Revista Brasileira de Ornitologia, 23(4), 428-436
December 2015

ARTICLE

An intratropical migratory passerine can quickly improve its physiological condition during post migration, reproduction and departure phases on the breeding site in the *Cerrado*

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Received on 29 March 2015. Accepted on 10 November 2015.

ABSTRACT: Migration and reproduction are energetically expensive processes that migratory animal species must confront during their life-cycle. The relationship between hematocrit and mass in birds highlight their ability to invest energy in activities such as reproduction and migration and face costs linked to all subphases. We tested three hypotheses to evaluate the relationship between hematocrit and mass for an intratropical migrant bird, the Lesser Elaenia (*Elaenia chiriquensis*): (1) In the arrival phase, we expected that there would be a decrease in mass accompanied by a drop in hematocrit levels in a negative linear relationship; (2) during the reproduction phase we expected, at most, a weak relationship and a decrease in mass and hematocrit, due to the physiological complexity of this phase; (3) on the departure phase, we expected an increase in mass complemented by an increase in hematocrit as a positive linear relationship. We found that the Lesser Elaenia has average mass and hematocrit levels in the arrival phase similar to those in the other phases, thus not showing the expected trend as predicted above. On the other hand, during the reproduction phase, as expected, there was no significant relationship between mass and hematocrit levels, whereas a strong relationship between these variables was detected during the departure phase. Overall, the Lesser Elaenia arrives in good condition in their breeding sites, then it undergoes some physiological stress during the breeding period, but later is able to rapidly recover optimal physiological conditions upon departure to wintering grounds.

KEY-WORDS: breeding, body condition, *Elaenia chiriquensis*, hematocrit, life cycle phases, intratropical migration.

INTRODUCTION

Migration and reproduction are the two most energetically expensive processes that migratory species must face during their annual life-cycle. These processes impose drastic changes in energy demands, which require a series of physiological adjustments. Before migration, birds increase in body mass principally by storing fat for later use as fuel during flight (Newton 2008). However, other birds build muscle while reducing fat reserves. Muscle augmentation occurs as a consequence of hypertrophy of muscle tissue involved in flight (e.g. heart muscles and the pectorals), providing an alternative source of fuel and increased muscle strength and endurance (Whittow 2000, Arizmendi-Mejía *et al.* 2013). Migration is related to the status of a bird's physiological condition, thus birds in bad conditions tend to migrate later (González-Prieto & Hobson 2013). In addition, species that migrate without stopping rely solely on their endogenous resources to supply the energy during migration. Therefore, the nutrients and energy supplies are severely depleted as the bird arrives to its destination (Battley *et al.* 2001).

Understanding the underlying physiological processes necessary to achieve an adequate nutritional state for reproduction is essential, as it can have important consequences for individual fitness and future reproductive success. The ecophysiology of the post-migratory period preceding breeding (e.g. from arrival on the breeding grounds to egg-laying) has received relatively little attention (Arizmendi-Mejía *et al.* 2013) compared to the ecophysiology of the pre-migratory period (e.g. Marsh 1984, Jenni-Eiermann & Jenni 1991, Bairlein & Gwinner 1994). After arriving at the breeding grounds, migratory birds must recover their body condition and prepare for reproduction (e.g. defense of breeding territory, searching for mates, copulation, nest construction, and caring for nestlings and fledglings). These breeding activities impose additional energetic costs to birds already exhausted from migration (Arizmendi-Mejía *et al.* 2013). In addition, females need a substantial amount of lipids and proteins for the formation of eggs (Navarro *et al.* 2007, Eichhorn *et al.* 2010). Females in the best condition, generally characterized by high body mass, produce more offspring, while heavier males have higher survival rates than lighter individuals (Chastel *et al.* 1995). Moreover, conditions during reproduction and just before migration are also critical factors that influence survival, reproductive decisions and future reproductive success (Chastel *et al.* 1995). These decisions are particularly important for birds because individuals that are in poor condition may restrict investment in current reproduction in order to lessen its impact on future reproductive attempts (Williams 1966, Stearns 1992, Crossin *et al.* 2012). For example, Black-browed Albatross (*Thalassarche melanophris*) females that delay reproduction are in poor condition and have lower levels of steroids and yolk precursors (Crossin *et al.* 2012). Research on the condition of birds during phases of arrival, reproduction, and departure on a subsequent migration have focused mainly on some temperate passerines, marine birds, and other waterfowl, whereas tropical birds have received relatively little attention.

Avian body condition can be studied by measuring biochemical metabolites in the blood plasma and other hematological parameters (Vanderkist *et al.* 2000, Jenni-Eiermann *et al.* 2002). One of the most widely used hematological parameters is hematocrit, which serves as a good indicator of an individual's metabolic activity, nutritional status, and ability to transport oxygen (Ots *et al.* 1998, Whittow 2000, Lisečić *et al.* 2013). Hematocrit is the relative volume of erythrocytes in the total volume of blood (Bearhop *et al.* 1999). The lowest hematocrit levels for females occur during ovulation and hormones such as estrogen may diminish hematocrit (Rehder & Bird 1983, Whittow 2000). Although variation in hematocrit is incompletely understood in birds, it is greatly influenced by levels of dehydration and nutritional status (Hill *et al.* 2008). The relationship between blood volume and body mass is well-known for healthy humans and is widely utilized in hematological calculations in the treatment of diseases. Blood composes approximately 7 to 8.5% of an animal's body weight (Prosser & Weinstein 1950). In small mammals, hematocrit is correlated with body size, and is generally elevated due to high cardiorespiratory rates and lower body surface (Sealander 1964). In birds, differences between the values are based primarily on body size (Hatch & Smith 2010). Factors like age, sex, reproduction, elevation, parasitism, and nutritional status have been hypothesized to influence hematocrit values among wild birds (Fair *et al.* 2007).

Thus, different predicted relationships between body condition (as indicated by mass) and hematocrit levels exist during different phases of the life cycle, such as migration and reproduction. High levels of hematocrit are principally associated with an increase in intense physical exercise (Hõrak *et al.* 1998). For instance, low hematocrit levels (e.g. anemia) are associated with bacterial infections, the presence of parasites, and insufficient levels of micronutrients such as iron, copper, and vitamin B12 (Coles 1997). Hematocrit indicates intense aerobic and metabolic activities with relationship with the loss and gain of mass of an organism and overall health condition (Burkhard *et al.* 2001, Navarro *et al.* 2007). Hematocrit levels are highest as birds arrive on the breeding sites, and change substantially during the reproductive season, being expected to increase before departure for the wintering grounds (Jenni-Eiermann & Jenni 1994, Morton 1994). During the arrival phase at breeding grounds, for example, Montane Sparrows (*Zonotrichia leucophrys*) show relatively high levels of hematocrit until the end of nest construction (Morton 1994). Another research showed that hematocrit could be used to predict changes in body mass of migrants (Jenni-Eiermann & Jenni 1994).

Here, we examine the variation in body condition during three phases of the life cycle of a migratory Neotropical bird, the Lesser Elaenia (*Elaenia chiriquensis*). We analyze variation in body mass and hematocrit during: 1) arrival (post-arrival/pre-reproduction); 2) reproduction; and 3) departure (post-reproduction/pre-departure) on the breeding grounds. We hypothesize that phase and mass are related and affect hematocrit values on different periods of Lesser Elaenia breeding and migration, being a proxy of its ecophysiological condition. We predict that in the arrival phase, there will be a decrease in mass accompanied by a drop in hematocrit; during the reproductive phase there will be a weak or no relationship between mass and hematocrit levels due to the physiological complexity of this phase, with expected low levels for both hematocrit and mass; and finally, during the departure phase we expect an increase in mass accompanied by an increase in hematocrit (Morton 1994, Jenni-Eiermann & Jenni 1994, Arizmendi-Mejía *et al.* 2013).

METHODS

Study Species

The study species, the Lesser Elaenia (*Elaenia chiriquensis*), is a tyrant flycatcher, 11 centimeters in length, distributed from Costa Rica to Argentina (Ridgely & Tudor 1994). The species breeds in central-southeastern Brazil and migrates north apparently to the Amazon region (Marini & Cavalcanti 1990). Its breeding biology is well-known. In Distrito Federal, central Brazil, reproduction occurs from mid September until early December, when it constructs a cup-shaped nest and generally deposits two primarily white and spotted eggs (Medeiros & Marini 2007, Paiva & Marini 2013).

The Study Area

Data were collected within a 100-hectare grid at the Estação Ecológica de Águas Emendadas (hereafter ESECAE) in the Distrito Federal (15°29'S to 15°36'S, 47°31'W to 47°41'W; 1040 m altitude), central Brazil. ESECAE is an important protected area within central Brazil that is surrounded by other smaller protected areas, agriculture lands, and housing areas (Marinho-Filho *et al.* 1998). The area is characterized by both open and dense savannahs, as well as patches of forest and grasslands typical of the *Cerrado* region of Brazil. The climate of the region is strongly seasonal with a rainy season that extends from September to April, and a strong dry season during the other months of the year (Nimer 1989). More details about the area and about *Cerrado* are presented in Borges & Marini (2010) and Duca & Marini (2011).

Lesser Elaenia Captures

Birds were caught weekly with 5 mist-nets from August to December 2012, totaling 1,140 net-hours (19 weeks, four days a week and 3 hours a day). The first Lesser Elaenia of 2012 arrived on August 10. We considered the preceding 15 post-arrival days as the "Arrival phase" of the life cycle. In addition, the first individual with a brood patch was recorded on 3 of September, signifying start of breeding activities. The proportion of individuals with brood patches increased from the third week of September to the third week of November, thus we considered this period as the "Reproductive phase". As birds begin to depart by the third week of December, we considered the period from 15 to 30 December as the "Departure phase". During this period, few individuals maintained brood patches, implying in cessation of breeding activities. The Lesser Elaenia has very predictable departure dates (Paiva 2008, Paiva & Marini 2013).

Blood collection

Captured individuals had a small volume of their blood collected (70 to 140 μL) and were marked with a uniquely numbered aluminum band. Mass of the individual and the presence of a brood patch were recorded. Blood samples were obtained through the puncture of the brachial vein and collected via a heparinized capillary tube. The collection of blood conformed to ethical standards dealing with manipulation of wild animals, and the total blood collected from an individual did not exceed 1% of the individual's body mass (Thrall 2004). After collection, capillary tubes were sealed at one end and stored on ice. The blood samples were centrifuged for 10 minutes in a micro-hematocrit centrifuge at 12,000 rpm. Hematocrit was measured immediately after centrifugation of the samples with a micro-hematocrit table. The hematocrit values reported here represent averages of two or three micro-hematocrit capillary tubes per individual.

Statistical Analysis

To achieve the objectives, an ANCOVA model was used to assess the effects of different phases of the life cycle, body mass and the interaction between these variables on the hematocrit levels (hematocrit~phase+mass+phase*mass). Normality of the residuals for mass and hematocrit level across the life cycle phases was assessed via Shapiro-Wilk tests and values are presented in mean and standard deviation format. Post-hoc comparisons were performed using Tukey's test to compare average hematocrit values between different life cycle phases. All analyses were performed in Program R.

RESULTS

Contrary to expectations, hematocrit levels were not low when the Lesser Elaenia arrived at the breeding site. They were, however, relatively balanced compared to the average presented by the species during the departure phase (Table 1). In the reproductive phase, as expected, hematocrit showed low levels, which increased during the departure phase, also corroborating initial expectations (Table 1). In fact, there were significant differences in hematocrit for the different phases and the Tukey test indicated a significant difference during the departure period in relation to the arrival ($t = 2.76$, $P < 0.001$) and reproductive ($t = 4.39$, $P < 0.001$) periods. Hematocrit values averaged 54.44 ± 3.35% ($n = 99$), and surprisingly, nine individuals preparing to depart for the non-breeding grounds had hematocrit levels between 60 and 62%, a high value not recorded during other phases of the Lesser Elaenia sampling period. It is important to mention that plasma, the blood component remaining after centrifugation to access hematocrit, changed equally showing equilibrium on arrival, a small decrease in reproduction and an increase during the departure phase (Table 1).

The mass of the Lesser Elaenia in the arrival phase diverged from what was expected because it was relatively high compared to the averages exhibited during the total period (Table 1). There was a small decrease in mass during reproduction, but still close to average, and an increase in mass, as expected, during the departure phase (Table 1). Mass averaged 15.85 ± 1.29 g (n = 99), and differences between the phases are significant (F = 16.71, P < 0.001), especially relative to the departure phase, with individuals weighing approximately 16 g, and with little variation in the population.

The linear model explained variations in hematocrit levels of the Lesser Elaenia, including different phases (arrival, reproduction and departure), mass and the interaction between these variables (Table 2). Based on these relationships, the model demonstrated that the mass effect on hematocrit levels in the Lesser Elaenia was significant during the departure phase, and that the relationship between hematocrit level and the departure phase itself was highly significant (Table 3).

The effect of mass is demonstrated by the significant linear relationship between this parameter and hematocrit ($F_{2,98}$ = 50.06; r = 0.13; P < 0.001) (Figure 1A). There was no significant correlation in the arrival ($F_{2,27}$ = 0.27, r = 0.03, P = 0.402) (Figure 1B) and reproductive phases ($F_{2,45}$ = 5.03, r = 0.003, P = 0.479) (Figure 1C). However, in the departure phase, although the mass of individuals increase, there is a significant increased in hematocrit, with a robust relationship between mass and hematocrit ($F_{2,24}$ = -47.98, r = 0.51, P < 0.001) (Figure 1D).

TABLE 1. Average values of Lesser Elaenia hematocrit, plasma and mass in different phases while on the breeding grounds (arrival, reproduction and departure) in the Brazilian *Cerrado*. HCT=hematocrit, PLS=plasma, MS=mass.

Phase	**Parameter**			**n**
	HCT (%)	**PLS (%)**	**MS (g)**	
Arrival	54.43±2.03	45.57±2.03	16.19±1.47	28
Reproduction	52.89±2.32	47.11±2.32	15.30±1.17	46
Departure	57.19±4.26	42.81±4.26	16.45±0.89	25
Total period	54.44±3.35	45.56±3.35	15.85±1.29	99

TABLE 2. ANCOVA results explaining variation in hematocrit levels of Lesser Elaenia as a function of phase while on the breeding grounds (arrival, reproduction and departure), mass and their interaction.

Variable	**df**	**Sum Sq**	**Mean Sq**	**F**	**P**
Phase	2	295.2	147.58	27.08	**< 0.05**
Mass	1	44.7	44.69	8.20	**< 0.05**
Phase×Mass	2	255.1	127.57	23.41	**< 0.05**
Residual	93	506.8	5.45		

TABLE 3. Model estimates of ANCOVA explaining variation in hematocrit levels of Lesser Elaenia as a function of phase while on the breeding grounds (arrival, reproduction and departure), mass and their interaction.

Coefficients	**Estimates**	**SE**	**F**	**P**
Intercept	50.069	4.950	10.114	**<0.05**
Departure phase	-60.454	10.803	-5.874	**<0.05**
Reproduction phase	4.490	6.730	0.667	0.506
Mass	0.269	0.305	0.884	0.379
Departure ×mass	3.999	0.655	6.102	**<0.05**
Reproduction phase ×mass	-0.378	0.425	-0.889	0.376

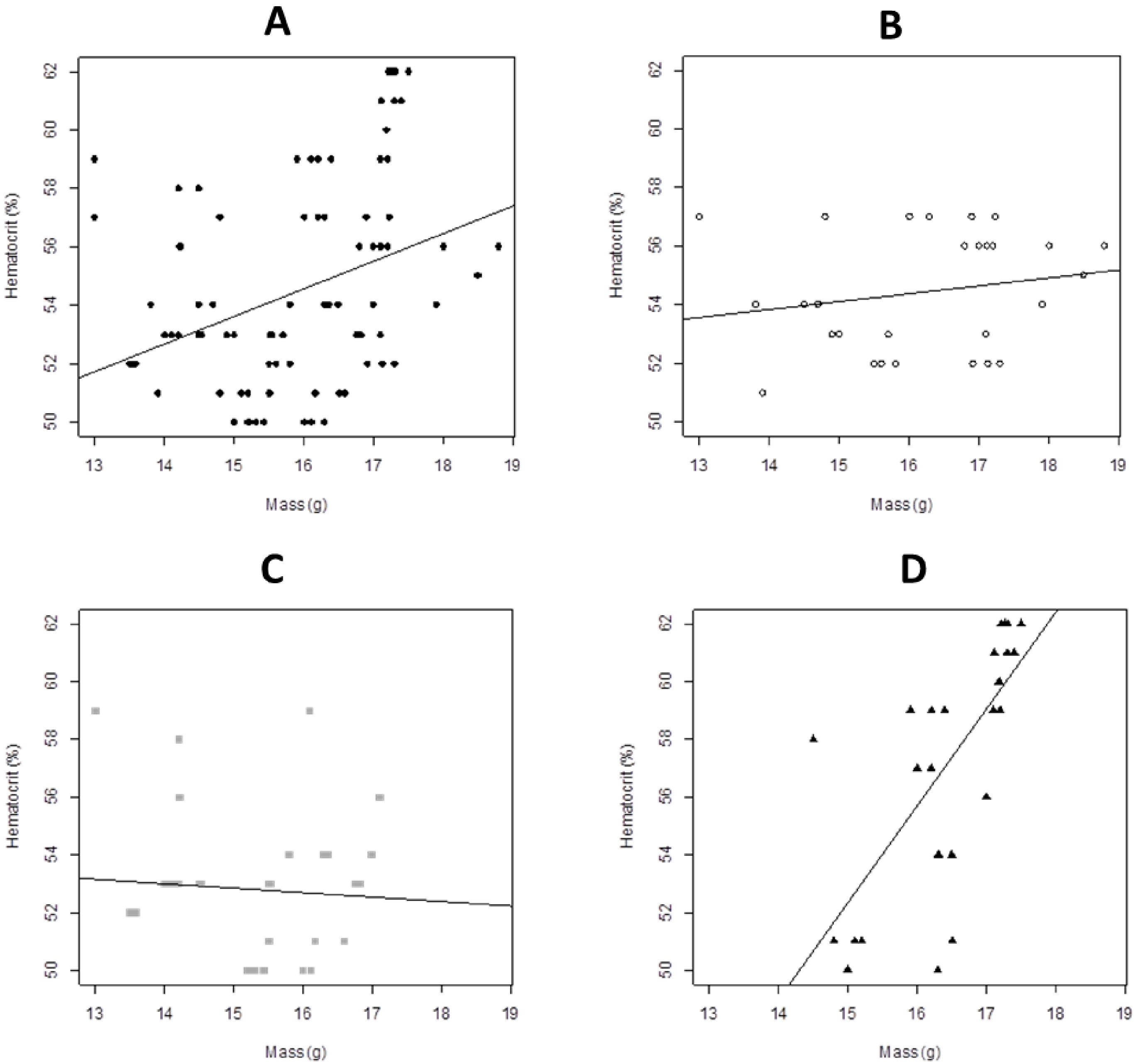

FIGURE 1. The relationship and correlation between hematocrit and mass of Lesser Elaenia in the *Cerrado* of Brazil. The phases were separated into: total period (A, closed circles), arrival phase (B, open circles), reproductive phase (C, gray squares), and departure phase (D, black triangles).

DISCUSSION

The temporal variation in hematocrit in the Lesser Elaenia is indicative of several expected physiological changes related to migration and reproduction. The relationship between hematocrit and mass, though specifically strong during the departure phase, was modest during the arrival and reproduction phases. Lesser Elaenia arrives at breeding grounds in good conditions, what does not support our prediction that they would have low hematocrit and mass, and that there would be a negative relationship between both. Unexpectedly, their mass does not notably decrease during the reproductive phase. In support of our prediction, we found that Lesser Elaenia departs for the wintering area in good condition.

Just after arrival to the breeding grounds, birds are in good condition but delay reproduction for a few weeks. Thus, they use this period between arrival and reproduction (approximately a month) to further improve their condition before nesting. This behavior might explain why mass does not decrease as expected during reproduction. That they arrive in relatively good condition suggests that this species has stopover sites during migration to the breeding grounds, possibly to refuel. Given that the Lesser Elaenia arrives in the *Cerrado* region in August, when weather is hot and very dry (Nimer 1989), making stopovers might improve its physiological condition as a strategy to withstand the harsh *Cerrado* climate. Some birds greatly improve their condition when they stopover. For example, the American Redstart (*Setophaga ruticulla*), increase their mass from 0.5–3.5% during stopover. Likewise, the Common Yellowthroat (*Geothlypis trichas*) can increase between 4.4–7.2%, and the Chestnut-sided Warbler (*Setophaga pensylvanica*) can extraordinarily increase its mass from 13.8–16.1 % before departing from stopover site (Winker *et al.* 1992). In the Gray Catbird (*Dumetella carolinensis*), some individuals arrive on the breeding grounds with lower hematocrit levels, which has been associated with dehydration and lower than average body condition (Hatch *et al.* 2010), and thus supports the hypothesis that successful arrival depends on the bird's condition (Morton 1994).

Even if these migrating birds stop along the route, the energetic cost of migration is still very large, given the total distance birds must fly. Lesser Elaenia apparently occur in the Amazon region during the non-breeding season, from where they migrate to the *Cerrado* to reproduce (Marini & Cavalcanti 1990, Medeiros & Marini 2007). The species may, therefore, move a few thousand kilometers between breeding and wintering sites. Although we do not have measures of hematocrit levels during the non-breeding season, we can compare values between individuals preparing to depart with those of individuals that had just arrived within 15 days to the breeding grounds. The departure group maintained hematocrit levels around 56% and up to 62%, while those arriving maintained levels around 54%. The opposite occurred in White-crowned Sparrows (*Zonotrichia leucophrys oriantha*), which arrive on the breeding grounds in the United States with hematocrit levels of 58 - 60% and departs to non-breeding areas in Mexico with levels of 54 - 55% (Morton 1994).

Lesser Elaenia might also not come from too far away, so it is possible that the population express different levels of hematocrit on arrival phase simply due to differences related to the effort of the distance traveled. Besides the distance, food resources and time of year can interfere with Neotropical migration effort and general bird migration (Rohwer *et al.* 2005). This relationship in the arrival phase is still unclear and may depend on the distance traveled, levels of water and mass loss during the trip. Future studies should investigate what is really happening in this population to answer if the connection of migration with its physiological condition, as presented here, is because it stops during migration, because it travels short distances to the breeding site, or due to other reasons.

Hematocrit values vary greatly among bird groups. Known avian hematocrit levels are derived primarily from the study of poultry, and provide reference values between 35–55% (Whittow 2000, Fair *et al.* 2007). In comparison, the values recorded in this study are high, especially considering that the Lesser Elaenia is a small tyrant flycatcher, with hematocrit levels of up to 62% during the departure phase. Other species of similar size and mass exhibit hematocrit levels of around 51–53.5%, such as the Lugre (*Carduelis spinus*) with 51%, the American Goldfinch (*Carduelis tristis*) with 53.5%, the Goldfinch (*Carduelis carduelis*) with 51%, the Yellow-rumped Warbler (*Dendroica coronata*) with 51.1%, the Eurasian Wren (*Troglodytes troglodytes*) with 53%, and 54% for the White-crowned Sparrow (Viscor & Fuster 1987, Morton 1994). Other hematocrit levels from wild birds are known to vary across groups and years, ranging from 44–48% in Cory's Shearwater (*Calonectris diomedera borealis*), 48% for the Red-tailed Hawk (*Buteo jamaicensis*) and 52% for the American Kestrel (*Falco sparverius*) (Hunter & Powers 1980). Despite the limited number of studies that have investigated hematocrit levels, it is becoming increasingly studied (Fair *et al.* 2007) and most of them support a positive relationship between hematocrit levels and bird mass. The relationship between hematocrit and body mass for Gray Catbird during the arrival phase, for example, was linear and negative, but in this species the hematocrit of migrants that arrived first was higher than migrants that arrived later (Hatch & Smith 2010, Hatch *et al.* 2010).

The Lesser Elaenia showed an uncommon pattern of body mass gain-loss during the analyzed period. In general, migratory birds can suffer a 26% reduction in mass during migration (Butler *et al.* 1998, Whittow 2000). The Least Flycatcher (*Empidonax minimus*), for example, is similar in size to the Lesser Elaenia, loses 0.30 g per day after arriving from migration, and over time, can gain 6–8% (0.05 g) of its mass per day while in residence at stop-over sites (Winker *et al.* 1992). Here, we show that body mass of the Lesser Elaenia decreases little during the reproductive period after arrival but increases again before departure to the non-breeding grounds. During the pre-departure period, adults that recently reproduced and juveniles require muscles associated with flight and the physiological machinery that supports aerobic activities for the return migration (Whittow 2000). Interestingly, it has been estimated that one week of weight gain may be necessary for one night of sustained flight during migration of a granivorous bird (Kendeigh *et al.* 1977). Muscle hypertrophy also occurs in Barnacle Goose (*Branta leucopsis*), resulting in a 1.1% increase in mass, and Snow Bunting (*Plectrophenax nivalis*) increases the muscle mass of the pectoral region before migration (Fry & Ferguson-Lees 1972, Marsh 1984). The Lesser Elaenia does not store much fat in preparation for migration, so most of its weight gain is probably associated with muscle hypertrophy and lean tissue gain (ZPP and MÂM *pers. obs.*).

The energetic cost of reproduction in birds is enormous and, as a result, they need to intake sufficient nutrients and energy reserves before egg formation, initiation of egg-laying and incubation. At the beginning of the reproductive phase, the hematocrit levels and body mass of Lesser Elaenia decrease. Females must form the eggs, which require large amounts of nutrients, especially lipids and proteins (Ankney & Alisauskas 1991). A relationship between sex hormones and hematocrit levels has been demonstrated for some species, with an elevation of androgens and estrogens, concomitant with a reduction of hematocrit levels (Rehder & Bird 1983). Both the energetic demands of reproduction and hormone levels could contribute to hematocrit reduction in the Lesser Elaenia during the reproductive phase. Moreover, hematocrit declines among certain bird species during the formation of egg yolk and before egg-laying, periods in which there is a reduction in blood volume that is associated with osmoregulatory adjustments for the formation of egg yolk precursors (Williams 2005, Fair *et al.* 2007, Navarro *et al.* 2007). For Great Tit (*Parus major*) the experimentally augmented clutch sizes influenced the condition of parents, with a decrease in leucocyte counts associated with reduced immunocompetence, increased hematocrit levels associated with greater muscular activity, and a reduction in mass (Hõrak *et al.* 1998).

With the scenario described in this study, the migration of the Lesser Elaenia perhaps demands more energy to maintain or improve body condition than reproduction does. This is also reinforced by another study with an immunological focus, which confirms that the immune status of this species changes more with migration than reproduction (Machado-Filho *et al.* 2010). Furthermore, immune conditions also seem to improve with better climatic conditions (Dubiec *et al.* 2005), so maybe this is the reason why the Lesser Elaenia has one of the shortest periods of occurrence in the reproductive area recorded for migratory neotropical flycatchers—about 132 days (Paiva & Marini 2013). This is approximately a four-month period and is the time necessary to adapt to climate (end of the drought and the beginning of the rainy season), breed and get physiologically prepared to migrate back to the wintering areas. Despite the short residence time, the species has a fecundity of 1.1 nestlings per female and produces 0.48 nestlings per nest in only 77 days (Medeiros & Marini 2007). However this seems to be their physiological limit, as their efficiency decreased with experimentally increased brood size (Sousa & Marini 2013). Thus, immunological and breeding data are in agreement with our results, with a diminished physiological condition during breeding, but higher values during arrival and principally in the departure phase.

We expected temporal changes in the relationship between hematocrit and mass in the Lesser Elaenia according to the requirements of reproduction in the *Cerrado*. However, we found a pattern whereby individuals arrived in relatively good condition, spent energy to breed, and were able to recover relatively quickly and depart to the wintering grounds. This study focused in that period, but it would be interesting to study other periods of the species' life cycle as well, when the bird departs to distinct places in nearby *Cerrado* areas and even far into Amazonia. Performance of capture-recapture studies of these birds in different migratory sites would also be interesting, as was done for the Common Tern (*Sterna hirundo*) in Brazil. At the Parque Nacional da Lagoa do Peixe in Rio Grande do Sul, the Common Tern also showed mass gain when individuals depart for breeding sites (Nascimento & Santos 2010).

Concluding Remarks

In the arrival phase, increase in average mass was also accompanied by increase in average hematocrit level. During the reproduction phase there was no relationship between these two variables. Finally, during the departure phase, an increase in mass was accompanied by an increase in hematocrit level. We found that this species undergoes changes in its mass and hematocrit level during its residence on the breeding grounds, but, as expected, in the reproductive phase there was no relationship between these two parameters. Nonetheless, these birds exhibit unique characteristics, such as arrival in very good condition and with enough time to adjust to the *Cerrado* climate in preparation for reproduction. This suggests that future studies should focus, for example, on how reproductive hormones (estradiol, luteinizing hormone, follicle stimulating hormone, prolactin, and others) influence hematocrit levels and body mass of this species at the onset of preparation for reproduction. The relationships we found suggest that increases in mass and hematocrit are tightly coupled during this phase of the lifecycle, demonstrating that the majority of individuals of the Lesser Elaenia preparing to depart to the non-breeding areas are in good physical condition.

ACKNOWLEDGEMENTS

We are grateful to CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) for the financial support. ZPP was supported by a fellowship from CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) and CNPq, and MÂM was supported by a research fellowship from CNPq. We are also grateful to Giane R. Paludo, Ludmilla M.S. Aguiar and Thalles S. Amaral for logistical support. We thank Matthew

Medeiros for criticizing a version of this manuscript and to CEMAVE and AEES for provided permits. All proceedings were approved by Brazilian National Center for Research and Conservation of Wild Birds (CEMAVE-SNA, #324625).

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Associate Editor: Marco Aurélio Pizo