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## Winter Body Mass and Overnight Energetics of a South Temperate Passerine

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Winter is a particularly stressful period for many small birds because of high energy demands at a time when foraging is restricted by shortened daylight hours and scarce food resources. Studies on passerines wintering in the North Temperate Zone commonly show that: (1) a diurnal gain in energy reserves with time is often reflected in the variation of body mass, with early morning showing the lowest levels and evening the highest (Newton 1969, Lehtikoinen 1987, Haftorn 1989); (2) ambient temperature influences energy utilization and, hence, body mass (Kontogiannis 1967, Kendeigh et al. 1969, Blem 1976, Carey et al. 1978, Rogers and Rogers 1990); (3) overnight mass loss is between 5 and 10% of a bird's evening mass (Kontogiannis 1967, Kendeigh et al. 1969, Ketterson and Nolan 1978, Lehtikoinen 1987, Haftorn 1989); and (4) the winter fat reserve generally is adequate for only one night's survival plus part of the following day (King 1972, Blem 1976). Equivalent data are largely lacking on small birds from the South Temperate Zone, where winter temperatures are relatively less severe due to the smaller land masses.

I investigated the diurnal variation and nocturnal loss in body mass of Grey-breasted Silvereyes (*Zosterops lateralis*) overwintering in Tasmania. Energy requirement and expenditure are estimated by the change in mass during the day and the amount lost overnight. The results are compared with those obtained from small birds of the North Temperate Zone.

**Methods.**—Silvereyes were captured at Mt. Nelson (42°55'S, 147°19'E) near Hobart, Tasmania, in mid-winter from late June to mid-July 1990. The 162 birds were sexed based on the amount and intensity of brown color on the flanks (Kikkawa 1963). I was able to separate 102 of these birds into two age classes (first-year birds and older birds) based on gape appearance, feather wear, bill and leg color, molt condition, vocalization, and skull ossification. Gonadal diagnosis of silvereyes killed in the course of other studies confirmed my sex and age determinations in all and 44 of 50 cases, respectively.

All birds were captured using mist nets and weighed to the nearest 0.1 g using an Ainsworth electronic balance as soon as possible after capture (< 1 h). The time of day was recorded to the nearest hour at each weighing. Masses at dusk and the following dawn in eight caged birds were taken to determine actual

overnight mass loss. These birds were held overnight without access to food in a room 2 to 4°C warmer than outside temperatures (–2 to 2°C).

**Results.**—Differences in body mass among sex and age classes were not significant (sex,  $F_{1,98} = 1.01$ ; age,  $F_{1,98} = 1.33$ ; interaction,  $F_{1,98} = 0.57$ ; all  $P > 0.1$ ; two-factor ANOVA). Therefore, data from all classes were pooled, producing a mean winter mass of  $11.85 \pm \text{SE}$  of 0.07 g.

Body mass increased significantly over the course of the day ( $r = 0.71$ ,  $P < 0.05$ ,  $n = 162$ ; Fig. 1). Diurnal mass variation in Tasmanian Silvereyes may be described by the following equation:

$$M = 10.855 + 0.08 T, \quad (1)$$

where  $M$  is body mass in grams and  $T$  is time of day (e.g. 900, 1200). During the study period, the sun rises in Hobart on average at approximately 0730 EST and sets at about 1700. Change in photoperiod was minimal throughout the three-week study period. The regression equation for body mass as a function of time gives estimates of 12.22 g at dusk and 11.46 g at dawn. The difference of 0.76 g, equivalent to the amount lost through a night's fast, was similar to the mean value of 0.73 g lost from eight wild birds held overnight. The estimated value of 0.76 g represents an overnight mass loss of 6.2% of the body mass at the onset of roosting. This percentage is similar to that lost by several small species during winter, but generally less than that determined for most northern passerines under similar temperature regimes (Table 1).

**Discussion.**—Variation in mass had a daily amplitude of 8.3% and, thus, was within the normal diurnal fluctuations found in small northern birds (King 1972). An analysis of body components of birds killed in another study on the same silvereye population (in prep.) showed that the fat reserve accumulated during the day equalled 8.0% of total body mass. This amount corresponds to 25.3 kJ of available energy reserve for a 12.22-g bird in the evening after correcting for structural fat (2.5% of body mass). The latter nonmobilizable fat was determined by analyzing the fat content of seven silvereyes that died as a result of starvation. Most studies have estimated that fat accounts for between 40 and 80% of the nocturnal mass loss (Newton 1969, Chaplin 1974, Carey et al. 1978, Webster 1989, Rogers and Rogers 1990). Using the middle value of 60%, the energy lost attributable to fat in the Silvereye would be 17.2 kJ. If the lean dry component (protein/carbohydrate) comprises one-third of the fat-free mass loss (the remaining two-thirds being water; see Bar-

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TABLE 1. Percentage overnight mass loss of small passerines during winter.

Species	Approximate body mass (g)	Average ambient temperature (°C)	Mass loss (%)	Reference
<i>Auriparus flaviceps</i>	7	5 <sup>a</sup>	6.7	Webster (1989)
<i>Parus palustris</i>	10	-7 <sup>a</sup>	8.2 <sup>a</sup>	Haftorn (1989)
<i>P. atricapillus</i>	12	0	5.2	Chaplin (1974)
<i>Zosterops lateralis</i>	12	0	6.2	This study
<i>Parus montanus</i>	13	-7 <sup>a</sup>	8.6 <sup>a</sup>	Haftorn (1989)
<i>Carduelis tristis</i>	14	-10	8.9	Carey et al. (1978)
<i>Acanthis flammea</i>	14	0	10.0 <sup>a</sup>	Chaplin (1974)
<i>Parus major</i>	19	0	7.7	Lehikoinen (1987)
<i>P. major</i>	19	-7 <sup>a</sup>	9.4 <sup>a</sup>	Haftorn (1989)
<i>Junco hyemalis</i>	20	4	7.2	Ketterson and Nolan (1978)
<i>Pyrrhula pyrrhula</i>	24	2 <sup>a</sup>	4.8	Newton (1969)
<i>Passer domesticus</i>	29	-5	8.6	Kendeigh et al. (1969)
<i>Carduelis chloris</i>	30	0	8.0	Lehikoinen (1987)

<sup>a</sup> Values calculated from information provided by cited article.

nett 1970, Carey et al. 1978), then an extra 1.9 kJ must be added, producing a total overnight energy expenditure of 19.1 kJ for a silvereye with 0.76 g mass loss. This value would be a slight overestimate because the nonfat components did not take into account urinary and fecal mass. However, the miscalculation is balanced by the undeclared energy available from food assimilated around dusk. It appears that the energy expended during the night is covered by fat stored in the previous evening.

The results were not unlike those reported for northern bird species in which fat stores are usually adequate for a single night, but inadequate for two or more consecutive nights without feeding (King 1972, Blem 1976). However, both overnight energy requirement and expenditure in the silvereye are generally less than those demonstrated in northern passerines (see Blem 1976). Overnight mass loss in

the silvereye is only 69% of that predicted by Lehikoinen's (1987) equation derived from six northern species at 0°C, and the energy expended is only 65% of that predicted by Kendeigh et al.'s (1977) equation (derived from 35 northern species), which took into consideration nighttime standard metabolism (at 0°C). Furthermore, the mean fat content (approx. 1 g for a 12-g Grey-breasted Silvereye) is less than that carried by most northern passerines of similar body size during winter (e.g. Carey et al. 1978, Dawson and Marsh 1986, Rogers and Smith 1993).

The relatively small degree of winter fattening in the silvereye (compared to that of northern species) may be a response to long-term average temperatures (see Evans 1969, Dawson and Marsh 1986, Peach et al. 1992, but see also Blem 1990). Birds probably respond to long-term fluctuations in temperature as a means of reducing the burden of carrying added energy loads above the normal amount required. Long-term winter temperatures at low elevations in Australia are not as severe as those in northern temperate regions, suggesting that the low overnight energy requirement and expenditure, and subsequently low winter fat reserves, are adaptive in the silvereye. Silvereyes probably possess other thermoregulatory mechanisms to alleviate the cost of carrying extra fat when confronted with unexpected cold. Besides huddling in groups, silvereyes may adopt controlled hypothermia. Prinzing et al. (1991) suggested that this physiological mechanism is utilized by all species if hunger and/or cold load is exceptionally severe, as has been found (or is thought) to occur in some Australian passerines (e.g. Collins and Briffa 1984, Chan et al. 1990). Simultaneous measures of body temperature and metabolic rate would be required to verify the phenomenon in the Grey-breasted Silvereye.

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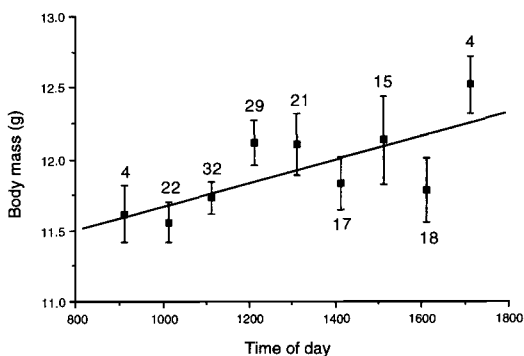


Fig. 1. Diurnal variation in body mass of Grey-breasted Silvereyes wintering at Mt. Nelson, Tasmania. Vertical bars represent  $\pm$  SE. Numbers represent sample size for each hour of capture.

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