PHYSIOLOGICAL RESPONSES TO GASTROINTESTINAL NEMATODE INFECTION IN SHEEP SELECTED FOR GENETIC DIFFERENCE IN RESISTANCE TO *HAEMONCHUS CONTORTUS*

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Certificate

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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Abstract

The benefit of selection for resistance to gastrointestinal (GI) nematode infection is a lower worm burden. The expectation is that resistant sheep should suffer less production loss due to a reduced parasite infection. Yet, productivity of resistant sheep is comparable to or lower than that of animals carrying a large parasite burden. This research was designed to determine if divergent selection for resistance to *H. contortus* had produced correlated changes in one or more of the following variables, voluntary feed intake and diet selection, ruminal digestion and nutrient partitioning.

In Chapter 3 voluntary feed intake, diet selection and production was determined in 54 Merino weaner rams from the *Haemonchus* selection flock, increased resistance to *Haemonchus* (IRH), decreased resistance to *Haemonchus* (DRH) and random bred control (C) selection lines. Weaner rams were fed *ad libitum* either a high (9.2 MJ ME/kg DM, 90 g MP/kg DM) or moderate (6.3 MJ ME/kg DM, 30 g MP/kg DM) quality diet and given the choice between the two diets, in the absence (NIL) and presence of *H. contortus* infection (INF). There were few differences in voluntary feed intake and diet selection among selection lines during both NIL and INF periods. Feed intake, growth and wool production of DRH animals remained the same as that of IRH, yet DRH animals had five times greater worm egg count (WEC) than IRH.

In Chapter 4 rumen fermentation and hence nutrient supply was determined in 29 Merino weaner wethers from the IRH, DRH and C selection lines. Weaner wethers were fed a restricted diet (5.9 MJ ME/kg DM, 29 g MP/kg DM) to maintain weight and were either worm-free or trickle infected with *H. contortus* infection. Measurements of rumen fermentation and daily faecal and urine output were taken at week 7 of infection, while animals were housed in metabolic crates and then euthanased to determine abomasal worm counts. IRH had significantly lower WEC than DRH and C lines, however, adult worm and larval counts though lower in IRH animals did not differ significantly among selection lines. DM and OM digestibility and *in sacco* degradability of IRH and DRH selection lines were greater than in C animals, but differences between resistant and susceptible lines were not apparent. The interaction between selection line and response to infection in some of the measured indicators of rumen function, suggests a notable shift in fermentation in IRH animals. Fermentation in the IRH line tended to alter in

response to *H. contortus* infection to favour the synthesis of microbial protein at the expense of propionic acid and the net effect may be translated into lower growth rates.

In Chapter 5 partitioning of amino acid-nitrogen between tissues was determined in 42 Merino weaner wethers from the IRH, DRH and C selection lines. Weaner wethers were fed a restricted diet (9.8 MJ ME/kg DM, 86 g MP/kg DM) calculated to allow a gain of 125 g/d bodyweight throughout the experimental period and were either worm-free or trickle infected with *H. contortus*. At 8 weeks post infection animals were injected with a single dose of ^{15}N labelled duckweed directly into the abomasum by laparoscope technique. Faecal and urine outputs were measured following injection. Animals were euthanased at either 6 or 24 h after the injection to collect tissue samples for calculation of percentage recovery of ^{15}N in tissue and to determine abomasal worm counts. WEC and worm counts at week 8 of infection were lower in the IRH than in DRH and C lines. IRH animals had a lower N digestibility, increased oxidation of amino acids and lower N balance but whole-body protein flux was unaffected. Alteration of amino acid metabolism, as assessed from ^{15}N uptake and excretion in response to *H. contortus* infection, appeared to differ between IRH and DRH animals. In IRH animals a greater recovery of ^{15}N in the thymus and abomasal smooth muscle indicated greater partitioning of amino acids towards the immune response. In DRH animals an increased recovery of ^{15}N in the spleen, in response to infection, may be a possible adaptation. It appears that divergent selection for WEC has not been associated with symmetrical changes in amino acid metabolism, but rather the partitioning of amino acid resources reflects the requirements of each selection line response to infection. If one were to assume that a lower worm burden results in higher growth rates, these results suggest that selection for increased resistance has been accompanied by a larger nutritional 'cost' than that observed with selection for decreased resistance.

The research has elucidated the biological basis for genetic correlations between parasite resistance and production traits. Furthermore, the studies have quantified the differences in nutrient intake, digestion and partitioning among divergent selection lines infected with *H. contortus,* which have not been previously reported.

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Table of Contents

Table of Tables

Tables of Figures

Table of Plates

List of Abbreviations

C	Random-bred
c.i.	Confidence interval
CP	Crude protein
Cr	Chromium
CrEDTA	Chromium complexed with ethylenediamine tetraacetic acid
CSIRO	Commonwealth Scientific and Industrial Research Organisation
d	day
DM	Dry matter
DRH	Decreased resistance to *Haemonchus*
EB	Evans Blue
ELISA	Enzyme-linked immunosorbant assay
FCE	Feed conversion efficiency
FD	Fibre diameter
FSR	Fractional synthesis rate
GI	Gastrointestinal
h	hour
H	High quality diet
Ig	immunoglobulin
IGF-1	Insulin growth factor
ILR	Irreversible loss rate
INF	Infected with *Haemonchus contortus*
IRH	Increased resistance to *Haemonchus*
l	litres
L_3	Third stage infective larvae
LWG	Liveweight gain
M1	Moderate quality diet 1
M2	Moderate quality diet 2
MCV	Mean corpuscular volume
ME	Metabolisable energy
ml	Millilitres
MP	Metabolisable protein
N	Nitrogen
NIL	Nil infected
OM	Organic matter
PBS	Phosphate buffered saline
PCV	Packed cell volume
PCVD	Packed cell volume decline
pi	Post infection
RBC	Red blood cell
s.d.	Standard deviation
s.e.	Standard error
VFA	Volatile fatty acids
WBC	White blood cell
WEC	Worm egg count