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SEASONAL TRENDS IN FOOD CONSUMPTION AND BODY MASS OF CAPTIVE REGENT HONEYEATERS *Xanthomyza phrygia* (MELIPHAGIDAE)

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In this study, the seasonal changes in food use and body mass in captive Regent Honeyeaters *Xanthomyza phrygia* between April and September were examined. Regent Honeyeaters had a higher body mass in autumn and early winter (April-June) than in late winter and spring (July-September). Nectar consumption varied significantly over the study period and reached an overall peak in July. Fruit consumption was considerably higher between April and July than between August and September. Hawking for insects was very low in autumn and early winter (April to June), but was pronounced in late winter and spring (August and September). These results suggest a seasonal change in dietary preferences from a carbohydrate-based diet to a more protein-based diet.

INTRODUCTION

The Regent Honeyeater is an endangered woodland honeyeater species (Garnett and Crowley 2000), which has suffered a dramatic decline in both its abundance and distribution (Franklin *et al.* 1989). Its dramatic decline has led to the formation of the National Regent Honeyeater Recovery Team (a multi-agency working group). The Recovery Team aims to implement the current recovery plan, which includes components relating to research and field management (Menkhorst *et al.* 1999). Management of the species is difficult due to the mobile lifestyle of the species and the broad range of habitat types it selects over regional scales. Most studies conducted so far have been field based and during the breeding period of the birds, when the birds remain in one location (e.g. Webster and Menkhorst 1992; Geering and French 1998; Oliver 1998a,b,c, 2000, 2001; Oliver *et al.* 1998). Detailed studies outside the breeding period are very limited (Oliver 1998a, 2000), because the birds leave the breeding area after the nestlings have fledged (Webster and Menkhorst 1992). Their movements after they leave the breeding areas and the resources they rely on are still little known (Cooke and Munro 2000; Geering 2001).

From previous studies it is known that many birds show distinct annual cycles in body weight, fat deposition (for summary, see Berthold 2001), as well as food consumption and preferences (Bairlein 2002). These cycles are also shown in captivity and provide a good indication about the species' behaviour in the wild (for summary see Berthold 2001; Munro 2002). In the present study we investigated seasonal changes in the feeding behaviour and weight of captive Regent Honeyeaters to gain knowledge about the dietary requirements and weight development of these endangered birds during a time when they are difficult to observe in the wild. This knowledge will be helpful for the future management of this species in the wild and in captivity.

METHODS

Study birds

The study was conducted on six, first-year Regent Honeyeaters (two females, four males) born at Taronga Zoo, Sydney (captive-bred F1 generation), as part of the Captive Breeding Program component of the Regent Honeyeater Recovery Plan (Menkhorst *et al.* 1999). All six birds were born between 5 August and 25 November 1997, and were raised by their natural parents.

The birds were kept in two adjoining, outdoor aviaries (aviary A: three males; aviary B: two females, one male). The birds were fed *ad libitum* with:

(1) a nectar substitute (Lorikeet and Honeyeater Food, Wombaroo Food Products, Adelaide, South Australia);

(2) a protein/insect substitute (Egg Cake, Draft Husbandry Manual, Taronga Zoo, Sydney; Parsons 1999); and

(3) two pieces of fruit (orange and papaya).

The nectar substitute contained sucrose, maldextrins, dextrins, lecithins, egg powder, casein hydrolysate, whey and soy protein isolates. It contained a minimum of 13 per cent protein, 5 per cent fat and 2 per cent fibre, as well as vitamins and minerals. The insect substitute consisted of a mixture of approximately equal amounts of boiled egg, fly pupae (bred at Taronga Zoo), and an insectivore rearing mix (Wombaroo Food Products, Adelaide, South Australia) covered with a sprinkle of millet. The insectivore rearing mix included whey and soy protein isolates, meat meal, fish meal, blood powder, rice bran, lecithins, vegetable oils, vitamins and minerals. It contained at least 52 per cent crude protein and 12 per cent crude fat, and maximally 5 per cent crude fibre.

Data collection

Data collection began on 16 April 1998 and continued until 25 September 1998. No data were collected between 29 July and 14 August 1998.

BODY MASS

Each bird was weighed to the nearest 0.1 gram once per week between 0730 and 0900 hours in the morning, to minimize diurnal weight variation.

FOOD CONSUMPTION

The most accurate method for determining food consumption per bird is measuring the volume or mass of food consumed in 24 hours. However, our birds were not in separate aviaries, so measuring daily food consumption per bird was not possible. In addition, it was not possible to measure consumption of fruit and insect mix accurately. The loss of insect mix through spilling by the birds and the loss of fruit due to break down during the day was impossible to quantify precisely.

A surrogate measure of food consumption used in this study was to quantify the percentage of time individuals spent feeding on a food item. In order to determine whether the percentage of time spent feeding on a food item reflects food consumption, we recorded nectar consumption for each aviary for ten days between 14 August to 25 September by measuring to the nearest one millilitre the amount of nectar consumed per day. A control bottle was placed outside the aviaries to quantify loss of nectar due to evaporation. It was negligible. There was no significant difference found between the nectar consumed in the two aviaries ($p > 0.05$, one-way ANOVA). A ten day comparison between the total volume of nectar consumed daily by the six study birds (252 ± 32.8 ml) and the average daily percentage of time spent nectar feeding (3.23 ± 1.81%) revealed a good correlation between these two measures ($r = 0.856$, Pearson's correlation, $n = 10$ (Zar 1984)). This indicates that feeding time (%) is a good reflection of nectar consumption.

The feeding activity of each bird was recorded continuously for five minutes per hour between 0700 and 1300 hours. Observation bouts were undertaken two to five times per week. The observations were recorded with a hand-held computer, the Psion Work*about* (Psion, PLC, England). The configuration for observations was designed using Observer v.3.0 (Noldus Information Technology, Netherlands), and down loaded onto the hand-held computer. The configuration allowed us to record the frequency and percentage of time spent feeding on each food source: nectar, fruit and insect mix. It soon became obvious that the study birds rarely fed on the insect mix provided for them, instead they preferred to hawk for live insects in the aviaries. Therefore frequency of hawking was also recorded. Frequency of hawking was used as a measure of insect consumption for this study, but it was not possible to discern whether each hawk yielded an insect, as some are minute in size (Oliver 1998b; Franklin *et al.* 1989), or how much insect biomass was consumed. There are also other means for birds to obtain insects, including snatching and gleaning of foliage, which were not considered in this study, but may well have been a food source for our birds.

Data analysis and statistics

Repeated Measures ANOVAs (Zar 1984) using SYSTAT Version 3.0 were used to analyze nectar consumption and body weights. For nectar consumption, the average percentage of time spent feeding on nectar for the 16 weeks from 16 April to 29 July and the 6 weeks from 19 August to 25 September was compared statistically. For the weight analysis, the average weights of each bird over half-month intervals were compared. To elucidate differences in hawking and fruit consumption for the different times of year, the percentage of observation bouts with hawking or fruit activity was calculated for the April-July period and the August-September period.

RESULTS

Body mass

Females were significantly lighter than males ($p < 0.01$, repeated measures ANOVA) (Table 1). Average half-monthly female body mass ranged from 38.4 to 40.3 grams, while males weighed between 45.9 and 49.8 grams (Fig. 1). Weights varied significantly over the nine, half-month intervals from April to September 1998 ($p < 0.01$, repeated measures ANOVA) with highest weights recorded between April and June for both males and females. Figure 1 shows the weight change over the period for male ($n = 4$) and female ($n = 2$) Regent Honeyeaters and the average of all six birds.

Nectar consumption

Nectar consumption (measured as average % of total time spent nectar feeding) varied significantly over the 23 weeks of measurements ($p < 0.001$, repeated measures ANOVA) (Table 1, Fig. 2). There was also a significant difference between individual birds ($p < 0.01$), but the trends for the two sexes were similar indicating that variability within sexes was not as large as variability between individuals. This analysis identified no significant diurnal trends ($p > 0.05$). Interaction between the individuals and the weekly changes were also not significant ($p > 0.05$). Thus despite significant individual differences ($p < 0.01$) the seasonal pattern was comparable. An overall peak in nectar consumption was recorded in late July (see Fig. 2).

Hawking and fruit consumption

Hawking for live insects was most common in August and September (Table 1), and 45 per cent of all five minute observations bouts in August and September contained hawking events. Hawking did not occur in April and May, and showed intermediate levels in June and July (Table 1). Only 2 per cent of all five minute observations bouts between April and July contained hawking events.

Feeding on fruit was recorded considerably more often in the April-July period than in the August-September period (Table 1). Eighteen per cent of all five minute observation bouts in the April-July period showing fruit feeding, while during the August-September period fruit feeding was recorded in only 6 per cent of all observation bouts.

TABLE 1

Body weight and food consumption (± standard error) of six Regent Honeyeaters between April and September 1998. Food consumption is presented as either the percentage of time spent on the food source (for nectar and insect mix), or as the average feeding frequency per five minute observation bout (for fruit feeding and hawking).

		MONTH					
Bird feature		April	May	June	July	Aug	Sept
Body mass (g)	Male	48.1 ± 1.8	48.0 ± 1.8	47.7 ± 2.1	46.5 ± 1.0	45.7 ± 0.4	46.1 ± 0.4
	Female	39.9 ± 0.1	40.2 ± 1.1	39.0 ± 1.4	38.6 ± 0.6	38.4 ± 0.5	39.3 ± 0.7
Nectar (%)		3.8 ± 0.5	3.5 ± 0.3	4.7 ± 0.4	5.6 ± 0.4	3.8 ± 0.5	3.8 ± 0.2
Insect mix (%)		Rarely eaten, time spent feeding on insect mix >0.02% of total feeding time					
Fruit (frequency)		1.9 ± 0.3	1.8 ± 0.5	1.7 ± 0.5	2.3 ± 0.7	0.5 ± 0.2	0.4 ± 0.1
Hawking (frequency)		0.0	0.0	0.1 ± 0.1	0.3 ± 0.0	0.6 ± 0.1	0.7 ± 0.1

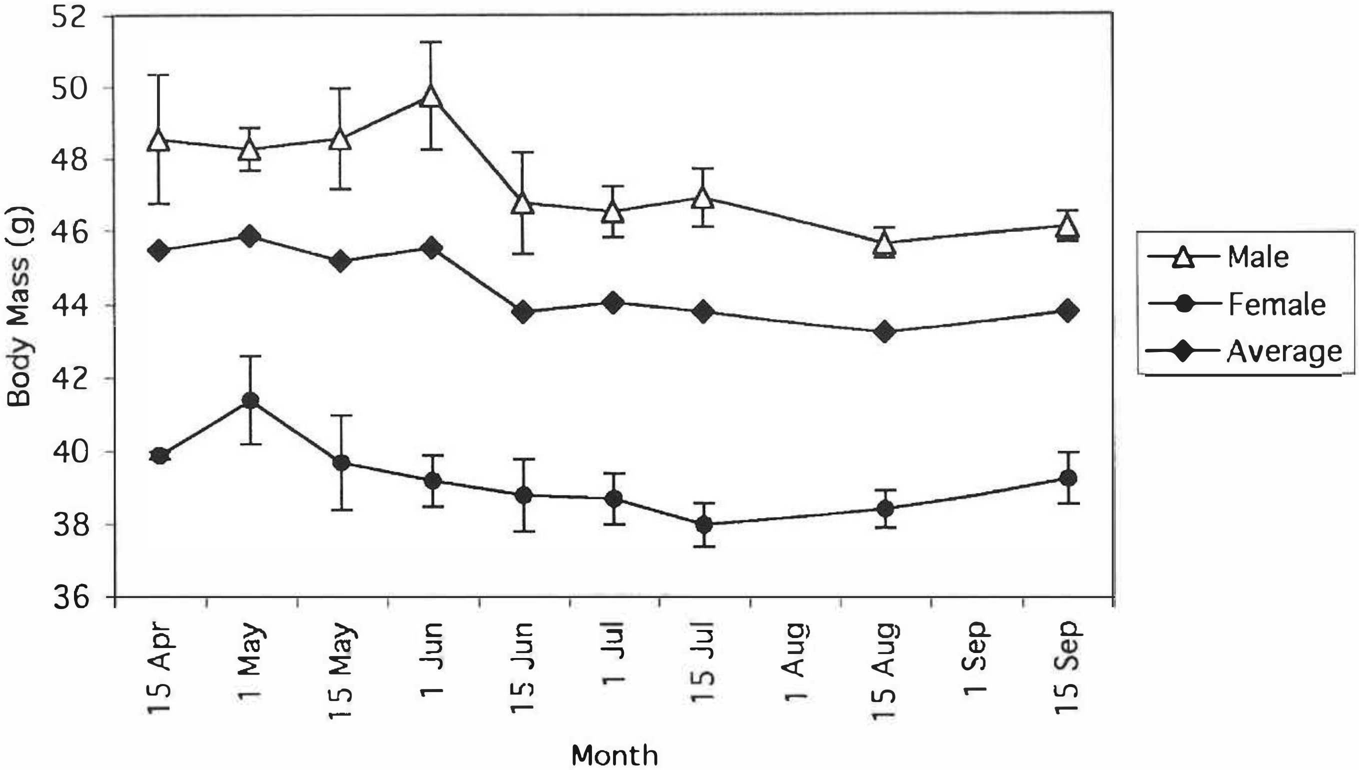

Figure 1. *Seasonal changes in average body mass (g) of six Regent Honeyeaters from April to September 1998. Average female (n = 2) and male (n = 4) body masses (± standard error) are also shown. No data were collected for the first half of August and September.*

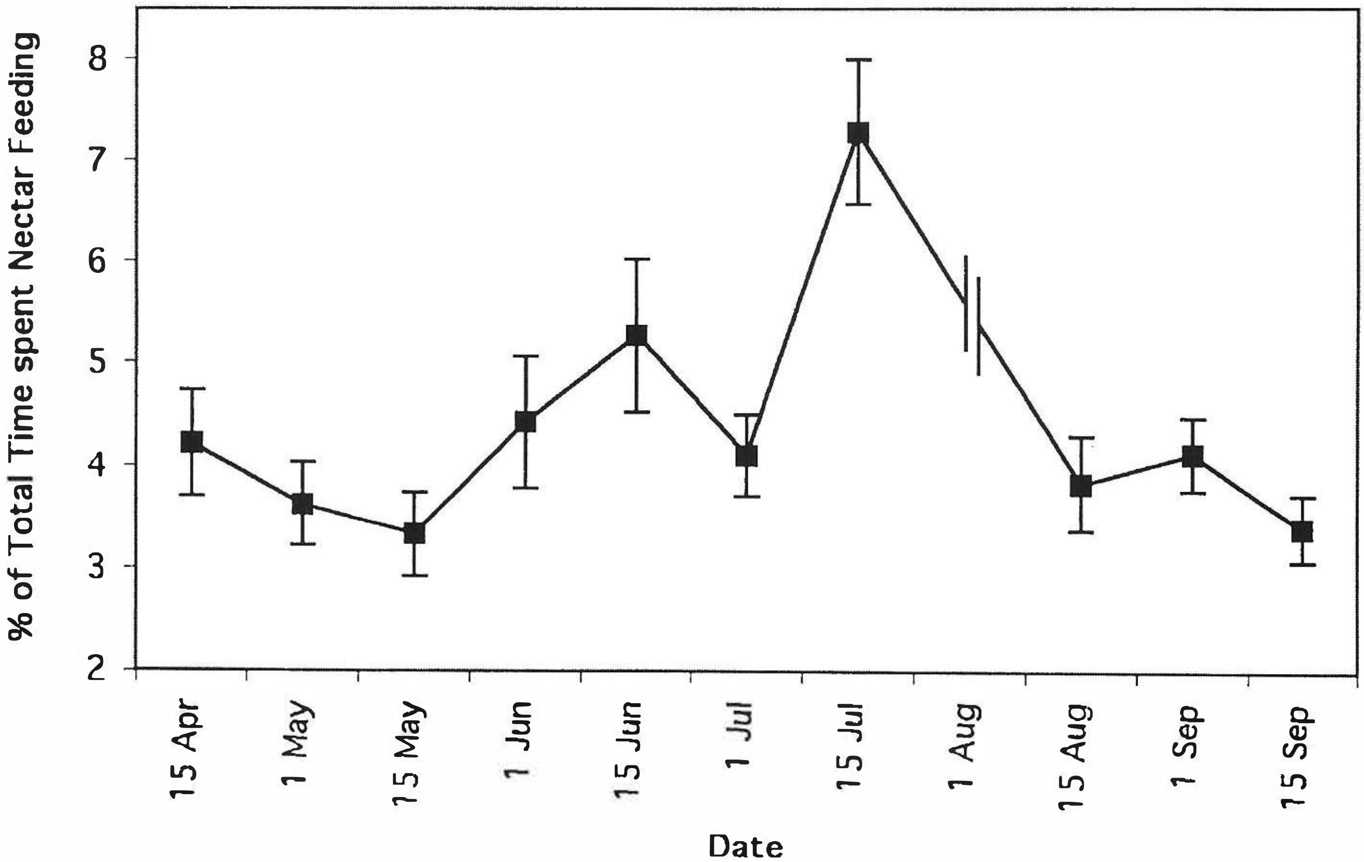

Figure 2. *Seasonal changes in average nectar consumption (% time spent nectar feeding) (± standard error) of six Regent Honeyeaters from April to September 1998. No data were collected for the first half of August.*

DISCUSSION

This study provides evidence that food consumption and body mass of captive bred Regent Honeyeaters vary significantly between autumn and spring. Body mass was highest in autumn to early winter (April-June), after which it decreased (Fig. 1). There was a significant difference in body mass between males and females. Sexual dimorphism has also been described for Regent Honeyeaters by Ley *et al.* (1996).

Nectar consumption increased between mid-May and mid-June and was, on average, higher in winter than in spring (Fig. 2). Fruit consumption was more common in autumn and early winter, while hawking for insects was much more common in late winter and spring (Table 1). Fruit and artificial nectar were available *ad libitum* throughout the study period, so the lower incidence of fruit and nectar feeding in late winter/spring was independent of availability. We did not measure the abundance of live insects but it would have been most likely that it was higher in spring than in winter (Pyke 1983; Bell 1985). A lower insect abundance and availability in autumn and winter could therefore explain the low incidence of hawking. However, it has been shown that hawking activity may not necessarily be affected by the abundance of flying insects on either a daily or seasonal basis (McFarland and Sale 1986). Further research into the seasonal hawking activity of Regent Honeyeaters should attempt to measure insect abundance to get an indication of whether availability is affecting resource use.

The differences found here in fruit feeding and hawking between autumn/winter and spring (Table 1) have not been previously described for the Regent Honeyeater. Recher and Abbott (1970) suggested that honeyeaters hawk for insects as a source of protein rather than as a means of gaining energy. Ford and Paton (1976) supported this and calculated that the New Holland Honeyeater at best barely replaced the energy it uses in hawking, while nectar feeding could provide up to ten times the energy expended. It is possible that the low occurrence of hawking recorded in the period from April to July represents a time when Regent Honeyeaters have a lower requirement for protein, while later during breeding and moult, protein requirements are high (Gill 1995). It appears that the relatively high protein content (13%) of our artificial nectar solution was sufficient to cover protein requirements during the non-breeding period, but higher amounts were required once our birds came into breeding condition at around August (Taronga Zoo records).

Regent Honeyeaters consumed a higher amount of nectar and fruit during autumn and winter than in spring. Previously, fruit consumption in the Regent Honeyeater has been described as high (24% of all feeding records) (Pyke 1980), or insignificant and an opportunistic supplement to nectar feeding (Franklin *et al.* 1989; Geering and French 1998; Oliver 1998c, 2000). The increased amount of fruit consumed during autumn and winter indicates that fruit may play a more important part in the diet of the Regent Honeyeater during this time of the year, but requires more investigation. The overall higher consumption of carbohydrate rich food (nectar and fruit) suggests higher carbohydrate requirements during this time (Munro 2002). There could be two major reasons for this. Firstly, carbohydrates provide a good source to cover the high energy demands during the cold climate, especially overnight. Secondly, Regent Honeyeaters could use carbohydrates as an energy source to prepare for and/or support their seasonal movements, which take place during autumn and winter (Cooke and Munro 2000). Similar changes in dietary composition from a protein-based diet to a carbohydrate-rich diet just prior to and/or during annual movements have been observed for numerous species (Bairlein 2002), including one Australian honeyeater (Munro 2002), suggesting a genetic control of food consumption and dietary preferences. It is not too far fetched to consider a similar control mechanism for the Regent Honeyeater, especially since it has been shown that its post-breeding movements appear to be under some genetic control (Cooke and Munro 2000).

The results presented here are subject to some limitations. The study is based on a small sample size and it is possible that birds sharing the same aviary influence each other. However, despite these limitations, the outcome of this study should be taken into consideration in the future management of Regent Honeyeaters in the wild and in captivity. Clearly, knowledge of dietary preferences is important for (1) the development of a suitable diet for captive held birds, and (2) the protection and improvement of habitats with appropriate food resources. Should the present decline of the species continue in the wild, it might also become necessary to supplement wild populations with captive-bred birds. In this case, knowledge about dietary requirements should aid in determining optimal times and locations for the release of captive-bred birds.

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