

SEASONAL BODY MASS CHANGES IN SIX FOREST PASSERINES OF SOUTHERN CHILE

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Resumen.—Cambios estacionales en el peso de seis paserinos de bosque del sur de Chile.—Investigamos las fluctuaciones de peso de seis paserinos en el sur de Chile incluyendo tres migratorios, el Fio-fio (*Elaenia albiceps chilensis*), el Chercan (*Troglodytes aedon chilensis*) y el Chincol (*Zonotrichia capensis australis*), y tres residentes, el Rayadito (*Aphrastura spinicauda spinicauda*), el Cometocino (*Phrygilus patagonicus*) y el Jilguero (*Carduelis barbata*). Nuestro objetivo fué determinar si alguna de estas especies muestra aumento en las reservas de grasa durante el invierno o antes de la migración a lo largo de su ciclo anual de cambio de masa corporal. Los resultados indicaron que las especies migratorias no presentaron un aumento de peso antes de la migración de otoño y que todas las especies residentes presentaron una disminución general en el peso durante los meses de invierno. Esto contrasta con muchos paserinos del hemisferio norte que tienden a engordar durante períodos de alta demanda metabólica como el invierno y el período anterior a la migración. Interpretamos estas observaciones como una indicación de que los inviernos templados del sur de Sudamérica no son tan energéticamente demandantes como los inviernos en latitudes semejantes en el hemisferio norte.

Abstract. —We investigated seasonal fluctuations in body mass of six southern Chilean passerines including the migrant White-crested Elaenia (*Elaenia albiceps chilensis*), the House Wren (*Troglodytes aedon chilensis*), and the Rufous-collared Sparrow (*Zonotrichia capensis australis*); and the year-round resident Thorn-tailed Rayadito (*Aphrastura spinicauda spinicauda*), the Patagonian Sierra-Finch (*Phrygilus patagonicus*), and the Black-chinned Siskin (*Carduelis barbata*). Our objective was to determine whether any of these species display a strategy of weight variation throughout the year. Birds were mist-netted year round for five years on Navarino Island, Chile. The three migrant species did not increase in mass prior to autumn migration. The resident species all showed a general decrease in mass during the winter months. This is in contrast to many Northern Hemisphere passerines that tend to increase mass before periods of high metabolic demand such as winter and migration. We interpret these observations as an indication that the mild winters of southern South America may not be as energetically demanding as winters at similar latitudes in the Northern Hemisphere, and that these Austral migratory species feed during migration thereby lessening the need for putting on premigratory fat.

Key words: birds, mass, southern Chile, winter fattening

INTRODUCTION

Body mass of birds has been used extensively as an indicator of their general condition

(Moreno 1989), and as a baseline descriptive statistic to compare body size between species (Dunning 2008). Data have been collected on the monthly body mass fluctuations of both

Northern Hemisphere migrant and resident birds (Rands *et al.* 2006), showing that body mass of birds varies daily and seasonally largely because of changes in body fat content and reproductive condition (Baldwin & Kendigh 1938, Clark 1979, Rands *et al.* 2006). Northern Hemisphere birds generally accumulate body fat reserves before seasonal events that have high-energy demands or low food availability. Examples of such events include incubation, migration, and harsh climatic conditions (Koenig *et al.* 2005). Northern latitude long-distance migrants experience the greatest change in body mass, which can be a gain of up to 100% of their pre-migration mass (Clark 1979, Bairlein 2002).

Many high latitude North American year-round resident species show an increase in body mass during autumn that peaks midwinter (Nolan & Ketterson 1983, Haftorn 1989). It is thought that an increase in fat reserves is a response to extreme cold temperatures and low predictability of their winter food (Gosler 2002). This has been documented in North American temperate forest passerines (Pravosudov & Grubb 1997) but has been little studied in high latitude South American temperate passerines. In southeastern Brazil, Goulart & Rodrigues (2007) found that the Rufous-fronted Thornbird (*Phacellodomus rufifrons*) showed no measurable seasonal change in body weight, however, this latitude with its tropical climate may not experience low enough temperatures to stimulate a response.

Another impressive adaptation in Northern Hemisphere passerines is the deposition of migratory fat prior to migration (Bairlein 2002, Berthold *et al.* 2003). Many migrants are not able to feed on their migratory route so must rely on fat they have stored prior to departure (Bairlein 2002). Migratory fattening is controlled by an innate program of circannual response which is thought to be predominantly synchronized by changes of photoperiod (Gwinner 1986, Haftorn 1989, Berthold 1996,

Rintamäki *et al.* 2003), whereas winter fattening shows high plasticity and may be under the control of environmental factors such as temperature and/or food predictability (Biebach 1996, Totzke *et al.* 2000).

There have been few published studies on South American passerines to determine if either of these adaptations exists in any species (Capllonch & Zelaya 2006, Goulart & Rodrigues 2007). In this study we test if bird mass varies with season. We use generalized additive models to analyze seasonal body mass fluctuations of migrant and resident passerine species in high latitude Southern Chile.

METHODS

Birds were captured by mist-netting that was conducted primarily at two sites on the northern coast of Navarino Island, Chile: the Omora Ethnobotanical Park (54°57'S; 67°39'W), near the town of Puerto Williams, and on Guerrico Hill (54°55'S; 67°54'W) 17 kilometres west of Puerto Williams. Both sites range from sea level to 100 m. Additional mist-netting, accounting for less than 1% of the dataset, was conducted at several other locations on the island. Navarino Island is characterized as an oceanic climate type with a mean annual temperature of 5.6°C and an annual temperature fluctuation of less than 10°C. Minimum temperatures below 0°C occur only during the winter months of July and August, and temperatures below -5°C are rare. In 2000, the minimum mean monthly temperature was 1.6°C and the maximum mean monthly temperature was 10.2°C. The average annual rainfall in Puerto Williams is less than 500 mm (Anderson *et al.* 2002).

The nets were open for six days each month in Omora Park, from January 2000 to May 2006 (Anderson & Rozzi 2000). They were opened one hour after sunrise and kept open for 6 to 12 hours each day. The nets were checked every 15 to 40 minutes depending on

weather and number of birds caught. Birds were also mist-netted 35 km east near the Guerrico River for 42 days between January 2000 and May 2006. Birds were identified to species and banded with a uniquely numbered aluminium band. Bird mass (Chardine 2008) was obtained using 10-, 60-, 100- or 500-gram Pesola™ scales. Mass was measured to within 0.1 gram or, for the 100- and 500-gram scales, to within 0.5 grams.

For this study we analyzed trends in mass in the following resident species: Thorn-tailed Rayadito (*Aphrastura spinicauda spinicauda*), Patagonian Sierra-Finch (*Phrygilus patagonicus*), and the Black-chinned Siskin (*Carduelis barbata*), and the migrant species White-crested Elaenia (*Elaenia albiceps chilensis*), House Wren (*Troglodytes aedon chilensis*) and Rufous-collared Sparrow (*Zonotrichia capensis australis*). Migrants here are defined as species that leave the area in the post-reproductive season and return at the end of the pre-reproductive season (Newton 2008).

Using egg-laying dates from Navarino Island and presence or absence of brood patches, we define the reproductive season here as the period from October through February, post-reproductive season from March through May, and pre-reproductive season from June through September (Anderson *et al.* 2002, Ippi *et al.* 2009). We did not collect information on fluctuations in food resource availability throughout the year, despite its potential effect on body mass. Previous studies have shown that winter food availability in particular would likely be reflected in body mass (Rands *et al.* 2006). For most species, it was not possible to reliably identify the sex of the captured birds, so sex was excluded from analyses. Because birds were banded upon capture, we were certain that each bird was only included once in the study.

To test for an influence of time of year on bird weight we used generalized additive mixed models (GAMMs). Generalized additive mod-

els are gaining popularity in ecology as a means of analyzing non-linear trends in the absence of a presupposed mathematical model (Crawley 2007). We fit a separate model for each species, and analyzed bird weights as a smoothed function of the Julian Day on which the bird was captured. We included the year of capture as a random effect in models to account for potential interannual variability in bird weights, using the *gam4* function in the *gam4* package (Wood 2006, Scheipl 2009) in R. v. 2.12 (www.r-project.org).

RESULTS

We obtained the body mass of 2,099 birds from six species, with sample sizes ranging from 153 to 914 individuals per species. All species displayed significant variations in weight across the duration of the sampling period (Table 1). However, the explanatory ability of the effect of the Julian Day on bird weights was generally low (mean = 9.4%), ranging from a low of 3.4% for the sierra-finch to a high of 23.1% for the wren. There was little evidence of interannual variability in bird weights. Inspection of the variance components from GAMMs indicated an average of only 3.0 % variation in bird weights between years, with the highest interannual variability (5.9%) observed for the sparrow.

The three resident species showed little variation in body mass throughout the year, with the lowest body mass for each species observed in midwinter (July) to early spring (September) and the highest body mass in late summer (February) (Fig. 1). The rayadito had a relatively constant body mass throughout the year with a slight decrease between summer (December-February) and autumn (April and May) and reached its lowest body mass in midwinter (July). For the siskin, body mass was lower in July. The sierra-finch's lowest mean mass was in September (early spring). Its body mass then increased to a maximum

TABLE 1. Summary of GAM fits for the effect of Julian Day on mass for six bird species.

| Species | n | R ² (adj) | P | Df |
|---|-----|----------------------|----------|------|
| Thorn-tailed Rayadito (<i>Aphrastura spinicauda spinicauda</i>) | 229 | 0.131 | > 0.0001 | 4.06 |
| White-crested Elaenia (<i>Elaenia albiceps chilensis</i>) | 376 | 0.045 | 0.0017 | 1.81 |
| House Wren (<i>Troglodytes aedon chilensis</i>) | 160 | 0.231 | > 0.0001 | 3.81 |
| Rufous-collared Sparrow (<i>Zonotrichia capensis australis</i>) | 153 | 0.080 | 0.0007 | 2.78 |
| Patagonian Sierra-finch (<i>Phrygilus patagonicus</i>) | 914 | 0.034 | > 0.0001 | 5.06 |
| Black-chinned Siskin (<i>Sporagra barbata</i>) | 267 | 0.085 | > 0.0001 | 2.41 |

in late summer during the post reproductive period (February).

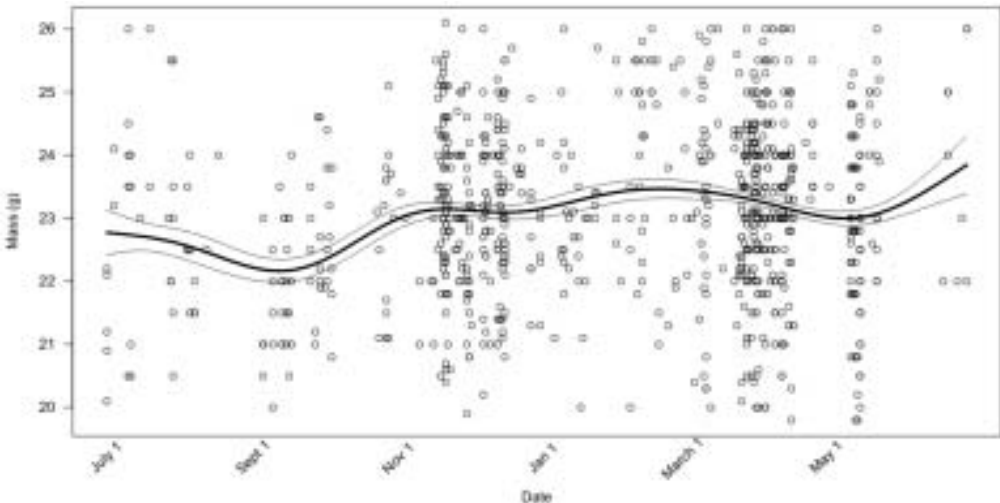
The three migratory species showed different seasonal patterns in body mass (Fig. 1). The elaenia returned to its breeding grounds of Navarino Island with its highest body mass, which then decreased slightly throughout the breeding season as eggs were incubated and chicks were reared, reaching its lowest body mass before migrating. The wren and the sparrow returned from migration with their lowest breeding ground body mass, which

increased into the fledgling period. The wren and sparrow reached their highest body mass in midsummer (January).

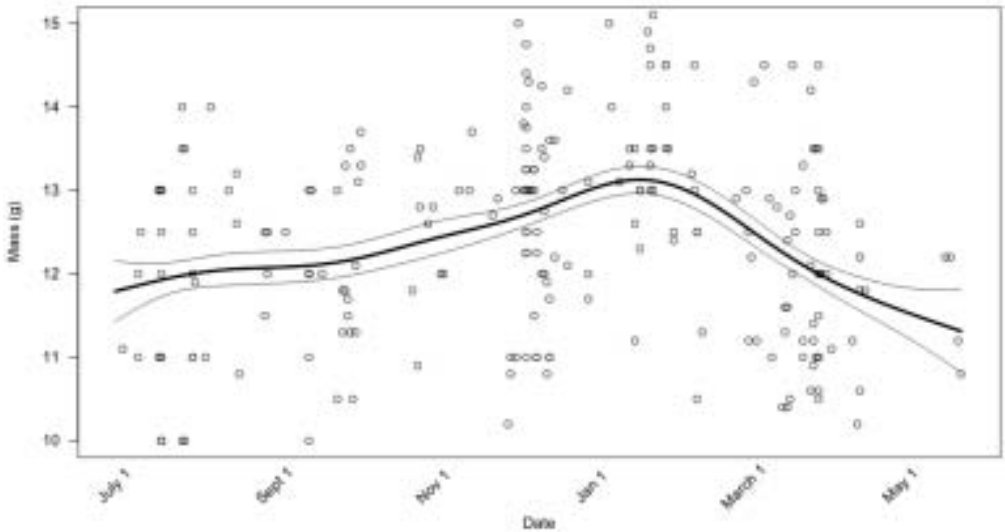
DISCUSSION

We detected significant effects of season on mass for all the birds collected in this study, but the species differed substantially in both the size and the type of their response to season. The three resident passerines we studied did not show a winter fattening as has been

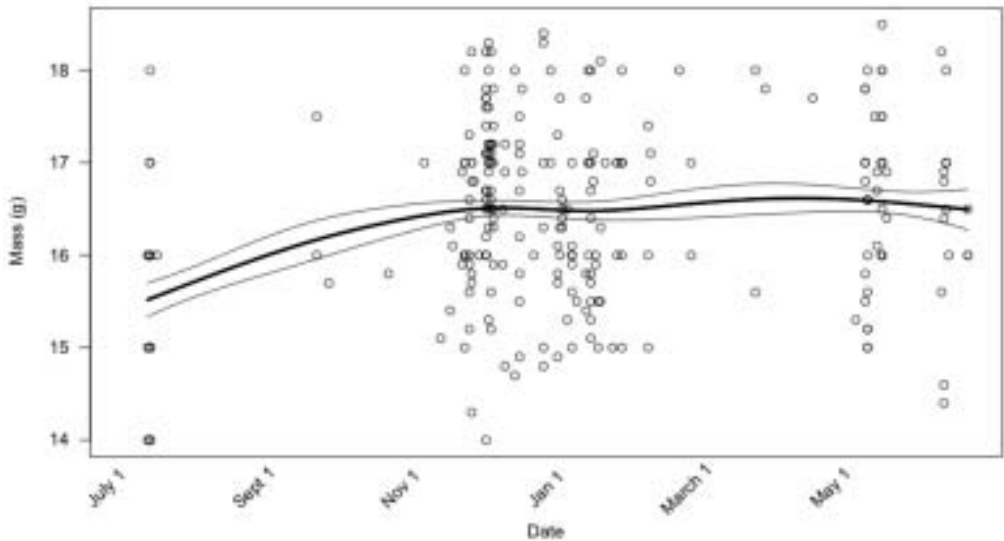
Patagonian Sierra-finch (*Phrygilus patagonicus*) resident:



Thorn-tailed Rayadito (*Aphrastura spinicauda spinicauda*) resident:



Black-chinned Siskin (*Sporagra barbata*) resident:

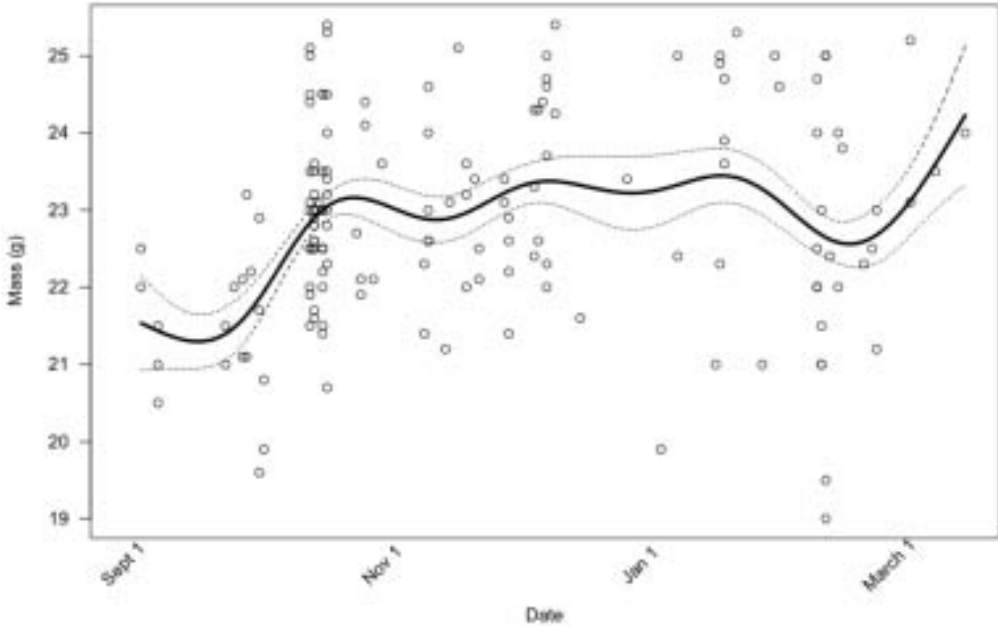


observed in some species from high latitude Northern Hemisphere sites (Middleton 1986, Dawson 1997). Resident rayaditos showed no mass gain leading up to winter, with their lowest annual mass occurring in mid-winter. Its principle summer food is insects (Moreno *et al.* 2005), while in the fall and winter months

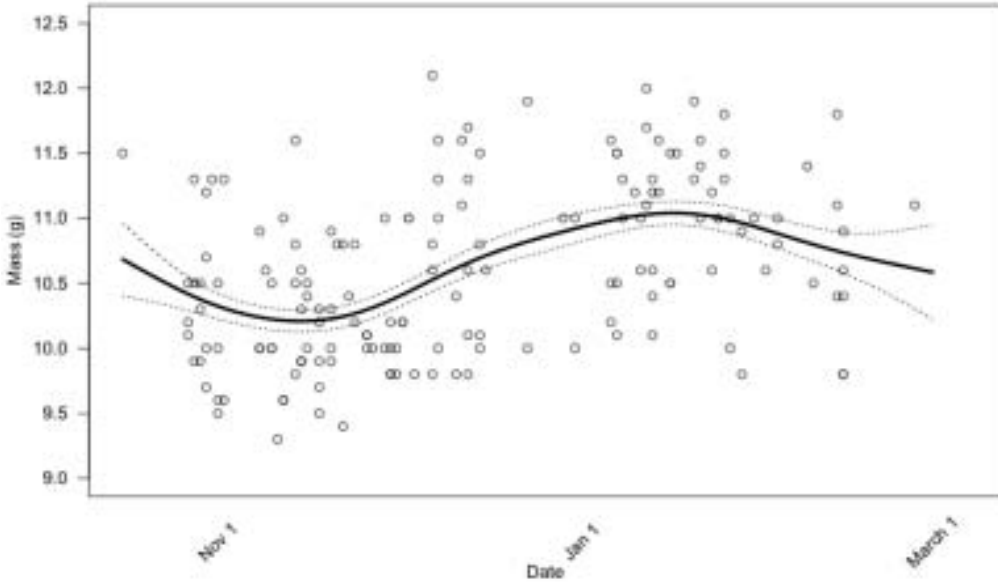
the rayadito has been documented to consume seeds and fruits that are less calorically rich, which could lead to lower body mass (Estades 2001, Remsen 2003, McGehee 2007).

The resident siskin also has its lowest monthly body mass in midwinter (July). Unlike the closely related *Spinus spp.* in North America

Rufous-collared Sparrow (*Zonotrichia capensis australis*) migrant:



House Wren (*Troglodytes aedon chilensis*) migrant:



(Dawson & Marsh 1986, Dawson 1997) the Black-chinned Siskin exhibited no winter mass gain. The siskin diet and foraging strategies are still relatively unknown (Archuby *et al.* 2007).

Perhaps there is an abundance of food available in winter and ambient temperatures are not low enough to trigger a winter fattening response in the siskin and rayadito as it does for

White-crested Elaenia (*Elaenia albiceps chilensis*) migrant:

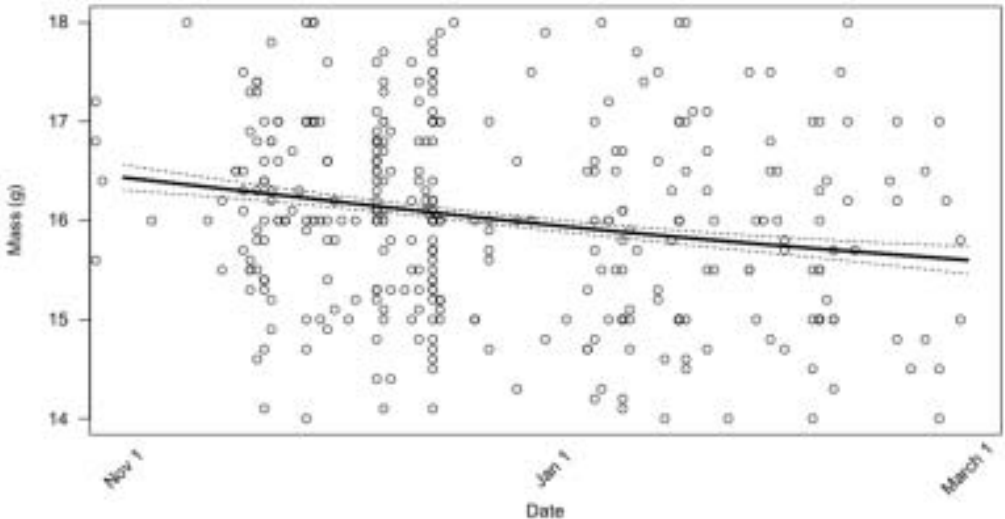


FIG 1: Bird mass changing with season. Each point represents an observed bird mass from a bird mist-netted on Navarino Island, Chile between January 2000 and May 2006. Solid line are the predicted fits of the GAM portions of GAMMs, pooled across years, and dashed lines indicate SEs of the predictions.

high latitude Northern Hemisphere birds. Due to its maritime climate, Navarino Island rarely gets below 0°C and has a milder winter than similar latitudes in North America and Europe (Bierman & Sealy 1985, Robinson *et al.* 2007).

Lowest body mass of the resident sierra-finch occurred in early spring (September) and body mass peaked in late summer (February). Little is known about the diet of this species, but it appears to be a generalist (McGehee & Eitniear 2007). Therefore, like the rayadito and siskin, the resident sierra-finch may not face winter food constraints or temperature extremes experienced by birds in the Northern Hemisphere high latitudes. Our findings for resident species concurred with a studies of Mountain Chickadees (*Poecile gambeli*) and Juniper Titmice (*Baeolophus ridgwayi*) in Utah, U.S.A. (Cooper 2007) and of the resident Superb fairy-wren (*Malurus cyaneus*) in Australia (Box *et al.* 2010). These species showed no winter fattening and the authors concluded it was because the winters were mild or to decrease predation risk.

For the three migratory species in our study there was no dramatic loss of body mass detected immediately after the birds arrived on the breeding ground, as is commonly seen in some Northern American passerines (Biermann & Sealy 1985). This suggests that sufficient food is available in late spring at high southern latitudes.

The migratory elaenia arrive on Navarino Island in October with its highest mass. It is reported to winter in Southern Brazil, a distance of almost 4,000km (Marini and Cavalcanti 1990). Mean body mass of elaenia's decreased though the summer months leading up to autumn migration. This could be due to increased competition for food with recently fledged elaenias, the energetic cost to adults of feeding fledglings, or the ability to feed during migration. There is some evidence that elaenias do feed during migration (Hiriart *et al.* 2000). It is possible that the high mass we recorded at the end of their spring migration (upon return to southern Chile) is a result of food consumed during spring migration or an

abundance of food on their wintering grounds an outcome documented in other migrating species (Schaub & Jenni 2000, Newton 2004). The only other published mass variation study on a South American tyrant flycatcher (Euler's Flycatcher *Latbrotricus euleri argentinus* from Northern Argentina) showed the same pattern of higher body mass when arriving on the breeding grounds followed by a gradual decrease over the breeding season (Capllonch & Zelaya 2006). However, Euler's Flycatchers did build up fat during the premigratory period.

The migratory wren had its lowest body mass in spring (October and November) and its highest body mass in midsummer (January), followed by a decrease prior to migration. A few wrens were seen on Navarino Island during winter months (McGehee & Arango pers. observ.), indicating that the winters may be mild enough to allow overwintering for some individuals. Overwintering and potentially short migrations could explain the lack of premigratory fattening in this species. Though little is known about the migratory routes or wintering grounds of the wren in Chile (Kroodsma & Brewer 2005) the increasing of its mass through the summer differs with the pattern of constant summer body mass observed in House Wrens in Canada (Biermann & Sealy 1985). House wrens in the Midwest U.S.A. lost mass into late summer perhaps due to raising a second brood or to implement a more efficient method of foraging (Freed 1981).

The migratory sparrow, like the wren, returns to its breeding grounds in southern Chile in September with its lowest breeding ground body mass, which increases throughout the breeding season, then drops dramatically prior to autumn migration. This apparent loss of mass could be a sampling artefact, where birds sampled in February are the subset of the population that have not gained enough weight to begin migration while the birds with higher body mass have already departed. Sparrow numbers on Navarino Island are greatly reduced in February, before becoming completely absent from

March until September (Ippi *et al.* 2009) Alternatively, low body mass prior to migration could be reflected by the hypothesis that the southern Chilean populations are short distance migrants (McGehee pers. observ., Chapman 1940, Couve & Vidal 2003), which would reduce the metabolic cost of migration. In contrast, three North American *Zonotrichia* exhibit premigratory fattening (King & Farner 1963, Moore *et al.* 1982, Falls & Kopachena 1994).

Collectively, these results suggest that winter fattening did not occur in the resident species studied, potentially due to the mild climate of Navarino Island (Lehikoinen 1987) and migratory birds do not put on premigratory fat, perhaps because they feed during migration or only travel a short distance to their wintering grounds. Further studies are warranted to see if these strategies are found in other Austral passerines. .

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