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RESEARCH ARTICLE

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The prevalence of damaged tails in New Zealand dairy cattle

EL Cuttance [a], WA Mason [a], SY Hea [b], MA Bryan [b] and RA Laven [c]

[a]EpiVets, Te Awamutu, New Zealand; [b]VetSouth Ltd., Winton, New Zealand; [c]Tāwharau Ora – School of Veterinary Science, Massey University, Palmerston North, New Zealand

ABSTRACT

Aims: To undertake a survey of the prevalence of tail deviations, trauma and shortening on a representative selection of New Zealand dairy farms, and to assess whether sampling based on milking order could be used instead of random sampling across the herd to estimate prevalence.

Methods: This was a cross-sectional observational study, with 200 randomly selected farms enrolled across nine regions of New Zealand via selected veterinary practices (one/region). Veterinary clinics enrolled 20–25 farms each depending on region, with 1–2 trained technicians scoring per region. All cows (n = 92,348) present at a milking or pregnancy testing event were tail scored using a modified version of the New Zealand Veterinary Association Industry Scoring System. Palpated lesions were recorded as deviated (i.e. non-linear deformity), shortened (tail shorter than normal) or traumatic (all other lesions). The location of lesions was defined by dividing the tail into three equal zones: upper, middle and lower. A cow could have more than one lesion type and location, and/or multiple lesions of the same type, but for the prevalence calculation, only the presence or absence of a particular lesion was assessed. Prevalence of tail damage calculated using whole herd scoring was compared to random sampling across the herd and sampling from the front and back of the milking order. Bootstrap sampling with replacement was used to generate the sampling distributions across seven sample sizes ranging from 40–435 cows.

Results: When scoring all cows, the median prevalence for deviation was 9.5 (min 0.9, max 40.3)%; trauma 0.9 (min 0, max 10.7)%, and shortening was 4.5 (min 1.3, max 10.8)%. Deviation and trauma prevalence varied between regions; the median prevalence of deviations ranged from 6% in the West Coast to 13% in Waikato, and the median prevalence of all tail damage from 7% in the West Coast to 29% in Southland. Sampling based on milking order was less precise than random sampling across the herd. With the latter and using 157 cows, 95% of prevalence estimates were within 5% of the whole herd estimate, but sampling based on milking order needed > 300 cows to achieve the same precision.

Conclusions and clinical relevance: The proportion of cows identified as having damaged tails was consistent with recent reports from New Zealand and Ireland, but at 11.5%, the proportion of cows with trauma or deviation is below acceptable standards. An industry-wide programme is needed to reduce the proportion of affected cows.

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Introduction

The wellbeing of farm animals is of increasing consumer interest (Bennett 1995; McEachern *et al.* 2007). While historically wellbeing may have been defined and measured around an animal's health and production (Hewson 2003), there is a growing interest in considering animals as sentient beings (Proctor 2012), with New Zealand including this view within legislation in the Animal Welfare Amendment Act (No. 2) in 2015. In addition, affective state (the biological and psychological state of an animal as it attempts to cope with its environment and its ability to display natural behaviour) is now seen as an important part of animal welfare (Mellor and Beausoleil 2015).

Tail damage affects animal health (freedom from pain and distress), natural behaviour and affective state. The tail is a very sensitive appendage containing a large number of pain receptors (Nickel *et al.* 1992) and the tail also plays a notable role in natural behaviour, being important for communication, locomotion, and fly control (Kiley-Worthington 1976; Matthews *et al.* 1995; Phipps *et al.* 1995). Through these impacts, tail damage has a negative impact on a cow's affective state, especially if the tail damage is repeated (Ledger and Mellor 2018).

The key to characterising the problem of damaged tails is appropriately defining what "damaged" means. Tails can be injured in a variety of ways; for example, a sharp edge can slice through the skin and

CONTACT RA Laven r.laven@massey.ac.nz
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underlying tissue, or a wire or similar (or even a faecal ring) can wrap around the tail causing necrosis from the skin inwards. However, the most common injury, and the injury of most concern in dairy cattle, is an injury that tears or separates the fascia (connective tissue) from the underlying tail vertebrae. This is often colloquially referred to as a “broken tail” (Laven and Jermy 2020), although vertebral fractures are not the principal feature in most cases. Tearing and separation of the fascia usually leads to swelling of the tail at the point of injury, which when the injury becomes stable, leaves a hard swelling that is detectable by palpation. If the damage is more severe and leads to partial or full dislocation of the affected vertebral bodies, then the swelling will be accompanied by deviation, which is often permanent.

This issue is separate from the issue of short tails, which are tails that have been shortened in response to a tail injury or docked deliberately as a husbandry procedure. Tail docking other than switch removal (removal of just the last 2–3 caudal vertebrae) has been illegal in New Zealand since 2005 (Anonymous 2005), and illegal for any part of the tail since 2018 (Anonymous 2018). In New Zealand, tails shortened by more than two vertebrae (or at all in cows ≤ 4 years old) should only be present in cows where amputation has been carried out by a veterinarian with suitable anaesthesia and in response to tail damage. Lack of records, especially in farms that have recently purchased cows, can mean this is difficult to establish and often the cause of the tail damage that necessitated tail shortening is unknown.

In New Zealand, there is increasing interest in recording tail damage as an indication of stockpersonship and animal welfare, and following a small number of high-profile prosecutions under the Animal Welfare Act 1999 (Anonymous 1999) of farms with high prevalence of damage. Moono *et al.* (2022) reported the range in prevalence of tail damage on 29 farms enrolled with WelFarm (www.welfarm.co.nz), where palpation of tails was used to diagnose and follow-up the prevalence of tail damage in cows over a number of years. Damaged tails were classified as tails with palpated fractures or dislocations, soft tissue trauma, such as wounds or swelling, and lacerations or bony changes associated with a single vertebra. They reported a range in mean prevalence by region and by year from 3.5% (64 cases in 1,835 cows) in Taranaki in 2014–2015 to 28.7% (1,434/4,988) in Southland/Otago in 2017–2018. Although this survey collected data from multiple regions across New Zealand, all farmers included in the survey willingly paid to have a WelFarm assessment (which included tail damage assessment). Therefore, it is very possible that these farmers are not representative of New Zealand farmers, especially in regard to tail damage. Nevertheless, the high prevalence on many farms reported by Moono *et al.* (2022) highlights the importance of the problem. If we are to develop targets for change on New Zealand dairy farms, we need a representative wide-scale sample from across New Zealand which will allow us to calculate the true mean and range of prevalence of tail damage on New Zealand dairy farms.

For many welfare assessments, sampling procedures are used to minimise the cost and time required for the assessment (Van Os *et al.* 2018). As most welfare assessment schemes do not include explicit recommendations to record the percentage of damaged tails (Laven and Jermy 2020), there are currently no published recommendations on the proportion of a herd which needs to be sampled in order to accurately estimate the prevalence of damaged tails. In particular, there are no data as to whether sampling based on milking order – as has been suggested for lame cows (Main *et al.* 2010) – can be used as an alternative to random sampling of the whole herd.

Therefore, the twin aims of this research were to undertake a survey of the prevalence of tail damage on a representative selection of New Zealand dairy farms, and to determine the best sampling approach to accurately determine the proportion of cows with damaged tails on a farm.

Materials and methods

All animal manipulations were approved by Massey University Animal Ethics Committee application AEC 21/71 on 3 December 2021.

Farm enrolment

This study was a cross-sectional observational study, with 200 farms enrolled across nine regions of New Zealand. Study size was based on an expected true prevalence of 14% (Bryan *et al.* 2019), with the aim of estimating prevalence with a precision of 5% at 95% confidence. The calculation identified that 186 farms were needed for this level of confidence and precision, which was inflated to 200 farms to allow for data loss.

A convenience sample of nine veterinary practices (one per region of New Zealand) were selected for the study. All active dairy clients within 100 km, or within 1 hour of travel from the enrolled regional veterinary practice were eligible to be enrolled. The number of farms enrolled depended on the region. Veterinary clinics in Waikato, Taranaki, Canterbury and Southland regions enrolled 25 farms each, and veterinary clinics from Northland, Bay of Plenty, Manawatū, West Coast and Otago enrolled 20 farms each. Each clinic listed the eligible dairy farms in alphabetical order and gave each farm a number from 1 to x (where x = total number of eligible dairy farms). A random number was then generated in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA, 2018) between 1 and 10, which was used to select the first farm on the list. Then every N^{th} farm (where N = x/number of farms to be enrolled) on the list was enrolled.

Each of the identified farms were contacted by phone to assess their willingness to be involved. This included a conversation informing the farmers that their veterinarian would be able to see their results but that all results would be anonymised once they had left the veterinary practice. If the farmers declined to participate, the reason was recorded and the farm immediately below or above that farm in the list was selected (based on veterinary choice). For each practice, its number of clients, the number of clients that were ineligible and the number of clients that refused to take part were all recorded.

Animal enrolment

All dairy cows present at the milking/pregnancy diagnosis at which scoring was to take place, were eligible to be tail scored.

Tail scoring

Tail scoring data were collected from all the animals present at milking time or pregnancy testing time (cows were in the milking parlour for the scoring event) between December 2021 and March 2022 by one or two trained technicians per region (total of 12 personnel). As far as possible, this ensured consistency of scoring between regions, and within each clinic. All scoring events took place at times convenient for the farmers and scorers and neither the time nor the event at which scoring took place were recorded. Initial training was provided online by project managers EC and MB. Subsequently and prior to the study start date, a key staff member for each practice was personally trained on 1–2 herds by an experienced tail scorer from VetSouth (South Island regions) or VetEnt (North Island regions).

A modified version of the New Zealand Veterinary Association Industry Scoring System was used (Anonymous 2021a). Lesions were recorded as deviated (i.e. non-linear deformity), shortened (tail appearing shorter than normal) or as the result of trauma (all other lesions). All lesions on a tail were recorded so a cow could have more than one lesion type and location, and/or multiple lesions of the same type. The location of lesions on the tail was defined by dividing the tail into three equal zones: upper, middle and lower. Shortened tails were classified according to the zone within which shortening had occurred. Scores were recorded on either proprietary software (e.g. Infovet; Zoetis, Auckland, NZ) or on a pre-printed paper form, and returned to the project leader (EC).

Statistical analyses

Prevalence estimates

All raw data were converted to .csv files and imported into R (R Core Team 2022; R Foundation for Statistical Computing, Vienna, Austria) to be assessed for completeness, consistency, formatting, and logical coherence. For analysis, the recorded tail lesions were categorised as: presence of deviation, shortening, trauma, deviation and trauma, or presence of any tail damage at all. "Damaged" tails were classified as the combination of deviation and trauma together.

Animals could have multiple lesions recorded, but the presence of each lesion was recorded as a binary variable (present/absent) for each animal and not as the count of the lesions. The prevalence of tail damage for each of these outcomes was calculated for each farm by dividing the number of tail-damaged animals by the total number scored at each visit. Summary statistics included the median, IQR and range for each region and overall. These were presented in both tabular and graphical form. The location of damage for each of these categories was also collected and investigated. Data summaries of the proportion of each lesion and their location in the tail (upper, middle or lower third) were reported in tabular and graphical form.

Comparison of random sampling vs. sampling by milking order as estimates for herd prevalence

For this analysis, a convenience subset of the 200-farm dataset was used. This subset consisted of data from 44 farms, all of which had tail score records that also included the order by which the scored cows had entered the milking parlour. Farms were in this category simply as a function of how the technician recorded the tail scores. For these farms, every tag number was recorded as the cows were coming into the milking shed, as opposed to electronic recording using Infovet, when an individual tail score was assigned to each cow but the order in which cows arrived in the milking shed was not recorded. Using this dataset, the precision of the estimates of herd prevalence (compared to that recorded from the whole herd scoring) were compared for three sampling scenarios: random sampling throughout milking; sampling from the front of the herd (i.e. the first cows to be milked) and sampling from the back of the herd (i.e. the last cows to be milked).

For all three scenarios the sampling distributions were generated using bootstrapping (resampling with replacement) with sample sizes of 40, 70, 157, 194, 245, 320 and 435. These sample sizes correspond to an expected precision (based on Wald confidence limits with 95% confidence; Vallejo *et al.* 2013) of 10%, 7.5%, 5%, 4.5%, 4%, 3.5% and 3% at the median prevalence of tail damage found in this study (i.e. 11.5%). For the random sampling throughout milking, cows were randomly selected from the whole herd with replacement until the required sample size was reached; e.g. for a sample size of 40, 40 selections were made. A similar process was used for the two milking order scenarios, except that, depending on sample size, the population used for sampling with replacement was based on milking order. For example, for the sample size of 40, the first (or last) 40 cows were identified and 40 random selections with replacement were made from that population. A total of 1,000 bootstrap samples were simulated for each farm (n = 44), sampling scenario (n = 3) and sample size (n = 7). The difference between the bootstrap estimates and the actual prevalence (from whole herd tail scoring) was then calculated by subtraction for each sample method, sample size and farm.

Results

Across the nine veterinary practices, there were a total of 1,294 eligible dairy clients. In order to enrol 200 farms, 270 clients were initially contacted with 70 clients deemed ineligible (e.g. if the client was very hard to contact or declined to be involved).

Prevalence of tail damage

A total of 92,348 dairy cows, across 200 farms from nine regions, had their tails scored (Table 1). The median herd size was 418 (IQR 258–608; min 61, max 1,879) cows, and the mean herd size was 462 cows. When scoring all cows, the median prevalence for tail deviation was 9.5% (min 0.9, max 40.3%), trauma 0.9% (min 0, max 10.7%); and shortening, 4.5% (min 1.3, max 10.8%). The prevalence of tail deviations varied between regions, with the median prevalence of deviations ranging from 6% in the West Coast, to 13% in Waikato (Table 2). The median prevalence of cows with any form of tail damage ranged between regions from 7% in the West Coast to 29% in Southland.

Table 1. The number of enrolled farms and cows that were tail scored across nine regions of New Zealand to investigate the prevalence of tail damage on dairy farms.

Region	Number of farms scored	Number of cows scored (% of total animals)	Median herd size (IQR)
Bay of Plenty	20	8,553 (9.3)	420 (279–534)
Canterbury	25	17,750 (19)	650 (520–816)
Manawatū	20	6,507 (7.0)	291 (214–365)
Northland	20	7,050 (7.6)	284 (254–419)
Otago	20	12,092 (13)	570 (515–708)
Southland	25	15,673 (17)	599 (479–716)
Taranaki	25	5,865 (6.4)	236 (184–283)
Waikato	25	9,670 (10)	349 (210–525)
West Coast	20	9,188 (9.9)	429 (252–647)
Total	200	92,348	418 (248–608)

Number of deviations

The number of tail deviations in affected cows ranged from 1 to 6 lesions per tail, with 1.0% of all animals scored having more than one deviation, equating to 8.5% of all animals with tail deviations.

Location of tail damage

The location on the tail where trauma or deviation occurred varied by region and lesion (Figure 1 and Table 2). Two thirds of deviated lesions occurred in the middle portion of the tail, and 31% in the lower third of the tail (Table 3). There was less variability in tail shortening (Tables 2 and 3). Eighty-two percent of all shortened tails had been shortened in the lower third of the tail, with 17% in the middle zone (equating to 1,570 animals with tails shortened in the middle third of the tail from the 92,348 animals scored; see Supplementary Figures S1, S2 and S3).

Number to score and sampling methods

For the subset data, the median prevalence of tail damage was 11.5% (IQR 6.7–15.1%). The median herd size was 278 (IQR 196–388) animals. In comparison, the median herd size for the full dataset was 418 (IQR = 258–608) animals. For this level of prevalence and with an infinite population, the predicted number of animals required for estimating tail damage prevalence at different levels of precision is displayed in Table 4 (Vallejo *et al.* 2013). The results of the bootstrap sampling for the three scenarios are presented in Table 5. This table summarises the distribution of the differences between estimates and actual prevalence by sample method and sample size, across all 44 farms (with 44,000 data points contributing to each row of Table 5).

For all sampling scenarios, the median difference (50th percentile) between herd prevalence estimated using bootstrapping and the prevalence estimated using whole herd assessment was close to zero (min −0.98%, max 0.42%), demonstrating that no diagnostically important systemic bias resulted from sampling animals at the front or back of the milking order. For the random sampling throughout the herd, the precision of the prevalence estimates matched that calculated using the Wald confidence limits. For example, sampling 157 animals with replacement estimated herd prevalence with a precision of 5.1% (half the

Table 2. Median, IQR and range of the prevalence of tail damage[a] from 92,348 cows across 200 farms from nine regions in New Zealand.

Type of tail damage[b]	Overall	Bay of Plenty	Canterbury	Manawatū	Northland	Otago	Southland	Taranaki	Waikato	West Coast
Deviated										
Median	9.5	9.2	11.7	10.1	10.2	6.2	9.5	7.1	13.2	6.2
IQR	6.3–13.5	8.1–13.8	8.9–13.5	7.4–16.5	6.7–13.9	4.3–8.6	7.4–12.5	5.4–10.2	11.8–16.7	4.4–9.2
Range	0.9–40.3	2.0–20.0	5.3–20.0	1.9–30.1	0.9–22.9	2.3–14.7	4.7–26.4	2.8–20.0	6.1–40.3	0.9–22.8
Trauma										
Median	0.9	0.4	0.7	0.4	0.0	4.4	4.9	0.9	0.9	0.6
IQR	0.3–2.8	0.0–0.5	0.4–1.4	0.3–1.0	0.0–0.1	2.6–6.7	3.3–5.2	0.3–2.8	0.7–1.1	0.1–1.1
Range	0.0–10.7	0.0–5.4	0.0–3.1	0.0–4.9	0.0–1.0	1.5–10.7	2.6–10.0	0.0–5.9	0.0–2.4	0.0–3.0
Shortened										
Median	4.5	6.3	6.1	4.1	0.2	8.0	14.2	5.0	3.2	0.5
IQR	1.3–10.8	3.4–11.5	2.5–8.4)	2.7–12.3	0.0–0.6	5.1–25.1	5.2–25.7	1.3–20.7	2.7–7.4	0.3–1.5
Range	0.0–70.4	1.3–49.3	0.4–32.7	0.0–69.1	0.0–3.3	1.1–56.7	1.2–59.1	0.0–45.9	0.5–57.2	0.0–70.4
Any damage										
Median	17.0	16.8	16.5	17.6	10.7	21.6	29.1	15.7	19.0	7.4
IQR	12.7–24.6	14.0–23.3	13.5–22.2	13.7–27.4	6.7–14.1	14.9–32.8	19.5–38.8	12.0–28.1	15.9–23.5	6.1–16.5
Range	1.7–73.7	3.3–54.2	10.0–35.2	6.3–70.1	1.7–22.9	9.9–63.4	12.8–65.4	6.0–57.3	9.4–62.0	3.1–73.7
Deviated + trauma										
Median	11.5	11.5	11.8	11.1	10.4	10.6	13.3	10.8	13.9	6.8
IQR	7.8–15.0	8.9–14.6	9.6–13.9	8.8–16.6	6.7–13.9	8.0–14.3	11.7–17.2	6.3–12.1	12.7–18.6	4.9–10.0
Range	0.9–40.7	2.0–20.0	5.3–21.7	2.3–31.9	0.9–22.9	4.9–19.7	7.8–29.6	3.5–20.4	6.7–40.7	2.8–23.9

[a]Defined using a modified version of the New Zealand Veterinary Association Industry Scoring System (Anonymous 2021a)
[b]Lesions were recorded as deviated (i.e., non-linear deformity), shortened (tail appearing shorter than normal) or trauma (all other lesions). All lesions on a tail were recorded so a cow could have more than one lesion type and location, and/or multiple lesions of the same type

width of the 95% CI presented in Table 5) compared to the predicted 5% (Table 4), and sampling 245 animals had a precision of 4.07% (Table 5) compared to the predicted 4% (Table 4).

At all sample sizes, the precision of sampling from the front or the back of the herd was poorer than that of random sampling. This was most apparent for lower sample sizes. For example, when 40 animals were sampled, the precision of the estimates were 15.35% and 15.24% for sampling from the front and back of the milking order, respectively, while sampling 40 cows randomly from across the herd had a precision of 9.95%. In contrast, sampling 435 animals had a precision of 3.74% and 3.75% for sampling from the front and back of the milking order, respectively, while random sampling had a precision of 3.08%. Thus, in contrast to random sampling where sampling 157 animals resulted in a precision of 5%, the lowest sample size analysed in this study where the precision of sampling from the front or the back of the milking order was < 5% was 320.

Discussion

This is the first study to estimate the prevalence of damaged tails in a representative sample of the New Zealand dairy farm population. This represents the largest study completed on this topic to date with 92,348 cattle scored from 200 farms across nine regions of New Zealand.

The median prevalence of tails with damage due to deviations and/or trauma was 11.5%, with the median prevalence of deviations alone being 9.5% and that of trauma being 0.9%. At the farm level, the prevalence of deviations ranged from 0.9 to 40.3% and the prevalence of trauma from 0–10.7%. There are very few studies for comparison, locally or internationally, that have similarly assessed damaged tails. However, two recent and relevant studies have been completed using definitions and methods of diagnosis aligned to the current definitions of tail damage. Moono *et al.* (2022) reported the prevalence of deviated tails at 10.2% in New Zealand herds, while Crossley *et al.* (2021) found 9.1% broken tails in a study from Southern Ireland. Earlier studies have reported lower figures for prevalence of tails with any form of damage. In a study from Ontario, Canada of 317 farms using tie stalls and with a definition of broken tails that would align with a break or dislocation under the current study, Zurbrigg *et al.* (2005) reported an overall prevalence of 3% of cattle but a farm-level prevalence from 0–50%, with only 5% farms with prevalence > 15%. This low prevalence of damage was also reported by De Wolf (2009) who recorded that on 16/23 pasture-based dairy farms in Uruguay < 1% of the cows had a broken tail (definition consistent with our definition of deviations).

The lack of studies on the prevalence of tail damage means that it is difficult to assess whether New Zealand has a high prevalence of tail damage or whether this is typical of dairy farming systems across the world. However, the prevalence of damaged tails recorded in this study is much higher than targets that have been set for damaged tails. Both Zurbrigg *et al.* (2005) and De Wolf (2009) concluded that a target of < 1% broken tails was achievable, while American Humane standards state that ≥ 98% of cattle must have undamaged, unbroken tails (Anonymous 2020)

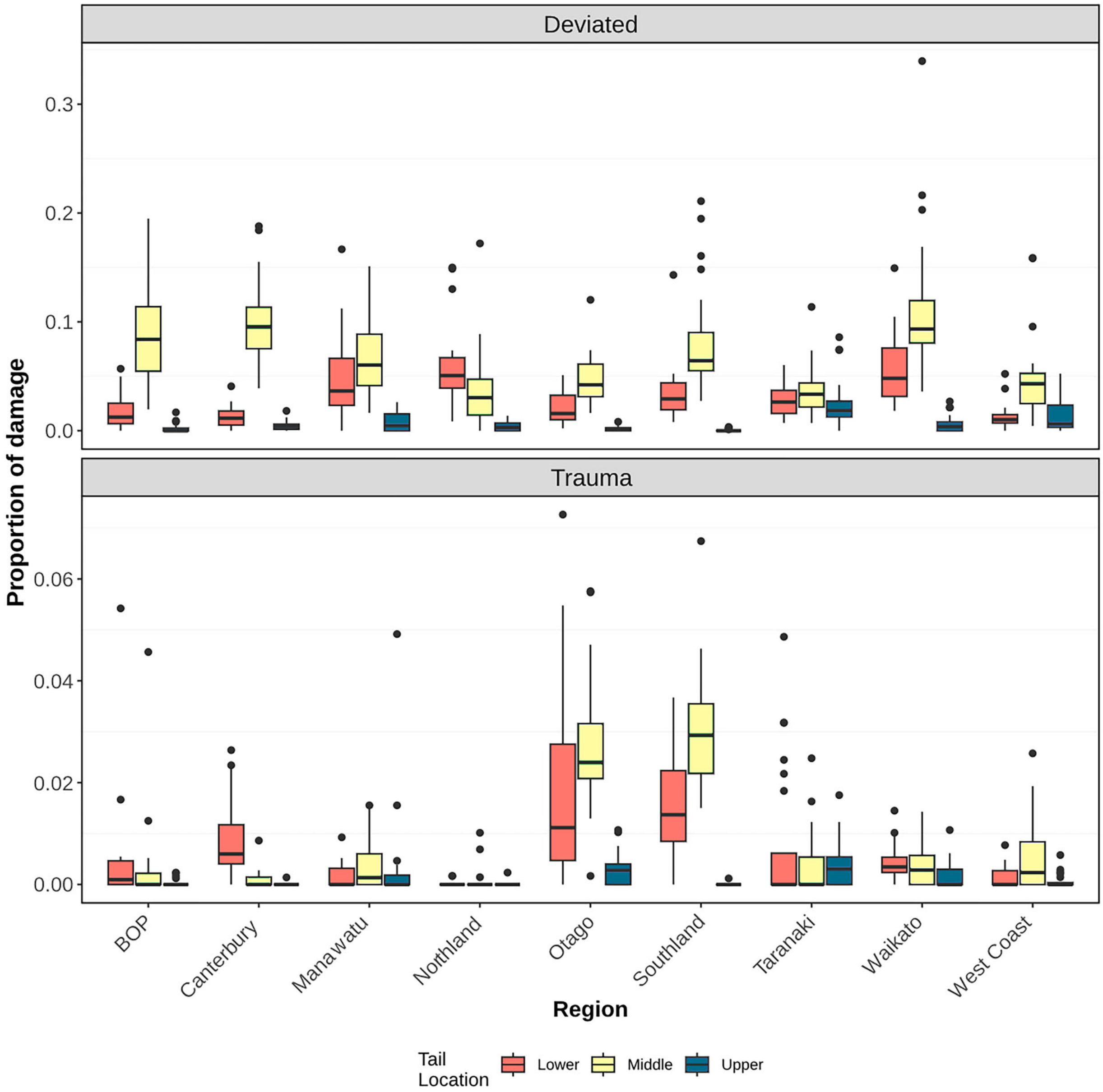

Figure 1. Boxplots summarising tail scoring data using a modified version of the New Zealand Veterinary Association Industry Scoring System (Anonymous 2021a) from 92,348 cows on 200 farms across 9 regions of New Zealand for the prevalence of deviated tail damage (non-linear deformity: top facet) and traumatic tail damage (all damage except deviation and shortening: bottom facet) by region and split by location of damage on the tail (Upper (blue/dark grey), middle (yellow/white) or lower (red/light grey) third of the tail). All lesions on a tail were recorded so a cow could have more than one lesion type and location, and/or multiple lesions of the same type. Each box represents the 25th and 75th percentile with the median marked by a horizontal line. Each whisker extends to 1.5 times the IQR and outliers outside this point are marked by solid grey dots. To view the figure in colour please see the online version.

and the UK Royal Society for Prevention of Cruelty to Animals welfare standards state that it is possible to maintain a herd with no broken tails (Anonymous 2021b). In this survey, 75% of farms had a prevalence of deviations and trauma of ≥ 8%, with only 1/200 (0.5%) and 15/200 (7.5%) achieving < 1 and 5%, respectively. Furthermore, 20% of farms had a prevalence of deviation and trauma that was ≥ 16.5%. There is clearly a need to reduce the prevalence of both deviations and trauma in New Zealand dairy cattle (especially the former). To do this will require a better understanding of the causes of deviation and trauma. As far as the authors are aware there are no published studies on the causes of damaged tails, but the wide between-farm range in tail damage prevalence from this survey suggests that it is very likely that there are specific farm-level risk factors that influence tail damage prevalence. Understanding these factors will be the key to improvement in the future.

The sampling method was designed to get a representative sample of New Zealand farmers but maintain some level of consistency with scoring. This sampling method had two limitations. The first was that the

Table 3. The proportion of cows (n = 92,348) from 200 farms across nine regions in New Zealand with deviated (non-linear deformity), tail shortening[a], or traumatic (all other lesions) tail damage[b] for the lower, middle and upper third of the tail. The percentage of each lesion type at each position is shown in parentheses.

	Proportion of animal (% of lesion)		
Position on tail	Deviated	Trauma	Shortened
Upper	0.001 (7)	0.0016 (9)	0.001 (1)
Middle	0.07 (66)	0.009 (51)	0.017 (17)
Lower	0.03 (31)	0.007 (41)	0.082 (82)

[a]Shortened tails appeared shorter than normal and were classified according to the zone within which shortening had occurred.
[b]Scored using a modified version of the New Zealand Veterinary Association Industry Scoring System (Anonymous 2021a). All lesions on a tail were recorded so a cow could have more than one lesion type and location, and/or multiple lesions of the same type.

Table 4. The required number of animals to sample to achieve the stated level of precision[a].

Number sampled	Precision (%)
40	10.0
44	9.5
49	9.0
55	8.5
62	8.0
70	7.5
80	7.0
93	6.5
109	6.0
130	5.5
157	5.0
194	4.5
245	4.0
320	3.5
435	3.0

[a]Based on Wald confidence limits with 95% confidence; (Vallejo *et al.* 2013) for estimating the prevalence of herd level tail damage when the median prevalence of damage = 11.5%, α = 0.05, and the population is assumed to be infinite.

sampling method involved selecting farms from a veterinary clinic client list. While farmers did not have to pay to be involved, likely reducing the bias that may have existed in Moono *et al.* (2022), they did have the right to refuse to partake in the study. In total, 35% (70/200) of the initial sample population were not enrolled, highlighting the scale of this issue (although some could not be contacted and may have been willing to be enrolled). It is possible that if a farmer was aware of existing tail damage they may have opted not to be involved, thereby reducing the overall average prevalence result. Despite the potential differences in selection between the current study and Moono *et al.* (2022), the median results are actually very similar (9.5% deviation *vs.* 10.2%, respectively). This may suggest, contrary to previous thought, that having to pay for tail scoring does not disincentivise uptake by farmers who suspect they have high levels of tail damage in their herds; or that farms with high prevalence are equally likely to say no in both sampling systems.

The second limitation was that while individuals carrying out the tail scoring were trained to score using set criteria, this project still had different individuals scoring different regions. Carrying out this project over nine veterinary clinics enabled greater consistency with individual scorers than if we had sampled 200 farms across > 20 veterinary clinics (as would have been the situation in a true random sample of farms across the country) but regional differences cannot be distinguished from scoring differences between individuals. There were, for example, large differences in the length of tail scoring experience of the scorers. Therefore, large regional differences such as that shown between Northland and Southland, are not necessarily a true regional difference and are quite possibly related to the sensitivity of the scorer. A consistent score system or a sign off system that includes assessment of agreement (like the training in body condition score recording offered by DairyNZ[1]) will be needed to assess true regional differences in the future. It is also possible that a scorer's sensitivity may increase over time, and more work is needed to assess this.

The analysis of sample size showed that sampling from the front or back of the milking order did not bias the estimate of the prevalence of tail damage, in contrast to data in relation to lameness prevalence where milking order may be related to risk of lameness (Beggs *et al.* 2019). However, estimates based on sampling by milking order were, except for large samples (> 400), much less precise than estimates from random sampling throughout the herd. For example, random sampling from the whole herd resulted in a precision of 5% when 157 cows were sampled, whereas > 300 cows were required to get similar precision when cattle were sampled from the front or back of the milking order. Although over all 44 farms there was no meaningful bias from sampling from the front or back of the milking order, at the individual farm level there could be a significant skew in the distribution of lame cows which may differ between farms. Furthermore, the precision of front and back sampling is likely to be worse for small herds than our simulation indicates, as when our sample size was larger than herd size (e.g., when our sample size was 245 and herd size was 184), our simulation is effectively sampling randomly across the herd. Thus, except in very large herds or if precision is of very limited importance, sampling based on milking order rather than random sampling throughout the herd is unlikely to be of practical use.

If random sampling is to be used, a decision needs to be made as to the precision required for the estimate in order to determine sample size. This is a clinical rather than a statistical decision. Based on the data

[1]https://www.dairynz.co.nz/support/training/bcs-assessor-certification/

Table 5. Bootstrap sampling distribution for different sampling scenarios (front of herd, back of herd and randomly throughout the herd) compared to the herd-level prevalence of tail damage estimated from 92,348 cows across 200 farms and 9 regions of New Zealand.

Number sampled	Sampling scenario	2.5th percentile (%)[a]	50th percentile (%)[b]	97.5th percentile (%)[c]	95% width[d]
40					
	Random sample of herd	−9.00	−0.26	10.89	19.89
	Sample front of herd	−10.81	0.30	19.88	30.69
	Sample last of herd	−11.49	−0.98	18.99	30.48
70					
	Random sample of herd	−7.19	−0.24	8.01	15.20
	Sample front of herd	−9.34	0.42	14.40	23.74
	Sample last of herd	−9.80	0.00	13.65	23.45
157					
	Random sample of herd	−4.96	−0.07	5.24	10.20
	Sample front of herd	−6.54	−0.30	9.40	15.94
	Sample last of herd	−6.52	−0.04	7.84	14.36
194					
	Random sample of herd	−4.34	−0.06	4.63	8.97
	Sample front of herd	−5.84	−0.14	7.64	13.48
	Sample last of herd	−6.03	−0.07	6.87	12.90
245					
	Random sample of herd	−3.94	−0.03	4.19	8.13
	Sample front of herd	−5.33	−0.03	5.87	11.20
	Sample last of herd	−5.59	−0.13	5.68	11.27
320					
	Random sample of herd	−3.41	−0.04	3.63	7.04
	Sample front of herd	−4.48	−0.10	4.81	9.29
	Sample last of herd	−4.89	−0.03	4.80	9.69
435					
	Random sample of herd	−2.98	−0.02	3.17	6.15
	Sample front of herd	−3.48	−0.09	4.00	7.48
	Sample last of herd	−4.07	−0.04	3.43	7.50

[a]2.5% of all differences between prevalence estimated using sampling scenario and whole herd assessment are more negative than this figure (e.g. for a sample size of 40 where the bootstrap sampling was used on the last 40 cows in the milking order, sample prevalence was > 11.49% lower than whole herd prevalence in 2.5% of bootstrapped samples across all 44 herds).
[b]Median difference between prevalence estimated using sampling scenario and whole herd assessment (sample prevalence − whole herd prevalence).
[c]2.5% of all differences between prevalence estimated using sampling scenario and whole herd assessment are more positive than this figure (e.g. for a sample size of 40 where the bootstrap sampling was used on the last 40 cows in the milking order, sample prevalence was > 18.99% higher than whole herd prevalence in 2.5% of bootstrapped samples across all 44 herds).
[d]97.5th percentile − 2.5th percentile. As 50th percentile for all sample sizes was ∼0, this width is equal to ∼2* the precision for the sampling scenario.

from this survey, where the median prevalence of deviations was 9.5%, we would suggest that a precision of 5% should be used as this will differentiate farms with the median prevalence of deviations from farms with a prevalence of 15%. We have chosen this 15% threshold because, based on the current prevalence of tail deviations in New Zealand dairy cows identified by this study and Moono *et al.* (2022), we believe that farms with a prevalence of deviations > 15% should be actively monitoring how and when deviations are occurring and actively working towards reducing their prevalence. If programmes can be developed to reduce tail injury in New Zealand dairy cows, this threshold for action should reduce, which may also necessitate a change in the required precision. Similarly in countries where the proportion of cows with tail damage is less than that reported in this study, different thresholds for action and requirements for precision can be chosen.

This study showed that with a median prevalence of damaged tails (deviations and/or trauma) of 11.5%, randomly sampling 157 cows across a herd will result in an estimate of prevalence with a precision of 5%. However, it is important to note that that this sample size is based on bootstrap estimates and therefore sampling with replacement, whereas on-farm sampling will be undertaken using sampling without replacement. For this type of sampling, it may be better to use the finite correction factor and the binomial rather than the normal distribution (Vallejo *et al.* 2013). This alters the sample size required. Thus, with a median prevalence of 11.5%, a precision of 5% and a herd size of 418 (the median herd size in the survey population) the suggested corrected sample size is 133 (with 95% confidence). However, if these sample size corrections are used, they need to be accounted for in the calculation of the variance and resulting confidence intervals of the estimate (Sergeant 2018). Thus, for welfare assessments it may be easier to use sample sizes calculated without correcting for sampling a finite population. Sample sizes calculated without correction will always be larger than corrected sample sizes and therefore be more precise than the required precision for the expected prevalence, which may be useful if prevalence is higher than expected.

Nevertheless, irrespective of which sample size is chosen, in most of the herds assessed for this study, random sampling would significantly reduce the number of animals that are observed for tail damage compared to assessing the whole herd. However, in contrast to housed cattle where random sampling would significantly reduce the time taken for an assessment, on most New Zealand farms (where cows are kept permanently at pasture) cows are only available for assessment when they are bought in for a management procedure (such as milking or pregnancy diagnosis). In such cases there is limited value in random sampling as the assessor still has to be present for the whole of milking/pregnancy diagnosis task, so no time is saved, especially when recording tail damage is the only assessment being made.

Thus, based on the results of this survey, we suggest that, under New Zealand conditions, whole-herd observation of tail damage should be the method of choice for determining herd prevalence. There needs to be engagement with the dairy industry, dairy veterinarians, and government to introduce a national approach to tail scoring, with the results of this survey being used to benchmark farms as part of a national monitoring programme. Further research is needed to identify the key risk factors determining the prevalence of tail damage so that a programme to reduce tail damage on New Zealand farms can be developed.

Conclusions

From 92,348 cattle scored from 200 farms across nine regions of New Zealand, 11.5% of cattle had tails that were damaged (deviated and/or trauma). Another 4.5% of cattle had tails that were shortened. Random sampling from the whole herd was more accurate (greater precision, no meaningful difference in bias) than sampling based on milking order and may be useful in housed herds where random sampling will reduce the time taken to assess tail damage. Under New Zealand conditions, sampling of the whole herd should be the preferred option as random sampling is not likely to significantly reduce the time taken. Further research across other dairy systems is required to establish whether the level of tail damage reported in this survey is similar to or different from the norm.

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ORCID

E L Cuttance http://orcid.org/0000-0003-0354-5295
W A Mason http://orcid.org/0000-0002-0006-7323
S Y Hea http://orcid.org/0000-0003-3464-9804
M A Bryan http://orcid.org/0000-0002-5932-673X
R A Laven http://orcid.org/0000-0002-8938-8595

References

*__Anonymous__. *Animal Welfare Act 1999*. https://www.legislation.govt.nz/act/public/1999/0142/latest/DLM49664.html (accessed 15 May 2023). New Zealand Government Printer, Wellington, NZ, 1999

*__Anonymous__. *Animal Welfare (Painful Husbandry Procedures) Code of Welfare*. https://www.mpi.govt.nz/animals/animal-welfare/codes/all-animal-welfare-codes/ (accessed 25 January 2024). Ministry for Primary Industries, Wellington, NZ, 2005

*__Anonymous__. *Animal Welfare Standards for Dairy Cattle*. https://urldefense.proofpoint.com/v2/url?u=https-3A__www.americanhumane.org_app_uploads_2021_08_Dairy-2DCattle-2DFull-2DStandards.pdf&d=DwIFaQ&c=euGZstcaTDllvimEN8b7jXrwqOf-v5A_CdpgnVfiiMM&r=cIKE-qLzzlOp7D7D9RkSpvjBA8jFMWeRKGDCHCWjGYg&m=unEblNG4psCS4cxBzYkYyT9sMZVL1XmWwkigoB_jHFMfk6Svu0ZpvMICwQUZO4ox&s=_u9c7nAry5ReXOX1i780Z15CjqUZLne_gsqnbJhZlAo&e= (accessed 16 February 2024). American Humane, Washington, DC, USA, 2020

*__Anonymous__. *Code of Welfare: Painful Husbandry Procedures*. https://www.mpi.govt.nz/animals/animal-welfare/codes/all-animal-welfare-codes/code-of-welfare-painful-husbandry-procedures/ (accessed 25 January 2024). Ministry for Primary Industries, Wellington, NZ, 2018

*__Anonymous__. *NZVA Standardised Tail Scoring System*. https://nzva.org.nz/assets/Policies-Guidelines-Resources/tail_scoring.pdf (accessed 25 January 2024). New Zealand Veterinary Association, Wellington, NZ, 2021a

*__Anonymous__. *Royal Society for the Prevention of Cruelty to Animals (RSPCA) Welfare Standards for Dairy Cattle*. https://science.rspca.org.uk/sciencegroup/farmanimals/standards/dairycattle (accessed 6 August 2022). RSPCA, Southwater, UK, 2021b

Beggs D, Jongman E, Hemsworth P, Fisher A. Lame cows on Australian dairy farms: a comparison of farmer-identified lameness and formal lameness scoring, and the position of lame cows within the milking order. *Journal of Dairy Science* 102, 1522–9, 2019. https://doi.org/10.3168/jds.2018-14847

Bennett R. The value of farm animal welfare. *Journal of Agricultural Economics* 46, 46–60, 1995. https://doi.org/10.1111/j.1477-9552.1995.tb00751.x

*__Bryan MA, Fruean SN, Moono P.__ Tail damage and tail scoring in NZ dairy cows – what is normal. *Newsletter of the Society of Dairy Cattle Veterinarians*. Pp 10–1. New Zealand Veterinary Association, Wellington, NZ, 2019

Crossley RE, Bokkers EAM, Browne N, Sugrue K, Kennedy E, de Boer IJM, Conneely M. Assessing dairy cow welfare during the grazing and housing periods on spring-calving, pasture-based dairy farms. *Journal of Animal Science* 99, skab093, 2021. https://doi.org/10.1093/jas/skab093

*__De Wolf A.__ A welfare assessment system for dairy cows on pasture and the comparison to a welfare scoring system for cows in cubicles. *Research Project Veterinary Medicine*, University of Utrecht, Utrecht, Netherlands, 2009

Hewson CJ. What is animal welfare? Common definitions and their practical consequences. *The Canadian Veterinary Journal* 44, 496, 2003

Kiley-Worthington M. The tail movements of ungulates, canids and felids with particular reference to their causation and function as displays. *Behaviour* 56, 69–114, 1976. https://doi.org/10.1163/156853976X00307

Laven R, Jermy M. Measuring the torque required to cause vertebral dislocation in cattle tails. *New Zealand Veterinary Journal* 68, 107–11, 2020. https://doi.org/10.1080/00480169.2019.1685019

Ledger RA, Mellor DJ. Forensic use of the Five Domains Model for assessing suffering in cases of animal cruelty. *Animals* 8, 101, 2018. https://doi.org/10.3390/ani8070101

Main DCJ, Barker ZE, Leach KA, Bell NJ, Whay HR, Browne WJ. Sampling strategies for monitoring lameness in dairy cattle. *Journal of Dairy Science* 93, 1970–8, 2010. https://doi.org/10.3168/jds.2009-2500

*__Matthews LR, Phipps A, Verkerk GA, Hart D, Crockford JN, Carragher JF, Harcourt RG.__ *The effects of tail docking and trimming on milker comfort and dairy cattle health, welfare and production.* Animal Behaviour and Welfare Research Centre, Hamilton, NZ, 1995

McEachern MG, Schröder MJ, Willock J, Whitelock J, Mason R. Exploring ethical brand extensions and consumer buying behaviour: the RSPCA and the "freedom food" brand. *Journal of Product & Brand Management* 16, 168–77, 2007. https://doi.org/10.1108/10610420710751546

Mellor DJ, Beausoleil N. Extending the 'Five Domains' model for animal welfare assessment to incorporate positive welfare states. *Animal Welfare* 24, 241, 2015. https://doi.org/10.7120/09627286.24.3.241

Moono P, Fruean S, Hampson D, Bryan M. The frequency of tail damage amongst cows from a sample of New Zealand dairy farms participating in an animal welfare programme. *New Zealand Veterinary Journal* 70, 248–55, 2022. https://doi.org/10.1080/00480169.2022.2069174

*__Nickel R, Schummer A, Seiferle E.__ Tiefe Hals, Rumpf, Schwanzfaszie [Deep neck, trunk, tail fascia]. In: *Lehrbuch der Anatomie der Haustiere, Band 1: Bewegungsapparat* [*Textbook of the Anatomy of Domestic Animals, Volume I: Musculoskeletal System*]. Sixth Edtn. Pp 336–7. Verlag Paul Parey, Berlin, Germany, 1992

Phipps A, Matthews L, Verkerk G. Tail docked dairy cattle: fly induced behaviour and adrenal responsiveness to ACTH. *Proceedings of the New Zealand Society of Animal Production* 55, 61–3, 1995

Proctor H. Animal sentience: where are we and where are we heading? *Animals* 2, 628–39, 2012. https://doi.org/10.3390/ani2040628

*__Sergeant E.__ *Epitools – Epidemiological Calculators*. http://epitools.ausvet.com.au (accessed 10 May 2023). Ausvet, Fremantle, Australia, 2018

Vallejo A, Muniesa A, Ferreira C, de Blas I. New method to estimate the sample size for calculation of a proportion assuming binomial distribution. *Research in Veterinary Science* 95, 405–9, 2013. https://doi.org/10.1016/j.rvsc.2013.04.005

Van Os JM, Winckler C, Trieb J, Matarazzo SV, Lehenbauer TW, Champagne JD, Tucker CB. Reliability of sampling strategies for measuring dairy cattle welfare on commercial farms. *Journal of Dairy Science* 101, 1495–504, 2018. https://doi.org/10.3168/jds.2017-13611

Zurbrigg K, Kelton D, Anderson N, Millman S. Tie stall design and its relationship to lameness, injury, and cleanliness on 317 Ontario dairy farms. *Journal of Dairy Science* 88, 3201, 2005. https://doi.org/10.3168/jds.S0022-0302(05)73003-4

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