THE UTILIZATION OF *EUCALYPTUS* FOLIAGE BY THE GREATER GLIDER (*Petauroides volans*) AND THE BRUSHTAIL POSSUM (*Trichosurus vulpecula*).

A thesis submitted for the degree of
Doctor of Philosophy in the University of New England.

by

WILLIAM JOHN FOLEY

B. Nat. Res. Hons II(i)

The Department of Biochemistry
and Nutrition, The University
of New England, Armidale,
N.S.W., Australia

August, 1984.

PREFACE

The studies presented in this thesis were completed by the author while a postgraduate student in the Department of Biochemistry and Nutrition at the University of New England, Armidale, N.S.W., Australia. Assistance given by other persons is indicated in the text or in the list of acknowledgements. All references cited are included in a bibliography. The work is otherwise original.

* * *

I certify that the substance of this thesis has not already been submitted for any degree and is not being currently submitted for any other degree. I certify that any help received in preparing this thesis and all sources used, have been acknowledged in the thesis.

AUGUST, 1984 W. J. POLEY.

SUMMARY

The utilization of *Eucalyptus* foliage as a food source by Greater Gliders (*Petauroides volans*) and Brushtail Possums (*Trichosurus vulpecula*) was studied in captive animals fed diets of *E. radiata* and *E. melliodora* respectively.

The rate of passage of solute (^{51}Cr-EDTA) and particulate (^{103}Ru-Phenanthroline) digesta markers was slow in both species. The mean retention time (MRT) of the two markers was 50h and 46h in the Greater Gliders and 51h and 46h in the Brushtail Possums. The lack of separation between these two markers was consistent with the lack of selective retention of fine particles in the hindgut of the Brushtail Possum. However, fine particles occurred in greater quantities in caecal digesta of the Greater Glider (48% DM) than in the stomach (30% DM) or faeces (16% DM). The rate of passage of an alternative particle marker (^{51}Cr-mordanted large particles (<1.0mm>0.5mm)) in the Greater Gliders, was less than half that of ^{103}Ru-P. From this it was concluded that ^{103}Ru-P excretion reflected the excretion of fine digesta particles which were selectively retained in the caecum along with solute digesta.

The foliage fed to both species was relatively low in nitrogen compared with many other plant species, and although the NDF content was moderate, this fibre was highly lignified (lignin:NDF ≃ 0.4-0.5). There was little seasonal variation in foliage composition. The digestibility of the fibre fraction of the leaves, although low, was similar to or higher than that found in a range of herbivores fed browse or foliage diets. Observations made of digesta fragments from the gut of both species with a scanning electron microscope showed that mesophyll and the less lignified parts of the vascular bundles were digested first. The epidermis and the more highly lignified tissues such as vessel elements proved most resistant to digestion. Bacteria were the only micro-organisms observed in the hindgut of either species, and many of these attached to plant particles by means of extracellular materials.

Both species maintained positive nitrogen balance on the foliage diets but maintenance nitrogen requirements were higher than those of other arboreal marsupials fed eucalypt diets. Greater Gliders required 0.56 g $\cdot kgW^{-0.75} \cdot d^{-1}$ of truly digestible nitrogen while Brushtail Possums required 0.42 g $N \cdot kgW^{-0.75} \cdot d^{-1}$. The major nitrogen loss in the Brushtails was faecal nitrogen and in particular NDFN. This was atttributed to relatively low feed intakes, a low digestibility of fibre and to the lack of an effective mechanism for retaining fine particles such as bacteria in the caecum. In contrast, the high maintenance nitrogen requirement of the Greater Glider was due to the loss of more than 50% of the truly digestible nitrogen intake in the urine, principally as NH_4. It was proposed that NH_4 was excreted to balance the urinary excretion of acidic detoxification products.

Supplementation of Brushtail Possums with polyethylene glycol (PEG) resulted in higher intakes of dry matter (37 - 48 $g \cdot kgW^{-0.75} \cdot d^{-1}$) metabolizable energy (ME) (0.27 - 0.45 $MJ \cdot kgW^{-0.75} \cdot d^{-1}$ and truly digestible nitrogen (0.44 - 0.64 g $N \cdot kgW^{-0.75} \cdot d^{-1}$) and higher digestibilities of neutral detergent fibre (27 - 48%). The overall dry matter digestibility of the diet was unchanged. These effects were attributed to the removal of the inhibitory effects of leaf tannins on microbial enzymes by PEG.

Although *E. radiata* contained significantly higher levels of essential oils than did *E. melliodora*, these were virtually completely absorbed in both species. Most of this oil was absorbed cranial to the hindgut and there seemed little possibility of significant interaction with the hindgut micro-organisms. Loss of terpenes during mastication occurred in Greater Gliders but was an insignificant route of loss compared to absorption from the stomach and small intestine.

The major factor limiting metabolizable energy intake in the Greater Glider was the high loss of energy in the urine. This was attributed to the excretion of essential oils and phenolic compounds, their detoxification products and nitrogen as NH_4. The maintenance energy requirement of the Greater Glider was estimated to be 0.35 $MJ \cdot kgW^{-0.75} \cdot d^{-1}$. The lower intakes and digestibilities of *E. melliodora* dry matter in the

Brushtail Possum were the major reasons for the lower intake of digestible energy compared with the Greater Glider, but lower urinary energy losses meant that ME intake as a proportion of GE intake was similar in the two species.

Measurement of the concentration of short chain fatty acids (SCFA) throughout the gut confirmed that the caecum of the Greater Glider and the caecum and proximal colon of the Brushtail Possum were the principal sites of microbial activity. The rate of SCFA production *in vitro* was 33 mmol $\cdot kgW^{-0.75} \cdot d^{-1}$ in the Greater Glider and 40 mmol $\cdot kgW^{-0.75} \cdot d^{-1}$ in the Brushtail Possum. These rates were slow compared with most other herbivores and this was attributed to the high degree of lignification of the diets. Acetate was the principal SCFA produced in both species followed by propionate in the case of the Greater Glider and by butyrate in the case of the Brushtail Possum. SCFA production contributed 8% of the digestible energy intake (DEI) of the Greater Glider but 16% of the DEI of the Brushtail Possum.

The energy required for free existence of Greater Gliders was measured (using $H^3H^{18}O$) in mixed eucalypt forest in south-eastern Queensland. The field metabolic rate for males was 547 $kJ \cdot kgW^{-1} \cdot d^{-1}$. The major energy expenditure was for basal metabolism and heat increment (43%) followed by activity (26%) and thermoregulation (9%). Feed intake was estimated to be about 50g of dry matter per day. Intake of water was 87 $ml \cdot kg^{-1} \cdot d^{-1}$ of which 61% came from preformed water in the leaves and 20% as oxidation water, with 16ml from sources such as dew or rainwater on leaves.

Efficient mastication and a relatively large hindgut, together with the selective retention of fine particles in the case of the Greater Glider, were important adaptations for utilizing *Eucalyptus* foliage diets. However, it seemed unlikely that either marsupial species could survive solely on these single species diets in the wild unless they were able to substantially increase their intake of easily digestible nutrients.

ACKNOWLEDGMENTS

I thank my supervisor, Associate Professor I.D. Hume for initially stimulating my interest in marsupial nutrition and for his guidance and advice in all stages of this study.

Greater Gliders were captured with the enthusiastic assistance of a large number of forestry workers but in particular I thank Messrs J. Brandis, J. Brandt, M. Inman, S. Sinclair,and D. Williams of the N.S.W. Forestry Commission and Mr C. Schubert of Allen Taylor Pty. Ltd. Mr and Mrs M. Ross of Ebor kindly allowed me to cut leaves from trees on their properties.

I am pleased to acknowledge the active collaboration of Dr E. Lassak (N.S.W. Department of Agriculture) and Dr J. Brophy, (University of New South Wales) in the studies described in Chapter 7 and Mr J. Kehl (Queensland Forestry Department) and Associate Professor K. Nagy (University of California, Los Angeles) in the studies described in Chapter 10.

Technical assistance was provided at various times by Mrs R. Busby, Mrs L. Jenkins, Mr J. Kent, Mr J. Lea and Ms A. Parker. Staff of the Faculty of Rural Science workshop and animal house, in particular Messrs H. Deiderick, M.E. Hope and D. Sharp. I extend my grateful thanks for the enthusiastic support of all these people. I would also like to thank the staff of the Electron Microscope Unit (Mr. M. Speak and Mr. P. Garlick) for their advice.

I am indebted to Dr S. Cork (CSIRO Wildlife and Rangelands Research), Mr M. Chilcott (University of New England), Dr D. Dellow, (DSIR Applied Biochemistry, New Zealand), Dr R. Jenness (University of Minnesota), Mr D. Tucker, (University of New England), Dr and Mrs K.

Rübsamen, (Universitat Hohenheim, Federal Republic of Germany) and Dr R. White, (University of Alaska) for useful discussions and assistance when required. Dr V. Bofinger provided statistical advice whenever necessary.

I also thank all the other technical and academic staff and postgraduate students of the Department of Biochemistry and Nutrition for their help and for providing such a pleasant working environment. In particular, I thank the departmental secretaries, Mrs J. Hansford and Mrs B. Harrison for their typing skills.

I thank Ms A. Hennell for her continuing suppport and encouragement throughout the study. I am also grateful to my parents for their support throughout my time at university. The work was funded by a University of New England Postgraduate Research Scholarship and the Department of Social Security.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES