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ARTICLE

Body condition of five passerines in a forest fragment and associated factors

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ABSTRACT: Body condition is a qualitative evaluation of an animal and is directly related to its fitness, with the relative mass index (RMI) as a tool for indirect estimation of energy reserves. This study evaluated if the body condition of birds differs between guilds, if it is reflected in levels of subcutaneous fat, and if it is influenced by the weather season and ectoparasite presence. The RMI was calculated for *Antilophia galeata* (frugivorous), *Arremon flavirostris*, *Eucometis penicillata* (omnivorous), *Basileuterus culicivorus*, and *Myiothlypis leucophrys* (insectivorous). It varied among guilds ($F_{2, 295} = 187.92$; $P < 0.05$), with insectivorous species having negative values. The RMI varied between the wet and dry seasons only for *A. galeata* ($F_{1, 1} = 7.28$; $P < 0.05$) but remained positive throughout the year in omnivorous species. The RMI did not vary with the presence/absence of ectoparasites nor among the different levels of subcutaneous fat, which were predominantly low. The negative RMI of insectivores and its variation in frugivorous between seasons suggest that the body condition is influenced by the type of diet and the availability of food resources, indicating that birds with a specialized diet may be more sensitive to environmental variations that result in fluctuations in the food supply.

KEY-WORDS: Cerrado, feeding guild, subcutaneous fat, tick, weather season.

INTRODUCTION

Studies of fauna that assess the individual physical condition by means of physiological indicators, such as body condition and hormonal status, may be advantageous in obtaining responses from the bird population based on landscape changes (Johnson *et al.* 1985, Janin *et al.* 2011), evaluation of environments in various degrees of conservation (Costa & Macedo 2005), and the conditions of these environments (Møller & Erritzøe 2003, Costa & Macedo 2005). Body condition is a qualitative evaluation of an animal and is directly related to fitness (Gosler 2005, Peig & Green 2010). This condition reflects the amount of energy reserves, the capacity to survive in adverse situations, resistance to parasites or diseases, and/or the ability to attract partners (Costa & Macedo 2005, Gosler 2005, Schulte-Hostedde *et al.* 2005).

The biotic or abiotic conditions, such as reduction in vegetation cover, can increase energy expenditure in defense against predators and therefore positively or negatively affect the body condition of an animal (Amo *et al.* 2007). Furthermore, they can change the viability as to the investment against parasites (Smallridge & Bull 2000) and even force individuals to move from ideal habitats (Amo *et al.* 2007). There are several physiological, biochemical, and morphological methods for evaluating the body condition of an individual (Stevenson & Woods-Jr. 2006, Labocha & Hayes 2012). According to Johnson *et al.* (1985), to assess fat reserves, the options are direct extraction of lipids, a method considered to be the most accurate and costly; measurement of the dry biomass through water extraction; measurement of fat deposits through animal dissection; and the RMI. This index is easily obtained through the mass of individuals caught in the field associated with a morphometric measurement (Jakob *et al.* 1996, García-Berthou 2001, Schulte-Hostedde *et al.* 2001, Velando & Alonso-Alvarez 2003, Ardia 2005, Gosler 2005, Schulte-Hostedde *et al.* 2005, Serrano *et al.* 2008, Peig & Green 2010).

Semideciduous seasonal forests are probably among the most threatened and fragmented ecosystems due to the intensification of land use for agriculture (Oliveira-Filho *et al.* 1994, Lopes *et al.* 2012). As birds are sensitive to habitat loss and in the face of fragmentation (Turner 1996, Marini 2001) it is possible that their body condition reflects environmental and physiological pressures and interactions. Thus, the objectives of this study were to evaluate if the body condition of birds varies among guilds — testing the hypothesis that species with more generalist diets will present a better body condition than the most specialist species — and to check if the body condition is related to subcutaneous fat levels and if it is influenced by the weather season and the presence of ectoparasites.

METHODS

Study area

This study was carried out in a forest fragment of 30 ha in the Cerrado Biome (18°57'03''S; 48°12'22''W) on the *Fazenda Experimental do Glória*, Uberlândia, state of Minas Gerais, Brazil, considered a peri-urban area. This area includes gallery forest formations and semideciduous seasonal forest, as well as total isolation in an agricultural matrix (Lopes *et al*. 2011).

The climate of the region is tropical, with a wet season (October to March) and a dry season (April to September). The mean temperature and rainfall vary between seasons (dry: 18°C and 12.1 mm; wet: 22.9°C and 228.5 mm), with 50% of the annual rainfall (1500 to 1600 mm) concentrated in December and February (Alves & Rosa 2008).

Bird sampling

Birds were captured with mist nets (12 × 3 m and mesh size 19 mm), with 17 to 25 nets arranged in linear transects, between 06:30 and 17:00 h. Bird catches were carried out monthly between September 2011 and August 2012.

Captured individuals were identified and received metal bands provided by CEMAVE/ICMBio (permit no. 359076 for projects no. 2943 and 3238). The nomenclature proposed by the Brazilian Ornithological Records Committee was followed (Piacentini *et al.* 2015). The measurements of the right tarsus were taken with a digital caliper (Lotus®) with 0.01 mm precision, and body mass was measured by means of dynamometer-type weighing (Pesola®) scales, with scales of 30, 60, and 100 g. The subcutaneous fat scale was adapted from IBAMA (1994), with four levels used (Fig. 1), and verified by blowing the feathers covering the wishbone, chest, abdomen, and flanks. Ticks were analyzed qualitatively (presence/absence) through bird body inspection while blowing among the feathers. The prevalence rate of ticks by species was calculated using the number of infested individuals divided by the number of individuals examined (Tolesano-Pascoli *et al.* 2010). Included in the analyses were species with at least five individuals caught in each season (dry and wet), in which it was possible to evaluate the biomass, length of right tarsometatarsus, presence/absence of ectoparasites, and level of subcutaneous fat.

Data analysis

Body condition: was calculated by means of a simple linear regression between the log-transformed (log10) values of biomass and the right tarsus length of every individual. The residuals were used as body condition indices (RMI). The RMI with a negative value indicates poor body condition when compared to positive values (Schulte-Hostedde *et al.* 2005).

Statistical analysis: The analysis of variance (ANOVA) verified if the RMI varied among the trophic guilds and among the subcutaneous fat levels of each species. The effect of season weather (dry and wet) and

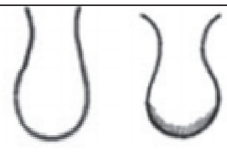
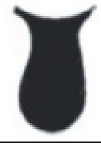
1		With or without a small amount of fat stored in the furcula's cavity but not enough to fill the cavity's bottom. No fat under the wings, abdomen, or elsewhere.
2		The bottom of the furcula's cavity is totally filled, completing 1/3 of the total cavity.
3		The furcula's cavity is 2/3 filled. Some fat can also be seen under the wings and usually in the abdomen.
4		The furcula's cavity is completely filled. A compact layer of fat can also be observed under the wings and abdomen.

Figure 1. Subcutaneous fat scale for birds. Adapted from IBAMA (1994), *Centro de Pesquisas para Conservação das Aves Silvestres* (CEMAVE-ICMBio).

ectoparasites (presence/absence of ticks) on the RMI of each species analyzed, as well as a potential interaction between these factors, was verified through the factorial analysis of variance (Factor ANOVA). Tests were carried out by Systat® 10.2 software (Systat Software, Inc 2002) at a significance level of 5% (Zar 2010).

RESULTS

Among the 470 individuals captured (39 species), 298 (five species, four families) were used in analyses: *Antilophia galeata* (*n* = 152), *Arremon flavirostris* (*n* = 34), *Basileuterus culicivorus* (*n* = 58), *Myiothlypis leucophrys* (*n* = 28), and *Eucometis penicillata* (*n* = 26) (Fig. 2).

These species are distributed in three feeding guilds: frugivorous, insectivorous, and omnivorous (Table 1). Positive values of RMI in both seasons were detected for *E. penicillata* (omnivorous), followed by *A. galeata* (frugivorous) and *A. flavirostris* (omnivorous) (Table 1). The RMI differed between guilds ($F_{2, 295}$ = 187.92; $P < 0.05$), with lower values for insectivores (-0.127 ± 0.130; Fig. 3).

Only *A. galeata* presented a difference in RMI between seasons ($F_{1, 1}$ = 7.28; $P < 0.05$; Table 2), with values higher in the wet season (0.086 ± 0.047) than in the dry season (0.064 ± 0.041) (Table 1). The species belonging to the Parulidae family, which are strictly insectivorous, had a negative RMI in both seasons (Table 1), thus presenting a body condition inferior to the other species analyzed.

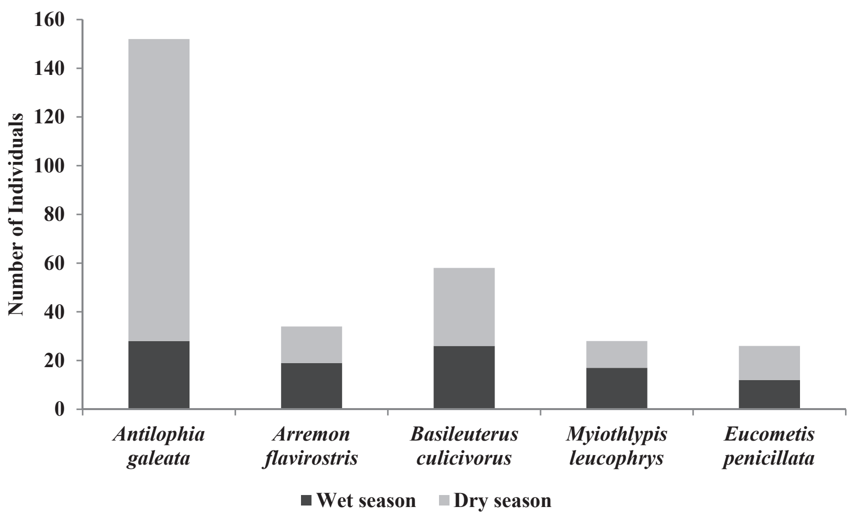


Figure 2. Number of individual birds, by species, captured during the wet and dry seasons in Uberlândia, state of Minas Gerais, between September 2011 and August 2012.

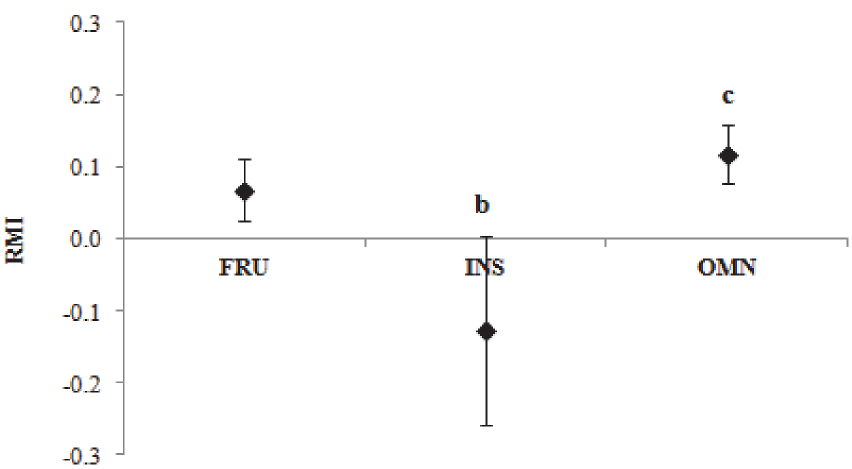


Figure 3. Mean ± standard deviation of the relative mass index (RMI) by feed guilds (FRU – frugivorous, INS – insectivorous, OMN – omnivorous) of birds captured at Uberlândia, state of Minas Gerais, between September 2011 and August 2012.

Table 1. Bird species recorded, relative mass index values (RMI) (mean ± SD) and prevalence rate of ticks (%). *Feed guild: FRU – frugivorous; INS – insectivorous; OMN – omnivorous, according to Moojen *et al.* (1941), Motta-Júnior (1990), Marini & Cavalcanti (1993), Silva (1996), Marini (1992b; 2001), Francisco & Galetti (2002), Piratelli & Pereira (2002), Manhães (2003), Durães & Marini (2003, 2005), Lopes *et al.* (2005), Scherer *et al.* (2005), Telino-Júnior *et al.* (2005), Lima (2008), Manica *et al.* (2010).

Families/species (*n*)	Guild*	RMI (mean ± SD)				Prevalence rate of ticks (%)	
		Wet season	Dry season	No Ticks	Ticks	Wet season	Dry season
Pipridae							
Antilophia galeata (Lichtenstein, 1823) (152)	FRU	0.086 ± 0.047	0.064 ± 0.041	0.067 ± 0.042	0.075 ± 0.047	18	19
Passerellidae							
Arremon flavirostris Swainson, 1838 (34)	OMN	0.062 ± 0.040	0.047 ± 0.036	0.056 ± 0.041	0.053 ± 0.024	5	33
Parulidae							
Basileuterus culicivorus (Deppe, 1830) (58)	INS	-0.206 ± 0.049	-0.236 ± 0.068	-0.221 ± 0.064	-0.232 ± 0.031	4	16
Myiothlypis leucophrys (Pelzeln, 1868) (28)	INS	-0.150 ± 0.023	-0.147 ± 0.085	-0.147 ± 0.035	-0.151 ± 0.072	35	64
Thraupidae							
Eucometis penicillata (Spix, 1825) (26)	OMN	0.137 ± 0.016	0.099 ± 0.046	0.128 ± 0.028	0.096 ± 0.051	17	50

Table 2. Results of the Factorial Analysis of Variance (Factorial ANOVA) for seasons (wet and dry) and ectoparasites ticks (presence/absence); and Analysis of Variance (ANOVA) for subcutaneous fat.

Species	Factors	*df*	*F*	*P*
Antilophia galeata	Season	1	7.276	0.008
	Ectoparasites	1	2.780	0.098
	Interaction (season*ectoparasites)	1	1.766	0.186
	Subcutaneous fat	3	1.215	0.306
Arremon flavirostris	Season	1	0.085	0.772
	Ectoparasites	1	0.006	0.937
	Interaction (season*ectoparasites)	1	0.281	0.600
	Subcutaneous fat	2	0.244	0.785
Basileuterus culicivorus	Season	1	0.242	0.625
	Ectoparasites	1	0.102	0.751
	Interaction (season*ectoparasites)	1	0.176	0.677
	Subcutaneous fat	3	0.717	0.546
Myiothlypis leucophrys	Season	1	0.028	0.869
	Ectoparasites	1	0.039	0.844
	Interaction (season*ectoparasites)	1	0.000	0.998
	Subcutaneous fat	2	0.896	0.422
Eucometis penicillata	Season	1	3.378	0.080
	Ectoparasites	1	1.442	0.243
	Interaction (season*ectoparasites)	1	0.000	0.993
	Subcutaneous fat	2	1.599	0.224

Myiothlypis leucophrys presented the highest prevalence rates for ectoparasites (ticks) in both seasons (Table 1). The RMI of the species was not influenced by the presence/absence of ectoparasites or by the subcutaneous fat (Table 2). The level of subcutaneous fat predominant for each species in both the wet and dry seasons was level 1 (Figs. 4A, B).

DISCUSSION

The Pipridae family, in general, comprises birds that are easily collected and well represented in collections (Anciães & Peterson 2006, Magalhães *et al.* 2007). *Antilophia galeata* is typical to the Cerrado Forest environments (Silva 1995), present in semideciduous seasonal forests, including small urban fragments (Franchin & Marçal-Júnior 2004, Silva & Melo 2011). It is considered predominantly frugivorous but can be more omnivorous (Marini 1992a) when compared with, for example, *Pipra fasciicauda*, a more specialized frugivorous species. *Antilophia galeata* was the only species to vary in RMI between the dry and wet seasons, being greater in the latter. The reproduction of *A. galeata* at the beginning of the dry season (Marini 1992a), which generates high energy demand, coupled with greater availability of fruit during the wet season (Silva *et al.* 2009, Melo *et al.* 2013) may explain such variation in body condition. In addition, this variation in RMI can be explained by the isolation of the study area, which can be a limiting factor in meeting nutritional needs. This fragment presents a well-structured sub-forest, with no impact of grazing or cattle trampling. Regarding the degree of isolation, the mean distance from other forest patches is 1.9 km, one of which is located within an urban area.

Arremon flavirostris and *E. penicillata*, which are generalists, although not differing seasonally in RMI, had positive values, indicating a good and stable body condition

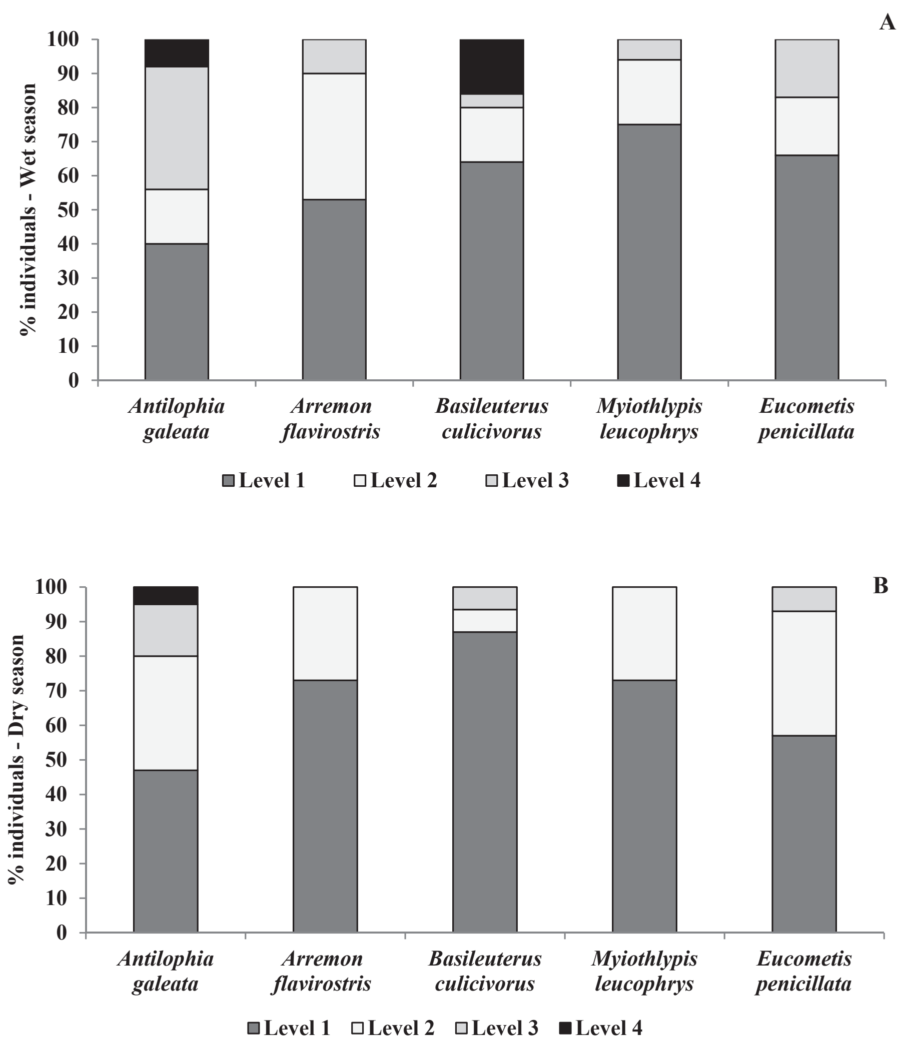


Figure 4. Percentage of individuals captured concerning subcutaneous fat factor levels (1 to 4) in the wet (**A**) and dry (**B**) seasons at Uberlândia, state of Minas Gerais, between September 2011 and August 2012.

throughout the year. Birds with a more generalized diet tend to keep their behavior and physiology stable in the face of variations in their habitat, as they feed on fruits of various species and are able to supplement their diet with animal items (Howe 1993, Scherer *et al.* 2007). The ability to shift the diet seasonally can be especially important in environments such as the Cerrado, which has well-defined dry and rainy seasons and large seasonal variations in productivity, especially fruits (Batalha & Montovani 2000, Silva *et al.* 2009, Melo *et al.* 2013). Furthermore, in the case of fragmented forests, omnivory may be a key characteristic, and this guild tends to predominate in small fragments (D'Angelo-Neto *et al.* 1998, Ribon *et al.* 2003).

On the other hand, despite the fact that the seasons had no effect on the RMI of insectivorous species, *B. culicivorus* and *M. leucophrys* showed negative values in both seasons. These species inhabit forest environments, foraging in the understory (Marini & Cavalcanti 1993), and may be affected by the dry season, when low humidity can interfere with the survival and reproduction of arthropods (Janzen & Schoener 1968, Battirola *et al.* 2007), resulting in lower availability of this resource (Teles 2013). In contrast, the absolute abundance of potential arthropods may not reflect their availability for foraging birds (Smith & Robertson 2008). It is expected that insectivorous birds restricted to a given stratum and foraging substrate, as is the case of *B. culicivorus* and *M. leucophrys*, are more susceptible to fragmentation (Marini & Cavalcanti 1993, Chatellenaz 2008, Lima & Manhães 2009).

Corroborating with Marini & Couto (1997) and Kanegae (2003), the prevalence rate of ticks in this study was greater in the dry season, a period in which food resources for birds may be scarcer. The presence/absence of ectoparasites did not affect the RMI of the species analyzed, so it is recommended that future studies assess possible interactive or synergic effects of parasite communities (endo-, hemo-, ectoparasites) on host birds (Cornelius *et al.* 2014, Biard *et al.* 2015).

No relationship was found between RMI values and subcutaneous fat levels in the species analyzed. Considering the predominance of low fat levels in both seasons, it is suggested the energy demand is stable throughout the year, explaining the lack of fat accumulation by these species. This fact may reflect an individual inability to obtain specific items from their diets or include new items in periods of food shortage.

Furthermore, there are two events in the life of birds with high energy demand that were not evaluated in this study: molt and breeding (Merilä 1997). Studies carried out in Brazil indicate that these two events overlap minimally throughout the year, given that breeding takes place preferably during the greater availability of food resources (Sick 1997, Oniki & Willis 1999, Piratelli *et al.* 2000, Marini & Durães 2001, Maia-Gouvêa *et al.* 2005).

Another factor that may contribute to the prevalence of individuals with low levels of fat in both seasons is that birds of this region do not need to accumulate large amounts of fat, since they are not migratory species and the region does not have a severe cold season. Fat accumulation influences the body mass of birds and can negatively affect flight aerodynamics (Witter & Cuthill 1993).

Therefore, the body condition of the species analyzed seems to be influenced by the diet and food availability, suggesting that birds with a specialized diet may be more sensitive to environmental variations, which result in fluctuations in resources. *Antilophia galeata* is a frugivorous species with an important role in the dynamics of seed dispersal and regeneration of forests. This highlights the importance of the maintenance and conservation of forest fragments as well as the maintenance of connectivity between them for the conservation of birds in this region.

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