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APPENDIX I

VARIATION IN MEAN KIDNEY WEIGHT AND MEAN BODY WEIGHT

Table 1 Variation in mean kidney weight and mean body weight between months of low KW/BW ratios (Bennett's wallaby: June 88 and May 89, Tasmanian pademelon: June and July 1988) and months of high KW/BW ratios (the remaining months sampled, see Figure 4.2, Chapter 4).

	Mean KW/BW Ratio (g/kg)	**Mean Body Weight (kg)**	**Mean Kidney Weight (g)**	**Sample Size**
Bennett's Wallaby				
High KW/BW ratio	2.08 ± 0.24	13.09 ± 3.78	27.12 ± 8.05	123
Low KW/BW ratio	1.84 ± 0.26	10.58 ± 2.24	19.58 ± 5.22	46
Variation (%)	12	19	28	
Tasmanian pademelon				
High KW/BW ratio	1.98 ± 0.23	6.03 ± 1.55	11.83 ± 3.16	237
Low KW/BW ratio	1.76 ± 0.27	5.51 ± 2.10	9.45 ± 3.50	45
Variation (%)	11	9	20	

Table 2 Variation in mean kidney weight and mean body weight relative to variation in KW/BW ratio among study areas. Only study areas with the greatest difference in KW/BW ratios are compared.

	Mean KW/BW Ratio (g/kg)	**Mean Body Weight (kg)**	**Mean Kidney Weight (g)**	**Sample Size**
Bennett's Wallaby				
Western Lakes	2.17 ± 0.27	13.32 ± 3.20	28.62 ± 6.67	113
Buckland	1.66 ± 0.17	10.75 ± 2.27	17.79 ± 3.57	61
Variation (%)	23	19	38	
Tasmanian pademelon				
Soldiers Marsh	2.09 ± 0.24	5.63 ± 1.61	11.60 ± 2.97	47
View Point	1.83 ± 0.21	5.48 ± 1.29	10.02 ± 2.60	76
Variation (%)	12	3	14	

APPENDIX II

VARIATION IN PROSTATE WEIGHT

Horak (1980) demonstrated that prostate weights of Tasmanian pademelons increased in March/April just prior to the major period of births in autumn/winter. Horak suggested it was possible that prostate weights may increase again during the spring/summer period of births but had no data on prostate weights to test this. To this end prostate weights were collected during the period which was not sampled by Horak to test his claim. The results shown in Figure 1 indicate that prostate weight increased significantly between October and November ($F_{(1,28)}=31.05$, $p<0.0001$) and decreased again between December and February ($F_{(1,26)}=9.15$, $p<0.005$).

The spring/summer variation in prostate weight for Bennett's wallaby is shown in Figure 2. Prostate weights increased significantly between December and February ($F_{(1,20)}=62.78$, $p<0.0001$).

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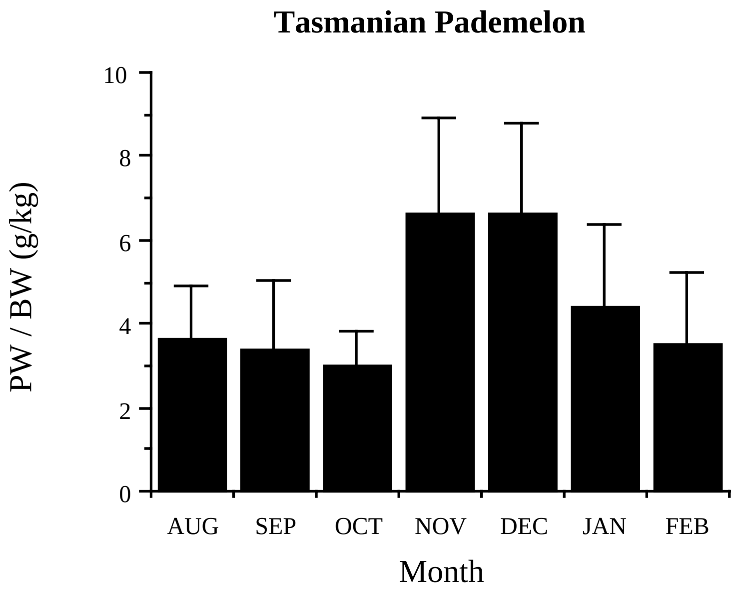

Figure 1 Variation in Tasmanian pademelon prostate weight between August 1989 and February 1990.

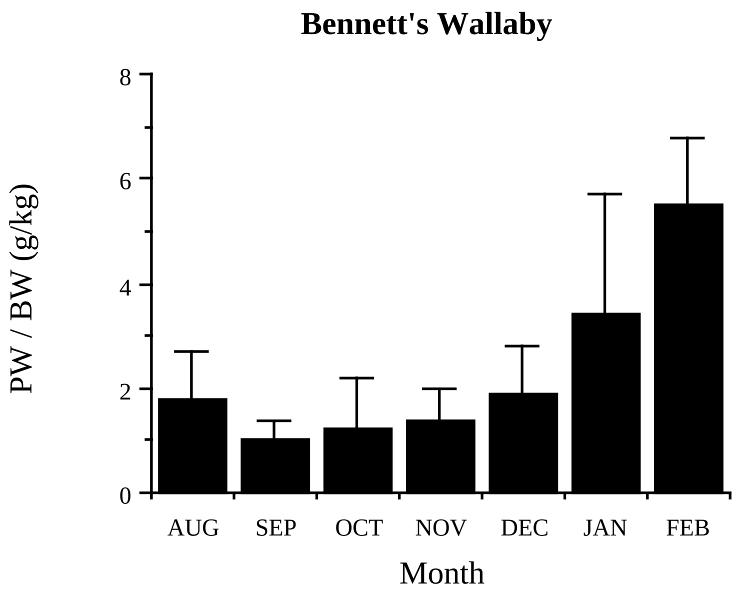

Figure 2 Variation in Bennett's wallaby prostate weight between August 1989 and February 1990.

APPENDIX III

QUALITY OF DIET

1 INTRODUCTION

The aim of this section is to assess the quality of diet for Bennett's wallaby and the Tasmanian pademelon by measuring the protein content of gut samples. A similar approach has been used for other macropods (Main 1970; Bakker and Main 1980; Shepherd 1987) and ungulates (Corn and Warren 1985). This information would prove useful in assessing patterns in growth and condition. However, the quality of food available says nothing about the quantity of food available. This will depend on factors such as vegetation present, stocking levels, harvesting rates and weather.

Like all macropods Tasmanian pademelons and Bennett's wallabies are foregut fermenters, which means that ingested food is subjected to microbial attack before exposure to gastric and intestinal enzyme action (Hume 1982). A deficiency in nitrogen supply results in poor microbial growth and consequently reduced fibre digestion and intake (Van Soest 1982). This, in turn, would lead to a reduction in available nutrients and possibly malnutrition. However, it has been shown that where diet is deficient in protein, some macropods can recycle urea to the forestomach where the microbes can utilise it for protein synthesis (Hume 1982). Nitrogen is not likely to be in short supply in areas with high rainfall and longer growing seasons (Hume 1982; Freudenberger *et al.* 1989).

2 METHODS

Stomach samples were collected from the anterior portion of the forestomach and frozen until analysis. Protein content was measured by the Kjeldahl method in 2.0 grams of undried stomach sample. The constant relationship between nitrogen and protein content for most plant species (% nitrogen x 6.25% = % protein) was assumed. All analyses were undertaken by the Tasmanian Government Analyst.

3 RESULTS

Comparison between sexes and age groups

Protein content in the diet of both species for each sex and age group is shown in Table 1. There were no significant differences in protein content in the diet between these groups. Thus the data were combined to compare protein levels in each species between seasons and between years

Comparison between seasons and years

Protein content in the diet of both species for each year is shown in Table 2. For the Tasmanian pademelon at Rushy Lagoon the protein content in the diet was significantly higher in summer 1989 than in winter 1989. There were no other significant differences in protein content in the diet for either species. With the exception of Tasmanian pademelons at Rushy Lagoon, the data were further combined to compare differences between species and study areas.

Comparison between study areas

Protein content in the diet of each species at each study area are given in Table 3. The habitat type has also been included as an indication of food sources and land management practices. Protein content in the diet varied between study areas for Bennett's wallabies ($F_{(6,144)}$=11.72, $p<0.001$) and Tasmanian pademelons ($F_{(8,155)}$=17.57, $p<0.001$). In general protein levels in the diet were higher in areas of pasture (Rushy Lagoon, Lagoon of Islands and Maria Island) than in areas of native vegetation (Styx, Buckland and Western Lakes).

Comparison between species

The protein levels in the diet of each species are compared in Table 4. The protein levels in the diet of Tasmanian pademelons were generally higher than those in the diet of Bennett's wallabies and in half of these comparisons the differences were statistically significant. The exception to this trend was the Lagoon of Islands study area where the protein measurement was higher in Bennett's wallabies, although not significant.

4 DISCUSSION

Bennett's wallabies feed primarily on grasses (Calaby 1983; Statham 1983; Southwell 1987; Jarman and Phillips 1989). Although the diet of the Tasmanian pademelon also includes grasses, it is more varied containing forbs, shrubs and browse (Statham 1983; Johnson and Rose 1983). This difference in diet is reflected in the tooth morphology of both species. Sanson (1978) believes that there are two basic types of masticatory organisation; (i) an ancestral browsing grade and (ii) a derived grazing grade. The pademelons are considered to have a browsing grade dentition whereas the larger wallabies such as Bennett's wallaby are grazers or intermediate browser/grazers (Sanson 1989). Dawson (1989) considered that size was important in determining diet choice in macropods for two reasons:

Table 1 Comparison of protein content (%N x 6.25%) in stomach samples between males and females and adults and juveniles.Values in parentheses refer to sample sizes.

Bennett's Wallaby

Study Area	Adult Male	Adult Female	Juvenile Male	Juvenile Female	F-test	Significance
Florentine Valley 1988	31.2 ± 3.0 (4)	31.2 ± 3.0 (8)	37.2 ± 2.6 (3)	33.9 ± 5.5 (6)	$F_{(3,17)} = 2.11$	ns
Florentine Valley 1989	32.8 ± 0.8 (4)	33.8 ± 2.2 (6)	32.1 ± 2.3 (2)	31.7 ± 3.0 (6)	$F_{(3,14)} = 0.83$	ns
Maria Island	29.1 ± 2.4 (7)	33.4 ± 4.0 (9)	32.8 ± 4.9 (3)	28.9 ± 3.9 (5)	$F_{(3,20)} = 2.70$	ns
Western Lakes	28.2 ± 4.3 (5)	27.8 ± 3.2 (7)	31.0 (1)	29.4 ± 3.1 (3)	$F_{(2,12)} = 0.21$	ns

Tasmanian Pademelon

Study Area	Adult Male	Adult Female	Juvenile Male	Juvenile Female	F-test	Significance
Florentine Valley	35.4 ± 4.0 (11)	36.0 ± 4.5 (5)	35.0 ± 4.9 (4)	34.9 (1)	$F_{(2,17)} = 0.06$	ns
The Styx	26.2 ± 5.2 (10)	30.4 ± 6.2 (5)	28.7 ± 2.7 (3)	30.7 (1)	$F_{(2,15)} = 1.15$	ns
Buckland	31.5 ± 4.5 (4)	31.6 ± 2.6 (6)	36.0 ± 7.1 (3)	-	$F_{(2,10)} = 1.15$	ns
Granville Harbour	30.6 ± 2.7 (6)	32.6 ± 3.5 (6)	34.0 ± 2.0 (4)	31.8 ± 1.1 (4)	$F_{(3,16)} = 1.46$	ns

Table 2 Comparison of protein content (%N x 6.25%) in stomach samples between sampling periods. Values in parentheses refer to sample sizes.

Bennett's Wallaby

Site	Winter 88	Winter 89	Summer 89	F-test	Significance
Florentine Valley	32.8 ± 4.2 (21)	32.7 ± 2.3 (18)	30.7 ± 6.0 (12)	$F_{(2,48)} = 1.11$	ns
Buckland	28.1 ± 4.0 (16)	-	30.1 ± 4.0 (10)	$F_{(1,24)} = 1.53$	ns
Rushy Lagoon	-	35.5 ± 2.5 (4)	38.1 ± 3.9 (10)	$F_{(1,12)} = 1.41$	ns

Tasmanian Pademelon

Site	Winter 88	Winter 89	Summer 89	F-test	Significance
Florentine Valley	35.5 ± 4.0 (21)	33.8 ± 3.5 (11)	36.5 ± 4.7 (10)	$F_{(2,39)} = 1.28$	ns
Buckalnd	32.6 ± 4.5 (13)	-	30.7 ± 3.0(11)	$F_{(1,22)} = 1.34$	ns
Soldiers Marsh	-	32.1 ± 5.8 (6)	36.2 ± 3.5 (8)	$F_{(1,12)} = 2.74$	ns
Rushy Lagoon	-	35.7 ± 4.8 (15)	52.6 ± 6.2 (5)	$F_{(1,18)} = 73.54$	$p < 0.001$
Granville Harbour	-	32.1 ± 2.8 (20)	32.7 ± 4.2 (10)	$F_{(1,18)} = 0.20$	ns

Table 3 Comparison of protein content (%N x 6.25%) between study areas. Two Rushy Lagoon values are presented for the Tasmanian pademelon because a significant difference was found between seasons. Solid lines indicate study areas which were not significantly different from each other at the 0.05 level. IP=improved pasture, UP=unimproved pasture, NV=native vegetation, PP=pine plantation. Numbers in parentheses indicate sample sizes.

Bennett's wallaby

Study Area	**Habitat Type**	**Mean ± s.d.(n)**	**No Significant Differences**
Lagoon of Islands	IP	38.4 ± 4.6 (7)	
Rushy Lagoon	IP	37.3 ± 3.6 (14)	
Soldiers Marsh	NV	33.7 ± 5.4 (13)	
Florentine Valley	NV/PP	32.3 ± 4.2 (51)	
Maria Island	UP	31.2 ± 4.1 (24)	
Buckland	NV	28.9 ± 4.0 (26)	
Western Lakes	NV	28.4 ± 3.3 (16)	

Tasmanian pademelon

Study Area	**Habitat Type**	**Mean ± s.d.(n)**	**No Significant Differences**
Rushy Lagoon (Summer 1989)	IP	52.6 ± 6.1 (5)	
Maria Island	UP	36.4 ± 4.5 (7)	
Rushy Lagoon (Winter 1989)	IP	35.7 ±5.3 (15)	
Florentine Valley	NV/PP	35.3 ± 4.1 (42)	
Lagoon of Islands	IP	34.5 ± 4.1 (7)	
Soldiers Marsh	NV	34.5 ± 4.5 (14)	
Granville Harbour	UP	32.3 ± 3.3 (30)	
Buckland	NV	31.7 ± 3.9 (24)	
Styx	NV	27.93 ± 5.2 (19)	

Table 4 Comparison of protein levels between species. Two Rushy Lagoon values are presented for the Tasmanian pademelon because a significant difference was found between seasons (*=winter 1989, **=summer 1989). Numbers in rounded parentheses indicate sample sizes.

Study Area	**Bennett's wallaby**	**Tas. Pademelon**	**F-test**	**Significance**
Buckland	28.9 ± 4.0 (26)	31.7 ± 3.9 (24)	$F_{(1,48)} = 6.50$	$p<0.025$
Soldiers Marsh	33.7 ± 5.4 (13)	34.5 ± 4.9 (14)	$F_{(1,27)} = 0.13$	ns
Maria Island	31.2 ± 4.1 (24)	36.4 ± 4.5 (7)	$F_{(1,29)} = 8.62$	$p<0.01$
Florentine Valley	32.3 ± 4.2 (51)	35.3 ± 4.1 (42)	$F_{(1,91)} = 12.1$	$p<0.001$
Lagoon of Islands	38.4 ± 4.6 (7)	34.5 ± 4.1 (7)	$F_{(1,12)} = 3.99$	ns
Rushy Lagoon*	35.5 ± 2.5 (4)	35.7 ± 5.3 (15)	$F_{(1,17)} = 0.01$	ns
Rushy Lagoon**	38.1 ± 3.9 (10)	52.6 ± 6.1 (5)	$F_{(1,13)} = 32.0$	$p<0.001$

i) Smaller animals have a proportionally greater metabolic intensity than larger animals and thus need to process more food relative to their size.

ii) Fermentative digestion of plant fibre is a relatively slow process and Dellow *et al.* (1983) reported that the microbial activity in the forestomach of macropods is similar in animals of different body size and similar to that of ruminants.

Although smaller wallabies have a faster through-put of food than larger wallabies (Short 1985), the digestibility of a fibrous diet decreases as rate of passage increases (McIntosh 1966; Prince 1976). This led Dawson (1989) to consider that the only option for smaller mammals is to select plant material that is low in cell wall constituents (fibre) and high in cell wall contents (largely proteins, soluble carbohydrates and fats). With the exception of young grass, grasses are high in fibre and low in cell contents such as protein (Taylor 1981; Dawson 1989; Freudenberger *et al.* 1989; Norbury *et al.* 1989). Thus, although grasses are more abundant, special tooth morphology and more energy is required to break these food items into small fragments (Sanson 1989). By comparison, the soft growing tips of forbs, shrubs, and browse are low in fibre and have generally high nutrient levels (Dawson 1989). These plants or parts thereof require less energy to breakdown and digest.

Thus in general smaller to medium sized macropods such as the Tasmanian pademelon tend to be more generalist feeders, feeding on diets low in fibre and higher in nutrients (Dawson 1989). The larger wallabies such as the Bennett's wallaby and in particular the kangaroos have become specialist grass eaters feeding on diets high in fibre and generally low in nutrients. These two different nutritional strategies appear to be reflected in the results of this present study. The level of protein recorded in the diet of Tasmanian pademelons was generally higher than the levels recorded in the Bennett's wallaby.

Sexual dimorphism is common among the larger macropods with mature males doubling (or more) the size of mature females. Both Bennett's wallaby and the Tasmanian pademelon exhibit sexual dimorphism with mature males attaining weights 50% greater than females (Chapter 4). Dawson (1989) considered that larger animals should be able to process high fibre feed better and this has been demonstrated in grey kangaroos, *Macropus giganteus,* (Forbes and Tribe 1970). Similarly, the ability of juveniles to digest high fibre foods would be limited given the size of their digestive tracts and would therefore require low fibre diets. In the present study there was no evidence of variation in protein levels in the diet between sexes or age groups for either species. This suggests that, although the sex and age groups may differ in foods consumed, they were able to maintain similar levels of nitrogen, at least for the periods sampled in this study.

The nitrogen content in plants can also vary between seasons and years. Nitrogen levels may be low during summer or during droughts (Kinnear and Main 1975; Wake 1980; Hume 1982). However, nitrogen is less likely to be limiting where higher rainfall and longer growing seasons result in abundant green foliage (Hume 1982; Freudenberger *et al.* 1989). As stomach samples were obtained during periods of average rainfall it is not surprising that no differences in protein levels in the diet were recorded between years and seasons during this present study. It is also possible that selective grazing by the wallabies may be maintaining protein content in the diet during periods of nitrogen shortage.

Significant differences in the amount of protein in the diet were found between study areas. The occurrence of protein in the diet was higher in study areas which were actively managed for agricultural or forestry purposes than in study areas with natural vegetation. This probably reflects; 1) the fact that fertile areas of land are generally chosen for agricultural purposes and 2) the active management of these areas, particularly in the use of fertilisers.

5 SUMMARY

Quality of diet, as measured in terms of protein content in stomach samples, did not vary significantly between sex, age groups or seasons.

Quality of diet was generally higher in areas which were actively managed for agricultural or forestry purposes than in areas of natural vegetation.

The quality of diet was generally higher for the Tasmanian pademelon than for Bennett's wallaby which reflected differences in feeding strategies.

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APPENDIX IV

INDEX OF ABUNDANCE

1 INTRODUCTION

An index of abundance of each species was obtained by counting all wallabies seen while culling occurred and expressing this figure as the number of wallabies seen per kilometre. This method allows for:

(i) a comparison of the abundance of Tasmanian pademelons and Bennett's wallabies within a study area, assuming they are equally visible. As the Tasmanian pademelon is the smaller species, it is possible that its numbers may be underestimated in areas where there is dense undergrowth,

(ii) a comparison of the abundance of each individual species between sampling periods provided that a similar transect is traversed each time and that conditions such as weather and vegetation have not changed significantly.

Comparisons of the abundance of each species between habitats are less robust due to differences in sightability of animals as a result of differences in cover. However, some general comments can be made.

2 METHODS

Spotlight counts were always made by myself whilst hunters were shooting wallabies from a vehicle. The spotlight contained a 100 watt halogen globe. Vehicle speeds were usually less than 5 km/h and never more than 10 km/h. Two hand held counters were used to record the number of each species seen and the results were expressed as the number of wallabies seen per kilometre.

3 RESULTS AND DISCUSSION

3.1 Trends in Abundance Between Sampling Periods

The average spotlight count at each study area for each of the four sampling periods is shown in Table 1. Certain spotlight counts for Bennett's wallabies taken in November and early December have been deleted from the analyses because females were less visible at this time of the year resulting in lower counts (Figures 1 and 2). At this time of year females had retreated to areas of cover as they were carrying large young or had young just leaving the pouch. A similar response was reported by Catt (1977) who found a low proportion of females in an October-February sample. Johnson (1987) also found that female red-necked wallabies tended to shift their home ranges towards edges of large beds of cover as their young left the pouch.

No significant differences were recorded between sampling periods at each study area for Bennett's wallaby.

Significant differences in counts between sampling periods were recorded for the Tasmanian pademelon at Florentine Valley, Western Lakes and at Lagoon of Islands. Although not tested, because of insufficient data, there appeared to be a decrease in spotlight counts between winter and summer of 1989 at Granville Harbour.

The change in abundance at the Florentine Valley study area is believed to be a direct result of a 1080 poison operation between winter and summer of 1989. Thus, there was a decline in abundance of the Tasmanian pademelons in summer 1988 followed by a general increase in winter and summer of 1989. Interestingly, Bennett's wallaby did not appear to be affected. In his wallaby control study, Gregory (1988) found that Bennett's wallabies were not as readily controlled by 1080 poison as Tasmanian pademelons and he attributed this to a lack of acceptability of the bait by Bennett's wallabies. Body size may also be involved as McIlroy (1986) found that smaller macropods are generally more susceptible to 1080 poison than larger macropods. Mooney and Johnson (1979) reported that only large individuals of both wallaby species were seen after poisoning which indicated to them that small and young individuals were selectively poisoned. Johnson (1978) also found that the number of pademelons spotlighted in two areas after poisoning decreased significantly whereas the numbers of Bennett's wallaby did not change significantly.

The significant difference in abundance recorded at Western Lakes was due to a general increase in numbers of Tasmanian pademelons from 1988 to 1989. This confirms observations by the local ranger that the numbers of this species have been slowly increasing in this area in recent years. The data may also reflect the general increase in pademelon numbers throughout the State as indicated by spotlight surveys by the Department of Parks, Wildlife and Heritage (Driessen and Hocking 1982).

The change in abundance at Lagoon of Islands appeared to be related to season. Fewer Tasmanian pademelons were observed during summer counts than during winter counts. This was believed to be due to reduced sightability during summer as a result of tall grass. The change in abundance which appeared to occur at Granville Harbour was also likely to be due to an increase in vegetation height. In summer of 1989 the height of the bracken which covered large areas of pasture at this study area was noticeably higher than in winter of 1989.

Table 1 Average spotlight counts (number/km) for Bennetts Wallabies and Tasmanian Pademelons at each study area for winter and summer of 1988 and 1989. Numbers in rounded parentheses indicate number of counts. ns=not significant

Bennetts Wallaby

Study Area	Winter 1988	Summer 1988	Winter 1989	Summer 1989	F-test	Significance
Florentine Valley	2.5 ± 1.3 (2)	5.5 ± 2.9 (3)	3.8 ± 0.1 (3)	7.9 ± 1.6 (2)	$F_{[3,6]} = 3.17$	ns
Buckland	2.5 ± 0.7 (2)	-	2.5 ± 0.6 (4)	2.0 (1)	$F_{[1,4]} = 0.00$	ns
Rushy Lagoon	3.9 ± 0.3 (2)	4.5 ± 1.5 (2)	3.2 ± 1.3 (2)	5.6 (1)	$F_{[2,3]} = 0.62$	ns
View Point	1.3 ± 0.9 (5)	1.4 (1)	1.4 ± 0.3 (2)	3.1 ± 1.3 (2)	$F_{[2,6]} = 2.97$	ns
Lagoon of Islands	3.8 ± 2.4 (2)	3.7 ± 1.5 (3)	2.3 (1)	4.2 ± 2.6 (2)	$F_{[2,4]} = 0.04$	ns
Soldiers Marsh	6.7 ± 0.7 (4)	-	4.9 ± 2.2 (5)	3.7 (1)	$F_{[1,7]} = 2.32$	ns
Western Lakes	2.7 ± 0.8 (4)	3.0 ± 0.2 (2)	3.6 ± 0.9 (3)	4.4 (1)	$F_{[2,6]} = 1.33$	ns
Granville Harbour	-	-	0.9 ± 0.9 (2)	0.7 (1)	-	-

Tasmanian Pademelon

Study Area	Winter 1988	Summer 1988	Winter 1989	Summer 1989	F-test	Significance
Florentine Valley	3.2 ± 1.4 (2)	0.5 ± 0.4 (3)	1.5 ± 0.4 (3)	2.0 ± 0.6 (2)	$F_{[3,6]} = 5.94$	$p<0.05$
Buckland	2.1 ± 1.1 (2)	-	2.5 ± 0.8 (4)	2.1 ± 0.2 (2)	$F_{[2,4]} = 0.37$	ns
Rushy Lagoon	8.3 ± 2.1 (2)	2.9 ± 1.0 (2)	7.5 ± 0.4 (2)	7.6 (1)	$F_{[2,3]} = 9.00$	ns
View Point	3.9 ± 2.1 (5)	3.0 (1)	4.8 ± 0.1 (2)	5.6 ± 2.2 (2)	$F_{[2,6]} = 0.55$	ns
Lagoon of Islands	16.1 ± 0.8 (2)	5.6 ± 1.4 (3)	14 (1)	6.1 ± 1.5 (2)	$F_{[2,4]} = 44.5$	$p<0.005$
Soldiers Marsh	2.4 ± 1.1 (4)	-	2.4 ± 1.3 (5)	1.7 ± 1.0 (4)	$F_{[1,7]} = 0.61$	ns
Western Lakes	0.1 ± 0.1 (4)	0.1 ± 0.1 (2)	0.8 ± 0.1 (3)	0.5 ± 0.4 (3)	$F_{[2,6]} = 6.89$	$p<0.05$
Granville Harbour	-	-	30.1 ± 1.6 (2)	15.0 (1)	-	-

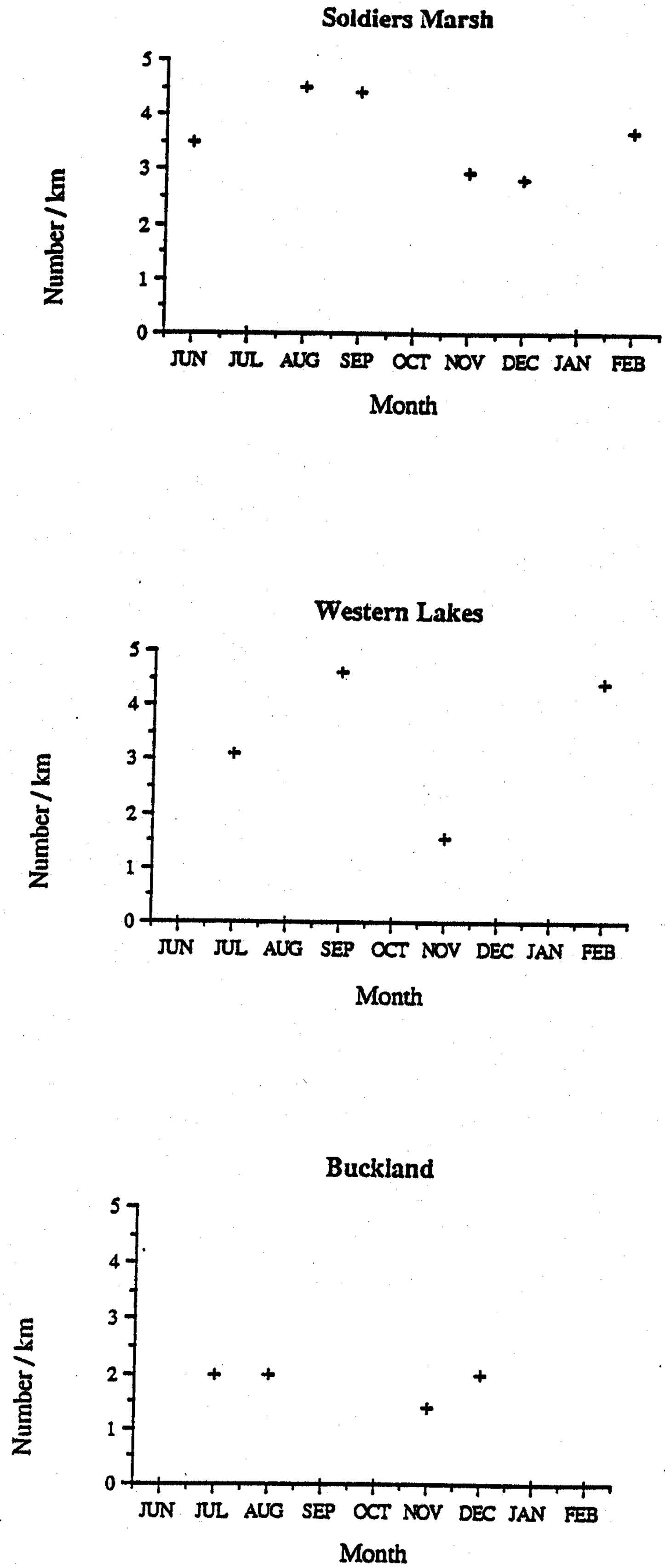

Figure 1 Spotlight counts for Bennett's wallaby between June and February. Note the decrease during November due to females with large young occurring in areas of cover.

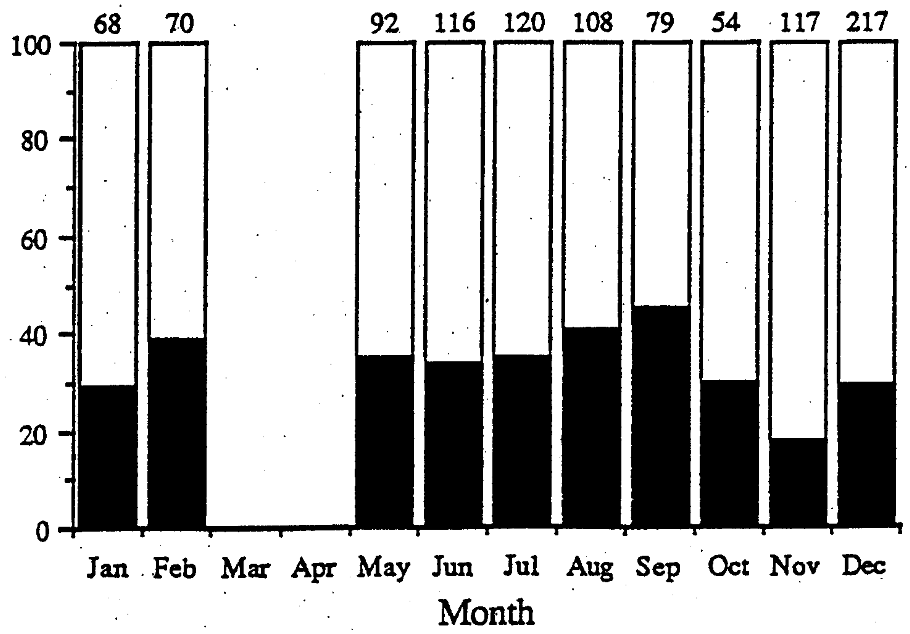

Figure 2 Monthly variation in the proportion of adult female Bennett's Wallabies recorded in shot samples. The data were pooled over 1988 and 1989 and all study areas. Sample sizes are given at the top of each column. No samples were obtained in March and April.

3.2 Comparisons between species and study areas

To compare the abundance of each species at each study area, the values in Table 1 were pooled where it was statistically valid to do so. The results, shown in Table 2, also include spotlight counts from the Styx, Maria Island and Lemont study areas which were sampled in only one time period. As has been mentioned, comparisons between study areas are not robust and only general comments can be made. At most study areas the abundance of each species differed significantly. The exceptions were Buckland and the Florentine Valley prior to poisoning. The spotlight counts from Maria Island also indicated that both species are in similar abundance, although further spotlight counts are required.

Bennett's wallabies occurred in low abundance in relation to Tasmanian pademelons at the Styx and Granville Harbour study areas. It can also be confidently said that the abundance of Bennett's wallaby at these two study areas was low in relation to their abundance at other study areas. The native vegetation in these areas was dense mixed forest which is not considered to be ideal habitat for this species (Hocking and Guiler 1983; Taylor *et al* 1985). Two possible reasons for their absence relate to their diet and/or their large size. Bennett's wallaby are predominantly grazers (Calaby 1983; Statham 1983; Southwell 1987; Jarman and Phillips 1989), thus there is typically a lack of grass in this habitat for this species. By comparison, Tasmanian pademelons consume a wider variety of food types (Statham 1983; Johnson and Rose 1983). The dense nature of the vegetation in this habitat would also restrict movement of the larger Bennett's wallaby. The Tasmanian pademelon, which is considerably smaller (less than 50% of the size of Bennett's wallaby) and has a more 'crouched' gait would have no trouble moving through such habitat.

The relatively high abundance of Bennett's wallabies in the Florentine Valley study area is unusual considering the dominance of dense mixed forest. However, this study area contained grassland originally created by aborigines through burning. In recent times pine trees have been planted over most of the area but grasses and small grasslands remain. Continual poisoning has probably had a greater impact on pademelon numbers than on Bennett's wallabies because of the smaller size of the former (as discussed above).

The abundance of Tasmanian pademelons was lower than that of Bennett's wallabies at Soldiers Marsh and Western Lakes. This is probably due to a lack of suitable cover at these two study areas. The vegetation of Soldiers Marsh consisted of large open marshes and open dry sclerophyll forests which are typical of Bennett's wallaby habitat. Tasmanian pademelons were only observed in association with dense vegetation which had a patchy distribution. Similarly the low alpine heath at Western Lakes provided little cover for Tasmanian pademelons and they were observed only where there were pockets of higher and more dense shrubs.

Table 2 Comparison of average spotlight counts (number/km) for Bennett's wallaby and the Tasmanian pademelon at each study area. Numbers in rounded parentheses indicate number of counts. ns=not significant.

Study Area	Bennett's Wallaby	Tasmanian Pademelon	F-test	Significance
Florentine Valley	4.9 ± 2.5 (10)	3.2 ± 1.4 (2)[a]	$F_{[1,10]} = 0.8$	ns
		1.2 ± 0.7 (8)[b]	$F_{[1,16]} = 15.4$	$p<0.005$
The Styx	0.03 ± 0.05 (4)	1.8 ± 0.6 (4)	$F_{[1,6]} = 35.1$	$p<0.005$
Granville Harbour	0.8 ± 0.6 (2)	30.1 ± 1.6 (2)	$F_{[1,3]} = 973.8$	$p<0.0001$
Buckland	2.4 ± 0.5 (7)	2.3 ± 0.7 (8)	$F_{[1,13]} = 0.2$	ns
Soldiers Marsh	5.5 ± 1.8 (10)	2.2 ± 1.1 (13)	$F_{[1,21]} = 28.8$	$p<0.0001$
Western Lakes	3.2 ± 0.9 (10)	0.7 ± 0.3 (6)[c]	$F_{[1,14]} = 46.7$	$p<0.0001$
View Point	1.7 ± 1.0 (10)	4.3 ± 1.8 (10)	$F_{[1,18]} = 16.6$	$p<0.001$
Lagoon of Islands	3.7 ± 1.7 (8)	15.4 ± 1.3 (3)[d]	$F_{[1,9]} = 119.4$	$p<0.0001$
		5.8 ± 1.3 (5)[e]	$F_{[1,11]} = 5.9$	$p<0.05$
Rushy Lagoon	4.1 ± 1.2 (7)	7.8 ± 1.2 (5)	$F_{[1,10]} = 29.7$	$p<0.001$
Lemont	2.4 (1)	4.1 (1)	-	-
Maria Island				
Darlington	52.4 (1)	63.5 (1)	-	-
Sth of Darlington	5.5 (1)	4.9 (1)	-	-

[a] pre-poison count, [b] post-poison count, [c] 1989 count only, [d] winter count, [e] summer count.

The abundance of Tasmanian pademelons at View Point, Lagoon of Islands and Rushy Lagoon was significantly higher than the abundance of Bennett's Wallaby. All three study areas contain a mosaic of pasture and native forest, are heavily shot, and have not been poisoned in recent years. Lemont could also be included in this group, although no information on poisoning is available. There appeared to be adequate habitat for both of these species at all four study areas. In fact with the exception of View Point the habitat of these study areas was more typical of Bennett's wallaby yet Tasmanian pademelons were significantly more abundant. According to the land owner and the local ranger, Bennett's wallabies were more abundant than Tasmanian pademelons prior to the commencement of shooting at Lagoon of Islands 15 years ago. It is possible that selective shooting for Bennett's wallabies at these study areas may have resulted in a low abundance of this species in relation to Tasmanian pademelons. Further support for this argument comes from Soldiers Marsh which was similar to these four study areas in terms of suitable habitat for Bennett's wallaby and sightability but with a lower hunting pressure. The abundance of Bennett's wallaby at this study area appeared to be higher than the four more heavily hunted study areas even though they contained improved pasture.

The abundance of Tasmanian pademelons at Granville Harbour was considerably higher than at all other study areas except Maria Island. This can be attributed to the removal of stock from the study area in 1987.

The counts from Darlington (Maria Island) indicate that both species occur in high abundance at this study area in comparison to other areas. The counts are likely to be slightly exaggerated due to the tame nature of the wallabies in this National Park, but the high abundance is real resulting in starvation problems during times of drought. The counts made south of Darlington in native forest indicate that the abundance of wallabies is much lower than at Darlington itself (taking into account the lower sightability in forest compared with pasture). This difference is believed to be a result of less food resources available in the forest habitat.

In general the abundance of the Tasmanian pademelon is highest in areas adjacent to pasture or plantations, although at the Florentine Valley study area their numbers are kept in check by 1080 poisoning. A similar trend in abundance is not present for Bennett's wallaby possibly due to selective hunting of this species in areas adjacent to pasture. The exception to this is Maria Island where there is no hunting.

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APPENDIX V

ADDITIONAL INFORMATION
(not directly related to thesis)

1 Mean Body Weights

The Tables over the page give the mean body weights for Bennett's wallabies and Tasmanian pademelons shot during the field study. All animals were weighed using a Salter 25 kg spring balance. Mean body weights are given for adults and juveniles for each sex. The method of differentiating adults and juveniles is given in Chapter 5.

It should be noted that mean body weights of both species vary throughout Tasmania (see Chapter 4).

KEY: S.D. = standard deviation, n = sample size, CV = coefficient of variation, 95%L and 95%U = 95% confidence limits.

Bennett's Wallaby Body Weights

Females

	Mean (kg)	S.D.	$\sum x$	$\sum x^2$	n	CV	95%L	95%U	Range
All	9.42	2.82	4739	48639.72	503	29.9	9.17	9.67	2.6 - 15.8
Adults	10.60	2.16	3920.8	43264.94	370	20.357	10.38	10.82	5.6 - 15.8
Juveniles	6.15	1.61	818.2	5374.78	133	26.14	5.88	6.43	2.6 - 10.8

Males

	Mean (kg)	S.D.	$\sum x$	$\sum x^2$	n	CV	95%L	95%U	Range
All	11.36	4.31	6869.9	89231.99	605	38.0	11.01	11.70	2.0 - 27.2
Adults	14.40	3.53	4450.5	67944.31	309	24.5	14.01	14.80	6.9 - 27.2
Juveniles	8.17	2.26	2419.4	21287.68	296	27.7	7.92	8.43	2.0 - 15.0

Tasmanian Pademelon Body Weights

Females

	Mean (kg)	S.D.	$\sum x$	$\sum x^2$	n	CV	95%L	95%U	Range
All	4.03	1.23	1896.0	8359.06	470	30.5	3.92	4.15	1.0 - 7.4
Adults	4.56	0.96	1540.4	7333.10	338	21.1	4.45	4.66	2.2 - 7.4
Juveniles	2.69	0.72	355.6	1025.96	132	26.7	2.57	2.82	1.0 - 4.5

Males

	Mean (kg)	S.D.	$\sum x$	$\sum x^2$	n	CV	95%L	95%U	Range
All	5.18	1.99	3211.8	19076.74	620	38.3	5.02	5.34	0.9 - 11.0
Adults	6.53	1.52	2260.9	15566.19	346	23.2	6.37	6.70	3.3 - 11.0
Juveniles	3.47	0.88	950.9	3510.55	274	25.3	3.37	3.58	0.9 - 6.9

2 Boned, Dressed and Gutted Weights

In recent years a small trade in wallaby meat has developed in Tasmania. While most meat is used for pet food the proportion of meat used for human consumption is steadily increasing. Bennett's wallaby is the main species used due to its larger size which brings a greater return per effort. Most wallaby meat enters the trade in a boned-out form in which the animals have been gutted, quartered and skinned above the line of the kidneys and below the rib cage. All bones are then removed from the hindquarters. Some wallaby meat also enters the trade in the quartered form which is generally referred to as a dressed carcass.

This section determines the relationship between boned-out weight, and size and age class. Some information is also presented for dressed carcass weight and gutted weight.

Wallabies were shot by commercial shooters from the back of a four wheel drive vehicle. All animals were sexed and total body weight was measured with a Salter 25 kg spring balance. The wallabies were again weighed after they had been (i) gutted, (ii) quartered or (iii) boned by the commercial shooters.

Boned out weights of Bennett's wallaby were obtained from the Western Lakes, Lemont and Lagoon of Islands study areas. Boned out weights for the Tasmanian pademelon were obtained from the Lagoon of Islands study area. Dressed carcass weights for Bennett's wallaby were obtained from the Western Lakes and Rushy Lagoon study areas. Dressed carcass weights for the Tasmanian pademelon were obtained from the Rushy Lagoon study area. Gutted weights for both species were obtained from the View Point study area.

Regressions of boned, dressed and gutted weights against age and body weight are shown in Figures 1-16. Only large, old males were shot when obtaining dressed carcass weights for the Tasmanian pademelon, hence only the regression between dressed weight and body weight is shown.

All regression equations were statistically significant. Boned, dressed and gutted weights were more highly correlated against body weight than against age. Where sexes were treated separately the correlations against age improved.

Although reasonable correlations were obtained between wallaby age and the various carcass weights, their use would appear to be of limited value for determining age structure as its accuracy is confounded by the fact that it is impossible to sex boned-out carcasses and it is virtually impossible to sex dressed carcasses. Thus it would be necessary to group the sexes which introduces large errors as there are significant differences in body weights of male and females for both species after an early age (see Chapter 4). In addition further errors are introduced due to significant differences in weights attained by both species between different areas of the State (see Chapter 4).

Good correlations were obtained between carcass weights and total body weight. One possible use of this relationship would be to use the mean wallaby weights given part 1 of this appendix to estimate the number of wallabies shot from gross meat weights sent to the Parks and Wildlife Service from meat processors.

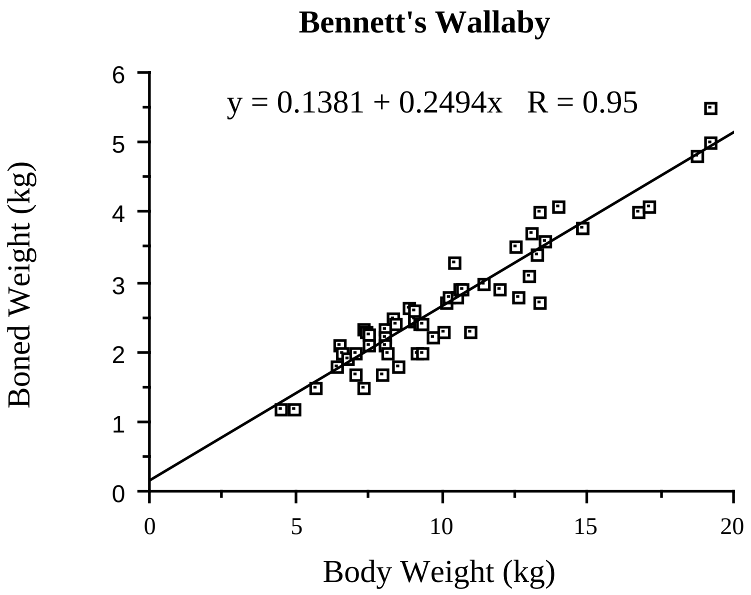


Figure 1 Relationship between boned weight and body weight for Bennett's wallaby (F = 493.9, df = 57, $p < 0.0001$).

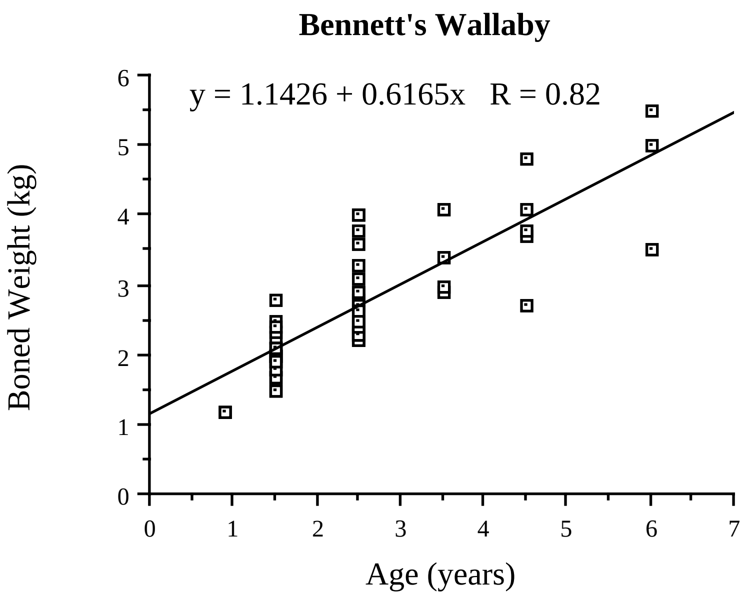
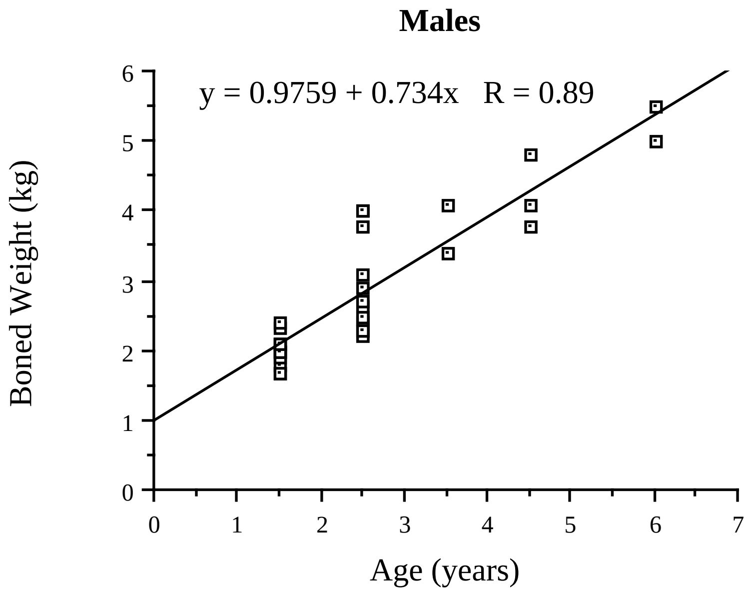


Figure 2 Relationship between boned weight and age for Bennett's wallaby (F = 118.7, df = 31, $p < 0.0001$).



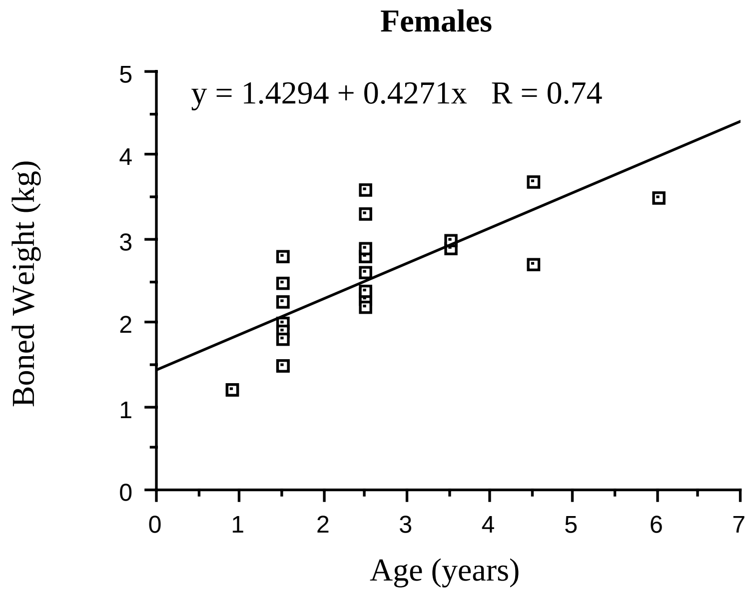


Figure 3 Relationship between boned weight and age for Bennett's wallaby (Males: $F = 118.7$, $df = 31$, $p < 0.0001$; Females: $F = 29.3$, $df = 25$, $p < 0.0001$).

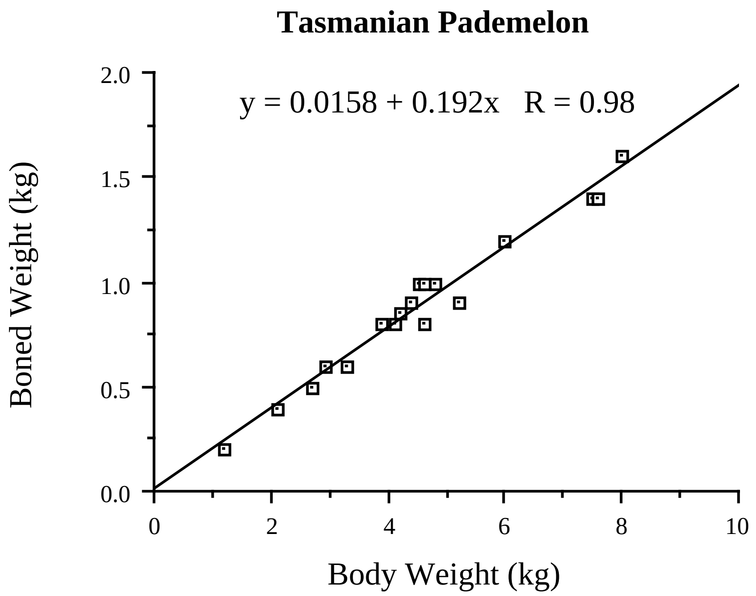


Figure 4 Relationship between boned weight and body weight for the Tasmanian pademelon ($F = 464.1$, $df = 17$, $p < 0.0001$).

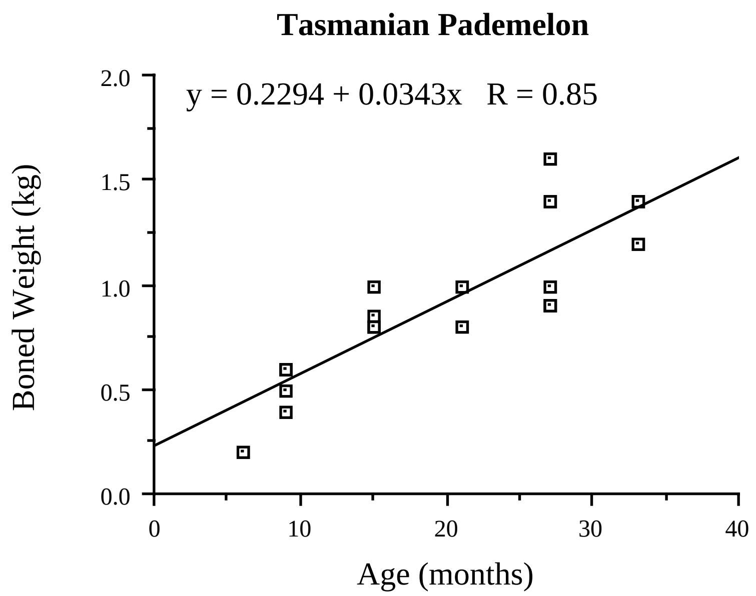
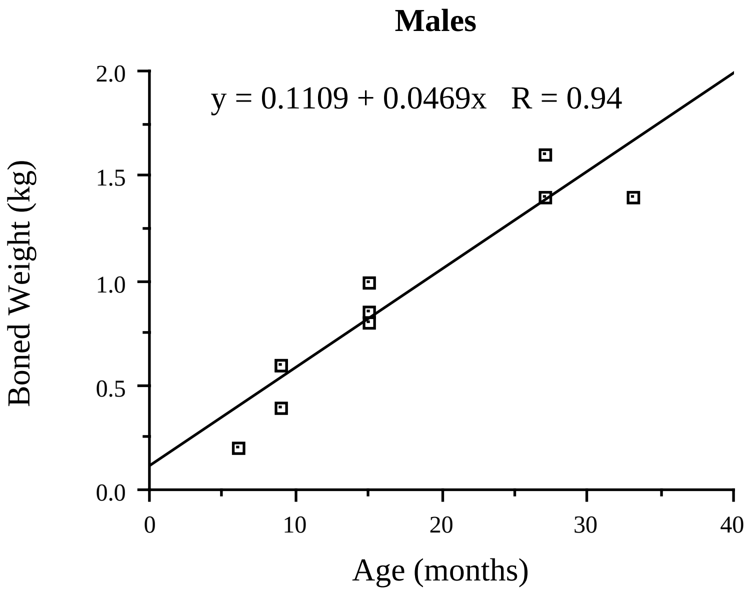


Figure 5 Relationship between boned weight and age for the Tasmanian pademelon ($F = 40.3$, $df = 17$, $p < 0.0001$).



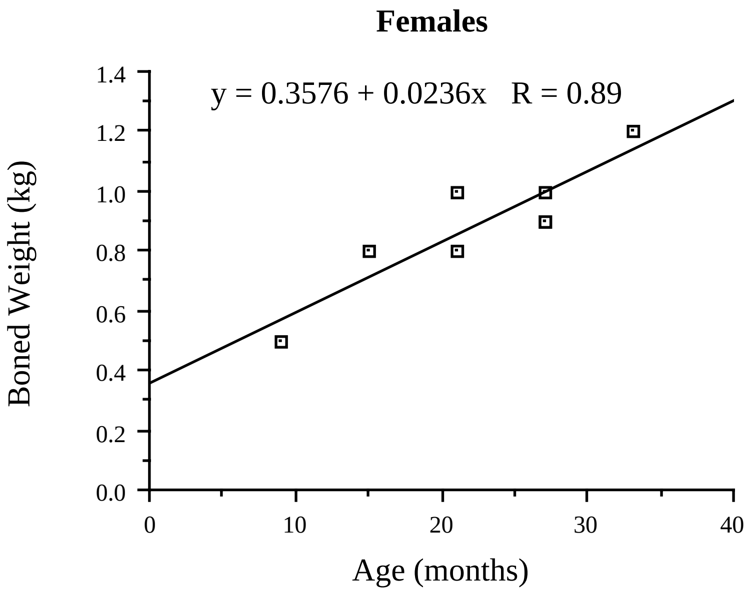


Figure 6 Relationship between boned weight and age for the Tasmanian pademelon (Males: $F = 63.3$, $df = 9$, $p < 0.0001$; Females: $F = 23.3$, $df = 7$, $p < 0.0001$).

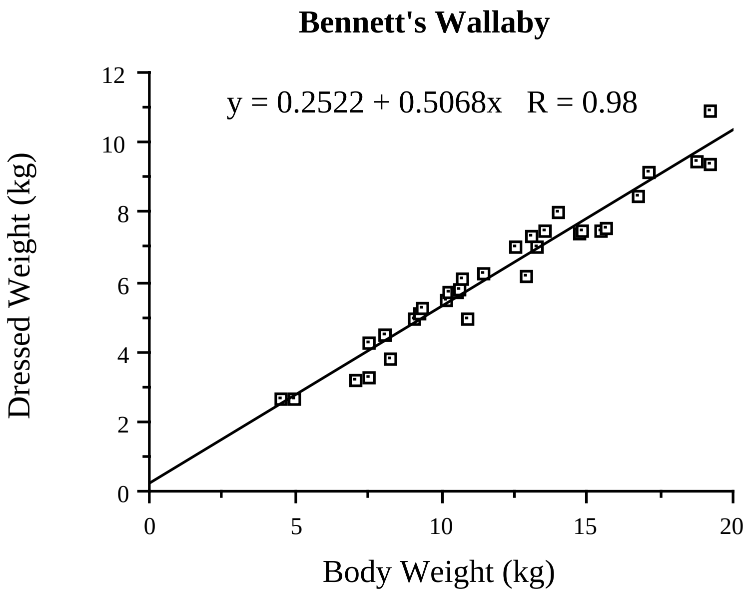


Figure 7 Relationship between dressed weight and body weight for Bennett's wallaby ($F = 659.2$, $df = 32$, $p < 0.0001$).

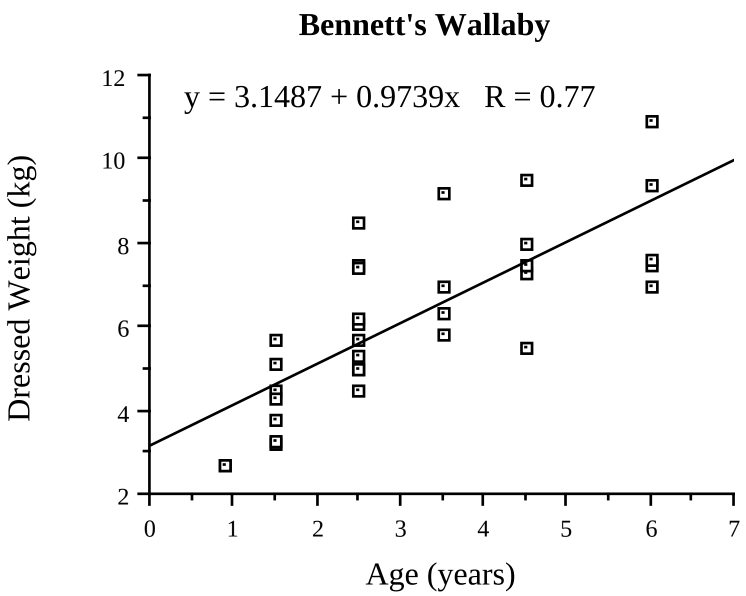
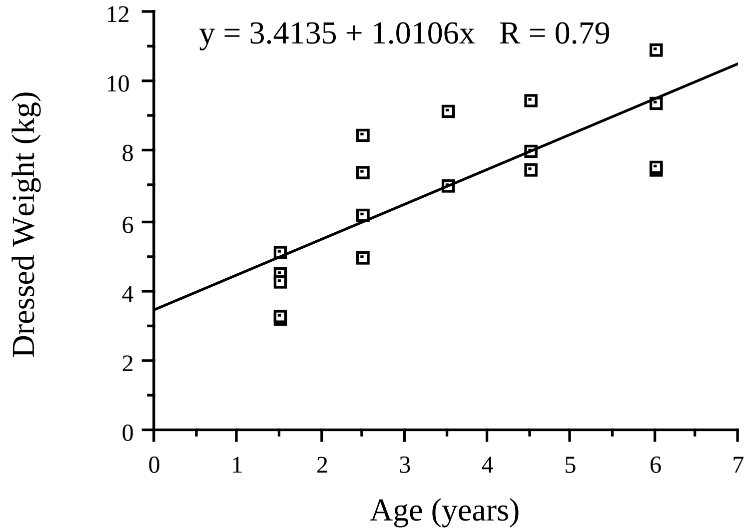


Figure 8 Relationship between dressed weight and age for Bennett's wallaby ($F = 44.3$, $df = 32$, $p < 0.0001$).

Males



Females

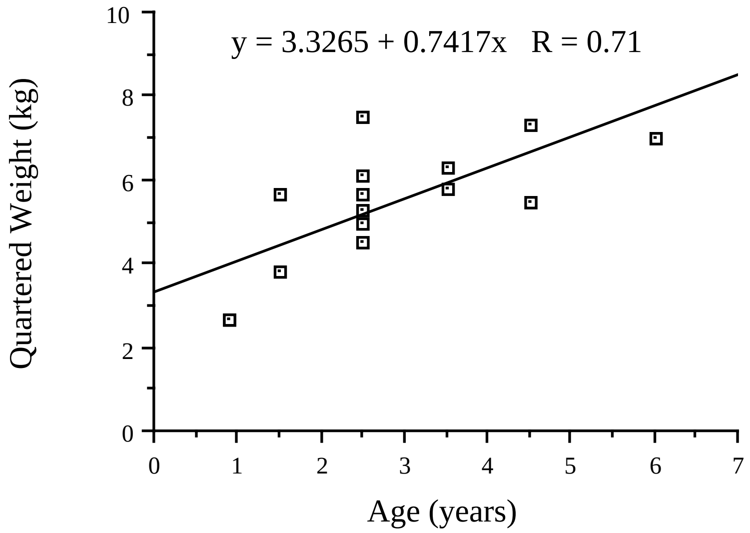


Figure 9 Relationship between dressed weight and age for Bennett's wallaby (Males: $F = 25.7$, $df = 17$, $p < 0.0001$; Females: $F = 13.5$, $df = 14$, $p = 0.0028$).

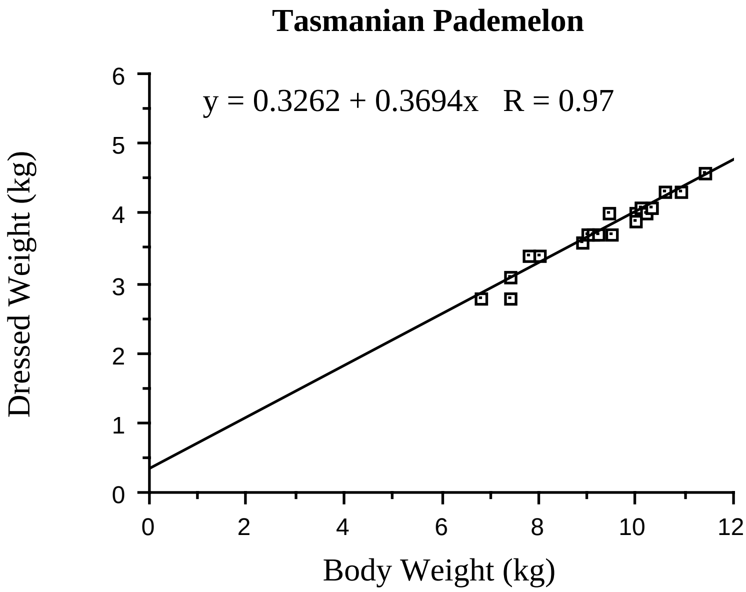


Figure 10 Relationship between dressed weight and body weight for the Tasmanian pademelon ($F = 364.8$, $df = 20$, $p < 0.0001$).

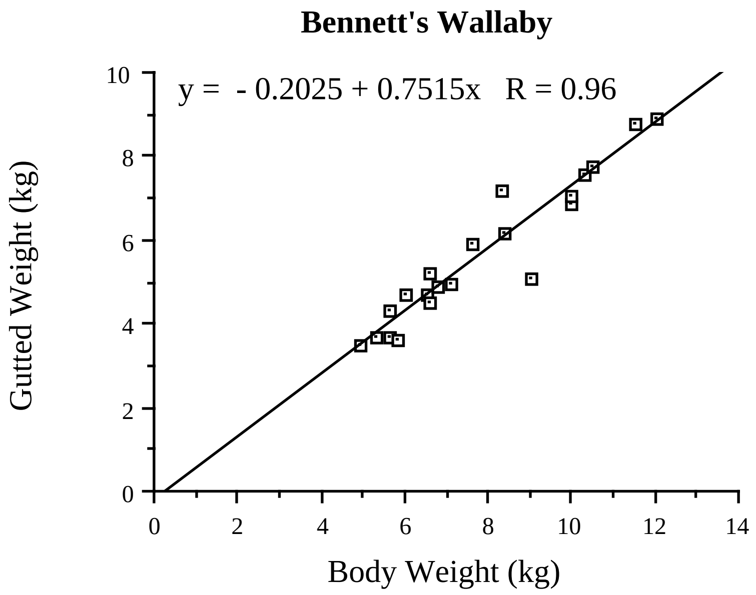


Figure 11 Relationship between gutted weight and body weight for Bennett's wallaby ($F = 204.2$, $df = 20$, $p < 0.0001$).

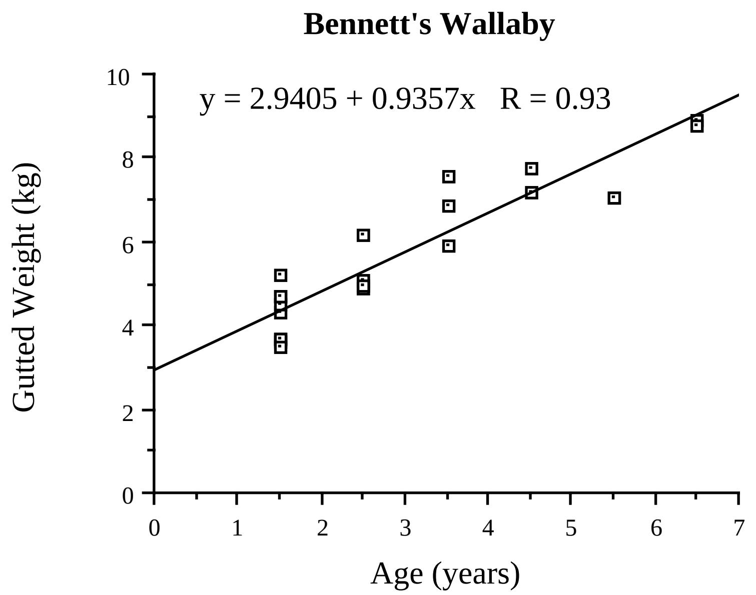
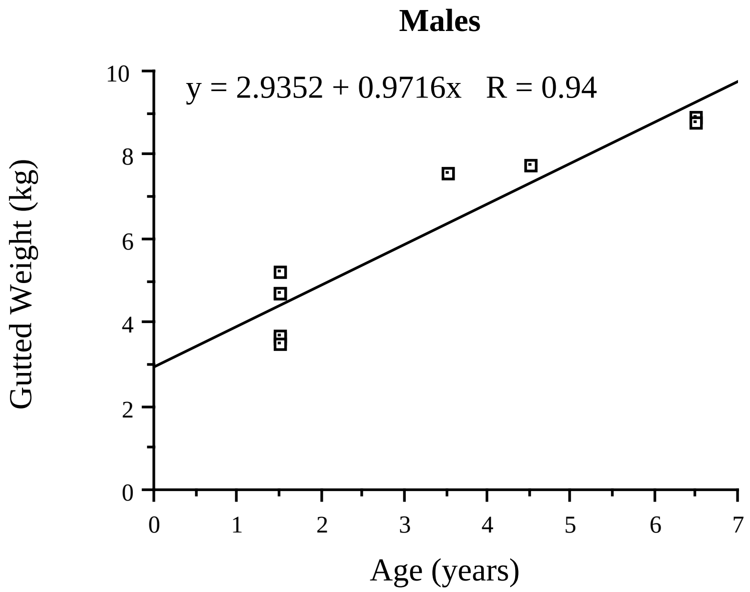


Figure 12 Relationship between gutted weight and age for Bennett's wallaby ($F = 116.6$, $df = 20$, $p < 0.0001$).



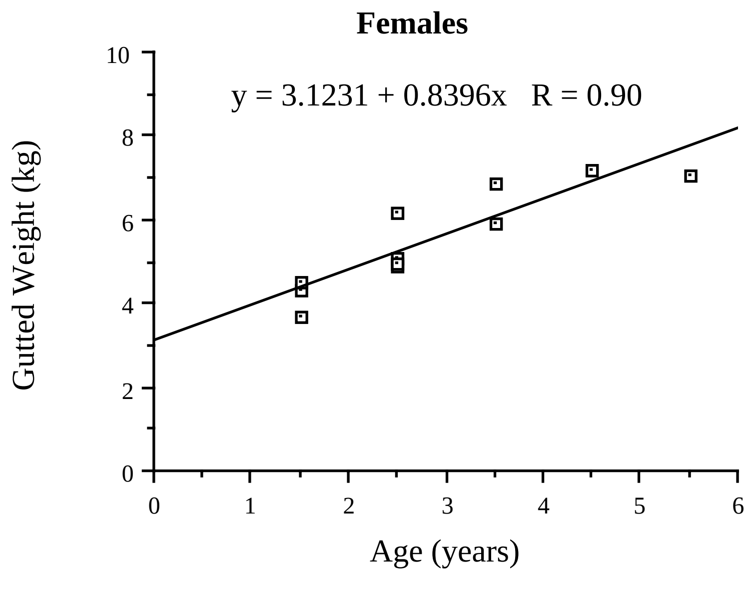


Figure 13 Relationship between gutted weight and age for Bennett's wallaby (Males: F = 62.3, df = 9, p < 0.0001; Females: F = 37.0, df = 10, p = 0.0002).

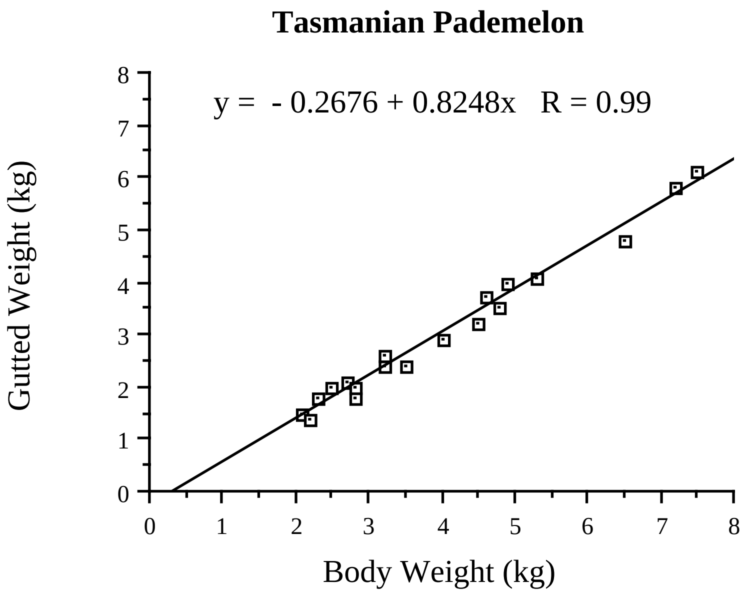


Figure 14 Relationship between gutted weight and body weight for the Tasmanian pademelon (F = 965.4, df = 18, p < 0.0001).

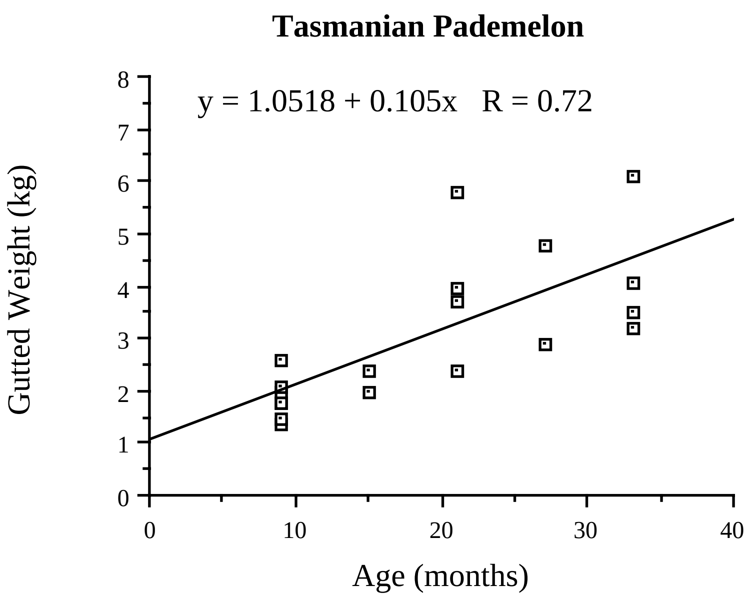


Figure 15 Relationship between gutted weight and age for the Tasmanian pademelon (F = 18.6, df = 18, p = 0.0005).

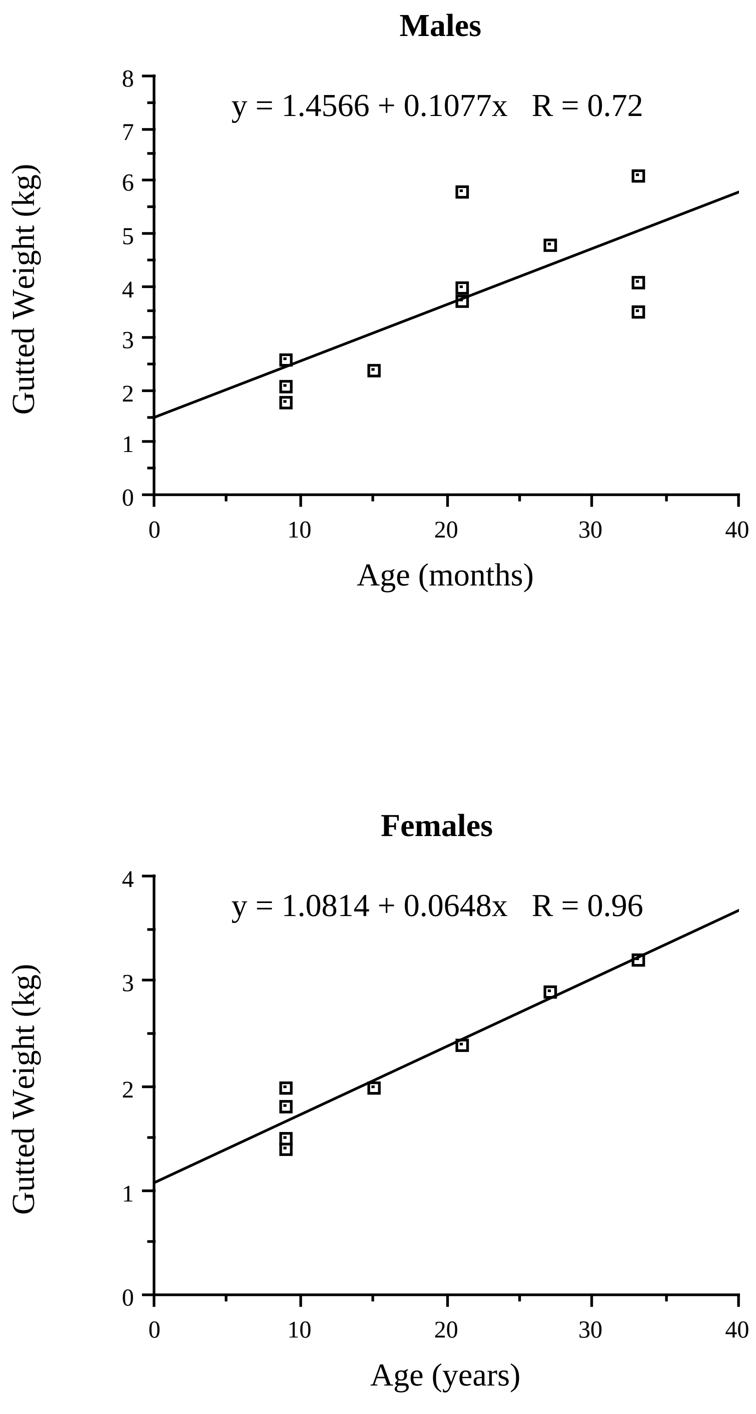


Figure 16 Relationship between gutted weight and age for the Tasmanian pademelon (Males: F = 9.9, df = 10, p = 0.0118; Females: F = 66.7, df = 7, p < 0.0002).

3 Correlations Between Skin Measurements and Age

Wallabies have been harvested in Tasmania for their skins since the earliest days of European settlement. The size of this harvest has fluctuated greatly depending upon the strength of overseas markets which determine the price paid to hunters for skins. Thus during the late 1970s and early 1980s skin prices improved which lead to a massive increase in the trade of skins. Since 1986 the trade has virtually ceased due to the loss of access to overseas markets.

The aim of the section is to determine the usefulness of obtaining age structures of wallabies from skin measurements.

Bennett's wallaby skins were obtained from the Lemont and Nunamara study areas. Tasmanian pademelon skins were obtained from the Nunamara study area. In addition to skin weight, skin measurements were taken as shown in Figure 1. All skins were air dried for six weeks before the measurements were taken.

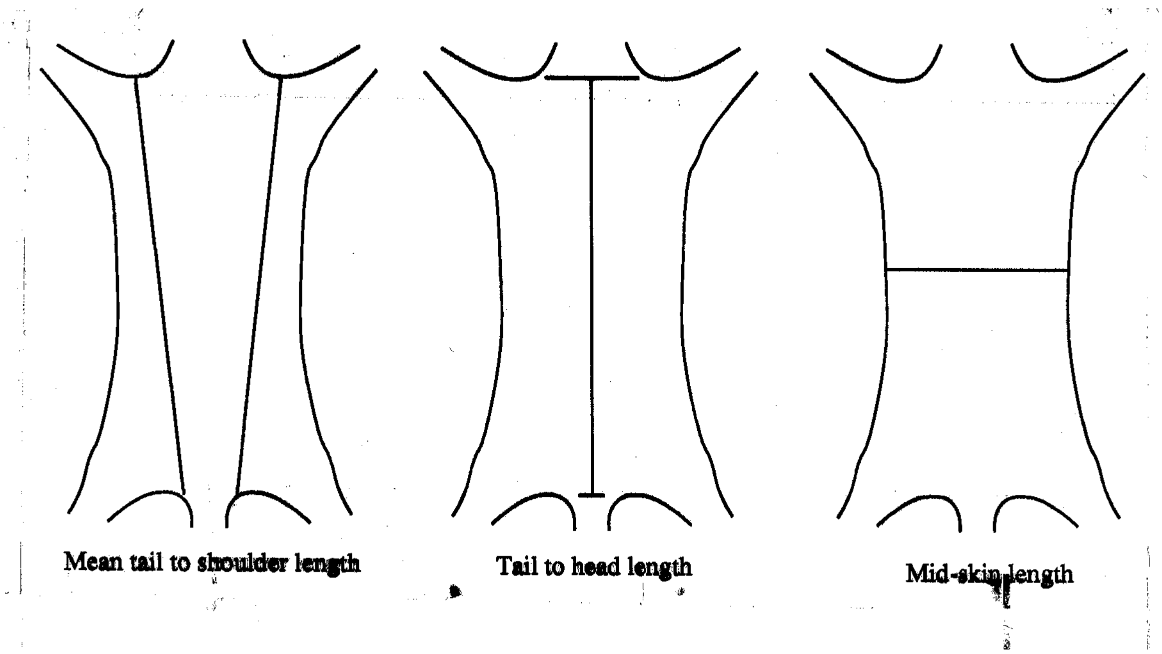


Figure 1 Skin measurements

The various correlations between skin measurements and age are shown in Figures 2-9. As sex can not be determined from the skins males and females were combined. For Bennett's wallabies significant correlations were obtained between age and skin weight, mean tail to shoulder length and tail to head length. However, the regressions only accounted for 30-40% of the variation. No significant regression was found between mid-skin width and age for Bennett's wallaby. For the Tasmanian pademelon significant correlations were obtained between age and mean tail to shoulder length and tail to head length. The regressions accounted for 50-60% of the variation. No significant regressions were found between age and mid-skin width and skin weight. The regression equations for Bennett's wallaby were statistically more significant than those for the Tasmanian pademelon. This is probably due the greater size range found in Bennett's wallaby.

The relationship between skin measurements and age is confounded by a number of factors:

1) A significant difference in size between males and females.
2) Different skinning and pegging-out methods among hunters which introduce major errors. For example the distance skins are stretched will greatly influence results.
3) Wallabies of the same age may vary significantly in size depending on the locality in which they were obtained (see chapter 4).
4) Weights of skins may vary depending on the drying time and the quality of the fur.

Consequently skin measurements can not be used to determine the detailed age structure of populations of either Bennett's wallaby or the Tasmanian pademelon. It may be possible to determine the ratio of adults to juveniles.

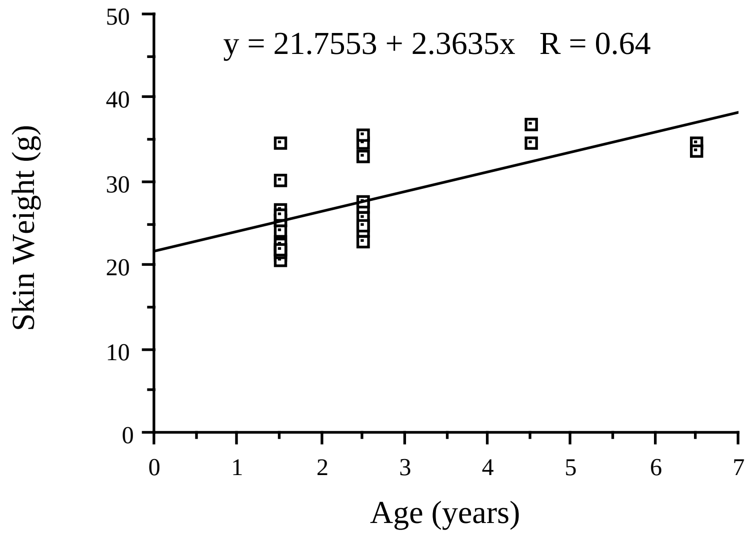


Figure 2 Relationship between skin weight and age for Bennett's wallaby (F = 17.3, df = 26, p = 0.0003).

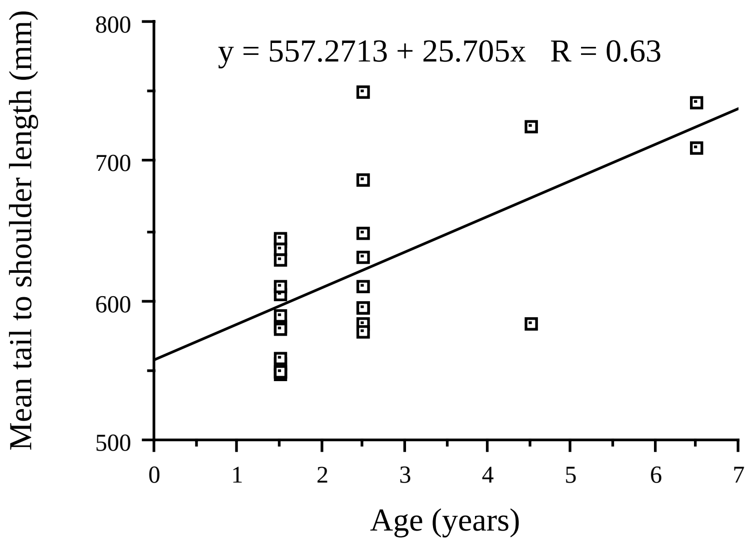


Figure 3 Relationship between mean tail to shoulder length and age for Bennett's wallaby (F = 16.1, df = 26, p = 0.0005).

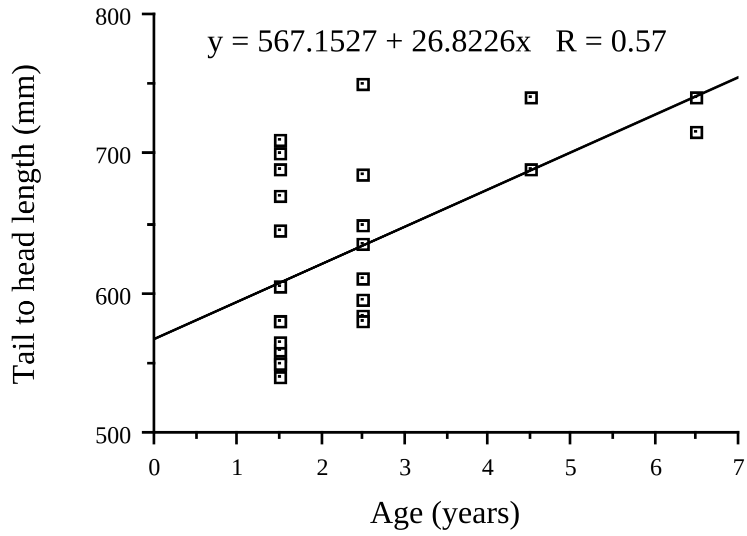


Figure 4 Relationship between tail to head length and age for Bennett's wallaby (F = 12.2, df = 26, p = 0.0018).

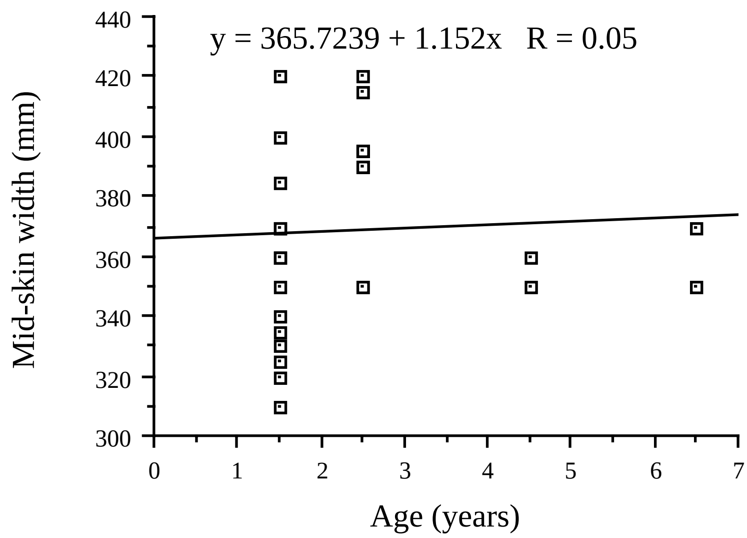


Figure 5 Relationship between mid-skin width and age for Bennett's wallaby (F = 0.071, df = 26, p = 0..7917).

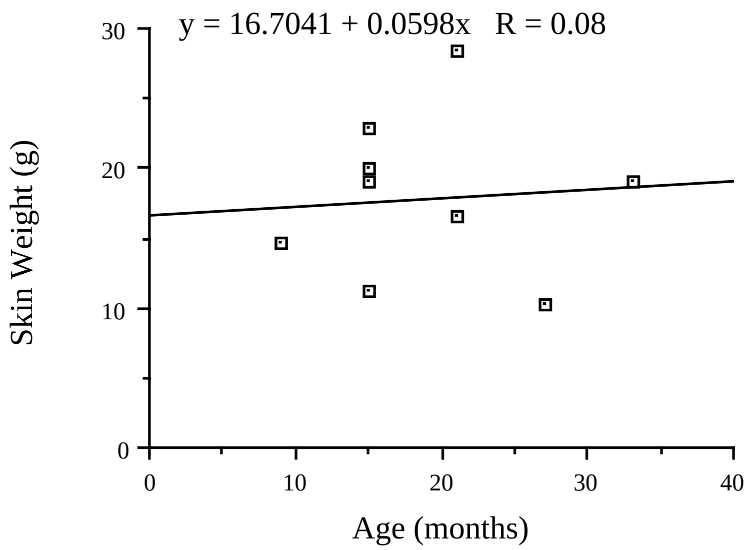


Figure 6 Relationship between skin weight and age for the Tasmanian pademelon (F = 0.06, df = 9, p = 0.8186).

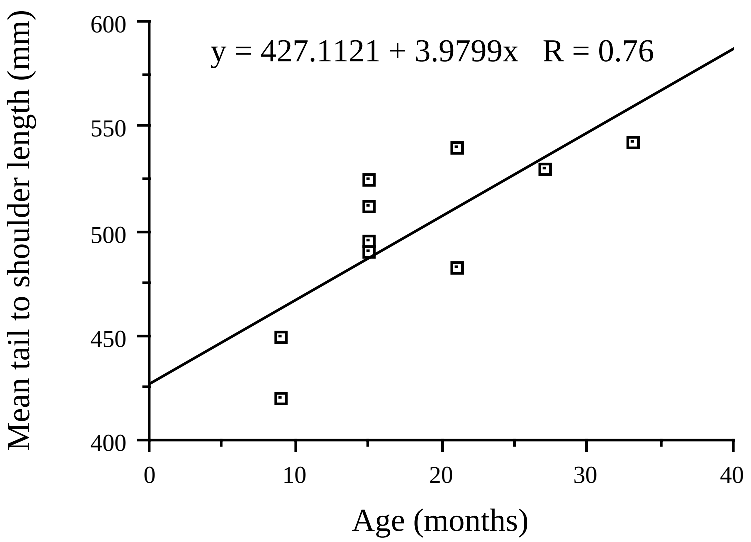


Figure 7 Relationship between mean tail to shoulder length and age for the Tasmanian pademelon (F = 10.8, df = 9, p = 0.0111).

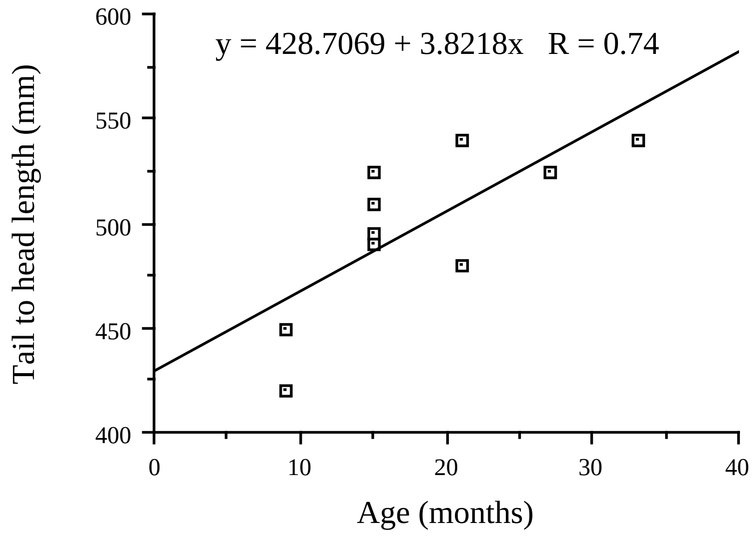


Figure 8 Relationship between tail to head length and age for the Tasmanian pademelon (F = 9.7, df = 9, p = 0.0143).

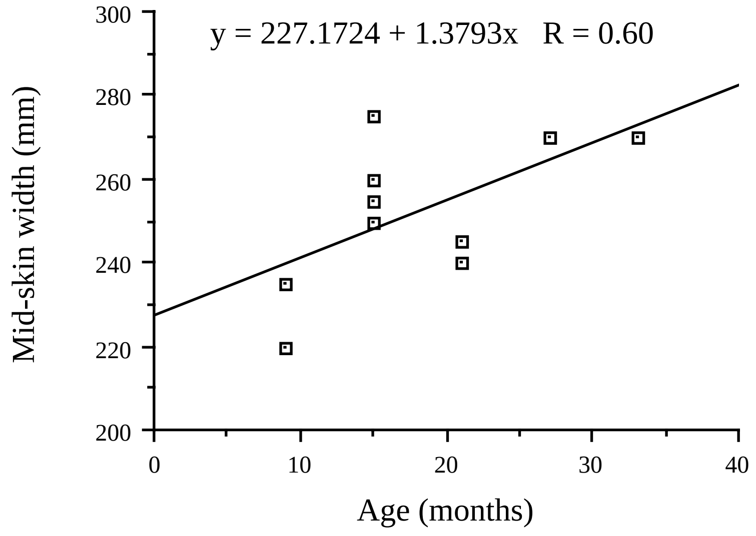


Figure 9 Relationship between mid-skin width and age for the Tasmanian pademelon (F = 4.5, df = 9, p = 0.0668).

4 Size at Sexual Maturity

Probit analysis was used to assess weight at sexual maturity in same way that age at sexual maturity was determined in Chapter 5. The results are shown below.

Species	Sex	Median Weight at Maturity (kg)	95% Confidence Limits lower	95% Confidence Limits upper
Tasmanian Pademelon	Male	4.5	4.4	4.7
	Female	3.1	2.9	3.2
Bennett's Wallaby	Male	10.5	10.2	10.8
	Female	7.1	6.9	7.4

5 Testes Measurements

During this study a number of external testes measurements were taken in order to determine their relationship with testes weight. This information would prove useful for field studies involving live animals. The relationship between testes + scrotum weight and testes weight was also determined as the former weight is quicker to determine.

Testes were severed at the part of the peduncle closest to the body. The testes were kept frozen until the measurements were taken. Testes height, width and length are illustrated in Figure 1. All measurements were made using vernier callipers. Testes volume was measured by calculating the amount of water displaced by the testes when they were placed in a graduated volumetric cylinder.

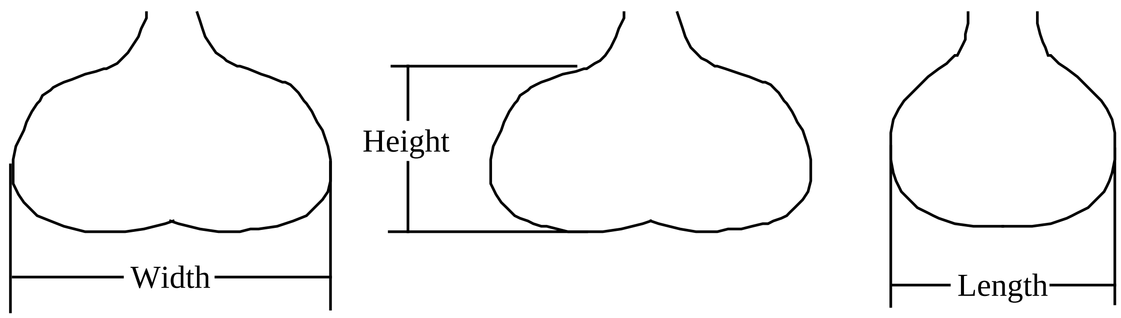


Figure 1 External testes measurements.

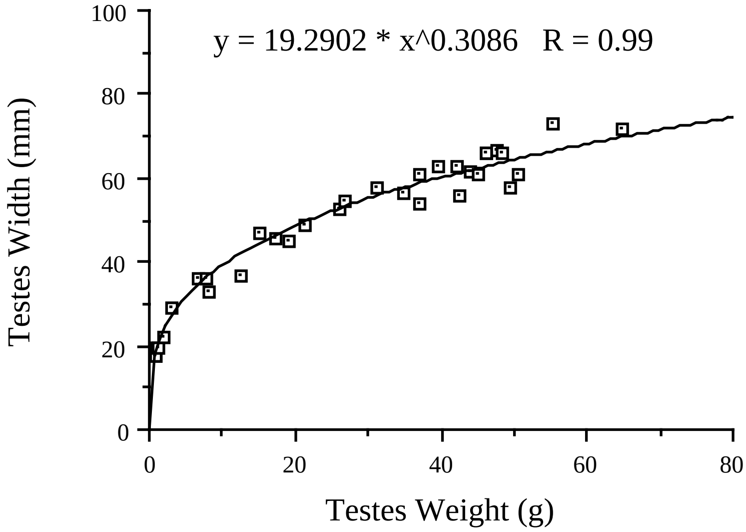


Figure 2 Relationship between testes width and testes weight for Bennett's wallaby (sample size = 34).

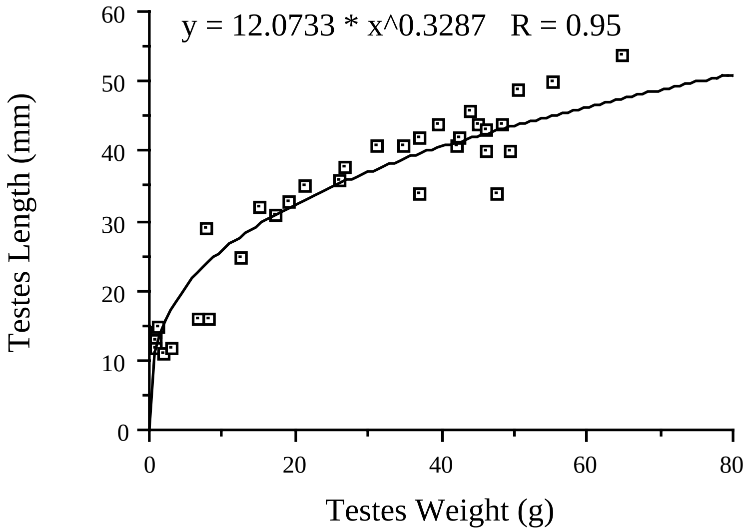


Figure 3 Relationship between testes length and testes weight for Bennett's wallaby (sample size = 34).

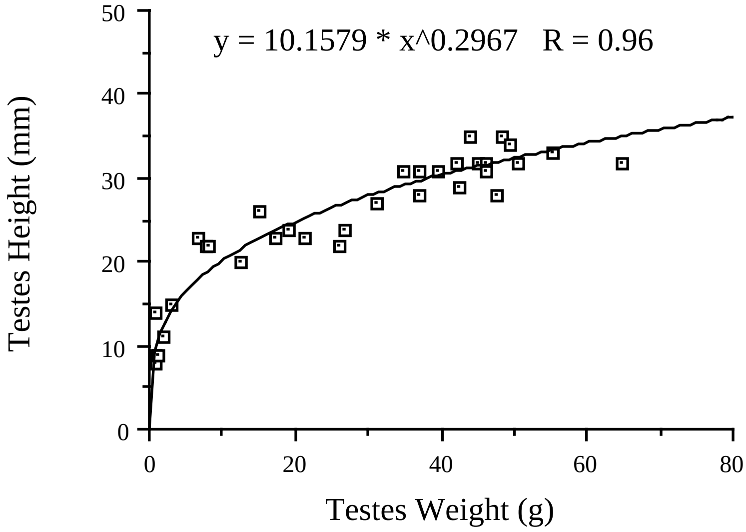


Figure 4 Relationship between testes height and testes weight for Bennett's wallaby (sample size = 34).

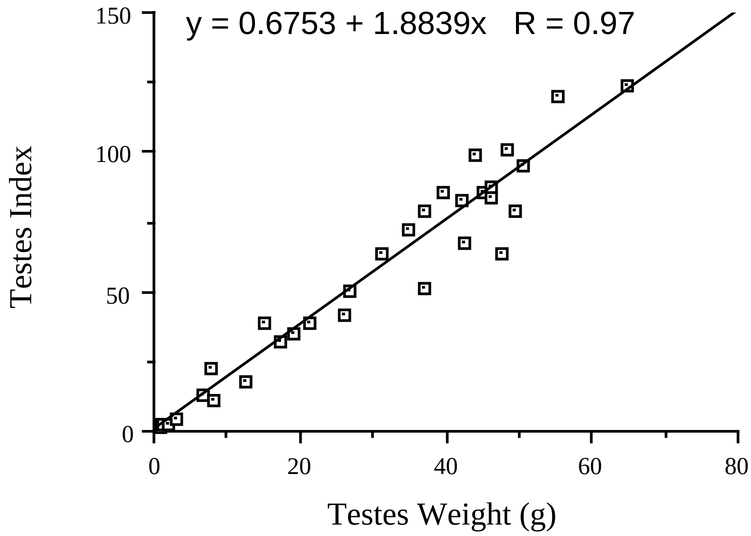


Figure 5 Relationship between testes index (width x length x height) and testes weight for Bennett's wallaby (sample size = 34).

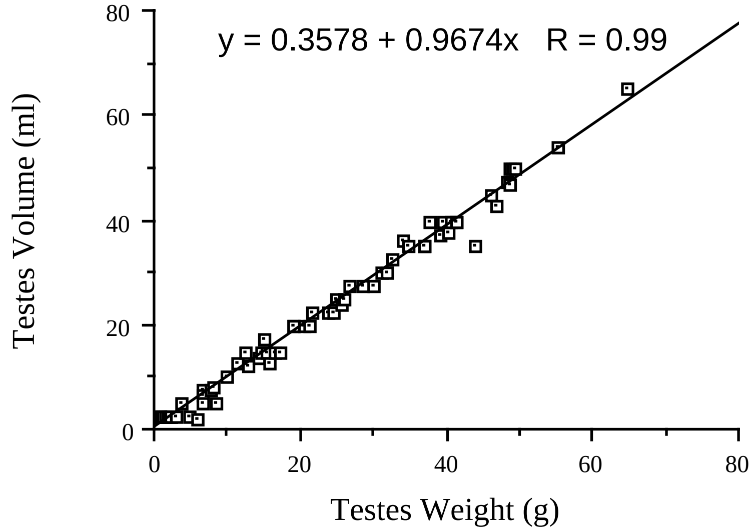


Figure 6 Relationship between testes volume and testes weight for Bennett's wallaby (sample size = 69).

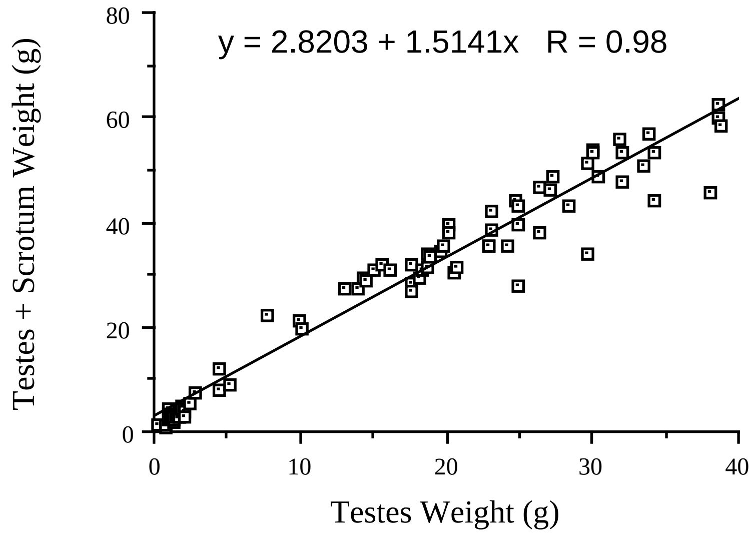


Figure 7 Relationship between testes and scrotum + testes weight for Bennett's wallaby (sample size = 90).

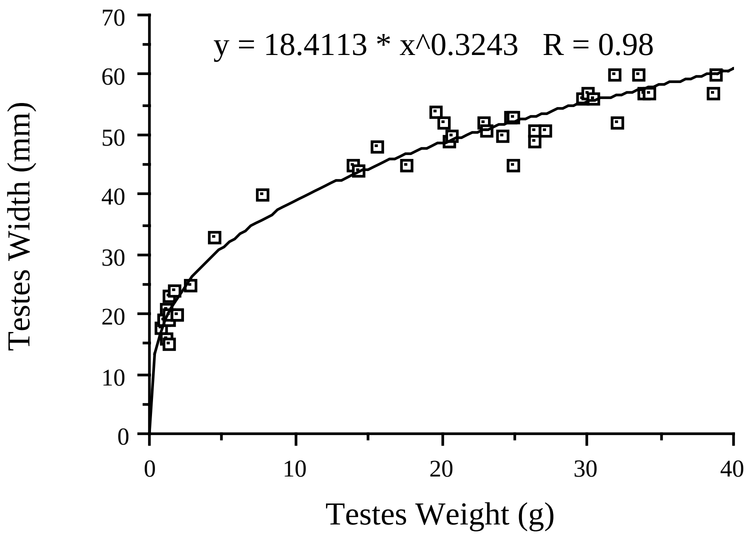


Figure 8 Relationship between testes width and testes weight for the Tasmanian pademelon (sample size = 45).

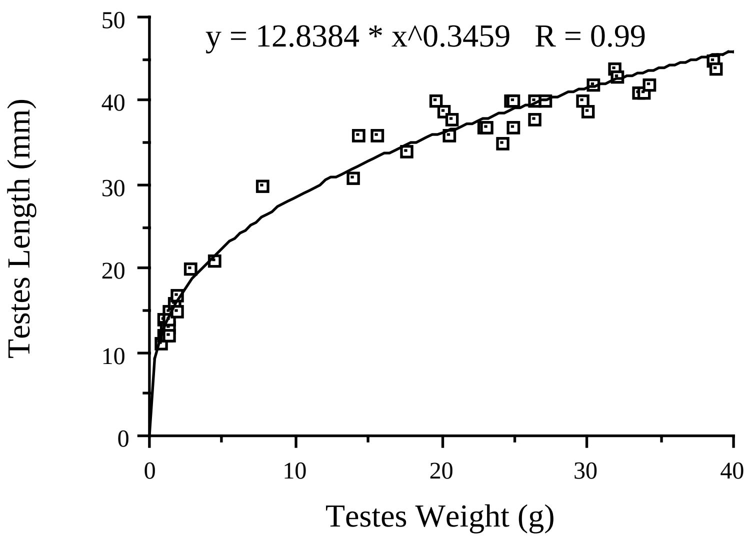


Figure 9 Relationship between testes length and testes weight for the Tasmanian pademelon (sample size = 45).

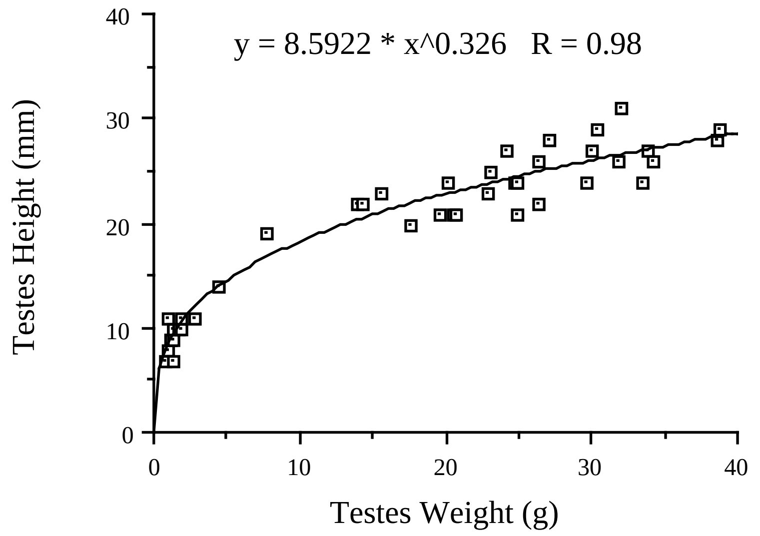


Figure 10 Relationship between testes height and testes weight for the Tasmanian pademelon (sample size = 45).

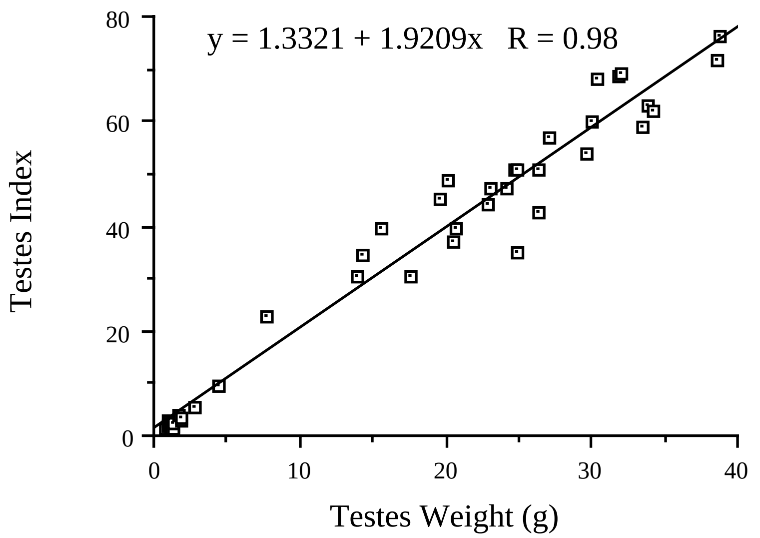


Figure 11 Relationship between testes index (width x length x height) and testes weight for the Tasmanian pademelon (sample size = 45).

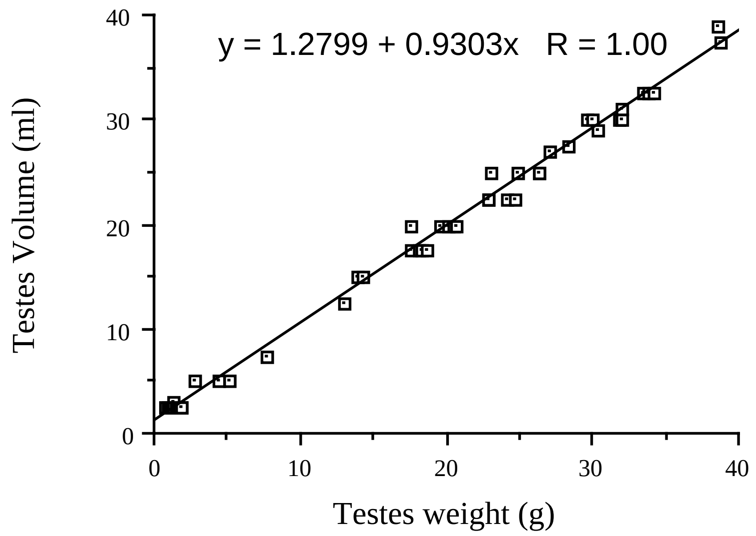


Figure 12 Relationship between testes volume and testes weight for the Tasmanian pademelon (sample size = 83).

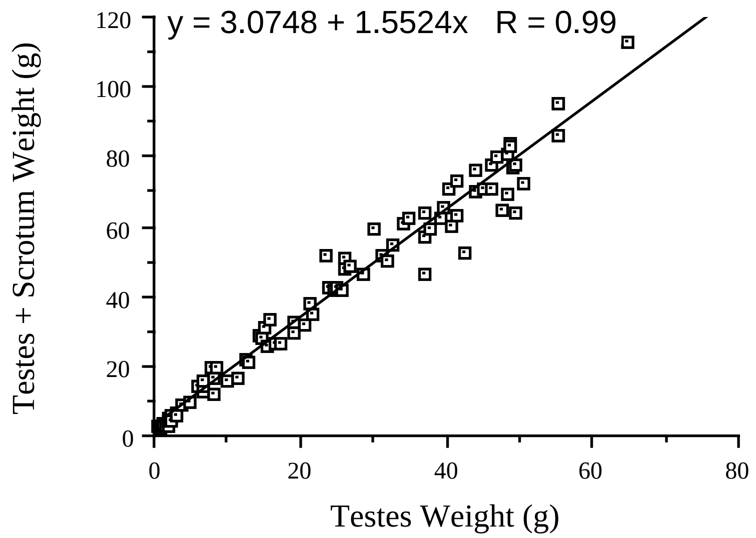


Figure 13 Relationship between testes + scrotum weight and testes weight for the Tasmanian pademelon (sample size = 86).