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Diurnal pattern of mass in an urban Marlborough population of silvereyes (*Zosterops lateralis*)

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Abstract Silvereyes (*Zosterops lateralis*) in an urban population in Marlborough, New Zealand showed considerable diurnal changes in body mass. At first light, average mass was 12.39 g, rising to 13.91 g by dusk. This represented a 12% average loss of mass overnight. The overall average mass was 13.22 g; birds were 6% below average at 0700 h, but increased rapidly to be near the average for most of the day, rising significantly in the 2 hours before dusk (1700 h). This pattern of diurnal mass change is consistent with theoretical models suggesting that birds should manipulate daily mass gain in order to trade-off starvation risk with mass-dependent predation risk.

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INTRODUCTION

The silvereye (*Zosterops lateralis)* ranges widely across Australasia and the South-western Pacific. Up to 10 subspecies are recognised in Australia alone (Higgins *et al.* 2006). The Tasmanian subspecies *Z. l. lateralis* colonised New Zealand in 1856 (Heather & Robertson 1996), and is now the second most commonly recorded native bird in New Zealand (Robertson *et al*. 2007).

Northern hemisphere studies have shown that some species of birds are capable of manipulating their diurnal body mass to use different weight gain strategies in response to predation risk. Mass-dependent predation-risk theory proposes that birds should delay mass gain to later in the day, and in this manner, escape more readily from predators by being able to fly more rapidly or with greater manoeuvrability (Cresswell 1998; Macleod *et al.* 2005). Mass-dependent predation-risk theory has not been investigated in any New Zealand bird, although Barnett and Briskie (2007) showed that the mass of silvereyes in the evening was significantly higher than in the morning. This paper summarises the diurnal mass changes in silvereyes in an urban garden in Blenheim, New Zealand in order to determine if such changes occur and if the pattern of mass gain is similar to that observed in northern hemisphere species.

METHODS

Silvereyes form flocks in the winter and undertake considerable local movements to seek out food sources (Heather & Robertson 1996; Higgins *et al.* 2006). This enables silvereyes to be caught readily in large numbers during winter, providing a good species to study diurnal weight change.

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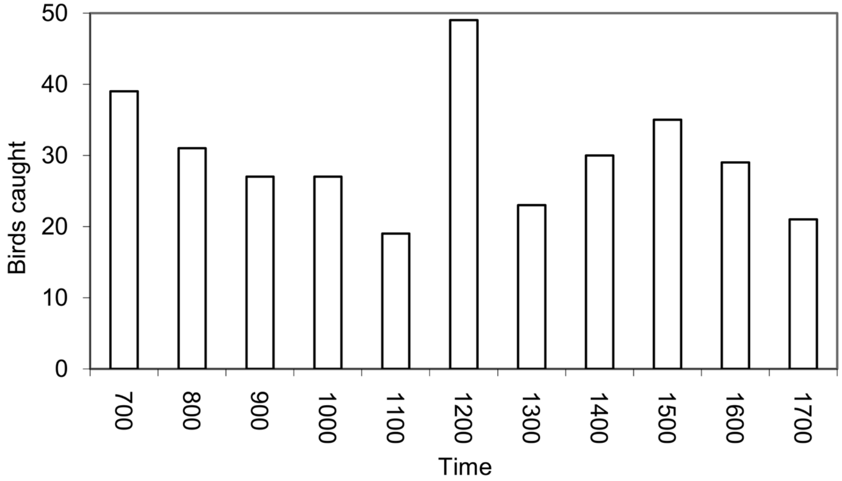


Fig. 1. Number of silvereyes captured and weighed each hour.

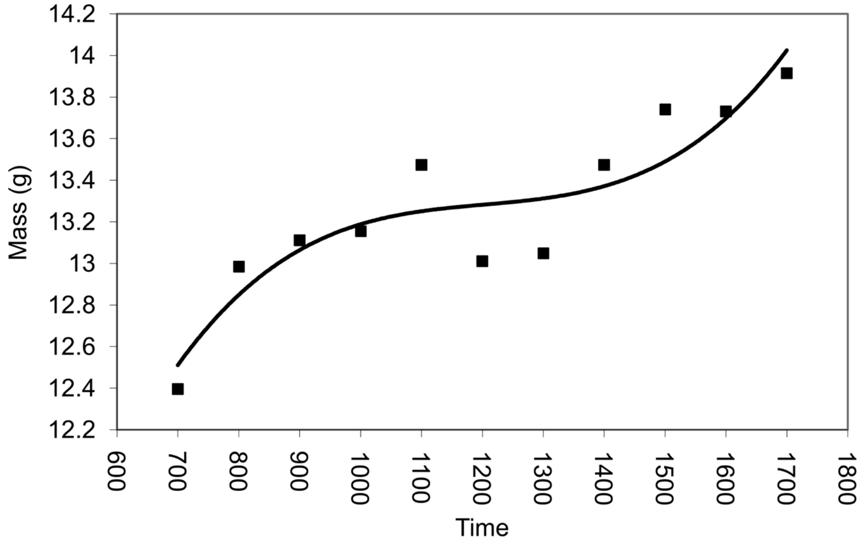


Fig. 2. Diurnal mass change in silvereyes.

During winter (July) 2007, silvereyes were caught in an urban garden in Blenheim, Marlborough, New Zealand, using a funnel cage trap baited with lard. The trap was operated from dawn until dusk each trapping day, with first light around 0700 h and dark falling about 1730 h (New Zealand standard time). Birds were banded with a single metal band, and their body mass recorded using an electronic scale to 0.1 g. Masses were assigned to the hour of capture, with birds caught between 0700-0759 h recorded as 0700 h, 0800-0859 h as 0800 h, and so on. Silvereyes re-trapped in a different hourly period were recorded as a new mass. In addition, individual birds that were trapped in the same day before 1000 h, and then again after 1500 h, were used to directly compare diurnal mass change in individual birds.

Data was pooled to determine the average mass during each hour period. A Student's t-test was used to compare masses between morning and evening. Polynomial lines were fitted to show the fluctuations of weight change during the day.

RESULTS

A total of 330 silvereyes were captured and weighed between 1-15 Jul 2007, with an average of 30 captures (range 19 - 49) during each 1-hour period (Fig. 1).

Across the entire day, the average body mass of silvereyes was 13.22 g (SE = 1.08; n = 330). At 0700 h, the average mass was 12.39 g, rising to an average of 13.91 g by 1700 h (Fig. 2). Silvereyes weighed 6% below average at 0700 h, rapidly increasing to within 2% of

Fig. 3. Percent mass change from average for silvereyes caught in urban Marlborough in relation to the time of day.

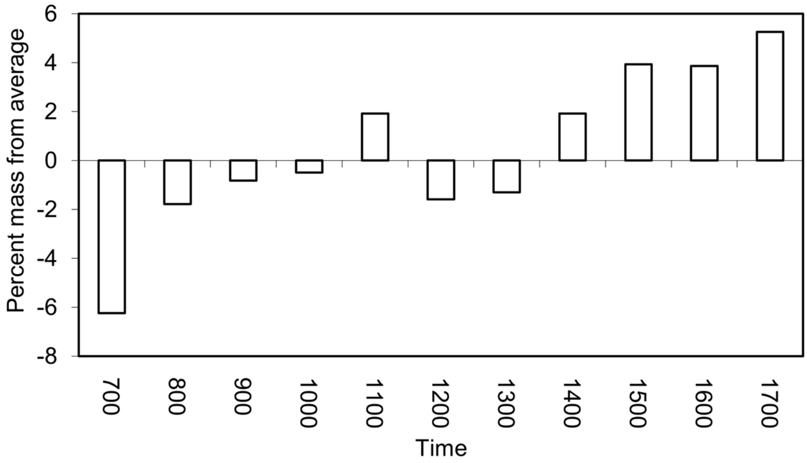
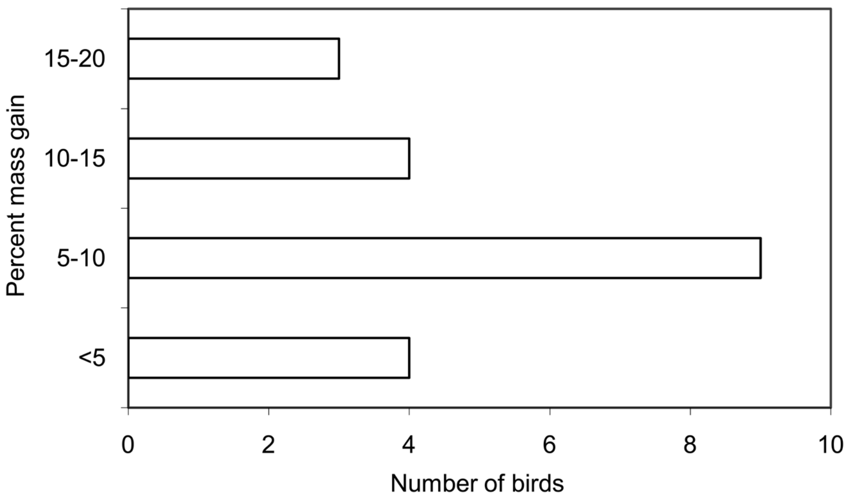


Fig. 4. Percent mass gain in silvereyes re-trapped on the same day, comparing difference between mass when first captured before 1000 h, and then when re-captured after 1500 h.



average mass, which they maintained over the course of the day, until 1400 h, when mass increased until 1700 h, when birds were 5% heavier than average (Fig. 3). The average mass of silvereyes caught before 1000 h (12.73 g, SE = 1.13, n = 96) was significantly lighter than the average mass of birds caught after 1500 h (13.78 g, SE = 1.07, n = 85; t-test: $P < 0.001$).

A total of 20 individuals were caught twice in the same day and were weighed before 1000 h, and then again after 1500 h. All birds put on weight, with afternoon masses averaging 8.7% (range 2.5 - 17.1%) heavier than morning masses (Fig. 4). The average afternoon mass (14.14 g, SE = 1.27, n = 20) was significantly heavier than the average morning mass (13.02 g, SE = 1.17, n = 20; t-test: $P < 0.001$).

DISCUSSION

Silvereyes lost a considerable amount of body mass overnight, with morning masses significantly lighter than evening masses. The mass of individual birds increased over the day between 2.5% to 17.1%, and overall, the average population mass increased 12% from dawn to dusk. Although much of the overnight weight loss will involve emptying of gut contents, it is likely to also involve reduction in body fat. Cresswell (1998) showed that blackbirds (*Turdus merula*) lost more weight during colder nights and considered this was due to the metabolism of fat reserves.

Small birds must build up body reserves to survive the night when they cannot feed but are still expending energy to stay warm (Lehikoinen 1987; Haftorn 1992a; Hafton 1992b; Gosler 1996; Thomas 2000). The recorded incidences of mass mortality of some New Zealand passerines, such as fantail (*Rhipidura fuliginosa*; Merton & Bell 1975; Heather & Robertson 1996), and welcome swallow (*Hirundo tahitica*; *pers. obs*.) may indicate that in some winters our insectivorous passerines are unable to build sufficient fat reserves to maintain body temperature overnight.

Silvereyes showed an ability to rapidly recover the mass they lost overnight, returning to within 2% of the daily average within 1 hour of dawn. This rapid increase is likely the result of birds actively foraging at first light to fill an empty stomach. Body masses of silvereyes then remained relatively constant, before increasing towards the end of the day. This pattern is typical of a species trading off starvation risk with mass-dependent predation risk (Macleod *et al.* 2005). To avoid starvation, silvereyes must rapidly increase body weight early in the day, but delay maximising weight gain to minimise predation risk by reduced flight performance when escaping from predators. This hypothesis has been tested in several European passerines (Cresswell 1998; Macleod *et al.* 2005) but has not yet been studied in a New Zealand native species. Discovering that northern hemisphere theories are applicable to New Zealand passerines opens up additional areas of research, and could be used to enhance conservation management of threatened passerine species by supplementing their diet to ensure weight gains are achieved before dark.

Further studies of mass regulation in native species are needed to investigate mass-dependent predation theory, in particular on insectivorous species. All bird banders in New Zealand should record body mass, wing length and time of capture for all birds captured, and provisions should be made for a central repository for this information. Such data collection would enable further investigation into the regulation of body mass in birds, including regional differences, seasonal changes, and habitat effects. The presence of a variety of native species on both the mainland, and offshore islands free of introduced predators, also provides an opportunity to determine whether changes in predation risk affect any strategies of mass regulation.

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