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Molt-Breeding cycle in passerines from a foothill forest in southeastern Brazil

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RESUMO. **Ciclo de muda e reprodução em passeriformes de uma floresta de encosta no sudeste do Brasil.** O ciclo de muda e reprodução em passeriformes foi estudado durante dois anos em uma área de floresta na encosta da Serra dos Órgãos, sudeste do Brasil. Muda não acidental foi registrada 358 vezes em 940 capturas de 56 espécies. O período de muda foi de outubro a maio, com um pico entre janeiro e abril, e foi similar entre espécies insetívoras e onívoras. Frugívoros não foram considerados nesse estudo devido ao pequeno tamanho da amostra. Placas de incubação, consideradas como uma evidência de atividade reprodutiva, foram registradas entre setembro e fevereiro. Nenhuma ave foi capturada substituindo penas de vôo enquanto apresentava placa de incubação, revelando uma falta de sobreposição individual entre muda e atividades reprodutivas. Entretanto, para algumas espécies foram registrados diferentes indivíduos em muda ou com placa de incubação ativa nos mesmos meses. Não foi encontrada variação no peso entre indivíduos em muda e sem muda.
PALAVRAS-CHAVE: Floresta Atlântica, muda, passeriforme, reprodução

ABSTRACT. Molt-breeding cycle in passerines was studied over two years in a forested area in the foothills of Serra dos Órgãos, southeastern Brazil. Non-accidental molt was recorded 358 times among 940 captures of 56 species. Birds molted from October to May, with a peak between January and April. The molt timing was similar in insectivorous and omnivorous passerines species. Frugivorous species were not considered in this study due to small sample sizes. Brood patches, considered as an evidence of breeding activity, were recorded between September and February. No bird was captured replacing flight feathers together with active brood patch, suggesting that individual birds did not overlap breeding and molt. However, in some species, different individuals molting or with an active brood patch were found in the same month. Body mass variation was not found among molting and non-molting passerines.
KEY WORDS: Atlantic Forest, molt, passerine, reproduction

A biological cycle can be defined as a sequence of natural events of fundamental importance to the life of a bird that takes place consistently during a specific season and several studies have focused on biological cycles in birds (Davis 1945, Miller 1961, 1963, Snow and Snow 1964, Ward 1969, Wolf 1969, Fogden 1972, Snow 1976, Fogden and Fogden 1979).

Due to energy demands, breeding and molt typically occur when plenty of food is available because of energy demands (Davis 1945, Poulin *et al*. 1992). Absence of overlap between breeding and molt has been recognized as an important ecological adaptation to occurrence of the two processes in the annual cycle without competition for energy (Kendeigh 1949, Farner 1964). In most bird species molt does not overlap with breeding activity (Miller 1962, 1963, Snow and Snow 1964, Stresemann and Stresemann 1966, Payne 1972), although records of molt / breeding do exists in some species (Miller 1961, Foster 1974, 1975). Adult birds may molt while still in the parental care period, representing a partial overlap (Evans 1966, Zaias and Breitwisch 1990). Coexistence of molt and breeding can also be related to the fact that immature birds start their molt before the molt of the adult birds (Snow 1976, Mallet-Rodrigues *et al*. 1995).

Despite relevant, studies on the molt cycle in communities of Neotropical birds are still scarce (Davis 1945, Miller 1961, Snow 1976, Poulin *et al*. 1992, Piratelli *et al*. 2000, Marini and Durães 2001). Thus, the general patterns of molt in those birds are still poorly known. The importance of molt in the life of birds and the scarcity of studies related to this subject in Brazilian birds have led to the present study, whose main objective is to describe molt patterns in a passerine community from Atlantic Forest region.

STUDY AREA AND METHODS

This study was carried out in the southern foothills (from 250 to 360 m) of the Serra dos Órgãos (22^0 31' S, 43^0 01' W), located in southeastern Brazil about 60 km from the city of Rio de Janeiro. The climate of the study area (following Bernardes 1952) may be considered as intermediate between hot and humid without a dry season (corresponding to Af in Köppen's classification) and mesothermic with mild summers and no dry season (Köppen's type Cfb). Rainfall is abundant during the whole year, even in the driest period (IBDF 1984). Monthly precipitation and mean temperature during the study period were obtained from the Meteorological Station of Teresópolis (Instituto Nacional de Meteorologia – INMET) about 15 km of the study area (Figure 1).

The typical vegetation in the region is the evergreen tropical Atlantic forest (Hueck 1972) that covers the escarpments of the Serra do Mar and Serra da Mantiqueira from the base of the mountain to 1500-1700 m above sea level (IBDF 1984). Most of the study area is covered by primary forest (*sensu* Eiten 1983), with trees approximately 25

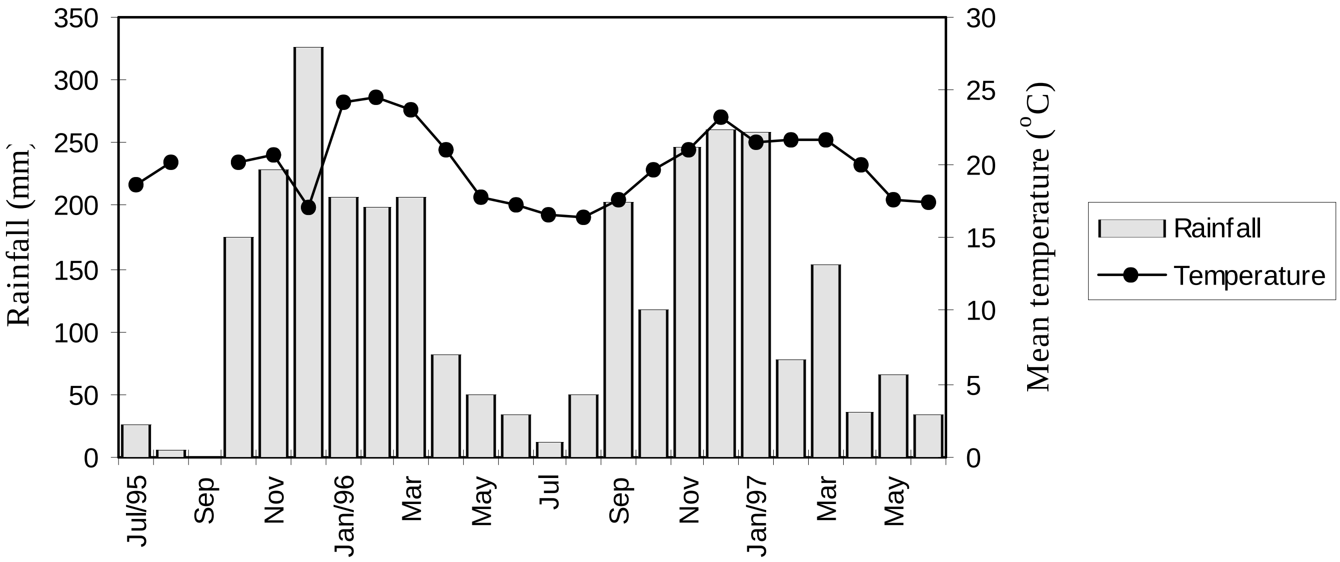

Figure 1. Rainfall and mean temperature in a foothill forest in Southeastern Brazil. Data from Meteorologic Station of Teresópolis, near (± 15 km) to the study area.

m high and a relatively dense understory with several overlapping arboreal strata.

The study was carried out along a section of trail approximately 300 m long, and thirty six visits were made to the study area from July 1995 to June 1997, at fortnightly intervals and with a mean duration of two days for each visit. The only month when the area was not visited was November 1995. Birds were captured using five mist nets (12 x 2.6 m, with 36 mm mesh) during 74 days of netting (3,510 net hours). Each bird was banded, weighed and carefully examined for the presence and state of molt and brood patch. The presence of brood patch was considered as an evidence of breeding activity. Active brood patch was characterized by its more intense vascularization than inactive brood patch. After each bird had been examined, it was released close to the net in which it was caught.

Differentiation between accidental and seasonal molt in flight feathers was based on the relative symmetry shown in the latter. The same concept was not used for the body feathers because of the difficulty of distinguishing between the replacement of accidentally lost body feathers and seasonal molt. Only presence or absence of body feathers molt were recorded.

A *t*-test was used to evaluate a possible difference in body mass between molting and non-molting birds related to largest energetic demand in molting birds. For this, data on molting and non-molting birds captured in the same months were used. Correlation between molt of distinct feather tracts (flight and body feathers) was determined using Spearman rank correlation (Siegel 1975, Sokal and Rohlf 1981). Results were considered statistically significant at $P \leq 0.05$. The scientific nomenclature adopted and the systematic order of the families and species follow CBRO (2005). Two trophic guilds (insectivorous and omnivorous passerine species) were compared to evaluate possible differences in annual patterns of molt and breeding activity. Frugivorous species were not considered in this study due to its irregularly distributed monthly samples, with small sample sizes in many months. Diet characterization followed Sick (1997).

RESULTS

A total of 940 individuals of 56 passerine species was captured in the study area, of which 358 (38%) were in molt. The White-shouldered Fire-eye *Pyriglena leucoptera* was the most common species in the sample, with 56 molting individuals captured (47%). Only five species had twenty or more molt records. Flight feather and body molt were simultaneously recorded in the same individual in 164 captures (17.4%) (Table 1).

Accidental loss of remiges and rectrices was recorded in 44 and 157 birds, respectively. Birds with accidental molt of rectrices were found in all months of the study period (except June 1997), varying between 7% and 44% of the total captured each month. Accidental molt of remiges appeared at lower frequencies, varying between 2% and 11% of the captures in some scattered months.

Molt in passerines was concentrated in the period of decreasing temperature and rainfall in the study region. Flight feather molt records were absent in the coldest and drier period of the year (July and August). Symmetrical flight feather molt was recorded mainly fom January to May, but there were also some records in October, November and December. Body feather molt was more frequently recorded together with flight feather molt. The highest frequency of birds molting body feathers has occurred in Fe-

Table 1. Number of individual passerines captured in the Serra dos Órgãos region, Rio de Janeiro, Brazil, and molt records for each species. Trophic guilds: I = Insectivores, O = Omnivores, F = Frugivores.

Species	birds captured	birds with brood patch*	Molting birds*
Dysithamnus stictothorax O	1	0 (0)	0 (0)
Dysithamnus mentalis O	7	0 (0)	1 (< 1.0)
Thamnomanes caesius I	1	0 (0)	0 (0)
Myrmotherula gularis I	27	0 (0)	15 (1.5)
Myrmotherula axillaris I	1	0 (0)	1 (< 1.0)
Myrmotherula unicolor I	12	2 (< 1.0)	5 (< 1.0)
Drymophila squamata I	24	4 (< 1.0)	7 (< 1.0)
Pyriglena leucoptera I	119	8 (< 1.0)	56 (6.0)
Myrmeciza loricata I	11	0 (0)	9 (< 1.0)
Conopophaga melanops I	45	4 (< 1.0)	21 (2.2)
Formicarius colma I	8	0 (0)	5 (< 1.0)
Sclerurus scansor I	14	1 (< 1.0)	6 (< 1.0)
Dendrocincla turdina I	25	3 (< 1.0)	6 (< 1.0)
Sittasomus griseicapillus I	10	3 (< 1.0)	6 (< 1.0)
Dendrocolaptes platyrostris I	1	0 (0)	0 (0)
Lepidocolaptes squamatus I	2	0 (0)	0 (0)
Xiphorhynchus fuscus I	47	2 (< 1.0)	19 (2.0)
Campylorhamphus falcularius I	1	0 (0)	1 (< 1.0)
Synallaxis ruficapilla I	1	0 (0)	0 (0)
Anabazenops fuscus I	4	0 (0)	1 (< 1.0)
Anabacerthia amaurotis I	2	0 (0)	0 (0)
Philydor atricapillus I	50	0 (0)	19 (2.0)
Philydor lichtensteini I	1	0 (0)	1 (< 1.0)
Automolus leucophthalmus I	35	2 (< 1.0)	20 (2.1)
Cichlocolaptes leucophrus I	1	0 (0)	0 (0)
Xenops minutus I	18	0 (0)	7 (< 1.0)
Xenops rutilans I	1	0 (0)	0 (0)
Mionectes oleagineus O	9	0 (0)	2 (< 1.0)
Mionectes rufiventris O	4	0 (0)	0 (0)
Leptopogon amaurocephalus O	16	0 (0)	9 (< 1.0)
Corythopis delalandi I	1	0 (0)	1 (< 1.0)
Hemitriccus orbitatus I	25	0 (0)	8 (< 1.0)
Tolmomyias sulphurescens O	4	0 (0)	3 (< 1.0)
Platyrinchus mystaceus I	14	0 (0)	4 (< 1.0)
Myiobius barbatus I	15	0 (0)	6 (< 1.0)
Lathrotriccus euleri O	9	0 (0)	3 (< 1.0)
Ilicura militaris F	1	0 (0)	0 (0)
Manacus manacus F	62	3 (< 1.0)	20 (2.1)
Chiroxiphia caudata F	37	2 (< 1.0)	15 (1.5)
Laniisoma elegans F	2	0 (0)	1 (< 1.0)
Cyclarhis gujanensis O	3	0 (0)	1 (< 1.0)
Vireo chivi O	5	0 (0)	0 (0)
Platycichla flavipes O	8	0 (0)	1 (< 1.0)
Turdus rufiventris O	9	0 (0)	3 (< 1.0)
Turdus albicollis O	48	3 (< 1.0)	6 (< 1.0)
Coereba flaveola O	3	0 (0)	1 (< 1.0)
Hemithraupis flavicollis O	3	0 (0)	3 (< 1.0)
Tachyphonus cristatus O	7	0 (0)	3 (< 1.0)
Tachyphonus coronatus O	31	1 (< 1.0)	9 (< 1.0)
Trichothraupis melanops O	88	0 (0)	26 (2.7)
Habia rubica O	42	3 (< 1.0)	16 (1.7)
Tangara seledon O	1	0 (0)	1 (< 1.0)
Haplospiza unicolor O	4	0 (0)	0 (0)
Saltator maximus O	4	0 (0)	3 (< 1.0)
Basileuterus culicivorus O	9	0 (0)	1 (< 1.0)
Euphonia xanthogaster O	7	0 (0)	6 (< 1.0)
Total	940	41 (4.3)	358 (38.0)

*Percent of all captured birds

bruary (Figure 2). Flight and body feathers molt showed high correlation ($r_S = 0.59$, n = 358, $P < 0.01$).

Insectivorous and omnivorous bird species had higher frequencies of molt between January and May, showing no differences with the general pattern (Figure 3).

Brood patches were recorded (41 individual birds of fourteen species) between September and February with a peak of active brood patches in November and December (Figure 2). No bird was found showing an active brood patch during the symmetrical molt of flight feathers. Inactive brood patches were recorded later (December to February) than the peak of active brood patch.

Mean body mass between molting and non-molting birds showed no significant differences (Table 2).

DISCUSSION

In contrast to the statements of some authors (Prys-Jones 1991, Sick 1997), only a single annual cycle was found, with one complete molt generally occurring after breeding. Although some individuals breed in autumn and winter (Sick 1997), birds from Southeastern Brazil generally breed from September to January (Euler 1900, Sick 1997). Here, molt in the studied passerine community occurred predominantly between January and May, with few records of flight feather molting in June, October, November and December. Symmetrical flight feathers molt was concentrated in the summer and autumn months, while the breeding season between September and February was fairly consistent with the period found by some authors in Brazil (Euler 1900, Piratelli *et al*. 2000, Marini and Durães 2001) and identical to that obtained by Davis (1945).

Distinct to the results of Snow and Snow (1964) and Poulin et al. (1992), the peak of the molt season occurred during the period of decreasing rainfall. A tendency for molt (especially flight feather molt) to be concentrated during the period of decreasing precipitation and mean temperature was found at the study site. However, occurrence of molt during a period of decreasing rainfall is a relevant point only if interpreted within its climatic context. The studies of Snow and Snow (1964) and Poulin *et al*. (1992) were carried out in dry seasonal habitats where the total amount and seasonal pattern of rainfalls is very different from the one reported in this study. Generally, rainy periods in a seasonal climate will affect positively food availability (especially in dry habitats), but periods of strong rainfalls can also be detrimental to foraging success (and hence breeding and molting) in wet habitats.

Flight feather molt here recorded in October, November and December may be considered as post-juvenal molt according to some authors (Miller 1961, Snow and Snow 1964, Evans 1966, Newton 1966, Fogden 1972, Mallet-Rodrigues *et al*. 1995, Sick 1997). Therefore, post-juvenal molt in the tropics would be complete and similar to adult post-nuptial molt (Fogden 1972, Mallet-Rodrigues *et al*.

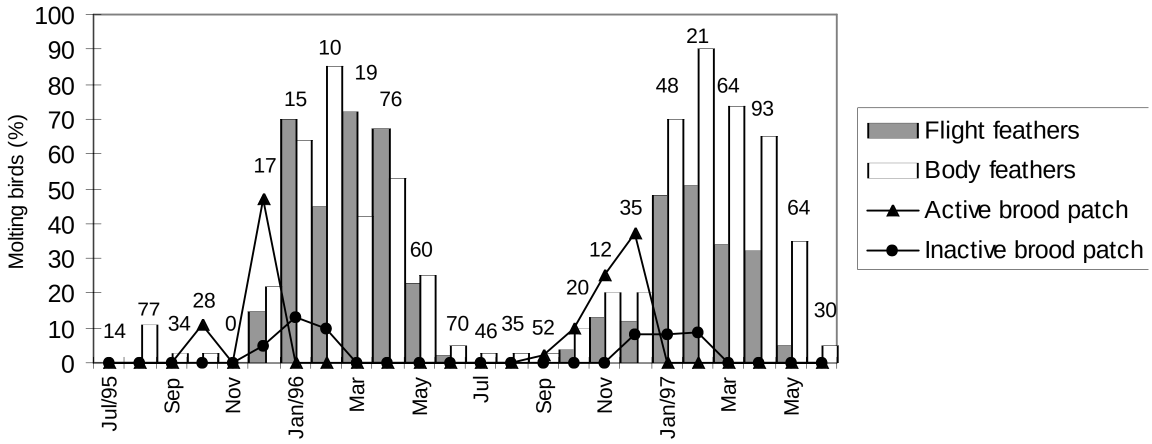

Figure 2. Molt frequencies for flight and body feathers and occurrence of active and inactive brood patch in passerines from a foothill forest in southeastern Brazil. Numbers above bars refer to total number of birds captured each month.

1995), contrasting with molt of temperate bird species (Snow 1967). Larger samples of molting birds in those months, including species in which it is easier to distinguish young and adult birds, are required to examine this question. It is also important to establish the age at which post-juvenal molt begins in Neotropical birds through recapture of molting birds that were banded as nestlings.

Accidental lost of rectrices was more common than that of primaries or secondaries, suggesting that rectrices are more subject to occasional replacement. The occurrence of several records of birds molting only the body feathers suggests a relative independence of molt in this feather, as noticed by several authors (Snow and Snow 1963, Keast 1968, Mallet-Rodrigues *et al*. 1995, Marini and Durães 2001). However, flight feather and body molt showed a significant correlation in this study, and this may be an evidence that the two processes are a single cycle of complete plumage replacement. Piratelli *et al*. (2000) also found a significant correlation between flight feather and body molt.

Snow (1976) showed that the molt cycle vary among different bird species in the same place because of differences in the timing of breeding. In his study, an important dif-

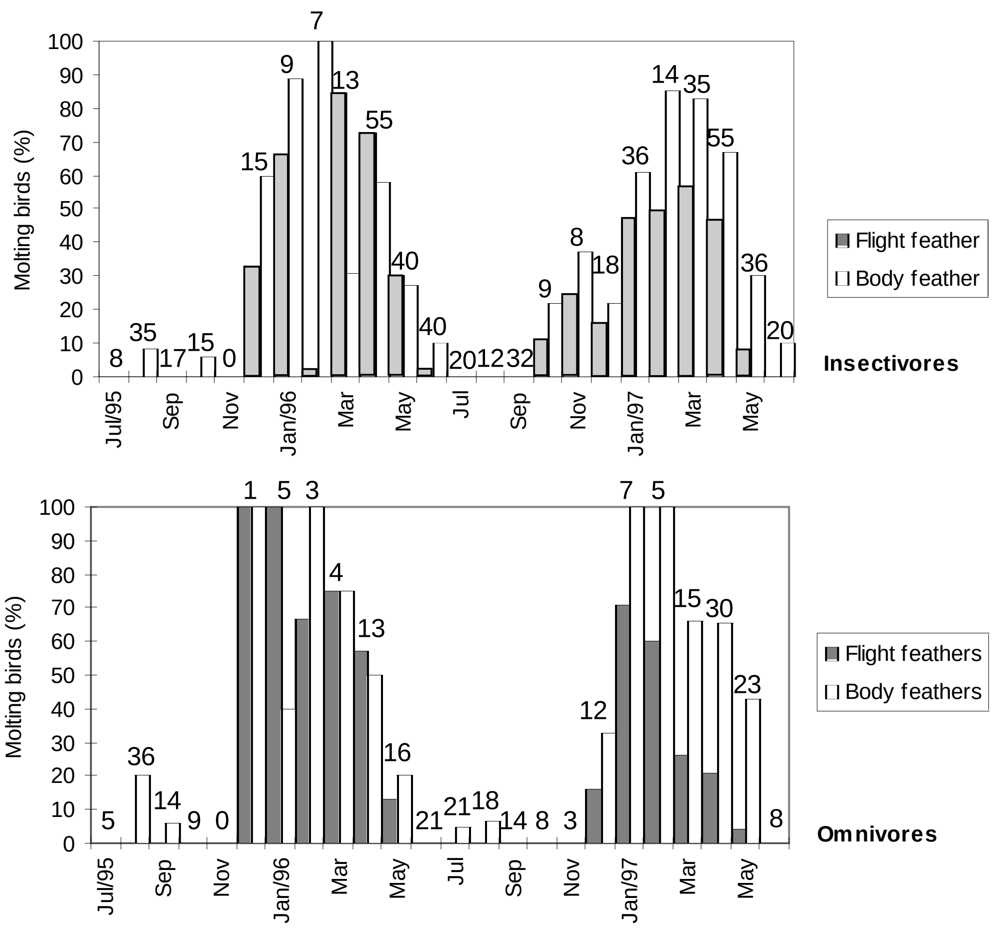

Figure 3. Molt frequencies for flight and body feathers in insectivores and omnivores passerine species from a foothill forest in Southeastern Brazil (numbers above bars are total of birds captured each month).

Table 2. Body mass of molting and non-molting birds of four passerines bird species from a foothill forest in Southeastern Brazil. Values refer to mean (± s.d.); sample size.

	non-molting	Molting	t-test*
Pyriglena leucoptera	29.7 (± 2.3); 24	30.1 (± 2.3); 46	0.31
Xiphorynchus fuscus	19.8 (± 2.3); 8	20.9 (± 2.7); 9	0.36
Myrmotherula gularis	12.2 (± 0.9); 6	11.9 (± 0.5); 9	0.1
Philydor atricapillus	22.1 (± 2.0); 8	21.9 (± 1.3); 7	0.2

* all P > 0.05

ference was observed between the molt timing in frugivorous and insectivorous birds. While molt in frugivorous species occurred towards the end of the dry season, in insectivores it took place at the beginning of the rainy season. Marini and Durães (2001) also found a slight variation in the time of the start of molt among different trophic guilds, starting, however, always with the end of incubation. Insectivorous birds started to molt earlier than frugivores and omnivores, but omnivores showed a shorter period of molt. At present study, a remarkable difference in relation to molt season among insectivorous and omnivorous bird species has not been found. These two trophic guilds had a single annual molt cycle with complete feather replacement, mainly concentrated in the summer and autumn. However, a more detailed examination of the molt timing including other distinct guilds was not performed in this study.

The overlap of molt and breeding is a much discussed topic. It has been recorded at low frequency by some authors (Miller 1961, Foster 1974, 1975, Marini and Durães 2001) and not found by others (Snow and Snow 1964, Wolf 1969, Payne 1972, Fogden and Fogden 1979, Mallet-Rodrigues *et al*. 1995). In this study, no evidence of simultaneous occurrence of molt and breeding activity (presence of an active brood patch) was found in a same individual. However, some species were recorded with a molt-breeding overlap, although in distinct individuals. Some individuals is molting while other individuals had an active brood patch in the same month. Such records were fairly common between October and February. Flight feather molt and brood patch were not recorded in July and August (winter), although some birds were captured molting body feathers. Davis (1945) called this period the "hibernal season", defining it as a period of absence of breeding and a reduction of the populational density and bird activity.

The scarce overlap between molt and breeding, even in the tropics, which has been observed in several studies (Miller 1961, Foster 1975, Piratelli *et al*. 2000, Marini and Durães 2001), may be due to the high energy required by each event. Evolutionary pressure for the non-overlapping of molt and breeding seems to represent a mechanism to avoid excessive expending of energy (Foster 1975).

In contrast to the results obtained by Newton (1966), no significant difference in mean body mass was found between molting and non-molting individuals of the same species. A more constant availability of food in the tropics may be related to this constancy of mass during the cycle. However, Fogden (1972) found a seasonal body mass change in birds after breeding and related it to alterations in muscle protein levels. He suggested that the fall in body mass was a consequence of breeding stress, and that the lost mass was not replaced in the following months both because of the stress of parental care of young and molt.

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