1	2	yes	0.718
23/01/2018	23	2	Resting	A	33	0	0.143	5	1	2	yes	0.947
23/01/2018	23	3	Resting	A	33	0	0.143	5	1	2	yes	0.851
23/01/2018	24	1	Resting	B	31	150	0.086	5	1	5	yes	0.605
23/01/2018	24	2	Resting	B	31	150	0.086	5	1	5	yes	0.612
23/01/2018	24	3	Resting	B	31	150	0.086	5	1	5	yes	0.669
23/01/2018	25	1	Resting	A	35	0	0.036	5	1	2	yes	0.890
23/01/2018	25	2	Resting	A	35	0	0.036	5	1	2	yes	1.040
23/01/2018	25	3	Resting	A	35	0	0.036	5	1	2	yes	0.833

23/01/2018	26	1	Resting	A	35	0	-0.071	5	1	2	yes	1.121
23/01/2018	26	2	Resting	A	35	0	-0.071	5	1	2	yes	1.005
23/01/2018	26	3	Resting	A	35	0	-0.071	5	1	2	yes	0.821
23/01/2018	27	1	Resting	A	36.5	0	0.071	5	1	2	yes	1.300
23/01/2018	27	2	Resting	A	36.5	0	0.071	5	1	2	yes	1.225
23/01/2018	27	3	Resting	A	36.5	0	0.071	5	1	2	yes	0.764
23/01/2018	28	1	Resting	B	34	50	0.014	5	1	5	yes	1.068
23/01/2018	28	2	Resting	B	34	50	0.014	5	1	5	yes	1.211
23/01/2018	28	3	Resting	B	34	50	0.014	5	1	5	yes	1.091
23/01/2018	29	1	Resting	A	36.5	0	NA	5	1	2	yes	0.791
23/01/2018	29	2	Resting	A	36.5	0	NA	5	1	2	yes	0.729
23/01/2018	29	3	Resting	A	36.5	0	NA	5	1	2	yes	0.597
23/01/2018	30	1	Resting	B	34.5	0	0.071	5	1	5	yes	0.609
23/01/2018	30	2	Resting	B	34.5	0	0.071	5	1	5	yes	0.480
23/01/2018	30	3	Resting	B	34.5	0	0.071	5	1	5	yes	0.840
23/01/2018	31	1	Resting	A	31.5	50	-0.143	5	1	2	yes	0.880
23/01/2018	31	2	Resting	A	31.5	50	-0.143	5	1	2	yes	0.761
23/01/2018	31	3	Resting	A	31.5	50	-0.143	5	1	2	yes	0.733
23/01/2018	32	1	Resting	A	34.5	0	-0.179	5	1	2	yes	0.695
23/01/2018	32	2	Resting	A	34.5	0	-0.179	5	1	2	yes	0.741
23/01/2018	32	3	Resting	A	34.5	0	-0.179	5	1	2	yes	1.454
23/01/2018	33	1	Resting	B	29.5	350	0.257	5	1	5	yes	0.691
23/01/2018	33	2	Resting	B	29.5	350	0.257	5	1	5	yes	0.884
23/01/2018	33	3	Resting	B	29.5	350	0.257	5	1	5	yes	1.006
23/01/2018	34	1	Resting	A	29	0	0.000	5	1	2	yes	1.005
23/01/2018	34	2	Resting	A	29	0	0.000	5	1	2	yes	0.854
23/01/2018	34	3	Resting	A	29	0	0.000	5	1	2	yes	0.828
23/01/2018	35	1	Resting	B	37	400	-0.014	5	1	5	yes	0.834
23/01/2018	35	2	Resting	B	37	400	-0.014	5	1	5	yes	0.934
23/01/2018	35	3	Resting	B	37	400	-0.014	5	1	5	yes	0.735
23/01/2018	36	1	Resting	B	38.5	200	0.186	5	1	5	yes	1.244
23/01/2018	36	2	Resting	B	38.5	200	0.186	5	1	5	yes	0.949
23/01/2018	36	3	Resting	B	38.5	200	0.186	5	1	5	yes	0.553
23/01/2018	37	1	Resting	A	36	0	0.036	5	1	2	yes	0.748
23/01/2018	37	2	Resting	A	36	0	0.036	5	1	2	yes	0.633
23/01/2018	37	3	Resting	A	36	0	0.036	5	1	2	yes	0.629
23/01/2018	38	1	Resting	A	25.5	0	0.179	5	1	2	yes	1.218
23/01/2018	38	2	Resting	A	25.5	0	0.179	5	1	2	yes	1.209
23/01/2018	38	3	Resting	A	25.5	0	0.179	5	1	2	yes	1.072
23/01/2018	39	1	Resting	A	32.5	0	-0.107	5	1	2	yes	0.995
23/01/2018	39	2	Resting	A	32.5	0	-0.107	5	1	2	yes	0.954
23/01/2018	39	3	Resting	A	32.5	0	-0.107	5	1	2	yes	0.960
23/01/2018	40	1	Resting	B	32	50	0.043	5	1	5	yes	1.113
23/01/2018	40	2	Resting	B	32	50	0.043	5	1	5	yes	1.121
23/01/2018	40	3	Resting	B	32	50	0.043	5	1	5	yes	0.725
23/01/2018	41	1	Resting	B	35.5	0	0.014	5	1	5	yes	1.594

23/01/2018	41	2	Resting	B	35.5	0	0.014	5	1	5	yes	2.350
23/01/2018	41	3	Resting	B	35.5	0	0.014	5	1	5	yes	1.899
23/01/2018	42	1	Resting	B	28.5	0	0.071	5	1	5	yes	1.035
23/01/2018	42	2	Resting	B	28.5	0	0.071	5	1	5	yes	1.244
23/01/2018	42	3	Resting	B	28.5	0	0.071	5	1	5	yes	1.346
30/01/2018	23	2	Resting	A	31	0	0.000	6	1	3	yes	0.932
30/01/2018	23	3	Resting	A	31	0	0.000	6	1	3	yes	0.889
30/01/2018	25	2	Resting	A	37.5	0	0.143	6	1	3	yes	0.752
30/01/2018	25	3	Resting	A	37.5	0	0.143	6	1	3	yes	0.794
30/01/2018	26	2	Resting	A	38.5	0	0.119	6	1	3	yes	0.757
30/01/2018	26	3	Resting	A	38.5	0	0.119	6	1	3	yes	0.726
30/01/2018	27	2	Resting	A	34	50	-0.071	6	1	3	yes	1.492
30/01/2018	27	3	Resting	A	34	50	-0.071	6	1	3	yes	1.329
30/01/2018	29	2	Resting	A	44	0	0.000	6	1	3	yes	0.612
30/01/2018	29	3	Resting	A	44	0	0.000	6	1	3	yes	0.553
30/01/2018	31	2	Resting	A	34	0	0.024	6	1	3	yes	0.821
30/01/2018	31	3	Resting	A	34	0	0.024	6	1	3	yes	0.632
30/01/2018	32	2	Resting	A	36	0	-0.048	6	1	3	yes	0.955
30/01/2018	32	3	Resting	A	36	0	-0.048	6	1	3	yes	0.745
30/01/2018	34	2	Resting	A	30.5	0	0.071	6	1	3	yes	1.975
30/01/2018	34	3	Resting	A	30.5	0	0.071	6	1	3	yes	1.709
30/01/2018	37	2	Resting	A	41	0	0.262	6	1	3	yes	0.771
30/01/2018	37	3	Resting	A	41	0	0.262	6	1	3	yes	0.659
30/01/2018	38	2	Resting	A	27	0	0.190	6	1	3	yes	1.096
30/01/2018	38	3	Resting	A	27	0	0.190	6	1	3	yes	0.823
30/01/2018	39	2	Resting	A	33.5	0	-0.024	6	1	3	yes	1.010
30/01/2018	39	3	Resting	A	33.5	0	-0.024	6	1	3	yes	0.910
06/02/2018	19	1	Resting	B	43	0	0.786	7	1	1	yes	0.998
06/02/2018	19	2	Resting	B	43	0	0.786	7	1	1	yes	0.957
06/02/2018	21	1	Resting	B	35	0	0.143	7	1	1	yes	0.555
06/02/2018	21	2	Resting	B	35	0	0.143	7	1	1	yes	0.696
06/02/2018	23	1	Resting	A	34.5	0	0.125	7	1	4	yes	0.791
06/02/2018	23	2	Resting	A	34.5	0	0.125	7	1	4	yes	0.774
06/02/2018	24	1	Resting	B	31.5	0	-0.214	7	1	1	yes	0.727
06/02/2018	24	2	Resting	B	31.5	0	-0.214	7	1	1	yes	0.907
06/02/2018	25	1	Resting	A	36.5	0	0.071	7	1	4	yes	0.805
06/02/2018	25	2	Resting	A	36.5	0	0.071	7	1	4	yes	0.739
06/02/2018	26	1	Resting	A	35	0	-0.036	7	1	4	yes	0.656
06/02/2018	26	2	Resting	A	35	0	-0.036	7	1	4	yes	0.721
06/02/2018	27	1	Resting	A	44	200	NA	7	1	4	yes	1.052
06/02/2018	27	2	Resting	A	44	200	NA	7	1	4	yes	1.268
06/02/2018	28	1	Resting	B	36.5	0	0.214	7	1	1	yes	1.809
06/02/2018	28	2	Resting	B	36.5	0	0.214	7	1	1	yes	1.404
06/02/2018	29	1	Resting	A	43.5	0	-0.018	7	1	4	yes	0.432
06/02/2018	29	2	Resting	A	43.5	0	-0.018	7	1	4	yes	0.524
06/02/2018	30	1	Resting	B	35.5	0	-0.071	7	1	1	yes	0.587

06/02/2018	30	2	Resting	B	35.5	0	-0.071	7	1	1	yes	0.945
06/02/2018	31	1	Resting	A	31	50	-0.089	7	1	4	yes	0.671
06/02/2018	31	2	Resting	A	31	50	-0.089	7	1	4	yes	0.968
06/02/2018	32	1	Resting	A	35	0	-0.071	7	1	4	yes	0.914
06/02/2018	32	2	Resting	A	35	0	-0.071	7	1	4	yes	1.270
06/02/2018	33	1	Resting	B	31.5	0	0.143	7	1	1	yes	1.280
06/02/2018	33	2	Resting	B	31.5	0	0.143	7	1	1	yes	1.309
06/02/2018	34	1	Resting	A	30.5	200	0.054	7	1	4	yes	1.899
06/02/2018	34	2	Resting	A	30.5	200	0.054	7	1	4	yes	NA
06/02/2018	35	1	Resting	B	38.5	0	-0.143	7	1	1	yes	0.882
06/02/2018	35	2	Resting	B	38.5	0	-0.143	7	1	1	yes	1.030
06/02/2018	36	1	Resting	B	36	0	-0.214	7	1	1	yes	0.661
06/02/2018	36	2	Resting	B	36	0	-0.214	7	1	1	yes	0.888
06/02/2018	37	1	Resting	A	36.5	50	0.036	7	1	4	yes	0.944
06/02/2018	37	2	Resting	A	36.5	50	0.036	7	1	4	yes	1.136
06/02/2018	38	1	Resting	A	26	50	0.107	7	1	4	yes	0.912
06/02/2018	38	2	Resting	A	26	50	0.107	7	1	4	yes	1.164
06/02/2018	40	1	Resting	B	33.5	0	-0.143	7	1	1	yes	0.493
06/02/2018	40	2	Resting	B	33.5	0	-0.143	7	1	1	yes	0.655
06/02/2018	41	1	Resting	B	36.5	0	-0.429	7	1	1	yes	1.602
06/02/2018	41	2	Resting	B	36.5	0	-0.429	7	1	1	yes	1.747
06/02/2018	42	1	Resting	B	32	0	0.286	7	1	1	yes	1.562
06/02/2018	42	2	Resting	B	32	0	0.286	7	1	1	yes	1.545
13/02/2018	19	1	Resting	B	38	0	0.036	8	1	2	yes	0.958
13/02/2018	19	2	Resting	B	38	0	0.036	8	1	2	yes	1.011
13/02/2018	19	3	Resting	B	38	0	0.036	8	1	2	yes	1.054
13/02/2018	21	1	Resting	B	36	0	0.143	8	1	2	yes	0.572
13/02/2018	21	2	Resting	B	36	0	0.143	8	1	2	yes	0.890
13/02/2018	21	3	Resting	B	36	0	0.143	8	1	2	yes	0.700
13/02/2018	23	1	Resting	A	33.5	150	0.071	8	1	5	yes	0.787
13/02/2018	23	2	Resting	A	33.5	150	0.071	8	1	5	yes	0.869
13/02/2018	23	3	Resting	A	33.5	150	0.071	8	1	5	yes	0.804
13/02/2018	24	1	Resting	B	33.5	0	0.036	8	1	2	yes	0.268
13/02/2018	24	2	Resting	B	33.5	0	0.036	8	1	2	yes	0.274
13/02/2018	24	3	Resting	B	33.5	0	0.036	8	1	2	yes	0.888
13/02/2018	25	1	Resting	A	33.5	0	-0.029	8	1	5	yes	0.825
13/02/2018	25	2	Resting	A	33.5	0	-0.029	8	1	5	yes	0.553
13/02/2018	25	3	Resting	A	33.5	0	-0.029	8	1	5	yes	0.683
13/02/2018	26	1	Resting	A	38.5	150	0.071	8	1	5	yes	0.771
13/02/2018	26	2	Resting	A	38.5	150	0.071	8	1	5	yes	0.757
13/02/2018	26	3	Resting	A	38.5	150	0.071	8	1	5	yes	0.857
13/02/2018	27	1	Resting	A	37	1100	0.043	8	1	5	yes	0.915
13/02/2018	27	2	Resting	A	37	1100	0.043	8	1	5	yes	0.787
13/02/2018	27	3	Resting	A	37	1100	0.043	8	1	5	yes	0.843
13/02/2018	28	1	Resting	B	36.5	0	0.107	8	1	2	yes	0.998
13/02/2018	28	2	Resting	B	36.5	0	0.107	8	1	2	yes	1.156

13/02/2018	28	3	Resting	B	36.5	0	0.107	8	1	2	yes	1.191
13/02/2018	29	1	Resting	A	42	400	-0.057	8	1	5	yes	0.533
13/02/2018	29	2	Resting	A	42	400	-0.057	8	1	5	yes	1.057
13/02/2018	29	3	Resting	A	42	400	-0.057	8	1	5	yes	0.627
13/02/2018	30	1	Resting	B	35.5	0	-0.036	8	1	2	yes	0.556
13/02/2018	30	2	Resting	B	35.5	0	-0.036	8	1	2	yes	0.780
13/02/2018	30	3	Resting	B	35.5	0	-0.036	8	1	2	yes	0.848
13/02/2018	31	1	Resting	A	33.5	250	0.000	8	1	5	yes	0.443
13/02/2018	31	2	Resting	A	33.5	250	0.000	8	1	5	yes	0.589
13/02/2018	31	3	Resting	A	33.5	250	0.000	8	1	5	yes	0.714
13/02/2018	32	1	Resting	A	32.5	1700	-0.129	8	1	5	yes	0.494
13/02/2018	32	2	Resting	A	32.5	1700	-0.129	8	1	5	yes	0.849
13/02/2018	32	3	Resting	A	32.5	1700	-0.129	8	1	5	yes	0.747
13/02/2018	33	1	Resting	B	33	0	0.179	8	1	2	yes	0.930
13/02/2018	33	2	Resting	B	33	0	0.179	8	1	2	yes	0.957
13/02/2018	33	3	Resting	B	33	0	0.179	8	1	2	yes	1.057
13/02/2018	34	1	Resting	A	30	0	0.029	8	1	5	yes	1.743
13/02/2018	34	2	Resting	A	30	0	0.029	8	1	5	yes	1.794
13/02/2018	34	3	Resting	A	30	0	0.029	8	1	5	yes	1.908
13/02/2018	35	1	Resting	B	38.5	0	-0.071	8	1	2	yes	0.553
13/02/2018	35	2	Resting	B	38.5	0	-0.071	8	1	2	yes	0.605
13/02/2018	35	3	Resting	B	38.5	0	-0.071	8	1	2	yes	0.651
13/02/2018	36	1	Resting	B	40	0	0.179	8	1	2	yes	0.610
13/02/2018	36	2	Resting	B	40	0	0.179	8	1	2	yes	0.681
13/02/2018	36	3	Resting	B	40	0	0.179	8	1	2	yes	0.672
13/02/2018	37	1	Resting	A	37.5	200	0.057	8	1	5	yes	0.496
13/02/2018	37	2	Resting	A	37.5	200	0.057	8	1	5	yes	0.649
13/02/2018	37	3	Resting	A	37.5	200	0.057	8	1	5	yes	0.626
13/02/2018	38	1	Resting	A	28.5	0	0.157	8	1	5	yes	0.447
13/02/2018	38	2	Resting	A	28.5	0	0.157	8	1	5	yes	0.499
13/02/2018	38	3	Resting	A	28.5	0	0.157	8	1	5	yes	0.502
13/02/2018	39	1	Resting	A	36	300	0.057	8	1	5	yes	0.432
13/02/2018	39	2	Resting	A	36	300	0.057	8	1	5	yes	0.496
13/02/2018	39	3	Resting	A	36	300	0.057	8	1	5	yes	0.474
13/02/2018	40	1	Resting	B	36.5	0	0.143	8	1	2	yes	0.429
13/02/2018	40	2	Resting	B	36.5	0	0.143	8	1	2	yes	0.584
13/02/2018	40	3	Resting	B	36.5	0	0.143	8	1	2	yes	0.488
13/02/2018	41	1	Resting	B	36.5	0	-0.214	8	1	2	yes	0.629
13/02/2018	41	2	Resting	B	36.5	0	-0.214	8	1	2	yes	0.745
13/02/2018	41	3	Resting	B	36.5	0	-0.214	8	1	2	yes	0.722
13/02/2018	42	1	Resting	B	32.5	0	0.179	8	1	2	yes	0.978
13/02/2018	42	2	Resting	B	32.5	0	0.179	8	1	2	yes	0.907
13/02/2018	42	3	Resting	B	32.5	0	0.179	8	1	2	yes	0.728
10/04/2018	19	1	Resting	B	42.5	0	0.357	16	2	1	yes	0.364
10/04/2018	19	2	Resting	B	42.5	0	0.357	16	2	1	yes	0.538
10/04/2018	19	3	Resting	B	42.5	0	0.357	16	2	1	yes	0.442

10/04/2018	21	1	Resting	B	36	0	-0.143	16	2	1	yes	0.532
10/04/2018	21	2	Resting	B	36	0	-0.143	16	2	1	yes	0.668
10/04/2018	21	3	Resting	B	36	0	-0.143	16	2	1	yes	0.524
10/04/2018	23	1	Resting	A	39.5	150	0.179	16	2	4	yes	0.498
10/04/2018	23	2	Resting	A	39.5	150	0.179	16	2	4	yes	0.450
10/04/2018	23	3	Resting	A	39.5	150	0.179	16	2	4	yes	0.520
10/04/2018	24	1	Resting	B	33.5	0	0.214	16	2	1	yes	0.442
10/04/2018	24	2	Resting	B	33.5	0	0.214	16	2	1	yes	0.325
10/04/2018	24	3	Resting	B	33.5	0	0.214	16	2	1	yes	0.274
10/04/2018	26	1	Resting	A	40	0	0.071	16	2	4	yes	0.414
10/04/2018	26	2	Resting	A	40	0	0.071	16	2	4	yes	0.421
10/04/2018	26	3	Resting	A	40	0	0.071	16	2	4	yes	0.358
10/04/2018	27	1	Resting	A	40.5	100	0.196	16	2	4	yes	0.342
10/04/2018	27	2	Resting	A	40.5	100	0.196	16	2	4	yes	0.426
10/04/2018	27	3	Resting	A	40.5	100	0.196	16	2	4	yes	0.397
10/04/2018	28	1	Resting	B	39.5	0	0.429	16	2	1	yes	0.364
10/04/2018	28	2	Resting	B	39.5	0	0.429	16	2	1	yes	0.320
10/04/2018	28	3	Resting	B	39.5	0	0.429	16	2	1	yes	0.346
10/04/2018	29	1	Resting	A	48	0	0.125	16	2	4	yes	0.635
10/04/2018	29	2	Resting	A	48	0	0.125	16	2	4	yes	0.577
10/04/2018	29	3	Resting	A	48	0	0.125	16	2	4	yes	0.454
10/04/2018	30	1	Resting	B	36	0	0.357	16	2	1	yes	0.520
10/04/2018	30	2	Resting	B	36	0	0.357	16	2	1	yes	0.372
10/04/2018	30	3	Resting	B	36	0	0.357	16	2	1	yes	0.438
10/04/2018	31	1	Resting	A	38.5	100	0.071	16	2	4	yes	0.388
10/04/2018	31	2	Resting	A	38.5	100	0.071	16	2	4	yes	0.300
10/04/2018	31	3	Resting	A	38.5	100	0.071	16	2	4	yes	0.293
10/04/2018	32	1	Resting	A	38.5	0	0.179	16	2	4	yes	0.613
10/04/2018	32	2	Resting	A	38.5	0	0.179	16	2	4	yes	0.451
10/04/2018	32	3	Resting	A	38.5	0	0.179	16	2	4	yes	0.522
10/04/2018	33	1	Resting	B	37.5	0	0.143	16	2	1	yes	0.534
10/04/2018	33	2	Resting	B	37.5	0	0.143	16	2	1	yes	0.578
10/04/2018	33	3	Resting	B	37.5	0	0.143	16	2	1	yes	0.489
10/04/2018	34	1	Resting	A	34	0	0.143	16	2	4	yes	0.447
10/04/2018	34	2	Resting	A	34	0	0.143	16	2	4	yes	0.469
10/04/2018	34	3	Resting	A	34	0	0.143	16	2	4	yes	0.388
10/04/2018	35	1	Resting	B	40.5	0	0.571	16	2	1	yes	0.447
10/04/2018	35	2	Resting	B	40.5	0	0.571	16	2	1	yes	0.433
10/04/2018	35	3	Resting	B	40.5	0	0.571	16	2	1	yes	0.345
10/04/2018	36	1	Resting	B	43	0	0.429	16	2	1	yes	0.391
10/04/2018	36	2	Resting	B	43	0	0.429	16	2	1	yes	0.380
10/04/2018	36	3	Resting	B	43	0	0.429	16	2	1	yes	0.333
10/04/2018	37	1	Resting	A	46.5	0	0.179	16	2	4	yes	0.847
10/04/2018	37	2	Resting	A	46.5	0	0.179	16	2	4	yes	0.788
10/04/2018	37	3	Resting	A	46.5	0	0.179	16	2	4	yes	0.827
10/04/2018	38	1	Resting	A	28.5	0	0.000	16	2	4	yes	0.390

10/04/2018	38	2	Resting	A	28.5	0	0.000	16	2	4	yes	0.320
10/04/2018	38	3	Resting	A	28.5	0	0.000	16	2	4	yes	0.334
10/04/2018	39	1	Resting	A	37	0	0.107	16	2	4	yes	0.868
10/04/2018	39	2	Resting	A	37	0	0.107	16	2	4	yes	0.600
10/04/2018	39	3	Resting	A	37	0	0.107	16	2	4	yes	0.637
10/04/2018	40	1	Resting	B	36	0	0.357	16	2	1	yes	0.482
10/04/2018	40	2	Resting	B	36	0	0.357	16	2	1	yes	0.474
10/04/2018	40	3	Resting	B	36	0	0.357	16	2	1	yes	0.600
10/04/2018	41	1	Resting	B	46.5	0	0.643	16	2	1	yes	0.388
10/04/2018	41	2	Resting	B	46.5	0	0.643	16	2	1	yes	0.461
10/04/2018	41	3	Resting	B	46.5	0	0.643	16	2	1	yes	0.545
10/04/2018	42	1	Resting	B	36.5	0	0.429	16	2	1	yes	0.425
10/04/2018	42	2	Resting	B	36.5	0	0.429	16	2	1	yes	0.463
10/04/2018	42	3	Resting	B	36.5	0	0.429	16	2	1	yes	0.422
17/04/2018	19	1	Resting	B	44	0	0.286	17	2	2	yes	0.337
17/04/2018	19	2	Resting	B	44	0	0.286	17	2	2	yes	0.582
17/04/2018	19	3	Resting	B	44	0	0.286	17	2	2	yes	0.392
17/04/2018	21	1	Resting	B	38.5	0	0.107	17	2	2	yes	0.875
17/04/2018	21	2	Resting	B	38.5	0	0.107	17	2	2	yes	0.865
17/04/2018	21	3	Resting	B	38.5	0	0.107	17	2	2	yes	0.942
17/04/2018	23	1	Resting	A	38	900	0.100	17	2	5	yes	0.852
17/04/2018	23	2	Resting	A	38	900	0.100	17	2	5	yes	0.881
17/04/2018	23	3	Resting	A	38	900	0.100	17	2	5	yes	0.979
17/04/2018	24	1	Resting	B	32.5	0	0.036	17	2	2	yes	0.538
17/04/2018	24	2	Resting	B	32.5	0	0.036	17	2	2	yes	0.652
17/04/2018	24	3	Resting	B	32.5	0	0.036	17	2	2	yes	0.651
17/04/2018	26	1	Resting	A	39.5	0	0.043	17	2	5	yes	0.553
17/04/2018	26	2	Resting	A	39.5	0	0.043	17	2	5	yes	0.506
17/04/2018	26	3	Resting	A	39.5	0	0.043	17	2	5	yes	0.548
17/04/2018	27	1	Resting	A	39	1100	0.114	17	2	5	yes	0.379
17/04/2018	27	2	Resting	A	39	1100	0.114	17	2	5	yes	0.382
17/04/2018	27	3	Resting	A	39	1100	0.114	17	2	5	yes	0.368
17/04/2018	28	1	Resting	B	38.5	0	0.143	17	2	2	yes	0.319
17/04/2018	28	2	Resting	B	38.5	0	0.143	17	2	2	yes	0.349
17/04/2018	28	3	Resting	B	38.5	0	0.143	17	2	2	yes	0.560
17/04/2018	29	1	Resting	A	45.5	NA	0.029	17	2	5	yes	0.490
17/04/2018	29	2	Resting	A	45.5	NA	0.029	17	2	5	yes	0.671
17/04/2018	29	3	Resting	A	45.5	NA	0.029	17	2	5	yes	0.629
17/04/2018	30	1	Resting	B	35	0	0.107	17	2	2	yes	0.686
17/04/2018	30	2	Resting	B	35	0	0.107	17	2	2	yes	0.816
17/04/2018	30	3	Resting	B	35	0	0.107	17	2	2	yes	0.772
17/04/2018	31	1	Resting	A	38	550	0.043	17	2	5	yes	0.619
17/04/2018	31	2	Resting	A	38	550	0.043	17	2	5	yes	0.423
17/04/2018	31	3	Resting	A	38	550	0.043	17	2	5	yes	0.548
17/04/2018	32	1	Resting	A	37	50	0.100	17	2	5	yes	0.445
17/04/2018	32	2	Resting	A	37	50	0.100	17	2	5	yes	0.538

17/04/2018	32	3	Resting	A	37	50	0.100	17	2	5	yes	0.792
17/04/2018	33	1	Resting	B	38	0	0.107	17	2	2	yes	0.469
17/04/2018	33	2	Resting	B	38	0	0.107	17	2	2	yes	0.611
17/04/2018	33	3	Resting	B	38	0	0.107	17	2	2	yes	0.490
17/04/2018	34	1	Resting	A	33.5	550	0.100	17	2	5	yes	0.421
17/04/2018	34	2	Resting	A	33.5	550	0.100	17	2	5	yes	0.764
17/04/2018	34	3	Resting	A	33.5	550	0.100	17	2	5	yes	0.869
17/04/2018	35	1	Resting	B	39.5	0	0.214	17	2	2	yes	0.863
17/04/2018	35	2	Resting	B	39.5	0	0.214	17	2	2	yes	0.954
17/04/2018	35	3	Resting	B	39.5	0	0.214	17	2	2	yes	0.848
17/04/2018	36	1	Resting	B	42.5	0	0.179	17	2	2	yes	0.455
17/04/2018	36	2	Resting	B	42.5	0	0.179	17	2	2	yes	0.535
17/04/2018	36	3	Resting	B	42.5	0	0.179	17	2	2	yes	0.528
17/04/2018	37	1	Resting	A	45.5	1100	0.114	17	2	5	yes	0.758
17/04/2018	37	2	Resting	A	45.5	1100	0.114	17	2	5	yes	0.934
17/04/2018	37	3	Resting	A	45.5	1100	0.114	17	2	5	yes	0.760
17/04/2018	38	1	Resting	A	27	0	-0.043	17	2	5	yes	0.647
17/04/2018	38	2	Resting	A	27	0	-0.043	17	2	5	yes	0.912
17/04/2018	38	3	Resting	A	27	0	-0.043	17	2	5	yes	0.757
17/04/2018	39	1	Resting	A	37	0	0.086	17	2	5	yes	1.085
17/04/2018	39	2	Resting	A	37	0	0.086	17	2	5	yes	1.403
17/04/2018	39	3	Resting	A	37	0	0.086	17	2	5	yes	1.242
17/04/2018	40	1	Resting	B	36.5	0	0.214	17	2	2	yes	0.491
17/04/2018	40	2	Resting	B	36.5	0	0.214	17	2	2	yes	0.622
17/04/2018	40	3	Resting	B	36.5	0	0.214	17	2	2	yes	0.551
17/04/2018	41	1	Resting	B	43	0	0.071	17	2	2	yes	0.453
17/04/2018	41	2	Resting	B	43	0	0.071	17	2	2	yes	0.497
17/04/2018	41	3	Resting	B	43	0	0.071	17	2	2	yes	0.406
17/04/2018	42	1	Resting	B	36	0	0.179	17	2	2	yes	0.524
17/04/2018	42	2	Resting	B	36	0	0.179	17	2	2	yes	0.706
17/04/2018	42	3	Resting	B	36	0	0.179	17	2	2	yes	0.551
04/05/2018	21	1	Resting	B	39	1500	0.071	19	2	4	yes	0.992
04/05/2018	21	2	Resting	B	39	1500	0.071	19	2	4	yes	1.097
04/05/2018	21	3	Resting	B	39	1500	0.071	19	2	4	yes	0.990
04/05/2018	23	1	Resting	A	38	0	0.000	19	2	1	yes	0.610
04/05/2018	23	2	Resting	A	38	0	0.000	19	2	1	yes	0.658
04/05/2018	23	3	Resting	A	38	0	0.000	19	2	1	yes	0.752
04/05/2018	24	1	Resting	B	33	350	0.036	19	2	4	yes	0.824
04/05/2018	24	2	Resting	B	33	350	0.036	19	2	4	yes	1.159
04/05/2018	24	3	Resting	B	33	350	0.036	19	2	4	yes	0.909
04/05/2018	26	1	Resting	A	40.5	0	0.214	19	2	1	yes	0.342
04/05/2018	26	2	Resting	A	40.5	0	0.214	19	2	1	yes	0.436
04/05/2018	26	3	Resting	A	40.5	0	0.214	19	2	1	yes	0.433
04/05/2018	27	1	Resting	A	40.5	0	0.429	19	2	1	yes	0.694
04/05/2018	27	2	Resting	A	40.5	0	0.429	19	2	1	yes	0.578
04/05/2018	27	3	Resting	A	40.5	0	0.429	19	2	1	yes	0.623

04/05/2018	28	1	Resting	B	39	850	0.089	19	2	4	yes	0.398
04/05/2018	28	2	Resting	B	39	850	0.089	19	2	4	yes	0.363
04/05/2018	28	3	Resting	B	39	850	0.089	19	2	4	yes	0.377
04/05/2018	29	1	Resting	A	47.5	0	0.357	19	2	1	yes	0.790
04/05/2018	29	2	Resting	A	47.5	0	0.357	19	2	1	yes	0.730
04/05/2018	29	3	Resting	A	47.5	0	0.357	19	2	1	yes	0.663
04/05/2018	30	1	Resting	B	36	700	0.089	19	2	4	yes	0.429
04/05/2018	30	2	Resting	B	36	700	0.089	19	2	4	yes	0.491
04/05/2018	30	3	Resting	B	36	700	0.089	19	2	4	yes	0.576
04/05/2018	31	1	Resting	A	37.5	0	0.286	19	2	1	yes	0.283
04/05/2018	31	2	Resting	A	37.5	0	0.286	19	2	1	yes	0.342
04/05/2018	31	3	Resting	A	37.5	0	0.286	19	2	1	yes	0.280
04/05/2018	32	1	Resting	A	36.5	0	-0.071	19	2	1	yes	0.853
04/05/2018	32	2	Resting	A	36.5	0	-0.071	19	2	1	yes	0.627
04/05/2018	32	3	Resting	A	36.5	0	-0.071	19	2	1	yes	0.574
04/05/2018	33	1	Resting	B	37.5	450	0.036	19	2	4	yes	0.722
04/05/2018	33	2	Resting	B	37.5	450	0.036	19	2	4	yes	0.883
04/05/2018	33	3	Resting	B	37.5	450	0.036	19	2	4	yes	0.821
04/05/2018	34	1	Resting	A	33.5	0	0.143	19	2	1	yes	0.606
04/05/2018	34	2	Resting	A	33.5	0	0.143	19	2	1	yes	0.305
04/05/2018	34	3	Resting	A	33.5	0	0.143	19	2	1	yes	0.431
04/05/2018	35	1	Resting	B	39.5	350	0.107	19	2	4	yes	0.814
04/05/2018	35	2	Resting	B	39.5	350	0.107	19	2	4	yes	0.740
04/05/2018	35	3	Resting	B	39.5	350	0.107	19	2	4	yes	1.316
04/05/2018	36	1	Resting	B	42	NA	0.071	19	2	4	yes	0.373
04/05/2018	36	2	Resting	B	42	NA	0.071	19	2	4	yes	0.316
04/05/2018	36	3	Resting	B	42	NA	0.071	19	2	4	yes	0.339
04/05/2018	37	1	Resting	A	45	0	0.714	19	2	1	yes	0.510
04/05/2018	37	2	Resting	A	45	0	0.714	19	2	1	yes	0.483
04/05/2018	37	3	Resting	A	45	0	0.714	19	2	1	yes	0.471
04/05/2018	38	1	Resting	A	29.5	0	0.357	19	2	1	yes	0.853
04/05/2018	38	2	Resting	A	29.5	0	0.357	19	2	1	yes	1.128
04/05/2018	38	3	Resting	A	29.5	0	0.357	19	2	1	yes	1.214
04/05/2018	39	1	Resting	A	36.5	0	0.071	19	2	1	yes	0.795
04/05/2018	39	2	Resting	A	36.5	0	0.071	19	2	1	yes	1.116
04/05/2018	39	3	Resting	A	36.5	0	0.071	19	2	1	yes	0.882
04/05/2018	40	1	Resting	B	38	400	0.161	19	2	4	yes	0.668
04/05/2018	40	2	Resting	B	38	400	0.161	19	2	4	yes	0.778
04/05/2018	40	3	Resting	B	38	400	0.161	19	2	4	yes	0.861
04/05/2018	41	1	Resting	B	43	100	0.036	19	2	4	yes	0.641
04/05/2018	41	2	Resting	B	43	100	0.036	19	2	4	yes	0.662
04/05/2018	41	3	Resting	B	43	100	0.036	19	2	4	yes	0.842
04/05/2018	42	1	Resting	B	36.5	100	0.107	19	2	4	yes	0.422
04/05/2018	42	2	Resting	B	36.5	100	0.107	19	2	4	yes	0.514
04/05/2018	42	3	Resting	B	36.5	100	0.107	19	2	4	yes	0.671
08/05/2018	19	1	Resting	B	39.5	NA	-0.014	20	2	5	yes	0.289

08/05/2018	19	2	Resting	B	39.5	NA	-0.014	20	2	5	yes	0.351
08/05/2018	21	1	Resting	B	39	NA	0.057	20	2	5	yes	1.144
08/05/2018	21	2	Resting	B	39	NA	0.057	20	2	5	yes	1.322
08/05/2018	23	1	Resting	A	38	0	0.000	20	2	2	yes	0.403
08/05/2018	23	2	Resting	A	38	0	0.000	20	2	2	yes	0.715
08/05/2018	24	1	Resting	B	33.5	850	0.043	20	2	5	yes	0.486
08/05/2018	24	2	Resting	B	33.5	850	0.043	20	2	5	yes	0.558
08/05/2018	26	1	Resting	A	40	0	0.071	20	2	2	yes	0.355
08/05/2018	26	2	Resting	A	40	0	0.071	20	2	2	yes	0.355
08/05/2018	27	1	Resting	A	41.5	0	0.286	20	2	2	yes	0.492
08/05/2018	27	2	Resting	A	41.5	0	0.286	20	2	2	yes	0.735
08/05/2018	28	1	Resting	B	38.5	NA	0.057	20	2	5	yes	0.307
08/05/2018	28	2	Resting	B	38.5	NA	0.057	20	2	5	yes	0.316
08/05/2018	29	1	Resting	A	46.5	0	0.107	20	2	2	yes	0.723
08/05/2018	29	2	Resting	A	46.5	0	0.107	20	2	2	yes	0.587
08/05/2018	30	1	Resting	B	35	900	0.043	20	2	5	yes	0.418
08/05/2018	30	2	Resting	B	35	900	0.043	20	2	5	yes	0.525
08/05/2018	31	1	Resting	A	37.5	0	0.143	20	2	2	yes	0.409
08/05/2018	31	2	Resting	A	37.5	0	0.143	20	2	2	yes	0.350
08/05/2018	32	1	Resting	A	37	0	0.000	20	2	2	yes	0.336
08/05/2018	32	2	Resting	A	37	0	0.000	20	2	2	yes	0.539
08/05/2018	33	1	Resting	B	37	1100	0.014	20	2	5	yes	0.915
08/05/2018	33	2	Resting	B	37	1100	0.014	20	2	5	yes	0.953
08/05/2018	34	1	Resting	A	33.5	0	0.071	20	2	2	yes	0.527
08/05/2018	34	2	Resting	A	33.5	0	0.071	20	2	2	yes	0.513
08/05/2018	35	1	Resting	B	37	NA	0.014	20	2	5	yes	0.603
08/05/2018	35	2	Resting	B	37	NA	0.014	20	2	5	yes	0.753
08/05/2018	36	1	Resting	B	41.5	850	0.043	20	2	5	yes	0.353
08/05/2018	36	2	Resting	B	41.5	850	0.043	20	2	5	yes	0.404
08/05/2018	37	1	Resting	A	44	0	0.286	20	2	2	yes	0.894
08/05/2018	37	2	Resting	A	44	0	0.286	20	2	2	yes	0.830
08/05/2018	38	1	Resting	A	29.5	0	0.179	20	2	2	yes	0.448
08/05/2018	38	2	Resting	A	29.5	0	0.179	20	2	2	yes	0.659
08/05/2018	39	1	Resting	A	37	0	0.071	20	2	2	yes	0.688
08/05/2018	39	2	Resting	A	37	0	0.071	20	2	2	yes	0.651
08/05/2018	40	1	Resting	B	37	1800	0.100	20	2	5	yes	0.380
08/05/2018	40	2	Resting	B	37	1800	0.100	20	2	5	yes	0.374
08/05/2018	41	1	Resting	B	42	NA	0.000	20	2	5	yes	0.416
08/05/2018	41	2	Resting	B	42	NA	0.000	20	2	5	yes	0.515
08/05/2018	42	1	Resting	B	36.5	1200	0.086	20	2	5	yes	0.331
08/05/2018	42	2	Resting	B	36.5	1200	0.086	20	2	5	yes	0.458
15/05/2018	23	1	Resting	A	37	0	-0.048	21	2	3	no	0.465
15/05/2018	23	2	Resting	A	37	0	-0.048	21	2	3	no	0.531
15/05/2018	23	3	Resting	A	37	0	-0.048	21	2	3	no	0.506
15/05/2018	26	1	Resting	A	39	0	0.000	21	2	3	no	0.535
15/05/2018	26	2	Resting	A	39	0	0.000	21	2	3	no	0.646

15/05/2018	26	3	Resting	A	39	0	0.000	21	2	3	no	0.722
15/05/2018	27	1	Resting	A	41.5	0	0.190	21	2	3	no	0.637
15/05/2018	27	2	Resting	A	41.5	0	0.190	21	2	3	no	0.569
15/05/2018	27	3	Resting	A	41.5	0	0.190	21	2	3	no	0.786
15/05/2018	29	1	Resting	A	46.5	0	0.071	21	2	3	no	1.160
15/05/2018	29	2	Resting	A	46.5	0	0.071	21	2	3	no	0.855
15/05/2018	29	3	Resting	A	46.5	0	0.071	21	2	3	no	1.225
15/05/2018	31	1	Resting	A	38.5	0	0.143	21	2	3	no	0.625
15/05/2018	31	2	Resting	A	38.5	0	0.143	21	2	3	no	0.666
15/05/2018	31	3	Resting	A	38.5	0	0.143	21	2	3	no	0.507
15/05/2018	32	1	Resting	A	37.5	0	0.024	21	2	3	no	0.735
15/05/2018	32	2	Resting	A	37.5	0	0.024	21	2	3	no	0.464
15/05/2018	32	3	Resting	A	37.5	0	0.024	21	2	3	no	0.444
15/05/2018	34	1	Resting	A	34	0	0.071	21	2	3	no	0.581
15/05/2018	34	2	Resting	A	34	0	0.071	21	2	3	no	0.573
15/05/2018	34	3	Resting	A	34	0	0.071	21	2	3	no	0.550
15/05/2018	37	1	Resting	A	44.5	0	0.214	21	2	3	no	0.778
15/05/2018	37	2	Resting	A	44.5	0	0.214	21	2	3	no	0.733
15/05/2018	37	3	Resting	A	44.5	0	0.214	21	2	3	no	0.610
15/05/2018	38	1	Resting	A	29.5	0	0.119	21	2	3	no	0.836
15/05/2018	38	2	Resting	A	29.5	0	0.119	21	2	3	no	0.908
15/05/2018	38	3	Resting	A	29.5	0	0.119	21	2	3	no	1.098
15/05/2018	39	1	Resting	A	36	0	0.000	21	2	3	no	1.054
15/05/2018	39	2	Resting	A	36	0	0.000	21	2	3	no	1.132
15/05/2018	39	3	Resting	A	36	0	0.000	21	2	3	no	1.140
22/05/2018	19	1	Resting	B	43	0	0.000	22	3	1	no	0.379
22/05/2018	19	2	Resting	B	43	0	0.000	22	3	1	no	0.431
22/05/2018	21	1	Resting	B	39	0	-0.143	22	3	1	no	1.173
22/05/2018	21	2	Resting	B	39	0	-0.143	22	3	1	no	1.045
22/05/2018	23	1	Resting	A	38	100	0.000	22	3	4	no	0.364
22/05/2018	23	2	Resting	A	38	100	0.000	22	3	4	no	0.558
22/05/2018	24	1	Resting	B	32	0	-0.214	22	3	1	no	0.598
22/05/2018	24	2	Resting	B	32	0	-0.214	22	3	1	no	0.862
22/05/2018	26	1	Resting	A	38	50	-0.036	22	3	4	no	0.408
22/05/2018	26	2	Resting	A	38	50	-0.036	22	3	4	no	0.620
22/05/2018	27	1	Resting	A	39.5	200	0.071	22	3	4	no	0.451
22/05/2018	27	2	Resting	A	39.5	200	0.071	22	3	4	no	0.663
22/05/2018	28	1	Resting	B	37	0	-0.214	22	3	1	no	0.293
22/05/2018	28	2	Resting	B	37	0	-0.214	22	3	1	no	0.387
22/05/2018	29	1	Resting	A	46.5	0	0.054	22	3	4	no	0.858
22/05/2018	29	2	Resting	A	46.5	0	0.054	22	3	4	no	0.883
22/05/2018	30	1	Resting	B	36.5	0	-0.071	22	3	1	no	0.609
22/05/2018	30	2	Resting	B	36.5	0	-0.071	22	3	1	no	0.870
22/05/2018	31	1	Resting	A	37.5	50	0.071	22	3	4	no	0.292
22/05/2018	31	2	Resting	A	37.5	50	0.071	22	3	4	no	0.311
22/05/2018	32	1	Resting	A	34.5	0	-0.089	22	3	4	no	0.347

22/05/2018	32	2	Resting	A	34.5	0	-0.089	22	3	4	no	0.595
22/05/2018	33	1	Resting	B	38.5	0	0.000	22	3	1	no	0.949
22/05/2018	33	2	Resting	B	38.5	0	0.000	22	3	1	no	1.246
22/05/2018	34	1	Resting	A	32.5	50	0.000	22	3	4	no	0.818
22/05/2018	34	2	Resting	A	32.5	50	0.000	22	3	4	no	0.987
22/05/2018	35	1	Resting	B	39	0	0.000	22	3	1	no	1.073
22/05/2018	35	2	Resting	B	39	0	0.000	22	3	1	no	1.144
22/05/2018	36	1	Resting	B	40	0	-0.071	22	3	1	no	0.660
22/05/2018	36	2	Resting	B	40	0	-0.071	22	3	1	no	0.383
22/05/2018	37	1	Resting	A	46	250	0.214	22	3	4	no	1.083
22/05/2018	37	2	Resting	A	46	250	0.214	22	3	4	no	1.081
22/05/2018	38	1	Resting	A	28.5	50	0.054	22	3	4	no	0.754
22/05/2018	38	2	Resting	A	28.5	50	0.054	22	3	4	no	1.113
22/05/2018	39	1	Resting	A	35	0	-0.036	22	3	4	no	0.484
22/05/2018	39	2	Resting	A	35	0	-0.036	22	3	4	no	0.577
22/05/2018	40	1	Resting	B	34.5	0	-0.286	22	3	1	no	0.647
22/05/2018	40	2	Resting	B	34.5	0	-0.286	22	3	1	no	0.777
22/05/2018	41	1	Resting	B	42.5	0	0.000	22	3	1	no	0.636
22/05/2018	41	2	Resting	B	42.5	0	0.000	22	3	1	no	0.699
22/05/2018	42	1	Resting	B	35.5	0	-0.286	22	3	1	no	0.378
22/05/2018	42	2	Resting	B	35.5	0	-0.286	22	3	1	no	0.549
29/05/2018	19	1	Resting	B	42.5	0	-0.036	23	3	2	no	0.284
29/05/2018	19	2	Resting	B	42.5	0	-0.036	23	3	2	no	0.404
29/05/2018	19	3	Resting	B	42.5	0	-0.036	23	3	2	no	0.600
29/05/2018	21	1	Resting	B	39.5	0	-0.036	23	3	2	no	1.290
29/05/2018	21	2	Resting	B	39.5	0	-0.036	23	3	2	no	1.151
29/05/2018	21	3	Resting	B	39.5	0	-0.036	23	3	2	no	1.317
29/05/2018	23	1	Resting	A	36.5	350	-0.043	23	3	5	no	0.764
29/05/2018	23	2	Resting	A	36.5	350	-0.043	23	3	5	no	0.976
29/05/2018	23	3	Resting	A	36.5	350	-0.043	23	3	5	no	1.520
29/05/2018	24	1	Resting	B	33	0	-0.036	23	3	2	no	0.933
29/05/2018	24	2	Resting	B	33	0	-0.036	23	3	2	no	0.996
29/05/2018	24	3	Resting	B	33	0	-0.036	23	3	2	no	1.025
29/05/2018	26	1	Resting	A	39	300	0.000	23	3	5	no	0.384
29/05/2018	26	2	Resting	A	39	300	0.000	23	3	5	no	0.423
29/05/2018	26	3	Resting	A	39	300	0.000	23	3	5	no	0.654
29/05/2018	27	1	Resting	A	40	1000	0.071	23	3	5	no	0.430
29/05/2018	27	2	Resting	A	40	1000	0.071	23	3	5	no	0.632
29/05/2018	27	3	Resting	A	40	1000	0.071	23	3	5	no	0.668
29/05/2018	28	1	Resting	B	38.5	0	0.000	23	3	2	no	0.476
29/05/2018	28	2	Resting	B	38.5	0	0.000	23	3	2	no	0.497
29/05/2018	28	3	Resting	B	38.5	0	0.000	23	3	2	no	0.692
29/05/2018	29	1	Resting	A	44.5	200	-0.014	23	3	5	no	0.768
29/05/2018	29	2	Resting	A	44.5	200	-0.014	23	3	5	no	0.681
29/05/2018	29	3	Resting	A	44.5	200	-0.014	23	3	5	no	0.760
29/05/2018	30	1	Resting	B	37.5	0	0.036	23	3	2	no	0.698

29/05/2018	30	2	Resting	B	37.5	0	0.036	23	3	2	no	0.845
29/05/2018	30	3	Resting	B	37.5	0	0.036	23	3	2	no	1.057
29/05/2018	31	1	Resting	A	38	50	0.071	23	3	5	no	0.705
29/05/2018	31	2	Resting	A	38	50	0.071	23	3	5	no	0.642
29/05/2018	31	3	Resting	A	38	50	0.071	23	3	5	no	0.882
29/05/2018	32	1	Resting	A	36.5	450	-0.014	23	3	5	no	0.429
29/05/2018	32	2	Resting	A	36.5	450	-0.014	23	3	5	no	0.513
29/05/2018	32	3	Resting	A	36.5	450	-0.014	23	3	5	no	0.902
29/05/2018	33	1	Resting	B	38	0	-0.036	23	3	2	no	0.729
29/05/2018	33	2	Resting	B	38	0	-0.036	23	3	2	no	0.822
29/05/2018	33	3	Resting	B	38	0	-0.036	23	3	2	no	0.783
29/05/2018	34	1	Resting	A	33	900	0.014	23	3	5	no	0.537
29/05/2018	34	2	Resting	A	33	900	0.014	23	3	5	no	0.518
29/05/2018	34	3	Resting	A	33	900	0.014	23	3	5	no	0.715
29/05/2018	35	1	Resting	B	40.5	0	0.107	23	3	2	no	0.867
29/05/2018	35	2	Resting	B	40.5	0	0.107	23	3	2	no	1.157
29/05/2018	35	3	Resting	B	40.5	0	0.107	23	3	2	no	1.571
29/05/2018	36	1	Resting	B	40.5	0	0.000	23	3	2	no	0.417
29/05/2018	36	2	Resting	B	40.5	0	0.000	23	3	2	no	0.492
29/05/2018	36	3	Resting	B	40.5	0	0.000	23	3	2	no	0.728
29/05/2018	37	1	Resting	A	43.5	1550	0.100	23	3	5	no	0.851
29/05/2018	37	2	Resting	A	43.5	1550	0.100	23	3	5	no	0.830
29/05/2018	37	3	Resting	A	43.5	1550	0.100	23	3	5	no	1.163
29/05/2018	38	1	Resting	A	29.5	850	0.071	23	3	5	no	0.373
29/05/2018	38	2	Resting	A	29.5	850	0.071	23	3	5	no	0.571
29/05/2018	38	3	Resting	A	29.5	850	0.071	23	3	5	no	0.674
29/05/2018	39	1	Resting	A	36	1300	0.000	23	3	5	no	0.816
29/05/2018	39	2	Resting	A	36	1300	0.000	23	3	5	no	0.833
29/05/2018	39	3	Resting	A	36	1300	0.000	23	3	5	no	1.040
29/05/2018	40	1	Resting	B	37.5	0	0.071	23	3	2	no	0.631
29/05/2018	40	2	Resting	B	37.5	0	0.071	23	3	2	no	0.673
29/05/2018	40	3	Resting	B	37.5	0	0.071	23	3	2	no	0.728
29/05/2018	41	1	Resting	B	42	0	-0.036	23	3	2	no	0.568
29/05/2018	41	2	Resting	B	42	0	-0.036	23	3	2	no	0.515
29/05/2018	41	3	Resting	B	42	0	-0.036	23	3	2	no	0.648
29/05/2018	42	1	Resting	B	36.5	0	-0.071	23	3	2	no	0.596
29/05/2018	42	2	Resting	B	36.5	0	-0.071	23	3	2	no	0.617
29/05/2018	42	3	Resting	B	36.5	0	-0.071	23	3	2	no	0.904
05/06/2018	19	1	Resting	B	44.5	0	0.071	24	3	3	no	0.494
05/06/2018	19	2	Resting	B	44.5	0	0.071	24	3	3	no	0.747
05/06/2018	19	3	Resting	B	44.5	0	0.071	24	3	3	no	0.570
05/06/2018	21	1	Resting	B	39	0	-0.048	24	3	3	no	0.908
05/06/2018	21	2	Resting	B	39	0	-0.048	24	3	3	no	1.052
05/06/2018	21	3	Resting	B	39	0	-0.048	24	3	3	no	1.199
05/06/2018	24	1	Resting	B	33.5	0	0.000	24	3	3	no	0.602
05/06/2018	24	2	Resting	B	33.5	0	0.000	24	3	3	no	0.610

05/06/2018	24	3	Resting	B	33.5	0	0.000	24	3	3	no	0.553
05/06/2018	28	1	Resting	B	39	0	0.024	24	3	3	no	0.335
05/06/2018	28	2	Resting	B	39	0	0.024	24	3	3	no	0.384
05/06/2018	28	3	Resting	B	39	0	0.024	24	3	3	no	0.386
05/06/2018	30	1	Resting	B	38.5	0	0.071	24	3	3	no	0.397
05/06/2018	30	2	Resting	B	38.5	0	0.071	24	3	3	no	0.441
05/06/2018	30	3	Resting	B	38.5	0	0.071	24	3	3	no	0.427
05/06/2018	33	1	Resting	B	38	0	-0.024	24	3	3	no	0.886
05/06/2018	33	2	Resting	B	38	0	-0.024	24	3	3	no	0.969
05/06/2018	33	3	Resting	B	38	0	-0.024	24	3	3	no	1.149
05/06/2018	35	1	Resting	B	40	0	0.048	24	3	3	no	0.701
05/06/2018	35	2	Resting	B	40	0	0.048	24	3	3	no	0.746
05/06/2018	35	3	Resting	B	40	0	0.048	24	3	3	no	0.818
05/06/2018	36	1	Resting	B	42	0	0.071	24	3	3	no	0.595
05/06/2018	36	2	Resting	B	42	0	0.071	24	3	3	no	0.573
05/06/2018	36	3	Resting	B	42	0	0.071	24	3	3	no	0.730
05/06/2018	40	1	Resting	B	40	0	0.167	24	3	3	no	0.717
05/06/2018	40	2	Resting	B	40	0	0.167	24	3	3	no	0.764
05/06/2018	40	3	Resting	B	40	0	0.167	24	3	3	no	0.685
05/06/2018	41	1	Resting	B	43.5	0	0.048	24	3	3	no	0.486
05/06/2018	41	2	Resting	B	43.5	0	0.048	24	3	3	no	0.550
05/06/2018	41	3	Resting	B	43.5	0	0.048	24	3	3	no	0.483
05/06/2018	42	1	Resting	B	38	0	0.024	24	3	3	no	0.513
05/06/2018	42	2	Resting	B	38	0	0.024	24	3	3	no	0.828
05/06/2018	42	3	Resting	B	38	0	0.024	24	3	3	no	0.585
12/06/2018	19	1	Resting	B	45.5	100	0.089	25	3	4	no	0.307
12/06/2018	19	2	Resting	B	45.5	100	0.089	25	3	4	no	0.372
12/06/2018	19	3	Resting	B	45.5	100	0.089	25	3	4	no	0.503
12/06/2018	21	1	Resting	B	41.5	0	0.054	25	3	4	no	0.635
12/06/2018	21	2	Resting	B	41.5	0	0.054	25	3	4	no	0.719
12/06/2018	21	3	Resting	B	41.5	0	0.054	25	3	4	no	0.814
12/06/2018	23	1	Resting	A	39.5	0	0.286	25	3	1	no	0.535
12/06/2018	23	2	Resting	A	39.5	0	0.286	25	3	1	no	0.529
12/06/2018	23	3	Resting	A	39.5	0	0.286	25	3	1	no	0.909
12/06/2018	24	1	Resting	B	36.5	50	0.107	25	3	4	no	0.653
12/06/2018	24	2	Resting	B	36.5	50	0.107	25	3	4	no	1.058
12/06/2018	24	3	Resting	B	36.5	50	0.107	25	3	4	no	0.827
12/06/2018	26	1	Resting	A	40.5	0	0.143	25	3	1	no	0.453
12/06/2018	26	2	Resting	A	40.5	0	0.143	25	3	1	no	0.646
12/06/2018	26	3	Resting	A	40.5	0	0.143	25	3	1	no	0.933
12/06/2018	27	1	Resting	A	42.5	NA	0.429	25	3	1	no	0.596
12/06/2018	27	2	Resting	A	42.5	NA	0.429	25	3	1	no	0.758
12/06/2018	27	3	Resting	A	42.5	NA	0.429	25	3	1	no	0.704
12/06/2018	28	1	Resting	B	40.5	250	0.071	25	3	4	no	0.357
12/06/2018	28	2	Resting	B	40.5	250	0.071	25	3	4	no	0.398
12/06/2018	28	3	Resting	B	40.5	250	0.071	25	3	4	no	0.481

12/06/2018	29	1	Resting	A	48	0	0.357	25	3	1	no	0.675
12/06/2018	29	2	Resting	A	48	0	0.357	25	3	1	no	1.005
12/06/2018	29	3	Resting	A	48	0	0.357	25	3	1	no	1.003
12/06/2018	30	1	Resting	B	39.5	150	0.089	25	3	4	no	0.532
12/06/2018	30	2	Resting	B	39.5	150	0.089	25	3	4	no	0.733
12/06/2018	30	3	Resting	B	39.5	150	0.089	25	3	4	no	0.813
12/06/2018	31	1	Resting	A	41	0	0.429	25	3	1	no	0.366
12/06/2018	31	2	Resting	A	41	0	0.429	25	3	1	no	0.480
12/06/2018	31	3	Resting	A	41	0	0.429	25	3	1	no	0.680
12/06/2018	32	1	Resting	A	37	0	0.214	25	3	1	no	0.349
12/06/2018	32	2	Resting	A	37	0	0.214	25	3	1	no	0.603
12/06/2018	32	3	Resting	A	37	0	0.214	25	3	1	no	0.759
12/06/2018	33	1	Resting	B	38	0	-0.018	25	3	4	no	1.059
12/06/2018	33	2	Resting	B	38	0	-0.018	25	3	4	no	1.561
12/06/2018	33	3	Resting	B	38	0	-0.018	25	3	4	no	1.043
12/06/2018	34	1	Resting	A	36	0	0.429	25	3	1	no	0.362
12/06/2018	34	2	Resting	A	36	0	0.429	25	3	1	no	0.497
12/06/2018	34	3	Resting	A	36	0	0.429	25	3	1	no	0.815
12/06/2018	35	1	Resting	B	41.5	0	0.089	25	3	4	no	0.408
12/06/2018	35	2	Resting	B	41.5	0	0.089	25	3	4	no	0.569
12/06/2018	35	3	Resting	B	41.5	0	0.089	25	3	4	no	0.641
12/06/2018	36	1	Resting	B	43	0	0.089	25	3	4	no	0.446
12/06/2018	36	2	Resting	B	43	0	0.089	25	3	4	no	0.595
12/06/2018	36	3	Resting	B	43	0	0.089	25	3	4	no	0.694
12/06/2018	37	1	Resting	A	45.5	NA	0.286	25	3	1	no	0.768
12/06/2018	37	2	Resting	A	45.5	NA	0.286	25	3	1	no	1.140
12/06/2018	37	3	Resting	A	45.5	NA	0.286	25	3	1	no	0.928
12/06/2018	38	1	Resting	A	32	0	0.286	25	3	1	no	0.471
12/06/2018	38	2	Resting	A	32	0	0.286	25	3	1	no	0.567
12/06/2018	38	3	Resting	A	32	0	0.286	25	3	1	no	1.012
12/06/2018	39	1	Resting	A	37.5	0	0.214	25	3	1	no	0.812
12/06/2018	39	2	Resting	A	37.5	0	0.214	25	3	1	no	0.743
12/06/2018	39	3	Resting	A	37.5	0	0.214	25	3	1	no	1.180
12/06/2018	40	1	Resting	B	41.5	NA	0.179	25	3	4	no	0.530
12/06/2018	40	2	Resting	B	41.5	NA	0.179	25	3	4	no	0.654
12/06/2018	40	3	Resting	B	41.5	NA	0.179	25	3	4	no	0.751
12/06/2018	41	1	Resting	B	45	100	0.089	25	3	4	no	0.340
12/06/2018	41	2	Resting	B	45	100	0.089	25	3	4	no	0.392
12/06/2018	41	3	Resting	B	45	100	0.089	25	3	4	no	0.516
12/06/2018	42	1	Resting	B	41	0	0.125	25	3	4	no	0.481
12/06/2018	42	2	Resting	B	41	0	0.125	25	3	4	no	0.724
12/06/2018	42	3	Resting	B	41	0	0.125	25	3	4	no	0.823
19/06/2018	19	1	Resting	B	45	650	0.057	26	3	5	no	0.345
19/06/2018	19	2	Resting	B	45	650	0.057	26	3	5	no	0.563
19/06/2018	19	3	Resting	B	45	650	0.057	26	3	5	no	0.659
19/06/2018	21	1	Resting	B	41.5	100	0.043	26	3	5	no	0.810

19/06/2018	21	2	Resting	B	41.5	100	0.043	26	3	5	no	1.065
19/06/2018	21	3	Resting	B	41.5	100	0.043	26	3	5	no	1.157
19/06/2018	23	1	Resting	A	38.5	0	0.071	26	3	2	no	0.879
19/06/2018	23	2	Resting	A	38.5	0	0.071	26	3	2	no	0.855
19/06/2018	23	3	Resting	A	38.5	0	0.071	26	3	2	no	0.816
19/06/2018	24	1	Resting	B	35.5	NA	0.057	26	3	5	no	0.438
19/06/2018	24	2	Resting	B	35.5	NA	0.057	26	3	5	no	0.600
19/06/2018	24	3	Resting	B	35.5	NA	0.057	26	3	5	no	0.626
19/06/2018	26	1	Resting	A	39.5	0	0.000	26	3	2	no	0.583
19/06/2018	26	2	Resting	A	39.5	0	0.000	26	3	2	no	0.575
19/06/2018	26	3	Resting	A	39.5	0	0.000	26	3	2	no	0.485
19/06/2018	27	1	Resting	A	43	0	0.250	26	3	2	no	0.577
19/06/2018	27	2	Resting	A	43	0	0.250	26	3	2	no	0.686
19/06/2018	27	3	Resting	A	43	0	0.250	26	3	2	no	0.679
19/06/2018	28	1	Resting	B	41.5	1100	0.086	26	3	5	no	0.512
19/06/2018	28	2	Resting	B	41.5	1100	0.086	26	3	5	no	0.492
19/06/2018	28	3	Resting	B	41.5	1100	0.086	26	3	5	no	0.485
19/06/2018	29	1	Resting	A	48.5	0	0.214	26	3	2	no	0.685
19/06/2018	29	2	Resting	A	48.5	0	0.214	26	3	2	no	0.428
19/06/2018	29	3	Resting	A	48.5	0	0.214	26	3	2	no	0.680
19/06/2018	30	1	Resting	B	40	150	0.086	26	3	5	no	0.651
19/06/2018	30	2	Resting	B	40	150	0.086	26	3	5	no	0.583
19/06/2018	30	3	Resting	B	40	150	0.086	26	3	5	no	0.686
19/06/2018	31	1	Resting	A	40	NA	0.143	26	3	2	no	0.501
19/06/2018	31	2	Resting	A	40	NA	0.143	26	3	2	no	0.503
19/06/2018	31	3	Resting	A	40	NA	0.143	26	3	2	no	0.563
19/06/2018	32	1	Resting	A	37.5	0	0.143	26	3	2	no	0.486
19/06/2018	32	2	Resting	A	37.5	0	0.143	26	3	2	no	0.680
19/06/2018	32	3	Resting	A	37.5	0	0.143	26	3	2	no	1.094
19/06/2018	33	1	Resting	B	39.5	50	0.029	26	3	5	no	1.118
19/06/2018	33	2	Resting	B	39.5	50	0.029	26	3	5	no	1.281
19/06/2018	33	3	Resting	B	39.5	50	0.029	26	3	5	no	1.336
19/06/2018	34	1	Resting	A	34.5	0	0.107	26	3	2	no	0.571
19/06/2018	34	2	Resting	A	34.5	0	0.107	26	3	2	no	0.733
19/06/2018	34	3	Resting	A	34.5	0	0.107	26	3	2	no	0.523
19/06/2018	35	1	Resting	B	41.5	200	0.071	26	3	5	no	0.480
19/06/2018	35	2	Resting	B	41.5	200	0.071	26	3	5	no	0.639
19/06/2018	35	3	Resting	B	41.5	200	0.071	26	3	5	no	0.782
19/06/2018	36	1	Resting	B	42.5	0	0.057	26	3	5	no	0.702
19/06/2018	36	2	Resting	B	42.5	0	0.057	26	3	5	no	0.470
19/06/2018	36	3	Resting	B	42.5	0	0.057	26	3	5	no	0.489
19/06/2018	37	1	Resting	A	43.5	0	0.000	26	3	2	no	0.886
19/06/2018	37	2	Resting	A	43.5	0	0.000	26	3	2	no	1.005
19/06/2018	37	3	Resting	A	43.5	0	0.000	26	3	2	no	1.111
19/06/2018	38	1	Resting	A	31.5	0	0.107	26	3	2	no	0.928
19/06/2018	38	2	Resting	A	31.5	0	0.107	26	3	2	no	1.457

19/06/2018	38	3	Resting	A	31.5	0	0.107	26	3	2	no	1.233
19/06/2018	39	1	Resting	A	37	NA	0.071	26	3	2	no	0.966
19/06/2018	39	2	Resting	A	37	NA	0.071	26	3	2	no	0.716
19/06/2018	39	3	Resting	A	37	NA	0.071	26	3	2	no	0.795
19/06/2018	40	1	Resting	B	41.5	1500	0.143	26	3	5	no	0.516
19/06/2018	40	2	Resting	B	41.5	1500	0.143	26	3	5	no	0.658
19/06/2018	40	3	Resting	B	41.5	1500	0.143	26	3	5	no	0.849
19/06/2018	41	1	Resting	B	45.5	1350	0.086	26	3	5	no	0.388
19/06/2018	41	2	Resting	B	45.5	1350	0.086	26	3	5	no	0.431
19/06/2018	41	3	Resting	B	45.5	1350	0.086	26	3	5	no	0.480
19/06/2018	42	1	Resting	B	40.5	NA	0.086	26	3	5	no	0.628
19/06/2018	42	2	Resting	B	40.5	NA	0.086	26	3	5	no	0.874
19/06/2018	42	3	Resting	B	40.5	NA	0.086	26	3	5	no	0.863
26/06/2018	1	1	Resting	C	40	0	0.000	27	3	1	yes	0.515
26/06/2018	1	2	Resting	C	40	0	0.000	27	3	1	yes	0.518
26/06/2018	1	3	Resting	C	40	0	0.000	27	3	1	yes	0.557
26/06/2018	2	1	Resting	C	38	0	0.000	27	3	1	yes	0.748
26/06/2018	2	2	Resting	C	38	0	0.000	27	3	1	yes	0.769
26/06/2018	2	3	Resting	C	38	0	0.000	27	3	1	yes	0.801
26/06/2018	3	1	Resting	C	34	0	0.000	27	3	1	yes	0.785
26/06/2018	3	2	Resting	C	34	0	0.000	27	3	1	yes	0.636
26/06/2018	3	3	Resting	C	34	0	0.000	27	3	1	yes	0.416
26/06/2018	4	1	Resting	C	45	0	0.000	27	3	1	yes	0.772
26/06/2018	4	2	Resting	C	45	0	0.000	27	3	1	yes	0.817
26/06/2018	4	3	Resting	C	45	0	0.000	27	3	1	yes	0.855
26/06/2018	5	1	Resting	C	37	0	0.000	27	3	1	yes	0.673
26/06/2018	5	2	Resting	C	37	0	0.000	27	3	1	yes	0.556
26/06/2018	5	3	Resting	C	37	0	0.000	27	3	1	yes	0.704
26/06/2018	6	1	Resting	C	40	0	0.000	27	3	1	yes	0.448
26/06/2018	6	2	Resting	C	40	0	0.000	27	3	1	yes	0.391
26/06/2018	6	3	Resting	C	40	0	0.000	27	3	1	yes	0.400
26/06/2018	23	1	Resting	A	40.5	0	0.143	27	3	3	no	1.019
26/06/2018	23	2	Resting	A	40.5	0	0.143	27	3	3	no	1.087
26/06/2018	23	3	Resting	A	40.5	0	0.143	27	3	3	no	1.335
26/06/2018	26	1	Resting	A	41	NA	0.071	27	3	3	no	0.501
26/06/2018	26	2	Resting	A	41	NA	0.071	27	3	3	no	0.520
26/06/2018	26	3	Resting	A	41	NA	0.071	27	3	3	no	0.691
26/06/2018	27	1	Resting	A	44.5	0	0.238	27	3	3	no	0.784
26/06/2018	27	2	Resting	A	44.5	0	0.238	27	3	3	no	0.762
26/06/2018	27	3	Resting	A	44.5	0	0.238	27	3	3	no	0.849
26/06/2018	29	1	Resting	A	48.5	0	0.143	27	3	3	no	0.748
26/06/2018	29	2	Resting	A	48.5	0	0.143	27	3	3	no	0.613
26/06/2018	29	3	Resting	A	48.5	0	0.143	27	3	3	no	0.667
26/06/2018	31	1	Resting	A	41.5	NA	0.167	27	3	3	no	1.047
26/06/2018	31	2	Resting	A	41.5	NA	0.167	27	3	3	no	0.950
26/06/2018	31	3	Resting	A	41.5	NA	0.167	27	3	3	no	0.875

26/06/2018	32	1	Resting	A	39.5	0	0.190	27	3	3	no	0.630
26/06/2018	32	2	Resting	A	39.5	0	0.190	27	3	3	no	0.414
26/06/2018	32	3	Resting	A	39.5	0	0.190	27	3	3	no	0.667
26/06/2018	34	1	Resting	A	35.5	0	0.119	27	3	3	no	0.503
26/06/2018	34	2	Resting	A	35.5	0	0.119	27	3	3	no	0.677
26/06/2018	34	3	Resting	A	35.5	0	0.119	27	3	3	no	0.756
26/06/2018	37	1	Resting	A	44.5	0	0.048	27	3	3	no	0.491
26/06/2018	37	2	Resting	A	44.5	0	0.048	27	3	3	no	0.693
26/06/2018	37	3	Resting	A	44.5	0	0.048	27	3	3	no	0.619
26/06/2018	38	1	Resting	A	32	50	0.095	27	3	3	no	0.590
26/06/2018	38	2	Resting	A	32	50	0.095	27	3	3	no	0.713
26/06/2018	38	3	Resting	A	32	50	0.095	27	3	3	no	1.141
26/06/2018	39	1	Resting	A	38.5	0	0.119	27	3	3	no	1.397
26/06/2018	39	2	Resting	A	38.5	0	0.119	27	3	3	no	1.072
26/06/2018	39	3	Resting	A	38.5	0	0.119	27	3	3	no	1.077
03/07/2018	1	1	Resting	C	41.5	0	0.214	28	3	1	yes	0.478
03/07/2018	1	2	Resting	C	41.5	0	0.214	28	3	1	yes	0.619
03/07/2018	1	3	Resting	C	41.5	0	0.214	28	3	1	yes	0.613
03/07/2018	2	1	Resting	C	39.5	0	0.214	28	3	1	yes	1.009
03/07/2018	2	2	Resting	C	39.5	0	0.214	28	3	1	yes	1.292
03/07/2018	2	3	Resting	C	39.5	0	0.214	28	3	1	yes	1.151
03/07/2018	3	1	Resting	C	36.5	0	0.357	28	3	1	yes	0.926
03/07/2018	3	2	Resting	C	36.5	0	0.357	28	3	1	yes	1.178
03/07/2018	3	3	Resting	C	36.5	0	0.357	28	3	1	yes	0.887
03/07/2018	4	1	Resting	C	46.5	0	0.214	28	3	1	yes	0.722
03/07/2018	4	2	Resting	C	46.5	0	0.214	28	3	1	yes	0.892
03/07/2018	4	3	Resting	C	46.5	0	0.214	28	3	1	yes	0.762
03/07/2018	5	1	Resting	C	40	0	0.429	28	3	1	yes	0.656
03/07/2018	5	2	Resting	C	40	0	0.429	28	3	1	yes	0.868
03/07/2018	5	3	Resting	C	40	0	0.429	28	3	1	yes	0.732
03/07/2018	6	1	Resting	C	41.5	0	0.214	28	3	1	yes	0.511
03/07/2018	6	2	Resting	C	41.5	0	0.214	28	3	1	yes	0.432
03/07/2018	6	3	Resting	C	41.5	0	0.214	28	3	1	yes	0.557
03/07/2018	19	1	Resting	B	42	0	NA	28	4	1	no	0.561
03/07/2018	19	2	Resting	B	42	0	NA	28	4	1	no	0.439
03/07/2018	19	3	Resting	B	42	0	NA	28	4	1	no	0.519
03/07/2018	21	1	Resting	B	43.5	0	0.143	28	4	1	no	1.138
03/07/2018	21	2	Resting	B	43.5	0	0.143	28	4	1	no	1.304
03/07/2018	21	3	Resting	B	43.5	0	0.143	28	4	1	no	1.266
03/07/2018	23	1	Resting	A	42	0	0.161	28	4	4	no	1.337
03/07/2018	23	2	Resting	A	42	0	0.161	28	4	4	no	1.410
03/07/2018	23	3	Resting	A	42	0	0.161	28	4	4	no	1.230
03/07/2018	24	1	Resting	B	38	0	0.214	28	4	1	no	0.724
03/07/2018	24	2	Resting	B	38	0	0.214	28	4	1	no	0.835
03/07/2018	24	3	Resting	B	38	0	0.214	28	4	1	no	0.679
03/07/2018	26	1	Resting	A	41.5	NA	0.071	28	4	4	no	0.862

03/07/2018	26	2	Resting	A	41.5	NA	0.071	28	4	4	no	0.801
03/07/2018	26	3	Resting	A	41.5	NA	0.071	28	4	4	no	0.642
03/07/2018	27	1	Resting	A	46	0	0.232	28	4	4	no	0.884
03/07/2018	27	2	Resting	A	46	0	0.232	28	4	4	no	1.078
03/07/2018	27	3	Resting	A	46	0	0.232	28	4	4	no	1.003
03/07/2018	28	1	Resting	B	44	0	0.143	28	4	1	no	0.467
03/07/2018	28	2	Resting	B	44	0	0.143	28	4	1	no	0.617
03/07/2018	28	3	Resting	B	44	0	0.143	28	4	1	no	0.638
03/07/2018	29	1	Resting	A	49	0	0.125	28	4	4	no	0.789
03/07/2018	29	2	Resting	A	49	0	0.125	28	4	4	no	0.831
03/07/2018	29	3	Resting	A	49	0	0.125	28	4	4	no	0.766
03/07/2018	30	1	Resting	B	42.5	0	0.643	28	4	1	no	0.746
03/07/2018	30	2	Resting	B	42.5	0	0.643	28	4	1	no	1.060
03/07/2018	30	3	Resting	B	42.5	0	0.643	28	4	1	no	0.847
03/07/2018	31	1	Resting	A	42	NA	0.143	28	4	4	no	0.975
03/07/2018	31	2	Resting	A	42	NA	0.143	28	4	4	no	1.350
03/07/2018	31	3	Resting	A	42	NA	0.143	28	4	4	no	1.120
03/07/2018	32	1	Resting	A	39.5	NA	0.143	28	4	4	no	0.728
03/07/2018	32	2	Resting	A	39.5	NA	0.143	28	4	4	no	0.974
03/07/2018	32	3	Resting	A	39.5	NA	0.143	28	4	4	no	0.711
03/07/2018	33	1	Resting	B	41	0	0.214	28	4	1	no	1.291
03/07/2018	33	2	Resting	B	41	0	0.214	28	4	1	no	1.515
03/07/2018	33	3	Resting	B	41	0	0.214	28	4	1	no	1.356
03/07/2018	34	1	Resting	A	36.5	0	0.125	28	4	4	no	1.041
03/07/2018	34	2	Resting	A	36.5	0	0.125	28	4	4	no	0.934
03/07/2018	34	3	Resting	A	36.5	0	0.125	28	4	4	no	0.799
03/07/2018	35	1	Resting	B	49	0	0.929	28	4	1	no	0.613
03/07/2018	35	2	Resting	B	49	0	0.929	28	4	1	no	0.817
03/07/2018	35	3	Resting	B	49	0	0.929	28	4	1	no	0.830
03/07/2018	36	1	Resting	B	45.5	0	0.214	28	4	1	no	0.562
03/07/2018	36	2	Resting	B	45.5	0	0.214	28	4	1	no	0.759
03/07/2018	36	3	Resting	B	45.5	0	0.214	28	4	1	no	0.647
03/07/2018	37	1	Resting	A	44.5	0	0.036	28	4	4	no	0.994
03/07/2018	37	2	Resting	A	44.5	0	0.036	28	4	4	no	1.276
03/07/2018	37	3	Resting	A	44.5	0	0.036	28	4	4	no	1.088
03/07/2018	38	1	Resting	A	33	0	0.107	28	4	4	no	0.956
03/07/2018	38	2	Resting	A	33	0	0.107	28	4	4	no	1.267
03/07/2018	38	3	Resting	A	33	0	0.107	28	4	4	no	1.069
03/07/2018	39	1	Resting	A	39	0	0.107	28	4	4	no	1.315
03/07/2018	39	2	Resting	A	39	0	0.107	28	4	4	no	1.388
03/07/2018	39	3	Resting	A	39	0	0.107	28	4	4	no	1.288
03/07/2018	40	1	Resting	B	45.5	0	0.500	28	4	1	no	0.450
03/07/2018	40	2	Resting	B	45.5	0	0.500	28	4	1	no	0.593
03/07/2018	40	3	Resting	B	45.5	0	0.500	28	4	1	no	0.508
03/07/2018	41	1	Resting	B	48.5	0	0.000	28	4	1	no	0.723
03/07/2018	41	2	Resting	B	48.5	0	0.000	28	4	1	no	0.596

03/07/2018	41	3	Resting	B	48.5	0	0.000	28	4	1	no	0.554
03/07/2018	42	1	Resting	B	44.5	0	0.429	28	4	1	no	0.724
03/07/2018	42	2	Resting	B	44.5	0	0.429	28	4	1	no	1.361
03/07/2018	42	3	Resting	B	44.5	0	0.429	28	4	1	no	1.100
10/07/2018	1	1	Resting	C	40.5	0	-0.143	29	4	1	yes	0.547
10/07/2018	1	2	Resting	C	40.5	0	-0.143	29	4	1	yes	0.764
10/07/2018	1	3	Resting	C	40.5	0	-0.143	29	4	1	yes	0.413
10/07/2018	2	1	Resting	C	40	0	0.071	29	4	1	yes	0.787
10/07/2018	2	2	Resting	C	40	0	0.071	29	4	1	yes	1.101
10/07/2018	2	3	Resting	C	40	0	0.071	29	4	1	yes	0.814
10/07/2018	3	1	Resting	C	36	0	-0.071	29	4	1	yes	0.680
10/07/2018	3	2	Resting	C	36	0	-0.071	29	4	1	yes	0.761
10/07/2018	3	3	Resting	C	36	0	-0.071	29	4	1	yes	0.597
10/07/2018	4	1	Resting	C	45.5	0	-0.143	29	4	1	yes	0.800
10/07/2018	4	2	Resting	C	45.5	0	-0.143	29	4	1	yes	0.720
10/07/2018	4	3	Resting	C	45.5	0	-0.143	29	4	1	yes	0.717
10/07/2018	5	1	Resting	C	40.5	0	0.071	29	4	1	yes	0.696
10/07/2018	5	2	Resting	C	40.5	0	0.071	29	4	1	yes	0.737
10/07/2018	5	3	Resting	C	40.5	0	0.071	29	4	1	yes	0.566
10/07/2018	6	1	Resting	C	41.5	NA	0.000	29	4	1	yes	0.401
10/07/2018	6	2	Resting	C	41.5	NA	0.000	29	4	1	yes	0.648
10/07/2018	6	3	Resting	C	41.5	NA	0.000	29	4	1	yes	0.417
10/07/2018	19	1	Resting	B	48	0	0.071	29	4	2	no	0.426
10/07/2018	19	2	Resting	B	48	0	0.071	29	4	2	no	0.413
10/07/2018	19	3	Resting	B	48	0	0.071	29	4	2	no	0.466
10/07/2018	21	1	Resting	B	41.5	0	-0.071	29	4	2	no	1.422
10/07/2018	21	2	Resting	B	41.5	0	-0.071	29	4	2	no	1.009
10/07/2018	21	3	Resting	B	41.5	0	-0.071	29	4	2	no	0.929
10/07/2018	23	1	Resting	A	40.5	0	0.086	29	4	5	no	0.679
10/07/2018	23	2	Resting	A	40.5	0	0.086	29	4	5	no	0.777
10/07/2018	23	3	Resting	A	40.5	0	0.086	29	4	5	no	0.703
10/07/2018	24	1	Resting	B	37.5	0	0.071	29	4	2	no	0.527
10/07/2018	24	2	Resting	B	37.5	0	0.071	29	4	2	no	0.749
10/07/2018	24	3	Resting	B	37.5	0	0.071	29	4	2	no	0.670
10/07/2018	26	1	Resting	A	41	0	0.043	29	4	5	no	0.779
10/07/2018	26	2	Resting	A	41	0	0.043	29	4	5	no	0.662
10/07/2018	26	3	Resting	A	41	0	0.043	29	4	5	no	0.613
10/07/2018	27	1	Resting	A	45.5	0	0.171	29	4	5	no	0.856
10/07/2018	27	2	Resting	A	45.5	0	0.171	29	4	5	no	1.233
10/07/2018	27	3	Resting	A	45.5	0	0.171	29	4	5	no	1.111
10/07/2018	28	1	Resting	B	45.5	0	0.179	29	4	2	no	0.464
10/07/2018	28	2	Resting	B	45.5	0	0.179	29	4	2	no	0.588
10/07/2018	28	3	Resting	B	45.5	0	0.179	29	4	2	no	0.403
10/07/2018	29	1	Resting	A	49	50	0.100	29	4	5	no	0.576
10/07/2018	29	2	Resting	A	49	50	0.100	29	4	5	no	0.790
10/07/2018	29	3	Resting	A	49	50	0.100	29	4	5	no	0.741

10/07/2018	30	1	Resting	B	41.5	NA	0.250	29	4	2	no	0.999
10/07/2018	30	2	Resting	B	41.5	NA	0.250	29	4	2	no	0.792
10/07/2018	30	3	Resting	B	41.5	NA	0.250	29	4	2	no	0.825
10/07/2018	31	1	Resting	A	42	NA	0.114	29	4	5	no	0.697
10/07/2018	31	2	Resting	A	42	NA	0.114	29	4	5	no	0.712
10/07/2018	31	3	Resting	A	42	NA	0.114	29	4	5	no	0.562
10/07/2018	32	1	Resting	A	39.5	0	0.114	29	4	5	no	0.670
10/07/2018	32	2	Resting	A	39.5	0	0.114	29	4	5	no	0.590
10/07/2018	32	3	Resting	A	39.5	0	0.114	29	4	5	no	0.463
10/07/2018	33	1	Resting	B	42	0	0.179	29	4	2	no	1.039
10/07/2018	33	2	Resting	B	42	0	0.179	29	4	2	no	1.132
10/07/2018	33	3	Resting	B	42	0	0.179	29	4	2	no	1.305
10/07/2018	34	1	Resting	A	36.5	NA	0.100	29	4	5	no	0.635
10/07/2018	34	2	Resting	A	36.5	NA	0.100	29	4	5	no	0.651
10/07/2018	34	3	Resting	A	36.5	NA	0.100	29	4	5	no	0.556
10/07/2018	35	1	Resting	B	44	0	0.107	29	4	2	no	0.532
10/07/2018	35	2	Resting	B	44	0	0.107	29	4	2	no	0.685
10/07/2018	35	3	Resting	B	44	0	0.107	29	4	2	no	0.566
10/07/2018	36	1	Resting	B	45	0	0.071	29	4	2	no	0.592
10/07/2018	36	2	Resting	B	45	0	0.071	29	4	2	no	0.563
10/07/2018	36	3	Resting	B	45	0	0.071	29	4	2	no	0.454
10/07/2018	37	1	Resting	A	46	0	0.071	29	4	5	no	0.859
10/07/2018	37	2	Resting	A	46	0	0.071	29	4	5	no	1.103
10/07/2018	37	3	Resting	A	46	0	0.071	29	4	5	no	0.506
10/07/2018	38	1	Resting	A	32	0	0.057	29	4	5	no	1.403
10/07/2018	38	2	Resting	A	32	0	0.057	29	4	5	no	1.349
10/07/2018	38	3	Resting	A	32	0	0.057	29	4	5	no	1.461
10/07/2018	39	1	Resting	A	38.5	50	0.071	29	4	5	no	0.389
10/07/2018	39	2	Resting	A	38.5	50	0.071	29	4	5	no	0.597
10/07/2018	39	3	Resting	A	38.5	50	0.071	29	4	5	no	0.319
10/07/2018	40	1	Resting	B	44	0	0.143	29	4	2	no	0.614
10/07/2018	40	2	Resting	B	44	0	0.143	29	4	2	no	0.547
10/07/2018	40	3	Resting	B	44	0	0.143	29	4	2	no	0.512
10/07/2018	41	1	Resting	B	48.5	0	0.000	29	4	2	no	0.801
10/07/2018	41	2	Resting	B	48.5	0	0.000	29	4	2	no	0.674
10/07/2018	41	3	Resting	B	48.5	0	0.000	29	4	2	no	0.500
10/07/2018	42	1	Resting	B	43	0	0.107	29	4	2	no	0.774
10/07/2018	42	2	Resting	B	43	0	0.107	29	4	2	no	0.640
10/07/2018	42	3	Resting	B	43	0	0.107	29	4	2	no	0.531
17/07/2018	1	1	Resting	C	42	0	0.214	30	4	1	yes	0.420
17/07/2018	1	2	Resting	C	42	0	0.214	30	4	1	yes	0.519
17/07/2018	2	1	Resting	C	41.5	0	0.214	30	4	1	yes	1.351
17/07/2018	2	2	Resting	C	41.5	0	0.214	30	4	1	yes	1.156
17/07/2018	3	1	Resting	C	39	0	0.429	30	4	1	yes	1.116
17/07/2018	3	2	Resting	C	39	0	0.429	30	4	1	yes	0.588
17/07/2018	4	1	Resting	C	48.5	0	0.429	30	4	1	yes	0.622

17/07/2018	4	2	Resting	C	48.5	0	0.429	30	4	1	yes	0.883
17/07/2018	5	1	Resting	C	42	0	0.214	30	4	1	yes	0.885
17/07/2018	5	2	Resting	C	42	0	0.214	30	4	1	yes	0.875
17/07/2018	6	1	Resting	C	42.5	NA	0.143	30	4	1	yes	0.551
17/07/2018	6	2	Resting	C	42.5	NA	0.143	30	4	1	yes	0.651
17/07/2018	19	1	Resting	B	50.5	0	0.167	30	4	3	no	0.456
17/07/2018	19	2	Resting	B	50.5	0	0.167	30	4	3	no	0.574
17/07/2018	21	1	Resting	B	44	0	0.071	30	4	3	no	1.350
17/07/2018	21	2	Resting	B	44	0	0.071	30	4	3	no	1.373
17/07/2018	24	1	Resting	B	39	0	0.119	30	4	3	no	0.996
17/07/2018	24	2	Resting	B	39	0	0.119	30	4	3	no	1.149
17/07/2018	28	1	Resting	B	45	0	0.095	30	4	3	no	0.404
17/07/2018	28	2	Resting	B	45	0	0.095	30	4	3	no	0.381
17/07/2018	30	1	Resting	B	42.5	0	0.214	30	4	3	no	0.713
17/07/2018	30	2	Resting	B	42.5	0	0.214	30	4	3	no	0.882
17/07/2018	33	1	Resting	B	41.5	0	0.095	30	4	3	no	1.103
17/07/2018	33	2	Resting	B	41.5	0	0.095	30	4	3	no	1.181
17/07/2018	35	1	Resting	B	44.5	0	0.095	30	4	3	no	0.968
17/07/2018	35	2	Resting	B	44.5	0	0.095	30	4	3	no	0.814
17/07/2018	36	1	Resting	B	45	0	0.048	30	4	3	no	0.814
17/07/2018	36	2	Resting	B	45	0	0.048	30	4	3	no	0.624
17/07/2018	40	1	Resting	B	43.5	0	0.071	30	4	3	no	0.603
17/07/2018	40	2	Resting	B	43.5	0	0.071	30	4	3	no	0.458
17/07/2018	41	1	Resting	B	49	0	0.024	30	4	3	no	0.521
17/07/2018	41	2	Resting	B	49	0	0.024	30	4	3	no	0.498
17/07/2018	42	1	Resting	B	44	0	0.119	30	4	3	no	0.879
17/07/2018	42	2	Resting	B	44	0	0.119	30	4	3	no	1.053
31/07/2018	1	1	Resting	C	42.5	0	0.214	32	4	1	yes	0.367
31/07/2018	1	2	Resting	C	42.5	0	0.214	32	4	1	yes	0.435
31/07/2018	1	3	Resting	C	42.5	0	0.214	32	4	1	yes	0.525
31/07/2018	2	1	Resting	C	41.5	0	0.143	32	4	1	yes	0.855
31/07/2018	2	2	Resting	C	41.5	0	0.143	32	4	1	yes	0.826
31/07/2018	2	3	Resting	C	41.5	0	0.143	32	4	1	yes	1.179
31/07/2018	3	1	Resting	C	40	0	0.429	32	4	1	yes	0.604
31/07/2018	3	2	Resting	C	40	0	0.429	32	4	1	yes	0.707
31/07/2018	3	3	Resting	C	40	0	0.429	32	4	1	yes	0.954
31/07/2018	4	1	Resting	C	47.5	0	0.214	32	4	1	yes	0.571
31/07/2018	4	2	Resting	C	47.5	0	0.214	32	4	1	yes	0.669
31/07/2018	4	3	Resting	C	47.5	0	0.214	32	4	1	yes	0.659
31/07/2018	5	1	Resting	C	43	0	0.071	32	4	1	yes	1.010
31/07/2018	5	2	Resting	C	43	0	0.071	32	4	1	yes	1.004
31/07/2018	5	3	Resting	C	43	0	0.071	32	4	1	yes	0.994
31/07/2018	6	1	Resting	C	44	0	0.214	32	4	1	yes	0.420
31/07/2018	6	2	Resting	C	44	0	0.214	32	4	1	yes	0.470
31/07/2018	6	3	Resting	C	44	0	0.214	32	4	1	yes	1.005
31/07/2018	19	1	Resting	B	49.5	0	0.071	32	4	5	no	0.557

31/07/2018	19	2	Resting	B	49.5	0	0.071	32	4	5	no	0.666
31/07/2018	19	3	Resting	B	49.5	0	0.071	32	4	5	no	1.087
31/07/2018	21	1	Resting	B	44	0	0.043	32	4	5	no	1.289
31/07/2018	21	2	Resting	B	44	0	0.043	32	4	5	no	1.293
31/07/2018	21	3	Resting	B	44	0	0.043	32	4	5	no	1.049
31/07/2018	23	1	Resting	A	40.5	0	-0.107	32	4	2	no	1.047
31/07/2018	23	2	Resting	A	40.5	0	-0.107	32	4	2	no	1.076
31/07/2018	23	3	Resting	A	40.5	0	-0.107	32	4	2	no	1.003
31/07/2018	24	1	Resting	B	38.5	0	0.057	32	4	5	no	0.594
31/07/2018	24	2	Resting	B	38.5	0	0.057	32	4	5	no	0.646
31/07/2018	24	3	Resting	B	38.5	0	0.057	32	4	5	no	0.605
31/07/2018	26	1	Resting	A	41	0	-0.107	32	4	2	no	0.769
31/07/2018	26	2	Resting	A	41	0	-0.107	32	4	2	no	1.165
31/07/2018	26	3	Resting	A	41	0	-0.107	32	4	2	no	0.688
31/07/2018	27	1	Resting	A	46	0	-0.036	32	4	2	no	0.699
31/07/2018	27	2	Resting	A	46	0	-0.036	32	4	2	no	0.787
31/07/2018	27	3	Resting	A	46	0	-0.036	32	4	2	no	0.668
31/07/2018	28	1	Resting	B	46	50	0.086	32	4	5	no	0.694
31/07/2018	28	2	Resting	B	46	50	0.086	32	4	5	no	0.757
31/07/2018	28	3	Resting	B	46	50	0.086	32	4	5	no	0.692
31/07/2018	29	1	Resting	A	48.5	0	-0.143	32	4	2	no	0.980
31/07/2018	29	2	Resting	A	48.5	0	-0.143	32	4	2	no	0.659
31/07/2018	29	3	Resting	A	48.5	0	-0.143	32	4	2	no	0.998
31/07/2018	30	1	Resting	B	41.5	0	0.100	32	4	5	no	0.957
31/07/2018	30	2	Resting	B	41.5	0	0.100	32	4	5	no	0.978
31/07/2018	30	3	Resting	B	41.5	0	0.100	32	4	5	no	1.038
31/07/2018	31	1	Resting	A	43	0	0.000	32	4	2	no	0.650
31/07/2018	31	2	Resting	A	43	0	0.000	32	4	2	no	0.829
31/07/2018	31	3	Resting	A	43	0	0.000	32	4	2	no	0.778
31/07/2018	32	1	Resting	A	41	0	0.143	32	4	2	no	0.456
31/07/2018	32	2	Resting	A	41	0	0.143	32	4	2	no	0.734
31/07/2018	32	3	Resting	A	41	0	0.143	32	4	2	no	0.428
31/07/2018	33	1	Resting	B	42	0	0.071	32	4	5	no	1.023
31/07/2018	33	2	Resting	B	42	0	0.071	32	4	5	no	1.082
31/07/2018	33	3	Resting	B	42	0	0.071	32	4	5	no	1.093
31/07/2018	34	1	Resting	A	37	0	-0.036	32	4	2	no	1.055
31/07/2018	34	2	Resting	A	37	0	-0.036	32	4	2	no	0.817
31/07/2018	34	3	Resting	A	37	0	-0.036	32	4	2	no	0.655
31/07/2018	35	1	Resting	B	44.5	50	0.057	32	4	5	no	0.442
31/07/2018	35	2	Resting	B	44.5	50	0.057	32	4	5	no	NA
31/07/2018	35	3	Resting	B	44.5	50	0.057	32	4	5	no	NA
31/07/2018	36	1	Resting	B	45	50	0.029	32	4	5	no	0.494
31/07/2018	36	2	Resting	B	45	50	0.029	32	4	5	no	0.697
31/07/2018	36	3	Resting	B	45	50	0.029	32	4	5	no	0.633
31/07/2018	37	1	Resting	A	44.5	0	-0.071	32	4	2	no	1.248
31/07/2018	37	2	Resting	A	44.5	0	-0.071	32	4	2	no	1.006

31/07/2018	37	3	Resting	A	44.5	0	-0.071	32	4	2	no	1.063
31/07/2018	38	1	Resting	A	33	0	0.036	32	4	2	no	0.772
31/07/2018	38	2	Resting	A	33	0	0.036	32	4	2	no	1.106
31/07/2018	38	3	Resting	A	33	0	0.036	32	4	2	no	1.181
31/07/2018	39	1	Resting	A	40.5	0	0.500	32	4	2	no	1.773
31/07/2018	39	2	Resting	A	40.5	0	0.500	32	4	2	no	1.537
31/07/2018	39	3	Resting	A	40.5	0	0.500	32	4	2	no	1.417
31/07/2018	40	1	Resting	B	43.5	0	0.043	32	4	5	no	0.734
31/07/2018	40	2	Resting	B	43.5	0	0.043	32	4	5	no	0.727
31/07/2018	40	3	Resting	B	43.5	0	0.043	32	4	5	no	0.874
31/07/2018	41	1	Resting	B	49	0	0.014	32	4	5	no	0.506
31/07/2018	41	2	Resting	B	49	0	0.014	32	4	5	no	0.625
31/07/2018	41	3	Resting	B	49	0	0.014	32	4	5	no	0.529
31/07/2018	42	1	Resting	B	44.5	0	0.086	32	4	5	no	0.783
31/07/2018	42	2	Resting	B	44.5	0	0.086	32	4	5	no	1.034
31/07/2018	42	3	Resting	B	44.5	0	0.086	32	4	5	no	0.875

Appendix 5-5 Summary of logistic regression models of the proportion of time spent grazing or walking or resting in relation to other activities

	Estimate	SE	2.50%	97.50%	p
Resting/ Total model					
(Intercept)	1.93	0.04	1.856828	2.004821	< 2e-16
WPT	0.02	0.00	0.01523	0.016621	< 2e-16
Period	0.01	0.00	0.008624	0.016175	1.22E-10
Day	-0.03	0.00	-0.02785	-0.02539	< 2e-16
Co-grazing (Yes)	-0.15	0.00	-0.15024	-0.14193	< 2e-16
LW	-0.04	0.00	-0.04156	-0.04033	< 2e-16
Waliking/ Total model					
	Estimate	SE	2.50%	97.50%	p
(Intercept)	-6.05196	0.13666	-6.3198	-5.78411	< 2e-16
WPT	-0.00921	0.001612	-0.01237	-0.00605	1.11E-08
Period	0.671909	0.00907	0.654132	0.689686	< 2e-16
Day	0.123977	0.002841	0.118409	0.129546	< 2e-16
Co-grazing (Yes)	0.300335	0.01038	0.279991	0.32068	< 2e-16
LW	0.005953	0.001444	0.003122	0.008784	3.77E-05
Grazing/ Total model					
	Estimate	SE	2.50%	97.50%	p
Grazing: Total model:	-1.88674	0.037159	-1.95957	-1.81391	<2e-16
WPT	-0.01544	0.000356	-0.01614	-0.01474	<2e-16
Period	-0.04614	0.001936	-0.04993	-0.04234	<2e-16
Co-grazing (yes)	0.132462	0.002128	0.128291	0.136633	<2e-16
weight	0.041195	0.000314	0.040579	0.04181	<2e-16

WPT = Week post treatment; LW= liveweight

Appendix 5-6 Summary of generalised linear mixed models for activity levels of lambs by week post treat and faecal egg counts

VeDBA$_{WALKING}$:					
	Estimate	SE	df	t value	p
(Intercept)	8.15E-01	3.28E-02	4.70E+02	24.879	< 2e-16
FEC	-4.12E-05	1.12E-05	1.05E+03	-3.684	0.000241
Co-grazing lambs (yes)	7.38E-02	1.69E-02	2.18E+02	4.363	1.98E-05
Liveweight_cs	-2.50E-02	7.91E-03	4.49E+02	-3.155	0.00171
Period2	-3.93E-02	2.44E-02	1.06E+03	-1.613	0.107125
Period3	-1.84E-02	3.69E-02	1.04E+03	-0.498	0.618393
Period4	1.16E-01	4.56E-02	1.04E+03	2.538	0.011294
Day	3.55E-02	3.78E-03	1.03E+03	9.391	< 2e-16
Week since start_cs	5.66E-02	1.85E-02	9.19E+02	3.059	0.002286
	Estimate	Std. Error	df	t value	p
(Intercept)	8.34E-01	3.34E-02	5.86E+02	24.98	< 2e-16
Week Post Treatment	-5.40E-03	2.11E-03	1.12E+03	-2.566	0.010426
Co-grazing lambs (yes)	6.08E-02	1.66E-02	2.30E+02	3.663	0.000309
Liveweight_cs	-1.98E-02	7.74E-03	4.46E+02	-2.564	0.010679
Period2	-4.04E-02	2.41E-02	1.13E+03	-1.677	0.093823
Period3	-1.88E-02	3.66E-02	1.11E+03	-0.512	0.608422
Period4	1.18E-01	4.46E-02	1.10E+03	2.655	0.008036
Day	3.49E-02	3.69E-03	1.09E+03	9.455	< 2e-16
Week since start_cs	4.67E-02	1.80E-02	9.92E+02	2.598	0.009517

VeDBA$_{STANDING}$:					
	Estimate	SE	df	t value	p
(Intercept)	-2.00E-01	1.25E-01	2.24E+00	-1.605	0.236
Week Post Treatment	5.58E-03	7.01E-03	1.10E+03	0.795	0.427
Co-grazing lambs (yes)	-3.34E-01	3.78E-02	8.86E+02	-8.821	< 2e-16
Liveweight_cs	-3.42E-02	2.47E-02	3.83E+02	-1.385	0.167
Day	5.43E-02	1.23E-02	1.10E+03	4.435	1.01E-05
Week since start_cs	-1.70E-01	2.72E-02	6.82E+02	-6.252	7.13E-10
	Estimate	SE	df	t value	p
(Intercept)	-2.17E-01	1.04E-01	2.20E+00	-2.083	0.16084
FEC	-1.10E-04	3.67E-05	1.05E+03	-3.003	0.00274
Co-grazing lambs (yes)	-2.90E-01	3.97E-02	6.10E+02	-7.312	8.29E-13
Liveweight_cs	-5.25E-02	2.52E-02	3.60E+02	-2.084	0.03787
Day	5.49E-02	1.26E-02	1.04E+03	4.349	1.51E-05
Week since start_cs	-1.45E-01	2.82E-02	5.28E+02	-5.141	3.85E-07

VeDBA$_{GRAZING}$:

	Estimate	SE	df	t value	p
(Intercept)	6.043404	0.297683	50.02048	20.301	< 2e-16
FEC	-0.00069	0.00017	1048.765	-4.045	5.61E-05
Co-grazing lambs (yes)	0.555209	0.179933	890.2153	3.086	0.00209
Liveweight_cs	0.783772	0.124672	763.2799	6.287	5.45E-10
Day	0.127993	0.058517	1037.345	2.187	0.02894
Week since start_cs	-0.96841	0.132894	705.4957	-7.287	8.5E-13
	Estimate	SE	df	t value	p
(Intercept)	6.07E+00	3.07E-01	5.99E+01	19.798	< 2e-16
Week Post Treatment	-6.34E-03	3.28E-02	1.12E+03	-0.193	0.8466
Co-grazing lambs (yes)	3.82E-01	1.73E-01	9.77E+02	2.21	0.0273
Liveweight_cs	8.21E-01	1.23E-01	8.07E+02	6.652	5.34E-11
Day	1.33E-01	5.75E-02	1.10E+03	2.316	0.0208
Week since start_cs	-1.07E+00	1.29E-01	7.71E+02	-8.298	4.73E-16

Appendix 6. Supplementary data for Chapter 6

Appendix 6-1 Data table of activity budgets, faecal egg counts and performance metrics of adult ewes

Sheep ID	Day	LW1	LW2	LW3	LWG	FEC1	FEC2	FEC3	BCS1	BCS2	Grazing	Resting	Walking
391	1	60	60.8	60.5	-0.02	100	50	50	2.5	2	2953	13558	48
391	2	60	60.8	60.5	-0.02	100	50	50	2.5	2	2953	13559	47
391	3	60	60.8	60.5	-0.02	100	50	50	2.5	2	2265	14124	170
391	4	60	60.8	60.5	-0.02	100	50	50	2.5	2	2417	14786	77
391	5	60	60.8	60.5	-0.02	100	50	50	2.5	2	1990	15207	83
391	6	60	60.8	60.5	-0.02	100	50	50	2.5	2	2212	14993	75
391	7	60	60.8	60.5	-0.02	100	50	50	2.5	2	2342	14888	50
391	8	60	60.8	60.5	-0.02	100	50	50	2.5	2	2175	15026	79
391	9	60	60.8	60.5	-0.02	100	50	50	2.5	2	2220	15006	54
391	10	60	60.8	60.5	-0.02	100	50	50	2.5	2	1520	15717	43
454	1	56	57.6	58	0.03	200	50	200	2.5	2	5532	10970	57
454	2	56	57.6	58	0.03	200	50	200	2.5	2	5723	10775	61
454	3	56	57.6	58	0.03	200	50	200	2.5	2	4034	12359	166
454	4	56	57.6	58	0.03	200	50	200	2.5	2	3818	13422	40
454	5	56	57.6	58	0.03	200	50	200	2.5	2	4721	12472	87
454	6	56	57.6	58	0.03	200	50	200	2.5	2	4799	12409	72
454	7	56	57.6	58	0.03	200	50	200	2.5	2	5504	11699	77
454	8	56	57.6	58	0.03	200	50	200	2.5	2	5639	11553	88
454	9	56	57.6	58	0.03	200	50	200	2.5	2	5803	11421	56
454	10	56	57.6	58	0.03	200	50	200	2.5	2	5516	11709	55
418	1	59.5	64.8	64	-0.06	450	50	100	2.5	2.5	5190	11302	67
418	2	59.5	64.8	64	-0.06	450	50	100	2.5	2.5	5353	11123	83
418	3	59.5	64.8	64	-0.06	450	50	100	2.5	2.5	3206	13199	154
418	4	59.5	64.8	64	-0.06	450	50	100	2.5	2.5	2969	14287	24
418	5	59.5	64.8	64	-0.06	450	50	100	2.5	2.5	3760	13477	43
418	6	59.5	64.8	64	-0.06	450	50	100	2.5	2.5	3623	13581	76
418	7	59.5	64.8	64	-0.06	450	50	100	2.5	2.5	5109	12096	75
418	8	59.5	64.8	64	-0.06	450	50	100	2.5	2.5	4980	12224	76
418	9	59.5	64.8	64	-0.06	450	50	100	2.5	2.5	4929	12242	109
418	10	59.5	64.8	64	-0.06	450	50	100	2.5	2.5	6052	11136	92
376	1	65	65.4	66.5	0.08	0	100	150	2	2	5839	10282	438
376	2	65	65.4	66.5	0.08	0	100	150	2	2	5986	10270	303
376	3	65	65.4	66.5	0.08	0	100	150	2	2	4967	11255	337
376	4	65	65.4	66.5	0.08	0	100	150	2	2	7784	9280	216
376	5	65	65.4	66.5	0.08	0	100	150	2	2	7729	9330	221
376	6	65	65.4	66.5	0.08	0	100	150	2	2	7328	9687	265
376	7	65	65.4	66.5	0.08	0	100	150	2	2	7213	9852	215

376	8	65	65.4	66.5	0.08	0	100	150	2	2	7883	9120	277
376	9	65	65.4	66.5	0.08	0	100	150	2	2	8466	8578	236
376	10	65	65.4	66.5	0.08	0	100	150	2	2	8269	8869	142
394	1	58.5	61.2	60	-0.09	0	50	100	2.5	2.5	7223	9143	193
394	2	58.5	61.2	60	-0.09	0	50	100	2.5	2.5	7900	8442	217
394	3	58.5	61.2	60	-0.09	0	50	100	2.5	2.5	4905	11312	342
394	4	58.5	61.2	60	-0.09	0	50	100	2.5	2.5	6229	10891	160
394	5	58.5	61.2	60	-0.09	0	50	100	2.5	2.5	6938	10142	200
394	6	58.5	61.2	60	-0.09	0	50	100	2.5	2.5	6707	10262	311
394	7	58.5	61.2	60	-0.09	0	50	100	2.5	2.5	7593	9394	293
394	8	58.5	61.2	60	-0.09	0	50	100	2.5	2.5	8469	8547	264
394	9	58.5	61.2	60	-0.09	0	50	100	2.5	2.5	8445	8643	192
394	10	58.5	61.2	60	-0.09	0	50	100	2.5	2.5	8041	9063	176
405	1	62	60	61	0.07	0	50	50	2	2	6239	10255	65
405	2	62	60	61	0.07	0	50	50	2	2	6696	9804	59
405	3	62	60	61	0.07	0	50	50	2	2	5227	11191	141
405	4	62	60	61	0.07	0	50	50	2	2	5280	11969	31
405	5	62	60	61	0.07	0	50	50	2	2	5218	12029	33
405	6	62	60	61	0.07	0	50	50	2	2	5529	11681	70
405	7	62	60	61	0.07	0	50	50	2	2	5571	11664	45
405	8	62	60	61	0.07	0	50	50	2	2	6160	11045	75
405	9	62	60	61	0.07	0	50	50	2	2	7269	9938	73
405	10	62	60	61	0.07	0	50	50	2	2	6260	10971	49
389	1	70.5	69.2	68.5	-0.05	0	50	150	2.5	3.5	6670	9758	131
389	2	70.5	69.2	68.5	-0.05	0	50	150	2.5	3.5	5765	10670	124
389	3	70.5	69.2	68.5	-0.05	0	50	150	2.5	3.5	5130	11117	312
389	4	70.5	69.2	68.5	-0.05	0	50	150	2.5	3.5	4984	12035	261
389	5	70.5	69.2	68.5	-0.05	0	50	150	2.5	3.5	5536	11483	261
389	6	70.5	69.2	68.5	-0.05	0	50	150	2.5	3.5	5498	11524	258
389	7	70.5	69.2	68.5	-0.05	0	50	150	2.5	3.5	6145	10899	236
389	8	70.5	69.2	68.5	-0.05	0	50	150	2.5	3.5	6060	10977	243
389	9	70.5	69.2	68.5	-0.05	0	50	150	2.5	3.5	6809	10290	181
389	10	70.5	69.2	68.5	-0.05	0	50	150	2.5	3.5	6100	11049	131
445	1	55.5	58.2	55.5	-0.19	200	250	150	2	2.5	5857	10555	147
445	2	55.5	58.2	55.5	-0.19	200	250	150	2	2.5	6872	9567	120
445	3	55.5	58.2	55.5	-0.19	200	250	150	2	2.5	4628	11720	211
445	4	55.5	58.2	55.5	-0.19	200	250	150	2	2.5	6010	11163	107
445	5	55.5	58.2	55.5	-0.19	200	250	150	2	2.5	6202	10968	110
445	6	55.5	58.2	55.5	-0.19	200	250	150	2	2.5	6285	10828	167
445	7	55.5	58.2	55.5	-0.19	200	250	150	2	2.5	6767	10293	220
445	8	55.5	58.2	55.5	-0.19	200	250	150	2	2.5	6573	10524	183
445	9	55.5	58.2	55.5	-0.19	200	250	150	2	2.5	6820	10302	158
445	10	55.5	58.2	55.5	-0.19	200	250	150	2	2.5	6712	10420	148

468	1	58	63	63.5	0.04	50	50	0	2.5	3	7151	9334	74
468	2	58	63	63.5	0.04	50	50	0	2.5	3	7695	8821	43
468	3	58	63	63.5	0.04	50	50	0	2.5	3	5747	10568	244
468	4	58	63	63.5	0.04	50	50	0	2.5	3	6880	10201	199
468	5	58	63	63.5	0.04	50	50	0	2.5	3	6780	10270	230
468	6	58	63	63.5	0.04	50	50	0	2.5	3	6552	10494	234
468	7	58	63	63.5	0.04	50	50	0	2.5	3	7032	10042	206
468	8	58	63	63.5	0.04	50	50	0	2.5	3	7864	9204	212
468	9	58	63	63.5	0.04	50	50	0	2.5	3	8065	9058	157
468	10	58	63	63.5	0.04	50	50	0	2.5	3	7752	9405	123
494	1	53.5	58.8	57.5	-0.09	550	400	350	2	2	2807	13652	100
494	2	53.5	58.8	57.5	-0.09	550	400	350	2	2	3421	13011	127
494	3	53.5	58.8	57.5	-0.09	550	400	350	2	2	2382	13960	217
494	4	53.5	58.8	57.5	-0.09	550	400	350	2	2	2846	14302	132
494	5	53.5	58.8	57.5	-0.09	550	400	350	2	2	2897	14263	120
494	6	53.5	58.8	57.5	-0.09	550	400	350	2	2	2867	14257	156
494	7	53.5	58.8	57.5	-0.09	550	400	350	2	2	3396	13780	104
494	8	53.5	58.8	57.5	-0.09	550	400	350	2	2	3597	13516	167
494	9	53.5	58.8	57.5	-0.09	550	400	350	2	2	3281	13885	114
494	10	53.5	58.8	57.5	-0.09	550	400	350	2	2	2338	14882	60
400	1	65	69.4	69	-0.03	550	100	100	2	2.5	5451	11000	108
400	2	65	69.4	69	-0.03	550	100	100	2	2.5	5234	11237	88
400	3	65	69.4	69	-0.03	550	100	100	2	2.5	3478	12872	209
400	4	65	69.4	69	-0.03	550	100	100	2	2.5	4128	13085	67
400	5	65	69.4	69	-0.03	550	100	100	2	2.5	4501	12660	119
400	6	65	69.4	69	-0.03	550	100	100	2	2.5	4586	12587	107
400	7	65	69.4	69	-0.03	550	100	100	2	2.5	5577	11601	102
400	8	65	69.4	69	-0.03	550	100	100	2	2.5	5732	11391	157
400	9	65	69.4	69	-0.03	550	100	100	2	2.5	5611	11563	106
400	10	65	69.4	69	-0.03	550	100	100	2	2.5	5466	11724	90
414	1	58	65.6	64	-0.11	1900	0	50	2	2.5	6799	9637	123
414	2	58	65.6	64	-0.11	1900	0	50	2	2.5	6528	9941	90
414	3	58	65.6	64	-0.11	1900	0	50	2	2.5	5846	10464	249
414	4	58	65.6	64	-0.11	1900	0	50	2	2.5	6474	10673	133
414	5	58	65.6	64	-0.11	1900	0	50	2	2.5	5823	11320	137
414	6	58	65.6	64	-0.11	1900	0	50	2	2.5	5779	11376	125
414	7	58	65.6	64	-0.11	1900	0	50	2	2.5	6849	10321	110
414	8	58	65.6	64	-0.11	1900	0	50	2	2.5	6638	10498	144
414	9	58	65.6	64	-0.11	1900	0	50	2	2.5	6664	10510	106
414	10	58	65.6	64	-0.11	1900	0	50	2	2.5	6219	10972	89
472	1	59.5	65.4	65	-0.03	650	0	150	2.5	3	4382	12090	87
472	2	59.5	65.4	65	-0.03	650	0	150	2.5	3	4167	12341	51
472	3	59.5	65.4	65	-0.03	650	0	150	2.5	3	3037	13352	170

472	4	59.5	65.4	65	-0.03	650	0	150	2.5	3	3330	13897	53
472	5	59.5	65.4	65	-0.03	650	0	150	2.5	3	3940	13241	99
472	6	59.5	65.4	65	-0.03	650	0	150	2.5	3	4509	12639	132
472	7	59.5	65.4	65	-0.03	650	0	150	2.5	3	4477	12714	89
472	8	59.5	65.4	65	-0.03	650	0	150	2.5	3	5008	12173	99
472	9	59.5	65.4	65	-0.03	650	0	150	2.5	3	5181	11997	102
472	10	59.5	65.4	65	-0.03	650	0	150	2.5	3	4462	12778	40
401	1	63	72	68.5	-0.25	0	0	0	3	3	5939	10538	82
401	2	63	72	68.5	-0.25	0	0	0	3	3	6124	10367	68
401	3	63	72	68.5	-0.25	0	0	0	3	3	3802	12554	203
401	4	63	72	68.5	-0.25	0	0	0	3	3	1580	15696	4
401	5	63	72	68.5	-0.25	0	0	0	3	3	2943	14306	31
401	6	63	72	68.5	-0.25	0	0	0	3	3	3276	13955	49
401	7	63	72	68.5	-0.25	0	0	0	3	3	4050	13167	63
401	8	63	72	68.5	-0.25	0	0	0	3	3	4181	13014	85
401	9	63	72	68.5	-0.25	0	0	0	3	3	5129	12057	94
401	10	63	72	68.5	-0.25	0	0	0	3	3	5207	12006	67
447	1	66.5	69.8	68.5	-0.09	0	0	0	3	3.5	5329	11139	91
447	2	66.5	69.8	68.5	-0.09	0	0	0	3	3.5	4928	11566	65
447	3	66.5	69.8	68.5	-0.09	0	0	0	3	3.5	2653	13705	201
447	4	66.5	69.8	68.5	-0.09	0	0	0	3	3.5	4599	12618	63
447	5	66.5	69.8	68.5	-0.09	0	0	0	3	3.5	4144	13034	102
447	6	66.5	69.8	68.5	-0.09	0	0	0	3	3.5	4461	12584	235
447	7	66.5	69.8	68.5	-0.09	0	0	0	3	3.5	4976	12065	239
447	8	66.5	69.8	68.5	-0.09	0	0	0	3	3.5	5045	11973	262
447	9	66.5	69.8	68.5	-0.09	0	0	0	3	3.5	5072	11997	211
447	10	66.5	69.8	68.5	-0.09	0	0	0	3	3.5	4655	12468	157
486	1	58	58.4	57.5	-0.06	600	0	150	3	2.5	6138	10366	55
486	2	58	58.4	57.5	-0.06	600	0	150	3	2.5	6011	10485	63
486	3	58	58.4	57.5	-0.06	600	0	150	3	2.5	4778	11629	152
486	4	58	58.4	57.5	-0.06	600	0	150	3	2.5	5764	11437	79
486	5	58	58.4	57.5	-0.06	600	0	150	3	2.5	4822	12372	86
486	6	58	58.4	57.5	-0.06	600	0	150	3	2.5	5951	11250	79
486	7	58	58.4	57.5	-0.06	600	0	150	3	2.5	6621	10584	75
486	8	58	58.4	57.5	-0.06	600	0	150	3	2.5	6160	11001	119
486	9	58	58.4	57.5	-0.06	600	0	150	3	2.5	6148	11022	110
486	10	58	58.4	57.5	-0.06	600	0	150	3	2.5	6621	10597	62
483	1	67.5	72	69.5	-0.18	0	0	0	3.5	3	6828	9623	108
483	2	67.5	72	69.5	-0.18	0	0	0	3.5	3	7928	8487	144
483	3	67.5	72	69.5	-0.18	0	0	0	3.5	3	4837	11454	268
483	4	67.5	72	69.5	-0.18	0	0	0	3.5	3	4903	12253	124
483	5	67.5	72	69.5	-0.18	0	0	0	3.5	3	5129	11939	212
483	6	67.5	72	69.5	-0.18	0	0	0	3.5	3	4989	12052	239

483	7	67.5	72	69.5	-0.18	0	0	0	3.5	3	5896	11160	224
483	8	67.5	72	69.5	-0.18	0	0	0	3.5	3	6549	10506	225
483	9	67.5	72	69.5	-0.18	0	0	0	3.5	3	6672	10373	235
483	10	67.5	72	69.5	-0.18	0	0	0	3.5	3	6630	10489	161
495	1	66.5	66	67.5	0.11	0	0	50	4	3.5	6728	9726	105
495	2	66.5	66	67.5	0.11	0	0	50	4	3.5	6843	9629	87
495	3	66.5	66	67.5	0.11	0	0	50	4	3.5	3292	13016	251
495	4	66.5	66	67.5	0.11	0	0	50	4	3.5	4101	13073	106
495	5	66.5	66	67.5	0.11	0	0	50	4	3.5	4458	12677	145
495	6	66.5	66	67.5	0.11	0	0	50	4	3.5	5254	11849	177
495	7	66.5	66	67.5	0.11	0	0	50	4	3.5	6052	11067	161
495	8	66.5	66	67.5	0.11	0	0	50	4	3.5	6235	10863	182
495	9	66.5	66	67.5	0.11	0	0	50	4	3.5	6759	10378	143
495	10	66.5	66	67.5	0.11	0	0	50	4	3.5	6029	11136	115
415	1	82	77.8	79	0.09	150	100	400	4	4	4045	12430	84
415	2	82	77.8	79	0.09	150	100	400	4	4	3699	12814	46
415	3	82	77.8	79	0.09	150	100	400	4	4	2148	14243	168
415	4	82	77.8	79	0.09	150	100	400	4	4	1667	15599	14
415	5	82	77.8	79	0.09	150	100	400	4	4	1986	15254	40
415	6	82	77.8	79	0.09	150	100	400	4	4	2898	14290	92
415	7	82	77.8	79	0.09	150	100	400	4	4	3398	13816	66
415	8	82	77.8	79	0.09	150	100	400	4	4	3429	13766	85
415	9	82	77.8	79	0.09	150	100	400	4	4	3103	14104	73
415	10	82	77.8	79	0.09	150	100	400	4	4	1704	15560	16
492	1	74.5	77.2	76.5	-0.05	0	0	100	4	4	6072	10384	103
492	2	74.5	77.2	76.5	-0.05	0	0	100	4	4	6646	9826	87
492	3	74.5	77.2	76.5	-0.05	0	0	100	4	4	3927	12427	205
492	4	74.5	77.2	76.5	-0.05	0	0	100	4	4	3857	13353	70
492	5	74.5	77.2	76.5	-0.05	0	0	100	4	4	5468	11701	111
492	6	74.5	77.2	76.5	-0.05	0	0	100	4	4	5192	11930	158
492	7	74.5	77.2	76.5	-0.05	0	0	100	4	4	6040	11125	115
492	8	74.5	77.2	76.5	-0.05	0	0	100	4	4	5583	11556	141
492	9	74.5	77.2	76.5	-0.05	0	0	100	4	4	6421	10652	207
492	10	74.5	77.2	76.5	-0.05	0	0	100	4	4	6483	10684	113
504	1	71.5	75.8	74.5	-0.09	22	0	0	3.5	3.5	5334	11134	91
504	2	71.5	75.8	74.5	-0.09	22	0	0	3.5	3.5	4869	11649	41
504	3	71.5	75.8	74.5	-0.09	22	0	0	3.5	3.5	2657	13747	155
504	4	71.5	75.8	74.5	-0.09	22	0	0	3.5	3.5	2779	14444	57
504	5	71.5	75.8	74.5	-0.09	22	0	0	3.5	3.5	3667	13500	113
504	6	71.5	75.8	74.5	-0.09	22	0	0	3.5	3.5	3371	13772	137
504	7	71.5	75.8	74.5	-0.09	22	0	0	3.5	3.5	4088	13088	104
504	8	71.5	75.8	74.5	-0.09	22	0	0	3.5	3.5	3693	13438	149
504	9	71.5	75.8	74.5	-0.09	22	0	0	3.5	3.5	3411	13713	156

504	10	71.5	75.8	74.5	-0.09	22	0	0	3.5	3.5	3142	14052	86
460	1	73	72.8	70	-0.2	150	1400	1300	4	4.5	4263	12234	62
460	2	73	72.8	70	-0.2	150	1400	1300	4	4.5	3770	12746	43
460	3	73	72.8	70	-0.2	150	1400	1300	4	4.5	3999	12363	197
460	4	73	72.8	70	-0.2	150	1400	1300	4	4.5	3676	13516	88
460	5	73	72.8	70	-0.2	150	1400	1300	4	4.5	3502	13693	85
460	6	73	72.8	70	-0.2	150	1400	1300	4	4.5	3204	13993	83
460	7	73	72.8	70	-0.2	150	1400	1300	4	4.5	4373	12794	113
460	8	73	72.8	70	-0.2	150	1400	1300	4	4.5	3769	13364	147
460	9	73	72.8	70	-0.2	150	1400	1300	4	4.5	3431	13725	124
460	10	73	72.8	70	-0.2	150	1400	1300	4	4.5	3418	13790	72
422	1	56.5	51.8	57.5	0.41	0	50	400	2.5	2.5	6251	9997	311
422	2	56.5	51.8	57.5	0.41	0	50	400	2.5	2.5	6773	9582	204
422	3	56.5	51.8	57.5	0.41	0	50	400	2.5	2.5	3491	12794	274
422	4	56.5	51.8	57.5	0.41	0	50	400	2.5	2.5	2847	14367	66
422	5	56.5	51.8	57.5	0.41	0	50	400	2.5	2.5	3353	13865	62
422	6	56.5	51.8	57.5	0.41	0	50	400	2.5	2.5	5343	11805	132
422	7	56.5	51.8	57.5	0.41	0	50	400	2.5	2.5	6575	10532	173
422	8	56.5	51.8	57.5	0.41	0	50	400	2.5	2.5	7542	9506	232
422	9	56.5	51.8	57.5	0.41	0	50	400	2.5	2.5	8588	8534	158
422	10	56.5	51.8	57.5	0.41	0	50	400	2.5	2.5	8054	9096	130
444	1	52.5	64.4	67	0.19	100	0	300	2.5	2.5	6367	10123	69
444	2	52.5	64.4	67	0.19	100	0	300	2.5	2.5	6478	10021	60
444	3	52.5	64.4	67	0.19	100	0	300	2.5	2.5	3916	12448	195
444	4	52.5	64.4	67	0.19	100	0	300	2.5	2.5	3163	14013	104
444	5	52.5	64.4	67	0.19	100	0	300	2.5	2.5	3900	13250	130
444	6	52.5	64.4	67	0.19	100	0	300	2.5	2.5	3215	13962	103
444	7	52.5	64.4	67	0.19	100	0	300	2.5	2.5	4379	12794	107
444	8	52.5	64.4	67	0.19	100	0	300	2.5	2.5	5035	12124	121
444	9	52.5	64.4	67	0.19	100	0	300	2.5	2.5	4622	12532	126
444	10	52.5	64.4	67	0.19	100	0	300	2.5	2.5	4380	12779	121
443	1	67.5	70.6	65	-0.4	0	50	350	2.5	3	4825	11695	39
443	2	67.5	70.6	65	-0.4	0	50	350	2.5	3	5815	10684	60
443	3	67.5	70.6	65	-0.4	0	50	350	2.5	3	3133	13291	135
443	4	67.5	70.6	65	-0.4	0	50	350	2.5	3	3320	13957	3
443	5	67.5	70.6	65	-0.4	0	50	350	2.5	3	4372	12874	34
443	6	67.5	70.6	65	-0.4	0	50	350	2.5	3	4075	13145	60
443	7	67.5	70.6	65	-0.4	0	50	350	2.5	3	5315	11876	89
443	8	67.5	70.6	65	-0.4	0	50	350	2.5	3	4782	12393	105
443	9	67.5	70.6	65	-0.4	0	50	350	2.5	3	5581	11617	82
443	10	67.5	70.6	65	-0.4	0	50	350	2.5	3	3346	13927	7
390	1	61	62	63.5	0.11	0	0	200	2.5	3	6783	9593	183
390	2	61	62	63.5	0.11	0	0	200	2.5	3	6521	9851	187

390	3	61	62	63.5	0.11	0	0	200	2.5	3	5967	10266	326
390	4	61	62	63.5	0.11	0	0	200	2.5	3	7871	9115	294
390	5	61	62	63.5	0.11	0	0	200	2.5	3	6935	9951	394
390	6	61	62	63.5	0.11	0	0	200	2.5	3	6561	10427	292
390	7	61	62	63.5	0.11	0	0	200	2.5	3	7390	9654	236
390	8	61	62	63.5	0.11	0	0	200	2.5	3	6681	10452	147
390	9	61	62	63.5	0.11	0	0	200	2.5	3	7437	9710	133
390	10	61	62	63.5	0.11	0	0	200	2.5	3	6078	11126	76
404	1	62	62.6	63.5	0.06	0	0	250	2.5	3	5995	10413	151
404	2	62	62.6	63.5	0.06	0	0	250	2.5	3	6301	10094	164
404	3	62	62.6	63.5	0.06	0	0	250	2.5	3	4336	11948	275
404	4	62	62.6	63.5	0.06	0	0	250	2.5	3	5095	11952	233
404	5	62	62.6	63.5	0.06	0	0	250	2.5	3	4782	12213	285
404	6	62	62.6	63.5	0.06	0	0	250	2.5	3	5461	11524	295
404	7	62	62.6	63.5	0.06	0	0	250	2.5	3	5265	11835	180
404	8	62	62.6	63.5	0.06	0	0	250	2.5	3	5683	11296	301
404	9	62	62.6	63.5	0.06	0	0	250	2.5	3	5743	11339	198
404	10	62	62.6	63.5	0.06	0	0	250	2.5	3	5369	11732	179
432	1	70	75	74.5	-0.04	150	0	200	2	3.5	4378	12091	90
432	2	70	75	74.5	-0.04	150	0	200	2	3.5	3750	12729	80
432	3	70	75	74.5	-0.04	150	0	200	2	3.5	1965	14384	210
432	4	70	75	74.5	-0.04	150	0	200	2	3.5	3426	13818	36
432	5	70	75	74.5	-0.04	150	0	200	2	3.5	3923	13263	94
432	6	70	75	74.5	-0.04	150	0	200	2	3.5	3580	13602	98
432	7	70	75	74.5	-0.04	150	0	200	2	3.5	4142	13021	117
432	8	70	75	74.5	-0.04	150	0	200	2	3.5	4355	12786	139
432	9	70	75	74.5	-0.04	150	0	200	2	3.5	4957	12196	127
432	10	70	75	74.5	-0.04	150	0	200	2	3.5	3512	13674	94
500	1	61	54.8	51	-0.27	0	0	600	2	1.5	2994	13524	41
500	2	61	54.8	51	-0.27	0	0	600	2	1.5	2499	14024	36
500	3	61	54.8	51	-0.27	0	0	600	2	1.5	2568	13862	129
500	4	61	54.8	51	-0.27	0	0	600	2	1.5	2641	14583	56
500	5	61	54.8	51	-0.27	0	0	600	2	1.5	1411	15840	29
500	6	61	54.8	51	-0.27	0	0	600	2	1.5	2011	15232	37
500	7	61	54.8	51	-0.27	0	0	600	2	1.5	2279	14960	41
500	8	61	54.8	51	-0.27	0	0	600	2	1.5	2760	14462	58
500	9	61	54.8	51	-0.27	0	0	600	2	1.5	2133	15104	43
500	10	61	54.8	51	-0.27	0	0	600	2	1.5	1751	15505	24
384	1	62	62.8	66.5	0.26	350	300	800	2.5	2.5	5683	10789	87
384	2	62	62.8	66.5	0.26	350	300	800	2.5	2.5	5991	10486	82
384	3	62	62.8	66.5	0.26	350	300	800	2.5	2.5	4406	11980	173
384	4	62	62.8	66.5	0.26	350	300	800	2.5	2.5	6374	10829	77
384	5	62	62.8	66.5	0.26	350	300	800	2.5	2.5	5588	11616	76

384	6	62	62.8	66.5	0.26	350	300	800	2.5	2.5	5687	11480	113
384	7	62	62.8	66.5	0.26	350	300	800	2.5	2.5	6320	10892	68
384	8	62	62.8	66.5	0.26	350	300	800	2.5	2.5	6849	10326	105
384	9	62	62.8	66.5	0.26	350	300	800	2.5	2.5	6876	10334	70
384	10	62	62.8	66.5	0.26	350	300	800	2.5	2.5	6192	11022	66
373	1	57.5	63.2	67.5	0.31	500	50	350	2.5	2.5	4722	11722	115
373	2	57.5	63.2	67.5	0.31	500	50	350	2.5	2.5	5703	10757	99
373	3	57.5	63.2	67.5	0.31	500	50	350	2.5	2.5	3608	12763	188
373	4	57.5	63.2	67.5	0.31	500	50	350	2.5	2.5	3903	13300	77
373	5	57.5	63.2	67.5	0.31	500	50	350	2.5	2.5	3539	13679	62
373	6	57.5	63.2	67.5	0.31	500	50	350	2.5	2.5	4930	12211	139
373	7	57.5	63.2	67.5	0.31	500	50	350	2.5	2.5	5912	11196	172
373	8	57.5	63.2	67.5	0.31	500	50	350	2.5	2.5	5431	11709	140
373	9	57.5	63.2	67.5	0.31	500	50	350	2.5	2.5	5863	11284	133
373	10	57.5	63.2	67.5	0.31	500	50	350	2.5	2.5	5648	11544	88
408	1	57	60.2	62.5	0.16	1200	150	350	2	2	5877	10608	74
408	2	57	60.2	62.5	0.16	1200	150	350	2	2	6969	9505	85
408	3	57	60.2	62.5	0.16	1200	150	350	2	2	5384	10936	239
408	4	57	60.2	62.5	0.16	1200	150	350	2	2	6855	10264	161
408	5	57	60.2	62.5	0.16	1200	150	350	2	2	7427	9596	257
408	6	57	60.2	62.5	0.16	1200	150	350	2	2	6636	10407	237
408	7	57	60.2	62.5	0.16	1200	150	350	2	2	7196	9910	174
408	8	57	60.2	62.5	0.16	1200	150	350	2	2	7144	9882	254
408	9	57	60.2	62.5	0.16	1200	150	350	2	2	8201	8842	237
408	10	57	60.2	62.5	0.16	1200	150	350	2	2	7165	9933	182
377	1	64.5	59.4	63	0.26	2050	200	450	2.5	2.5	5753	10466	340
377	2	64.5	59.4	63	0.26	2050	200	450	2.5	2.5	6392	9894	273
377	3	64.5	59.4	63	0.26	2050	200	450	2.5	2.5	4354	11848	357
377	4	64.5	59.4	63	0.26	2050	200	450	2.5	2.5	4603	12630	47
377	5	64.5	59.4	63	0.26	2050	200	450	2.5	2.5	5703	11511	66
377	6	64.5	59.4	63	0.26	2050	200	450	2.5	2.5	7662	9458	160
377	7	64.5	59.4	63	0.26	2050	200	450	2.5	2.5	7688	9447	145
377	8	64.5	59.4	63	0.26	2050	200	450	2.5	2.5	6954	10180	146
377	9	64.5	59.4	63	0.26	2050	200	450	2.5	2.5	7946	9210	124
377	10	64.5	59.4	63	0.26	2050	200	450	2.5	2.5	7374	9799	107
433	1	52.5	57.8	59	0.09	3650	0	300	2.5	2.5	6763	9620	176
433	2	52.5	57.8	59	0.09	3650	0	300	2.5	2.5	6740	9715	104
433	3	52.5	57.8	59	0.09	3650	0	300	2.5	2.5	4198	12077	284
433	4	52.5	57.8	59	0.09	3650	0	300	2.5	2.5	7218	9927	135
433	5	52.5	57.8	59	0.09	3650	0	300	2.5	2.5	5663	11493	124
433	6	52.5	57.8	59	0.09	3650	0	300	2.5	2.5	6690	10397	193
433	7	52.5	57.8	59	0.09	3650	0	300	2.5	2.5	7690	9414	176
433	8	52.5	57.8	59	0.09	3650	0	300	2.5	2.5	7096	10020	164

433	9	52.5	57.8	59	0.09	3650	0	300	2.5	2.5	7214	9907	159
433	10	52.5	57.8	59	0.09	3650	0	300	2.5	2.5	7180	9967	133
461	1	51.5	57.8	54.5	-0.24	500	450	1300	2	2	4155	12344	60
461	2	51.5	57.8	54.5	-0.24	500	450	1300	2	2	3384	13134	41
461	3	51.5	57.8	54.5	-0.24	500	450	1300	2	2	3218	13189	152
461	4	51.5	57.8	54.5	-0.24	500	450	1300	2	2	2774	14422	84
461	5	51.5	57.8	54.5	-0.24	500	450	1300	2	2	2921	14272	87
461	6	51.5	57.8	54.5	-0.24	500	450	1300	2	2	2776	14425	79
461	7	51.5	57.8	54.5	-0.24	500	450	1300	2	2	3114	14118	48
461	8	51.5	57.8	54.5	-0.24	500	450	1300	2	2	3357	13854	69
461	9	51.5	57.8	54.5	-0.24	500	450	1300	2	2	3117	14084	79
461	10	51.5	57.8	54.5	-0.24	500	450	1300	2	2	3059	14156	65
412	1	56	55.2	58.5	0.24	2350	100	550	2.5	2.5	6061	10373	125
412	2	56	55.2	58.5	0.24	2350	100	550	2.5	2.5	6566	9919	74
412	3	56	55.2	58.5	0.24	2350	100	550	2.5	2.5	4448	11883	228
412	4	56	55.2	58.5	0.24	2350	100	550	2.5	2.5	5144	12063	73
412	5	56	55.2	58.5	0.24	2350	100	550	2.5	2.5	4591	12598	91
412	6	56	55.2	58.5	0.24	2350	100	550	2.5	2.5	4738	12432	110
412	7	56	55.2	58.5	0.24	2350	100	550	2.5	2.5	5240	11902	138
412	8	56	55.2	58.5	0.24	2350	100	550	2.5	2.5	6264	10856	160
412	9	56	55.2	58.5	0.24	2350	100	550	2.5	2.5	6278	10914	88
412	10	56	55.2	58.5	0.24	2350	100	550	2.5	2.5	5695	11512	73
436	1	60	63.6	62	-0.11	600	100	500	2	2	5777	10498	284
436	2	60	63.6	62	-0.11	600	100	500	2	2	6223	10075	261
436	3	60	63.6	62	-0.11	600	100	500	2	2	4579	11418	562
436	4	60	63.6	62	-0.11	600	100	500	2	2	5404	11368	508
436	5	60	63.6	62	-0.11	600	100	500	2	2	5231	11509	540
436	6	60	63.6	62	-0.11	600	100	500	2	2	5237	11504	539
436	7	60	63.6	62	-0.11	600	100	500	2	2	5222	11556	502
436	8	60	63.6	62	-0.11	600	100	500	2	2	5920	10958	402
436	9	60	63.6	62	-0.11	600	100	500	2	2	6560	10402	318
436	10	60	63.6	62	-0.11	600	100	500	2	2	5484	11564	232
491	1	60	62.2	64	0.13	1150	100	1100	2	2	6078	10389	92
491	2	60	62.2	64	0.13	1150	100	1100	2	2	7458	9037	64
491	3	60	62.2	64	0.13	1150	100	1100	2	2	4112	12277	170
491	4	60	62.2	64	0.13	1150	100	1100	2	2	5413	11810	57
491	5	60	62.2	64	0.13	1150	100	1100	2	2	6039	11137	104
491	6	60	62.2	64	0.13	1150	100	1100	2	2	6387	10753	140
491	7	60	62.2	64	0.13	1150	100	1100	2	2	6364	10805	111
491	8	60	62.2	64	0.13	1150	100	1100	2	2	6839	10305	136
491	9	60	62.2	64	0.13	1150	100	1100	2	2	7514	9610	156
491	10	60	62.2	64	0.13	1150	100	1100	2	2	7221	9963	96
429	1	67.5	65.4	64	-0.1	1100	300	550	2.5	3	3396	13072	91

429	2	67.5	65.4	64	-0.1	1100	300	550	2.5	3	2054	14427	78
429	3	67.5	65.4	64	-0.1	1100	300	550	2.5	3	2230	14119	210
429	4	67.5	65.4	64	-0.1	1100	300	550	2.5	3	3495	13663	122
429	5	67.5	65.4	64	-0.1	1100	300	550	2.5	3	3387	13773	120
429	6	67.5	65.4	64	-0.1	1100	300	550	2.5	3	3713	13445	122
429	7	67.5	65.4	64	-0.1	1100	300	550	2.5	3	3446	13665	169
429	8	67.5	65.4	64	-0.1	1100	300	550	2.5	3	3895	13183	202
429	9	67.5	65.4	64	-0.1	1100	300	550	2.5	3	3459	13567	254
429	10	67.5	65.4	64	-0.1	1100	300	550	2.5	3	3192	13885	203
380	1	64.5	64.8	64.5	-0.02	900	1950	3600	2	2	3938	12535	86
380	2	64.5	64.8	64.5	-0.02	900	1950	3600	2	2	3866	12625	68
380	3	64.5	64.8	64.5	-0.02	900	1950	3600	2	2	2365	14011	183
380	4	64.5	64.8	64.5	-0.02	900	1950	3600	2	2	2249	14968	63
380	5	64.5	64.8	64.5	-0.02	900	1950	3600	2	2	2875	14259	146
380	6	64.5	64.8	64.5	-0.02	900	1950	3600	2	2	3093	13916	271
380	7	64.5	64.8	64.5	-0.02	900	1950	3600	2	2	3166	13834	280
380	8	64.5	64.8	64.5	-0.02	900	1950	3600	2	2	3726	13343	211
380	9	64.5	64.8	64.5	-0.02	900	1950	3600	2	2	3217	13910	153
380	10	64.5	64.8	64.5	-0.02	900	1950	3600	2	2	3348	13751	181
406	1	58	59	58	-0.07	1250	1700	3800	2	2	6473	9865	221
406	2	58	59	58	-0.07	1250	1700	3800	2	2	6910	9516	133
406	3	58	59	58	-0.07	1250	1700	3800	2	2	4169	12091	299
406	4	58	59	58	-0.07	1250	1700	3800	2	2	5915	11338	27
406	5	58	59	58	-0.07	1250	1700	3800	2	2	6853	10330	97
406	6	58	59	58	-0.07	1250	1700	3800	2	2	6304	10863	113
406	7	58	59	58	-0.07	1250	1700	3800	2	2	7093	10082	105
406	8	58	59	58	-0.07	1250	1700	3800	2	2	7516	9577	187
406	9	58	59	58	-0.07	1250	1700	3800	2	2	9005	8123	152
406	10	58	59	58	-0.07	1250	1700	3800	2	2	7814	9340	126
462	1	60.5	64.6	59.5	-0.38	0	150	450	3	2.5	5392	11055	112
462	2	60.5	64.6	59.5	-0.38	0	150	450	3	2.5	4287	12174	98
462	3	60.5	64.6	59.5	-0.38	0	150	450	3	2.5	3545	12846	168
462	4	60.5	64.6	59.5	-0.38	0	150	450	3	2.5	4049	13114	117
462	5	60.5	64.6	59.5	-0.38	0	150	450	3	2.5	4046	13133	101
462	6	60.5	64.6	59.5	-0.38	0	150	450	3	2.5	3738	13432	110
462	7	60.5	64.6	59.5	-0.38	0	150	450	3	2.5	4249	12898	133
462	8	60.5	64.6	59.5	-0.38	0	150	450	3	2.5	3914	13222	144
462	9	60.5	64.6	59.5	-0.38	0	150	450	3	2.5	4375	12767	138
462	10	60.5	64.6	59.5	-0.38	0	150	450	3	2.5	3593	13584	103
434	1	56.5	64.2	57.5	-0.48	250	50	250	3	2.5	5403	10999	157
434	2	56.5	64.2	57.5	-0.48	250	50	250	3	2.5	6226	10168	165
434	3	56.5	64.2	57.5	-0.48	250	50	250	3	2.5	4002	12289	268
434	4	56.5	64.2	57.5	-0.48	250	50	250	3	2.5	4980	12136	164

434	5	56.5	64.2	57.5	-0.48	250	50	250	3	2.5	4563	12565	152
434	6	56.5	64.2	57.5	-0.48	250	50	250	3	2.5	4692	12453	135
434	7	56.5	64.2	57.5	-0.48	250	50	250	3	2.5	5047	12103	130
434	8	56.5	64.2	57.5	-0.48	250	50	250	3	2.5	5203	11936	141
434	9	56.5	64.2	57.5	-0.48	250	50	250	3	2.5	5179	11968	133
434	10	56.5	64.2	57.5	-0.48	250	50	250	3	2.5	4423	12692	165
381	1	64.5	64.8	63.5	-0.09	350	50	400	3	3	8131	8331	97
381	2	64.5	64.8	63.5	-0.09	350	50	400	3	3	7092	9382	85
381	3	64.5	64.8	63.5	-0.09	350	50	400	3	3	4208	12166	185
381	4	64.5	64.8	63.5	-0.09	350	50	400	3	3	5656	11592	32
381	5	64.5	64.8	63.5	-0.09	350	50	400	3	3	6246	10950	84
381	6	64.5	64.8	63.5	-0.09	350	50	400	3	3	6090	11084	106
381	7	64.5	64.8	63.5	-0.09	350	50	400	3	3	7836	9346	98
381	8	64.5	64.8	63.5	-0.09	350	50	400	3	3	6699	10444	137
381	9	64.5	64.8	63.5	-0.09	350	50	400	3	3	7944	9218	118
381	10	64.5	64.8	63.5	-0.09	350	50	400	3	3	7353	9800	127
476	1	67	72.2	72.5	0.02	100	0	350	3	3.5	5725	10776	58
476	2	67	72.2	72.5	0.02	100	0	350	3	3.5	5564	10944	51
476	3	67	72.2	72.5	0.02	100	0	350	3	3.5	3025	13424	110
476	4	67	72.2	72.5	0.02	100	0	350	3	3.5	4385	12881	14
476	5	67	72.2	72.5	0.02	100	0	350	3	3.5	3610	13652	18
476	6	67	72.2	72.5	0.02	100	0	350	3	3.5	4526	12699	55
476	7	67	72.2	72.5	0.02	100	0	350	3	3.5	4492	12751	37
476	8	67	72.2	72.5	0.02	100	0	350	3	3.5	4706	12500	74
476	9	67	72.2	72.5	0.02	100	0	350	3	3.5	4574	12658	48
476	10	67	72.2	72.5	0.02	100	0	350	3	3.5	4687	12554	39
396	1	61	65.6	63.5	-0.15	50	450	650	3	3	6464	9965	130
396	2	61	65.6	63.5	-0.15	50	450	650	3	3	6512	9933	114
396	3	61	65.6	63.5	-0.15	50	450	650	3	3	4692	11612	255
396	4	61	65.6	63.5	-0.15	50	450	650	3	3	6488	10566	226
396	5	61	65.6	63.5	-0.15	50	450	650	3	3	5899	11102	279
396	6	61	65.6	63.5	-0.15	50	450	650	3	3	6871	10028	381
396	7	61	65.6	63.5	-0.15	50	450	650	3	3	6327	10632	321
396	8	61	65.6	63.5	-0.15	50	450	650	3	3	7036	9982	262
396	9	61	65.6	63.5	-0.15	50	450	650	3	3	7072	9987	221
396	10	61	65.6	63.5	-0.15	50	450	650	3	3	7275	9852	153
441	1	64.5	67.4	67	-0.03	150	200	700	3	3	4976	11516	67
441	2	64.5	67.4	67	-0.03	150	200	700	3	3	6230	10274	55
441	3	64.5	67.4	67	-0.03	150	200	700	3	3	4036	12365	158
441	4	64.5	67.4	67	-0.03	150	200	700	3	3	6946	10252	82
441	5	64.5	67.4	67	-0.03	150	200	700	3	3	5871	11300	109
441	6	64.5	67.4	67	-0.03	150	200	700	3	3	5908	11248	124
441	7	64.5	67.4	67	-0.03	150	200	700	3	3	6047	11132	101

441	8	64.5	67.4	67	-0.03	150	200	700	3	3	6350	10794	136
441	9	64.5	67.4	67	-0.03	150	200	700	3	3	6458	10770	52
441	10	64.5	67.4	67	-0.03	150	200	700	3	3	6501	10719	60
502	1	64.5	69.8	67	-0.2	0	150	550	3	3.5	6034	10473	52
502	2	64.5	69.8	67	-0.2	0	150	550	3	3.5	6108	10379	72
502	3	64.5	69.8	67	-0.2	0	150	550	3	3.5	3750	12663	146
502	4	64.5	69.8	67	-0.2	0	150	550	3	3.5	2983	14254	43
502	5	64.5	69.8	67	-0.2	0	150	550	3	3.5	3527	13676	77
502	6	64.5	69.8	67	-0.2	0	150	550	3	3.5	4182	13036	62
502	7	64.5	69.8	67	-0.2	0	150	550	3	3.5	4386	12832	62
502	8	64.5	69.8	67	-0.2	0	150	550	3	3.5	4565	12654	61
502	9	64.5	69.8	67	-0.2	0	150	550	3	3.5	4890	12318	72
502	10	64.5	69.8	67	-0.2	0	150	550	3	3.5	4704	12500	76
456	1	62	66	66	0	550	50	300	3	3.5	6253	10226	80
456	2	62	66	66	0	550	50	300	3	3.5	6033	10454	72
456	3	62	66	66	0	550	50	300	3	3.5	4829	11506	224
456	4	62	66	66	0	550	50	300	3	3.5	5838	11363	79
456	5	62	66	66	0	550	50	300	3	3.5	6400	10772	108
456	6	62	66	66	0	550	50	300	3	3.5	6090	11077	113
456	7	62	66	66	0	550	50	300	3	3.5	7171	10023	86
456	8	62	66	66	0	550	50	300	3	3.5	7288	9875	117
456	9	62	66	66	0	550	50	300	3	3.5	5688	11455	137
456	10	62	66	66	0	550	50	300	3	3.5	6601	10592	87
499	1	69.5	68.8	67	-0.13	550	400	1650	3	3	5250	11250	59
499	2	69.5	68.8	67	-0.13	550	400	1650	3	3	5290	11204	65
499	3	69.5	68.8	67	-0.13	550	400	1650	3	3	2958	13414	187
499	4	69.5	68.8	67	-0.13	550	400	1650	3	3	1595	15646	39
499	5	69.5	68.8	67	-0.13	550	400	1650	3	3	2635	14584	61
499	6	69.5	68.8	67	-0.13	550	400	1650	3	3	3462	13726	92
499	7	69.5	68.8	67	-0.13	550	400	1650	3	3	4021	13169	90
499	8	69.5	68.8	67	-0.13	550	400	1650	3	3	4292	12908	80
499	9	69.5	68.8	67	-0.13	550	400	1650	3	3	4264	12903	113
499	10	69.5	68.8	67	-0.13	550	400	1650	3	3	4105	13124	51
427	1	63	65.6	67.5	0.14	850	250	750	3	3	5784	10649	126
427	2	63	65.6	67.5	0.14	850	250	750	3	3	7544	8972	43
427	3	63	65.6	67.5	0.14	850	250	750	3	3	4924	11414	221
427	4	63	65.6	67.5	0.14	850	250	750	3	3	5845	11349	86
427	5	63	65.6	67.5	0.14	850	250	750	3	3	5967	11211	102
427	6	63	65.6	67.5	0.14	850	250	750	3	3	5910	11273	97
427	7	63	65.6	67.5	0.14	850	250	750	3	3	6376	10820	84
427	8	63	65.6	67.5	0.14	850	250	750	3	3	6941	10211	128
427	9	63	65.6	67.5	0.14	850	250	750	3	3	6873	10299	108
427	10	63	65.6	67.5	0.14	850	250	750	3	3	6418	10789	73

481	1	69	73.4	72.5	-0.06	850	130	1700	3	3.5	4048	12415	96
481	2	69	73.4	72.5	-0.06	850	130	1700	3	3.5	3699	12811	49
481	3	69	73.4	72.5	-0.06	850	130	1700	3	3.5	2582	13847	130
481	4	69	73.4	72.5	-0.06	850	130	1700	3	3.5	2935	14277	68
481	5	69	73.4	72.5	-0.06	850	130	1700	3	3.5	3126	14010	144
481	6	69	73.4	72.5	-0.06	850	130	1700	3	3.5	3264	13903	113
481	7	69	73.4	72.5	-0.06	850	130	1700	3	3.5	3774	13418	88
481	8	69	73.4	72.5	-0.06	850	130	1700	3	3.5	3517	13661	102
481	9	69	73.4	72.5	-0.06	850	130	1700	3	3.5	3575	13621	84
481	10	69	73.4	72.5	-0.06	850	130	1700	3	3.5	3228	14010	42
393	1	73	75.6	77	0.1	0	0	250	3.5	3.5	6559	9874	126
393	2	73	75.6	77	0.1	0	0	250	3.5	3.5	5704	10755	100
393	3	73	75.6	77	0.1	0	0	250	3.5	3.5	4652	11560	347
393	4	73	75.6	77	0.1	0	0	250	3.5	3.5	5899	11123	258
393	5	73	75.6	77	0.1	0	0	250	3.5	3.5	4710	12412	158
393	6	73	75.6	77	0.1	0	0	250	3.5	3.5	5196	11870	214
393	7	73	75.6	77	0.1	0	0	250	3.5	3.5	5969	11117	194
393	8	73	75.6	77	0.1	0	0	250	3.5	3.5	6619	10433	228
393	9	73	75.6	77	0.1	0	0	250	3.5	3.5	6464	10619	197
393	10	73	75.6	77	0.1	0	0	250	3.5	3.5	6270	10890	120
487	1	64	67.8	68	0.01	400	150	550	3.5	2.5	4475	11960	124
487	2	64	67.8	68	0.01	400	150	550	3.5	2.5	3926	12540	93
487	3	64	67.8	68	0.01	400	150	550	3.5	2.5	2637	13460	462
487	4	64	67.8	68	0.01	400	150	550	3.5	2.5	3973	12771	536
487	5	64	67.8	68	0.01	400	150	550	3.5	2.5	3550	13599	131
487	6	64	67.8	68	0.01	400	150	550	3.5	2.5	3910	13228	142
487	7	64	67.8	68	0.01	400	150	550	3.5	2.5	3957	13182	141
487	8	64	67.8	68	0.01	400	150	550	3.5	2.5	5013	11943	324
487	9	64	67.8	68	0.01	400	150	550	3.5	2.5	4650	12393	237
487	10	64	67.8	68	0.01	400	150	550	3.5	2.5	5453	11681	146
392	1	80.5	79.4	78	-0.1	150	600	1000	3.5	4	5149	11327	83
392	2	80.5	79.4	78	-0.1	150	600	1000	3.5	4	5003	11414	142
392	3	80.5	79.4	78	-0.1	150	600	1000	3.5	4	2751	13410	398
392	4	80.5	79.4	78	-0.1	150	600	1000	3.5	4	2908	14290	82
392	5	80.5	79.4	78	-0.1	150	600	1000	3.5	4	3993	13130	157
392	6	80.5	79.4	78	-0.1	150	600	1000	3.5	4	4124	13027	129
392	7	80.5	79.4	78	-0.1	150	600	1000	3.5	4	4401	12743	136
392	8	80.5	79.4	78	-0.1	150	600	1000	3.5	4	4726	12409	145
392	9	80.5	79.4	78	-0.1	150	600	1000	3.5	4	5084	12051	145
392	10	80.5	79.4	78	-0.1	150	600	1000	3.5	4	4973	12193	114

LW=liveweight; BCS=Body condition score

Appendix 7. Supplementary data for Chapter 7

Appendix 7-1 Movement data for resilient and resistant lambs

Sheep ID	Drench status	Genotype	Sex	LW	FEC	Distance	Day
2001	n	RT	f	30.4	100	2.687729618	1
2001	n	RT	f	30.4	100	2.201190454	2
2001	n	RT	f	30.4	100	1.760979047	3
2001	n	RT	f	30.4	100	1.734120623	4
2001	n	RT	f	30.4	100	1.943021468	5
2005	n	RL	f	27.4	200	2.994929361	1
2005	n	RL	f	27.4	200	2.035955002	2
2005	n	RL	f	27.4	200	1.53661228	3
2005	n	RL	f	27.4	200	1.468345087	4
2005	n	RL	f	27.4	200	1.964174957	5
2010	y	RL	m	49.8	100	1.747260814	1
2010	y	RL	m	49.8	100	2.086007519	2
2010	y	RL	m	49.8	100	2.09978301	3
2010	y	RL	m	49.8	100	2.065684533	4
2010	y	RL	m	49.8	100	2.105350961	5
2014	n	RT	f	28.6	0	2.485828254	1
2014	n	RT	f	28.6	0	2.074168818	2
2014	n	RT	f	28.6	0	2.334776978	3
2014	n	RT	f	28.6	0	1.912723495	4
2014	n	RT	f	28.6	0	2.320758777	5
2015	n	RL	m	27.6	200	2.555501308	1
2015	n	RL	m	27.6	200	1.72998696	2
2015	n	RL	m	27.6	200	2.258233055	3
2015	n	RL	m	27.6	200	1.974094821	4
2015	n	RL	m	27.6	200	2.281915948	5
2016	n	RL	f	35.6	100	2.376244003	1
2016	n	RL	f	35.6	100	2.029984294	2
2016	n	RL	f	35.6	100	2.482661603	3
2016	n	RL	f	35.6	100	2.080141277	4
2016	n	RL	f	35.6	100	2.447695956	5
2018	n	RT	m	30.6	0	3.100584574	1
2018	n	RT	m	30.6	0	2.010054071	2
2018	n	RT	m	30.6	0	1.786547302	3
2018	n	RT	m	30.6	0	1.657952389	4
2018	n	RT	m	30.6	0	1.883536571	5
2024	y	RL	m	42.6	200	2.565014769	1
2024	y	RL	m	42.6	200	2.473305677	2
2024	y	RL	m	42.6	200	2.842228007	3

2024	y	RL	m	42.6	200	2.91296188	4
2024	y	RL	m	42.6	200	2.292096452	5
2025	y	RL	m	40.8	500	2.288208195	1
2025	y	RL	m	40.8	500	2.481835526	2
2025	y	RL	m	40.8	500	2.358740153	3
2025	y	RL	m	40.8	500	3.222773158	4
2025	y	RL	m	40.8	500	2.507611312	5
2032	y	RT	f	39.4	0	1.967598409	1
2032	y	RT	f	39.4	0	2.119776326	2
2032	y	RT	f	39.4	0	2.136688226	3
2032	y	RT	f	39.4	0	2.040062451	4
2032	y	RT	f	39.4	0	1.982132723	5
2038	n	RL	m	31	3300	2.599992546	1
2038	n	RL	m	31	3300	2.242789567	2
2038	n	RL	m	31	3300	1.864571386	3
2038	n	RL	m	31	3300	1.980167112	4
2038	n	RL	m	31	3300	2.194593303	5
2039	n	RT	f	36.2	0	1.940814869	1
2039	n	RT	f	36.2	0	1.48385939	2
2039	n	RT	f	36.2	0	2.064039006	3
2039	n	RT	f	36.2	0	1.58899186	4
2039	n	RT	f	36.2	0	1.785957563	5
2041	y	RL	f	35.2	0	1.951063781	1
2041	y	RL	f	35.2	0	2.170979176	2
2041	y	RL	f	35.2	0	2.084479929	3
2041	y	RL	f	35.2	0	1.748065215	4
2041	y	RL	f	35.2	0	1.756605408	5
2042	n	RL	f	32.2	500	2.509152302	1
2042	n	RL	f	32.2	500	2.494371851	2
2042	n	RL	f	32.2	500	2.432898004	3
2042	n	RL	f	32.2	500	2.284309133	4
2042	n	RL	f	32.2	500	2.471984503	5
2050	y	RT	m	33.2	0	2.190180764	1
2050	y	RT	m	33.2	0	2.017059476	2
2050	y	RT	m	33.2	0	2.476180645	3
2050	y	RT	m	33.2	0	2.853922555	4
2050	y	RT	m	33.2	0	2.157925486	5
2051	n	RT	m	30.6	300	2.155722283	1
2051	n	RT	m	30.6	300	1.946357571	2
2051	n	RT	m	30.6	300	2.155396086	3
2051	n	RT	m	30.6	300	2.23072548	4
2051	n	RT	m	30.6	300	2.099218498	5
2064	y	RT	f	31.2	0	2.447459964	1

2064	y	RT	f	31.2	0	2.203576358	2
2064	y	RT	f	31.2	0	2.488303143	3
2064	y	RT	f	31.2	0	2.450212858	4
2064	y	RT	f	31.2	0	2.181673104	5
2073	y	RL	f	40	0	2.342597877	1
2073	y	RL	f	40	0	2.167294077	2
2073	y	RL	f	40	0	2.680844007	3
2073	y	RL	f	40	0	2.808745662	4
2073	y	RL	f	40	0	2.050293708	5
2079	y	RT	m	51	300	1.94137211	1
2079	y	RT	m	51	300	2.167131754	2
2079	y	RT	m	51	300	2.466389597	3
2079	y	RT	m	51	300	2.558608159	4
2079	y	RT	m	51	300	1.857245807	5
2081	y	RT	f	46.8	0	1.979551954	1
2081	y	RT	f	46.8	0	1.99830092	2
2081	y	RT	f	46.8	0	2.414009397	3
2081	y	RT	f	46.8	0	2.405026238	4
2081	y	RT	f	46.8	0	1.87575615	5
2083	n	RL	m	38.2	300	3.803013666	1
2083	n	RL	m	38.2	300	3.056035578	2
2083	n	RL	m	38.2	300	2.306685589	3
2083	n	RL	m	38.2	300	1.765808606	4
2083	n	RL	m	38.2	300	1.956935238	5