Comparison of Growth of Pouch Young of the Tasmanian Bettong, *Bettongia gaimardi*, in Captivity and in the Wild

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Abstract

Growth of pouch young of *Bettongia gaimardi* was compared in laboratory and field populations. Up to a pes length of 8 cm, weights of field and laboratory young were similar. For larger young, weights for field animals were significantly less than for those raised in captivity. The two groups did not differ in rate of growth of pes or in skeletal proportions. Previous studies of macropodids have found that growth rates are reduced only during periods of severe environmental stress. In contrast, in field populations of *B. gaimardi* lower growth rates of pouch young appear to be the norm. Differences in the seasonality and availability of food supplies between *B. gaimardi* and other species so far studied may be responsible for this difference.

Introduction

Numerous studies have detailed the growth of macropodid pouch young in captivity (e.g. Kirkpatrick 1965; Maynes 1972; Johnson 1978, 1979; Rose and McCartney 1982). Fewer studies have compared growth of captive animals with that in the wild. Sharman *et al.* (1964) considered growth of pouch young of *Macropus rufus* to be an 'all or none' phenomenon, and that severe drought conditions affected pouch young mainly through increased mortality (Frith and Sharman 1964). However, subsequent work on *M. rufus* and *M. robustus* showed that growth rates of older pouch young do decline during drought (Newsome 1965; Ealey 1967; Myers *et al.* 1976). Other studies comparing captive and field populations have found no differences in growth rates of pouch young (Shield and Woolley 1961; Sadleir 1963; Murphy and Smith 1970).

In this paper we compare the growth of pouch young in laboratory and field populations of the Tasmanian bettong, *Bettongia gaimardi*. Pouch life in this species is around 105 days. At the end of pouch life young weigh approximately 335 g and have a pes length of about 96 cm (Rose 1984). Weight of adults in the field is about 1.6 kg. The fungivorous diet of this species contrasts with the herbivorous diet of the larger macropodids.

Methods

Laboratory populations of *B. gaimardi* were maintained in outdoor enclosures at the University of Tasmania. Details on animal husbandry are given in Rose (1982); the bettongs were kept in roofed wire-mesh cages (4 by 4 by 3 m), provided with straw for nesting and with food and water in excess of requirements. Data on growth of pouch young were collected by R.W.R. and are reported in detail by Rose (1984). Weight and pes length of 10 animals were obtained at weekly intervals over the

0310-7833/87/030257$02.00
whole of pouch life; 26 measurements from another 15 pouch young of various ages were also taken. Only data covering the range of values of pes length obtained for field populations were included in the analysis.

Most of the data from field populations were obtained by R.J.T. in 1985. These populations encompassed the complete range of densities found for this species in Tasmania (Taylor, unpublished report) and were spread across its geographical range (Rose 1985). Rose (1984) found that removal of young from the pouch for measurement resulted in higher mortality rates in the wild; therefore, a pouch young was measured only if it had been ejected from the pouch by the mother whilst in a trap. Data collected by R.W.R. at intervals between 1976 and 1980 were also included. Ten pouch young were weighed, and pes length measured, independently by each of us; pes lengths were within 1 mm and weights within 2 g. We therefore concluded that the two sets of data were comparable.

Twenty-eight pouch young were measured in the field, and whenever a female with a pouch young was recaptured, the pes length of the young was measured again. Because the laboratory data contained measurements taken sequentially on the same animals, as well as independent observations, the mean weight of pouch young for each 0.5-cm interval of pes length was used in the analysis; this gave 17 values for pes and weight. Rose (1984) found no sexual dimorphism among pouch young born in captivity, and examination of the data from field animals also showed no differences between the sexes; data for male and female pouch young were therefore grouped. For pouch young, regressions relating weight and pes length for field and laboratory animals were first logarithmically transformed to a straight-line relationship and then compared by analysis of covariance. The logarithmic transformation resulted in residuals which appeared random. Differences in skeletal proportions between field and captive animals were investigated by the method of Wood et al. (1983). Differences in ages estimated from aging keys (Rose 1984) using pes and head lengths were compared between field and laboratory animals.

Weights of adults of various sizes were compared by means of the condition index technique of Bakker and Main (1980). This involved regressing a measure of body length against the cube root of weight and using the slope of the regression to calculate an intercept value for each individual. This was then used as an index of weight adjusted for size. Leg length provides the best predictor of body weight for *B. gaimardi* (Taylor 1986). However, as this was not measured on the laboratory animals, pes length was used.

**Results**

Weights of young of different sizes in the field and in captivity are shown in Fig. 1. The best fit to the data ($r^2 = 0.975$) was obtained from a regression model in which the lines for the laboratory and field animals have a common intercept but differ significantly in slope ($F_{1,41} = 35.66, P < 0.001$). The equations for these lines were, for captive young: $\ln W = 0.371p + 2.307$; and for young in the field: $\ln W = 0.332p + 2.307$; where $W$ is weight in grams and $p$ is pes length in centimetres. The weights of field and laboratory animals are similar for individuals with a pes length in the range 2–8 cm. For individuals with a longer pes, field animals weigh considerably less than laboratory animals and the differences increase with pes length (Fig. 1). Animals with a pes length of 8 cm are about 13 weeks old (Rose 1984). This is the age at which they begin to leave the pouch for the first time.

Data relating pes length and age in laboratory animals (from Rose 1984) were used to investigate possible differences in the growth rate of the pes between laboratory and field animals. No one equation provided a fit sufficiently accurate for prediction over the complete range of values of pes length. For pes lengths less than 5 cm ($= 10$ weeks of age: Rose 1984) an equation of the form: $\log Y = a \log X + b$ was used; for pes lengths greater than 5 cm an equation of the form: $Y = aX^3 + bX^2 + cX + d$ was used. These equations were picked to ensure the best fit to the data. No attempt was made to model growth. Changes in pes length of field pouch young with time were compared with those expected on the basis of the above equations (Table 1). The results show no consistent pattern; the pes of field animals did not grow more or less quickly than that of laboratory animals. Given the small amount of data and the short time over which growth was measured, no evidence of differences between laboratory and field animals was apparent. The data for laboratory animals represented mean values of pes length for a given age; thus the ages for field young are
the most likely for animals of their pes lengths. If there were evident differences between field and laboratory young it would have been important to test whether these were encompassed by values predicted from extreme ages within the confidence intervals for laboratory animals (see e.g. Wood et al. 1981; Poole et al. 1982).

Fig. 1. Relationship between weight and pes length in pouch young from laboratory (○) and field (●) populations. The number of animals in each 0.5-cm interval of pes length for the laboratory data, from 2.0-2.5 to 10.1-10.5, are: 9, 10, 8, 4, 8, 6, 8, 5, 8, 5, 7, 8, 7, 7, 15, 15, 16. Vertical lines representing the range of values are given for the laboratory animals with a pes length greater than 8 cm. Values for field populations are for individual animals.

Table 1. Change in pes length with time for field pouch young, compared with that expected on the basis of growth rates of laboratory animals

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>Initial length of pes (cm)</th>
<th>Interval between measurements (days)</th>
<th>Final length of pes (cm)</th>
<th>Predicted final length (cm)</th>
<th>Difference (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.3</td>
<td>4</td>
<td>0.4</td>
<td>0.5</td>
<td>-0.1</td>
</tr>
<tr>
<td>2</td>
<td>1.8</td>
<td>3</td>
<td>2.1</td>
<td>2.0</td>
<td>+0.1</td>
</tr>
<tr>
<td>3</td>
<td>2.1</td>
<td>6</td>
<td>2.6</td>
<td>2.6</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>2.2</td>
<td>3</td>
<td>2.5</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2.8</td>
<td>3</td>
<td>3.1</td>
<td>3.1</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>4.8</td>
<td>4</td>
<td>5.3</td>
<td>5.2</td>
<td>+0.1</td>
</tr>
<tr>
<td>7</td>
<td>7.3</td>
<td>3</td>
<td>7.4</td>
<td>7.4</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>8.2</td>
<td>2</td>
<td>8.3</td>
<td>8.2</td>
<td>+0.1</td>
</tr>
<tr>
<td>9</td>
<td>9.9</td>
<td>13</td>
<td>10.5</td>
<td>10.6</td>
<td>-0.1</td>
</tr>
</tbody>
</table>

Ages of pouch young estimated from pes and head lengths are shown in Fig. 2a for captive animals and Fig. 2b for laboratory animals. On average, estimates of age from pes length were 0.2 days less than those from head length in captive animals, and 0.8 days less in field animals; this difference was not statistically significant. There was thus no evidence of differences in skeletal proportions between captive and field animals.
Analysis of covariance showed no significant differences in the regression of the cube root of weight against pes length for the two sexes in adult animals from either field populations or laboratory stock. The sexes were therefore not treated separately. The equation used to compute a condition index (CI) for adult animals was: $CI = \sqrt[3]{W - 0.52p}$. Mean weights, pes lengths and condition indices (± standard deviations) were as follows:

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Weight (kg)</th>
<th>Pes (cm)</th>
<th>Condition index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory</td>
<td>25</td>
<td>1.86±0.22</td>
<td>11.8±0.3</td>
<td>6.16±0.41</td>
</tr>
<tr>
<td>Field</td>
<td>143</td>
<td>1.73±0.23</td>
<td>12.3±0.5</td>
<td>5.57±0.46</td>
</tr>
</tbody>
</table>

The condition indices for animals in the laboratory population were significantly higher than in the field populations ($t=5.97$, 166 d.f., $P<0.001$). Thus adults from field populations weighed significantly less than did those of the same size from laboratory populations.

**Discussion**

Previous studies have documented a reduction in growth rates of pouch young only during times of severe environmental stress (*M. rufus*: Newsome 1965; Myers *et al.* 1976; *M. robustus*: Ealey 1967). While the data for field populations of *B. gaimardi* were being collected rainfall was slightly below average, for the most part, with very high falls towards the end of 1985 (Bureau of Meteorology records), i.e., there was no drought. Nothing is known of the relationship between rainfall and the food supplies of *B. gaimardi*. However, we consider it unlikely that the above pattern of rainfall would have caused a significant reduction in the availability of food. It is possible that the animals held in the outdoor enclosures suffered less from environmental stress than did those in the wild, but macro-climatic parameters would not have differed. In the enclosures, animals could shelter in the hay provided, but the nests used by this species in the field probably provide equivalent shelter (Sampson 1971). Thus the lower growth rates of pouch young in field than in laboratory animals appear to be those normal for *B. gaimardi*.

Laboratory animals were provided with an excess of food and water and were in better condition that those in the field. Presumably, the high plane of nutrition of females in captivity allows them to supply more and/or better quality milk to the pouch young. Differences in growth between laboratory and field young become evident only towards the end of pouch life, when absolute increases in weight are greatest. Data collected by
Ealey (1967) suggested that in *M. robustus* the growth rate of the pes may slow down during drought. There was no evidence of differences in growth of the pes or in skeletal proportions between field and laboratory populations of *B. gaimardi*.

The lower weights of field young are surprising, considering that the populations were probably not under abnormal nutritional stress. In mammals, females tend usually to drain their own resources before milk production falls off at all (Sadleir 1969). Thus Murphy and Smith (1970) found no differences in growth rates of pouch young between field and laboratory populations of *M. eugenii*, despite the fact that females in the field were probably deficient in nitrogen and water. Green *et al.* (1980) found no differences in the composition of milk samples between captive and free-living *M. eugenii*.

The difference between *B. gaimardi* and the other macropodids so far studied may be related to diet. Small herbivores need to feed on high-quality foods, which are usually comparatively scarce; larger herbivores consume the more abundant lower-quality foods because higher-quality foods are too scarce to supply their metabolic requirements (Bell 1971; Jarman 1974; Demment 1983). The macropodids studied to date have been grazers, and species tend to go through a 'boom or bust' situation in relation to food supplies. Thus, either pouch young are produced at such a time that lactation ends during seasonal periods of high abundance of food (e.g. *M. eugenii*; Inns 1980; *Setonix brachyurus*: Dunnet 1962), or reproduction ceases when food supply is reduced during periods of environmental stress (e.g. *M. rufus*: Newsome 1965). Seasonality of reproduction in macropodids is closely related to seasonality of food supplies (Sharman *et al.* 1966; Tyndale-Biscoe 1973). Since *B. gaimardi* breeds throughout the year (Rose 1984), it is reasonable to assume that its food supplies remain relatively constant. It probably depends mainly on fungi (Statham 1983; Rose 1984; Taylor, unpublished data), and the diet of its congener *B. penicillata* has also been found to consist largely of fungi throughout the year (Christensen 1980). Thus *B. gaimardi* may not be subjected to large changes in food availability as do the other species studied, but theoretical considerations suggest that the food is always present in low quantities (Demment 1983; Demment and Van Soest 1985). This in turn may lead to suboptimal supplies of milk for the pouch young. If this hypothesis is correct, then differences in the growth rate of field and laboratory pouch young could be expected in other potoroids feeding on a similar diet (e.g. *Potorous tridactylus*, *B. penicillata*).

Acknowledgments

We would like to thank Paul Cramp for his help with the care and measurement of laboratory animals, and Nick Savva and Jim Williams for assistance in the field. Statistical analysis of the pouch young data was undertaken by Dr David Ratkowsky (Division of Mathematics and Statistics, CSIRO, Hobart). Professor D. M. Stoddart provided helpful comments on the manuscript. The Tasmanian National Parks and Wildlife Service issued permits to allow this work to be undertaken. Funding was provided by the University of Tasmania and the Australian National Parks and Wildlife Service.

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Manuscript received 17 March 1986; accepted 28 August 1986