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MIGRATORY FATTENING IN AN AUSTRALIAN INTRACONTINENTAL MIGRANT¹

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Key words: Australia; flight range; lipid content; migratory fattening; silvereye; *Zosterops lateralis*.

Tasmania is a large island separated from the Australian continent by Bass Strait (Fig. 1). Many bird species cross this body of water each year to winter on the Australian mainland before returning to the island to breed in the spring or summer (Ridpath and Moreau 1966). The migration of one such bird, the highly gregarious Grey-breasted Silvereye (*Zosterops lateralis*), is well documented (Ridpath and Moreau 1966, Mees 1974). Migrants include both sexes and both young and old birds, and they may winter as far north as southeastern Queensland (Mees 1974). The crossing of Bass Strait probably presents the most hazardous portion of their migration because refueling stations are limited and westerly winds increase flight costs. Many small birds from the north temperate region carry large lipid stores when preparing for migration (Blem 1980), but this phenomenon of migratory fattening has not been investigated in Australian passerine migrants. I report here the carcass composition of silvereyes captured from a cliff top at Cape Liptrap (38°55'S, 145°55'E) near the southern tip of Victoria (Fig. 1), where the birds were taking off for their return migration over Bass Strait towards Tasmania (Chan and Sutton 1993).

Silvereyes were captured during the austral spring between 29 October and 3 November. A total of 30 birds were caught in mist-nets while taking off for migratory flight. Each freshly-caught bird was immediately weighed to the nearest 0.1 g (=live mass), killed,

feathers plucked, dissected, its gut emptied, and weighed again (=fresh mass). The carcass was then frozen for later use.

In the lipid extraction procedure, carcasses were first dried in an oven at 60°C until constant mass was reached, and then homogenized. Mass of dried homogenate represents the dry carcass mass of bird and the water content is the difference between fresh mass and dried homogenate. The homogenate was emptied into a membranous thimble and extracted with 2:1 ethanol:diethyl ether in a Soxhlet apparatus for 4 hr. This is a method consistent with the recommendations by Dobush et al. (1985) for extracting lipid. Mass of the residue is the lean dry content; lipid content is the difference between dry and lean dry mass.

Live and fresh body mass of silvereyes captured from take-off flocks were (mean ± SE) 11.58 ± 0.18 g and 10.79 ± 0.19 g, respectively. The variation in fresh mass and lipid content was independent of sex ($F = 0.31$, $df = 1, 28$, $P > 0.05$, ANOVA). Subsequently, data from sex classes were pooled. The average lipid content was 1.79 ± 0.19 g, which represented 15.1% of live mass and 16.2% of fresh mass. An average of 42.6 ± 2.3% of the dry carcass mass was lipid. The relationship between dry carcass mass (4.20 ± 0.15 g) and fresh carcass mass was positive ($b = 0.684$, $r^2 = 0.657$, $P < 0.001$). This was due mainly to lipid content in the carcass ($b = 1.035$, $r^2 = 0.958$, $P < 0.001$), since the fat-free dry mass (mostly protein, Dobush et al. 1985) did not vary with dry carcass mass ($b = -0.034$, $r^2 = 0.025$, $P > 0.1$, Fig. 2). Migratory fattening therefore occurs in the silvereye, since in winter lipid reserve is only half the amount carried by premigratory birds (<8% of fresh mass, Chan, in press). Premigratory lipid reserve of silvereyes is less than that of a long-distance migrant but equivalent to a short-distance migrant (King and Farner 1965, Blem 1980). This is consistent with the overwater distance to be covered, which is approximately 250 km between Cape Liptrap and the northernmost coastline of Tasmania. Water content

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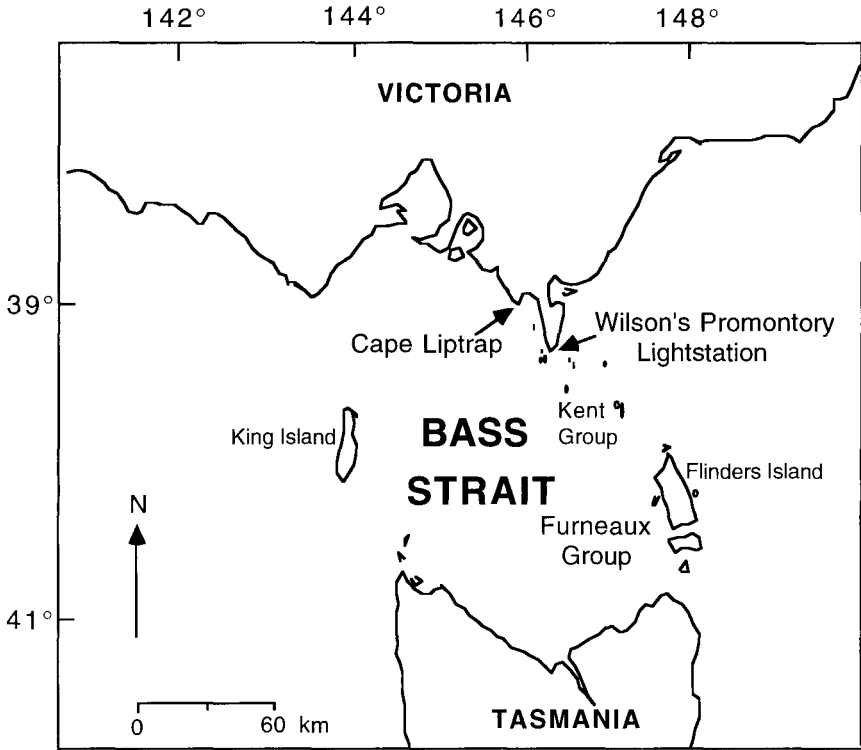


FIGURE 1. Map of Bass Strait, southeastern Australia, between the States of Victoria and Tasmania.

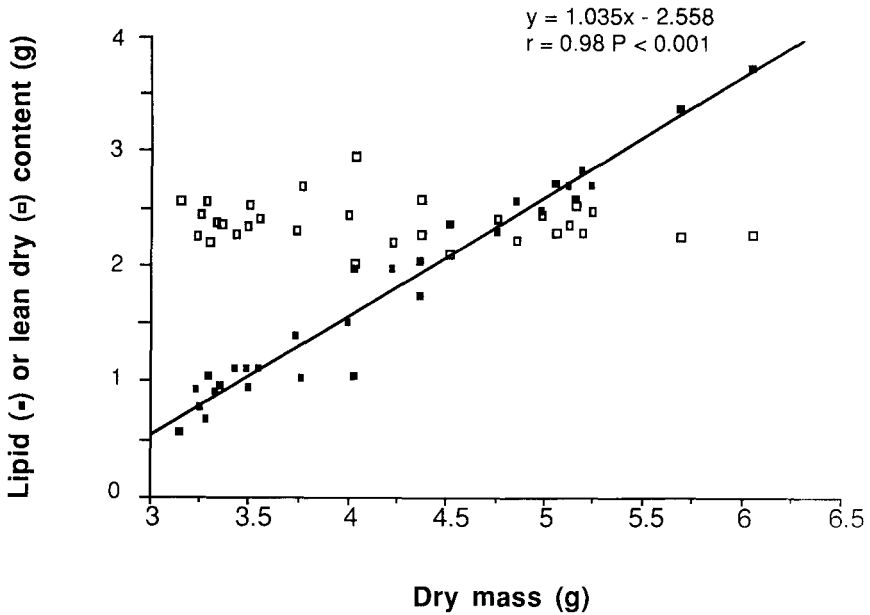


FIGURE 2. Relationship between lipid or lean dry content and dry mass. Shown regression line is for lipid content. Regression involving dry lean content was not significant.

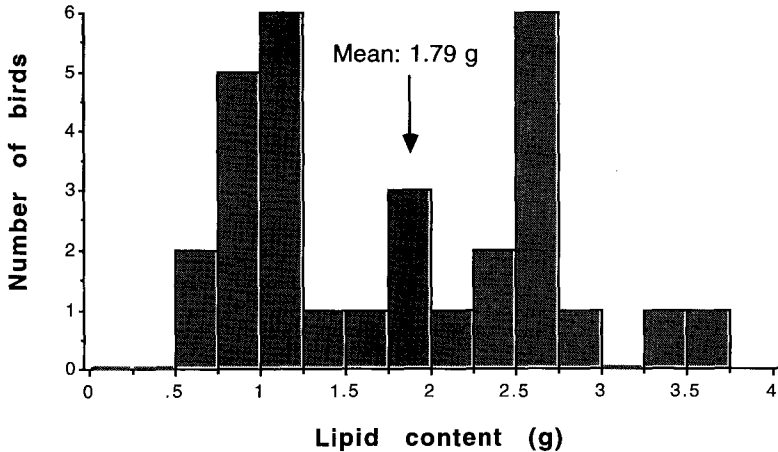


FIGURE 3. Frequency distribution of lipid content of silvereyes taking off for migratory flight from Cape Liptrap.

was $61.1 \pm 0.9\%$ of fresh mass and is a standard (hydrated) amount for an adult bird (Skadhauge 1981).

The distance a bird can fly per gram of fat is given by $E = 800/W(L/D)_{\text{eff}}$ (Pennycuik 1969), where E is in km/g, W is body mass in grams, and L/D is assumed to be 5.5 for small passerines. Assuming 0.29 g of the lipid content in the silvereye is structural lipid that cannot be used for migratory expenditure (2.5% of live mass; Chan, unpubl. data), a silvereye flying with an average 1.5 g mobilizable fat would be able to attain a flight range of 570 km. Flying at the predicted air speed of 6 m/s for a 12 g bird (Rayner 1988), the silvereye should cross the Bass Strait in about 11 hr in calm weather. This is approximately half the maximal flying time the bird is able to fly carrying 15% of take-off mass and a weight loss of 0.7% body mass per flying hour due to fat consumption (Alerstam 1981). Thus, most silvereyes taking off from Cape Liptrap carried sufficient energy reserve to cross Bass Strait, as only about 0.6 g mobilizable fat is required for a non-stop flight. Energy expenditure and flight time can further be reduced if winds are favorable for flying. Meteorological data obtained from the Commonwealth Bureau of Meteorology on nearby Wilson's Promontory Lightstation (see Fig. 1) show that winds more often than not exceed 12 m/s in the morning during spring. Although wind direction is predominantly WSW-WNW, approximately 25% are NNE-ESE, which are favorable for migratory flight. Furthermore, silvereyes were seen to fly at 200–600 m, and birds are known to alter their flight altitude to gain favorable winds (e.g., Gauthreaux 1991). Opposing winds will have the opposite effect by increasing energy expenditure and time-duration for continuous flight.

The unpredictability of weather in the Bass Strait has been known for a long time by sailors (Simpson 1972), with its changing cloud density and wind direction. The excess fat reserve of many silvereyes may be viewed as a response to this unpredictability associated with flights over ecological barriers, enhancing

the birds' "margin of safety" (Moore and Kerlinger 1991). However, despite the small sample size, variation in the take-off lipid content of silvereyes was quite large, ranging from 0.56 to 3.74 g, with 23% having less than 1.0 g fat (Fig. 3). This could reflect differential flight ranges, with some individuals (obese birds) probably undertaking a non-stop migration strategy to Tasmania and others (leaner birds) adopting an intermittent migration strategy by stopping over on intermediate islands (see Fig. 1) to replenish depleted energy supply before continuing their migration. In the case of strong opposing winds which make flight difficult, the use of stopover islands may be important particularly for lean birds. The extent of variations in pre-migratory lipid content is an interesting area that requires further investigation. Unfortunately, data regarding the stopover ecology, fat conditions of migrants crossing inland barriers, destinations of individual birds and whether the birds were experienced or inexperienced migrants, are not available for the silvereye nor for any migrant passerine within Australia. It is hoped that this study induces future interests in energetics regarding migration among birds from the southern temperate region for comparison with northern temperate birds.

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PTILOCHRONOLOGY: FOLLICLE HISTORY FAILS TO INFLUENCE GROWTH OF AN INDUCED FEATHER¹

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Key words: Follicle history; habitat monitoring; House Sparrow; *Passer domesticus*; ptilochronology.

Ptilochronology uses the width of daily growth bars on a feather as an index of a bird's nutritional condition while the feather was being grown (e.g., Grubb 1989, Waite 1990, White et al. 1991, Hogstad 1992). The validity of this index has been supported by two manipulative studies employing, respectively, supplemental feeding (Grubb and Cimprich 1990) and food deprivation (Grubb 1991). See Grubb (1992) for a photograph of daily growth bars. Among other uses (Grubb 1989, in press), this index has considerable potential for monitoring habitat quality. For example, comparison of growth bar widths has indicated that Loggerhead Shrikes (*Lanius ludovicianus*) living in citrus groves were in poorer nutritional condition than conspecifics in three other habitat types in southern Florida (T. C. Grubb, Jr. and R. Yosef, unpubl. ms.). In any protocol for long-term monitoring of habitat quality, an appealing design feature would employ daily growth bar widths on successive feathers pulled from the same follicle, thus controlling for any inter-follicle

ular variation in feather growth. However, before such a design could be employed, possible effects of follicle history and other factors on feather growth should be investigated. Here, we report on a controlled laboratory test of whether follicle history influenced the growth characteristics of a series of induced rectrices grown by House Sparrows (*Passer domesticus*). We arranged for various sparrows to grow a first, second, or third induced rectrix from the outermost right (R6) follicle of the tail at the same time that each of the birds grew a first induced rectrix from the outermost left (L6) follicle. We tested the prediction deduced from the null hypothesis that there should be no differences among the daily growth bar widths, total feather lengths, or total feather masses of first, second or third rectrices induced from the same follicle over a period of months.

METHODS

During October, we captured male House Sparrows in central Ohio and housed them individually in cuboidal wire-mesh cages 0.75 m on a side. From previous studies, we knew that cages this large were needed to minimize feather wear during long-term experiments. Our approved animal-holding facility at The Ohio State University, Columbus, Ohio, could only accommodate 12 such cages, so we replicated the experiment twice, during the winters of 1991–1992 and 1992–1993.

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