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EVALUATION OF HERB PASTURES FOR NEW ZEALAND DAIRY SYSTEMS

A thesis presented in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

in

Animal Sciences

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I dedicate this Thesis to the memory of my wonderful grandma,

Mi abuelita Mary (1914 – 2015)

Thanks for your love and live so long for us



ABSTRACT

Chicory (*Cichorium intybus* L.) and plantain (*Plantago lanceolata* L.) sown in pure swards or both herbs sown with red clover (*Trifolium pratense* L.) and white clover (*T. repens* L.) are able to produce large amounts of high-quality forage in summer and autumn, when production and quality of perennial ryegrass (*Lolium perenne* L.) are often limited. There have been many cases of poor persistence of chicory with current management practices, but there is limited information for plantain and the herb-clover mix pastures when grazed in dairy systems. Additionally, the presence of bioactive compounds in plantain has created interest in their potential effect on rumen fermentation. The objectives of this research were to evaluate the effect of grazing frequency, two and four weeks, on the agronomic characteristics and diet selection of chicory, plantain, and herb-clover mix pastures, with dairy cows during two growing seasons (2011-2012; 2012-2013) and to examine the effect of the bioactive compounds in plantain on *in vitro* rumen fermentation.

Chicory plants grazed every two weeks, rather than every four weeks, did not develop large taproots, and consequently stored less carbohydrate reserves (fructan and fructose) and failed to develop extra shoots. Chicory grazed every two weeks failed to persist, while chicory grazed every four weeks persisted only for the two growing seasons. For plantain the grazing frequency did not affect its plant density nor taproot diameter; however, the number of shoots per plant increased when grazed every two weeks compared to every four weeks. Overall, plantain and herb-clover mix pastures were more productive and persistent than chicory. The three pastures produced high-quality feed for dairy cows. Dairy cows preferred the herb-clover mix pasture, rather than pure chicory or plantain swards, and selected indiscriminately between chicory, plantain, and red clover. The diet selection for chicory and plantain varied between seasons and was affected by the vertical access and horizontal distribution of the species in the swards. The presence of bioactive compounds, aucubin and acteoside in plantain reduced the ammonia concentration during fermentation and probably causes less urea to be excreted in the cow's urine when grazing plantain. In conclusion, the herb-clover mix performed best due to its high herbage production and nutritive value and greater grazing preference by dairy cows, plus its potential to reduce the nitrogen lost from dairy systems.

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LIST OF ABBREVIATIONS

A	Potential of gas production
Ac	Acteoside
ADF	Acid detergent fibre
AM	Morning
Au	Aucubin
BCVFA	Branched chain volatile fatty acids
CH	Chicory
CH+10au	Chicory plus 10 mg aucubin/g DM
CH+20au	Chicory plus 20 mg aucubin/g DM
CH+40ac	Chicory plus 40 mg acteoside/g DM
CO ₂	Carbon dioxide
CP	Crude protein
CT	Condensed tannins
DM	Dry matter
DMI	Dry matter intake
ELH	Extended leaf height
FV	Feeding value
GIS	Geographic Information System
GP	Gas production
GPS	Global Positioning System
HPLC	High-performed liquid chromatography
HWSC	Hot water soluble carbohydrates
LAI	Leaf area index
LTA	Long term average
LW	Live weight

ME	Metabolisable energy
MeOH	Methanol
N	Nitrogen
N ₂ O	Nitrous oxide
NDF	Neutral detergent fibre
NH ₃	Ammonia
OM	Organic matter
OMD	Organic matter digestibility
PL	Plantain
PL+10au	Plantain plus 10 mg aucubin/g DM
PL+36ac	Plantain plus 36 mg acteoside/g DM
PM	Afternoon
R ^{1/2A}	Fermentation rate at T ^{1/2A}
RA	Relative abundance
RFC	Readily fermentable carbohydrates
SC	Structural carbohydrate
Si	Selection index
T ^{1/2A}	The half time when the potential gas production was reached
V _{24h}	Volume of gas produced after 24 h incubation
VFA	Volatile fatty acid
VFI	Voluntary feed intake
WSC	Water soluble carbohydrate

1 GENERAL INTRODUCTION

