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Sumário

Editorial

Iniciando mais um ano de publicações, com sua periodicidade rigorosamente em dia, o 19º volume da Revista Biociências traz aos seus leitores uma larga abrangência de assuntos das biociências em seus artigos. Entre os de ciências biológicas são tratadas as relações inseto-planta (mariposas e alamandas); plantas medicinais no Rio Grande do Sul; biologia de peixes marinhos na Bahia; acaricidas para parasitoses bovina; impacto do pisoteio de gado no solo; efeito mutagênico da poluição atmosférica em plantas bioindicadoras; uso de desinfetantes em parasitoses caninas e prática discente de biologia no ensino médio. Na área da saúde são apresentados os resultados da relação das queimadas no Pantanal Matogrossense nas doenças respiratórias, variação no tamanho corporal de passarinhos e epidemiologia de meningites em Minas Gerais. Desejamos a todos uma boa leitura!

Taubaté, 30 de junho de 2013
Simey Thury Vieira Fisch
Editora-chefe da Revista Biociências

Starting another year of publications, with its periodicity strictly up to date, the 19th volume of the "Revista Biociências" brings its readers a wide range of issues of biosciences in your articles. Among the biological sciences it was discussed the insect-plant relationships (moths and Alamandas); medicinal plants in Rio Grande do Sul; biology of marine fish in Bahia; acaricides to cattle parasites; use of disinfectants in canine parasites; impact of cattle trampling on soil; mutagenic effect of pollution atmospheric bioindicators and teaching practice of biology in high school. In the health area are presented results of the relationship between fires in Pantanal and respiratory diseases; variation in body size of birds and epidemiology of meningitis in Minas Gerais. We wish you all a good read!

Taubaté, June 30, 2013
Simey Thury Vieira Fisch
Editor-in-Chief of the journal Bioscience

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Allometric analysis of Rufous-collared Sparrow, *Zonotrichia capensis* Müller, 1776, living in two different climatic regions in the Southeast of Brazil

Analise alométrica do Tico-tico, *Zonotrichia capensis* Müller, 1776, residentes em duas diferentes regiões climáticas no sudeste do Brasil

Maria Cecília Barbosa Toledo [1]
Janaína Sant'Ana Maia [2]

Resumo

Espécies amplamente distribuídas geralmente apresentam variações intra-específicas devido a ajustes a diferentes condições climáticas. Dessa maneira, espera-se que raças de clima quente sejam menores que aquelas de clima frio. Portanto o objetivo desse estudo foi comparar a razão massa-superfície de indivíduos de *Zonotrichia capensis* residentes em duas condições climáticas diferentes em função da variação altitudinal. Para tanto, 44 indivíduos foram capturados, sendo 22 espécimens a 20m de altitude, em clima quente e úmido e outros 22 indivíduos a 1700m de altitude em clima sazonal frio com inverno seco e verão chuvoso. Foram obtidas medidas corporais, de massa (g), comprimento total (cm), comprimento da asa (cm) e as razões massa x comprimento total e massa x comprimento da asa. Os resultados mostraram que durante o inverno os indivíduos capturados em alta altitude foram significantemente mais leves e longos que aqueles capturados em baixa altitude . Dessa maneira, foi discutido como a sazonalidade, disponibilidade de alimento e diversidade de espécies pode interferir nas variações morfológicas intra-específicas.

Palavras-chave: variação de altitude, clima, massa corporal e superfície corporal, sazonalidade, *Zonotrichia capensis*

Abstract

Intraspecific variations are observed in widely distributed species due to adjustments to different climate conditions. In this way, warm climate races are expected to be smaller than cold climate ones. Therefore, the main goal of this study was to compare the mass-surface ratio of *Zonotrichia capensis* in two different climate conditions due to altitudinal variation. Forty-four individuals were measured, being 22 specimens at 20 m of altitude in warm and humid climate and 22 specimens at 1,700m of altitude in seasonal climate of dry winter and rainy summer. Body measures used were mass, *total length*, *wing length*, mass/*total length* ratio, and mass/*wing length* ratio. Results showed that only in the winter time individuals living in high altitudes were significantly lighter and longer than those living in lower altitudes. Results were discussed as to seasonality, availability of food, and species diversity to interfere in the intraspecific morphologic variations.

Keywords: altitudinal variation, climate, *body mass* and body surface, seasonality, *Zonotrichia capensis*

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Introduction

In widely geographically distributed species, morphological variations are expected due to adjustments to different climate conditions. In geographic regions whose temperatures are colder or warmer, maintenance of body temperature requires an increase in metabolic activity according to the need for gaining or losing heat (GILL, 1994).

Metabolic heat must be lost in the same rate it is produced, thus keeping the thermal equilibrium in warm-blooded organisms. The organism keeps its thermal equilibrium in relation to the environment through the processes of heat conduction, radiation and evaporation (SCHMIDT-NIELSEN, 2002). In other words, when the ambient temperature is lower than the body temperature, the organism tends to lose heat to the environment through radiation and conduction, and when the ambient temperature exceeds body temperature, the organism tends gains heat from the ambient through the same processes. Therefore, animals living in cold regions need to store energy (metabolic heat), which favors large body size and lower surface, whereas animals living in warm regions need to release metabolic heat plus ambient heat gain through evaporative heat loss, which favors small body size in relation to the body surface (MCNAB, 1979).

Currently, it is known that not only temperature, but other climate variables such as rainfall, amount of infrared radiation from the atmosphere and the soil, and wind speed influence the balance between body mass and heat conservation (JAMES, 1970; PORTER, et al., 2000; WHITE, et al., 2007). Therefore, the climate directly affects the survival of the individual through the heat balance/metabolic cost dichotomy, and each species interacts in a particular way with the climate variables. In tropical regions, high humidity of the air, abundance of food and climate variations in relatively short periods of time favor other systems besides mass/surface ratio for maintenance of thermal equilibrium by endothermic organisms. A study carried out with three Trochilidae species of a tropical region showed that there was a change in their body temperatures due to the ambient temperature, the hummingbirds seeking a thermoneutral state and the consequent metabolic energy saving (BECH, et al., 1997). Another hypothesis is that organisms in more seasonal environments have a larger body size because they store energy for the periods when heat conservation is necessary (LINDSTET and BOYCE, 1985).

However, some authors question size variation as being just a response to abiotic factors, since the habitat's resource availability and interspecific competition may also affect the size of individuals (ASHTON, 2001; McNAB, 1971; BLACKBURN and GASTON, 1996; YOM-TOV, 1999). This theory is especially true as to latitudinal variations. In other words, species are larger towards the North Hemisphere (BERGMANN, 1947; AHSTON, 2002) where species' productivity and richness are smaller. In this sense, there is also evidence that the size of birds increases with altitude (JAMES, 1970). Blackburn and Ruggiero (2001), for example, worked with both endemic and non-endemic birds in different latitudes and altitudes in the Andes Mountains and they say that the birds' body size variation in relation to altitude will vary according to altitudinal range and the place where studies are carried out. In the tropics, increased altitudes tend to cause lower temperature and humidity, more seasonality and increased radiation through a lower cloud formation (JANZEN, 1967; KÖRNER, 2007). Therefore, altitude has a direct effect in the climate, originating relatively narrow zones of distinct climates, establishing space variability in topography and vegetation, which results in community stratification. This environmental variability, in turn, creates opportunities for different functional sizes of individuals, which interact in a specific and particular manner with the climate variation (PORTER, et al., 2000).

Based on the hypothesis that widely distributed species shows a plasticity that allows morphometric changes, thus enabling individuals to adjustment in different climate zones (GILL, 1994). In this way, the main goal of this study was to test the intraspecific mass and surface variation in rufous-collared sparrow (*Zonotrichia capensis*) individuals living at 20 and 1,700 meters of altitude.

Materials and Methods

The rufous-collared sparrow *Zonotrichia capensis* is one of the most common species in the Southeast of Brazil; attain 15 cm long on average. It inhabits open fields, crops, farms, gardens and less urban areas. It is abundant from mountainous regions like Serra da Mantiqueira and Serra do Mar to the sea level of Brazilian Southeast (SICK, 1997).

For this study, *Z. capensis* individuals were captured at Serra da Mantiqueira, in the municipality of Campos do Jordão, and next to the sea level, in the municipality of Ubatuba. Campos do Jordão (22º44' S, 45º35' W) is located at 1,800 m of altitude and, according to the Köeppen classification. The predominant climate is temperate climate with dry winters, mesothermal and humid (CWb). In this region, annual precipitation is 2,000 mm, with less humid months from April to September and excessively rainy months from October to March, when 73% of all precipitation takes place. The coldest month is July, with mean temperature of 8.9°C and minimum temperature of minus 7.2°C. The warmest month is predominantly February, whose mean temperature is 17.7°C, with maximum temperature of 27.2°C (SEIBERT, et al., 1975).

The municipality of Ubatuba (23º18' S, 44º51' W) stands at 20m of altitude. Its climate, according to Köppen, is tropical rainforest with showers all year long (Af). The annual average precipitation and temperature recorded are around 2,624 mm and 21.9°C, respectively. The months with the highest and lowest rainfall, are January (376 mm) and June (87.9 mm), whereas February is the warmest (30.4°C) and July the coldest (12.6°C). The climate information at sea level were provided by the Climatology Section of the Campinas Agronomic Institute (IAC) and collected at the Ubatuba Experimental Station, in the State of São Paulo.

Adult individuals were captured and analyzed at each study site using 12 m long by 4 m wide mist nets. The nets were set in the morning and afternoon during the times the birds were active, and were inspected every 20 minutes to remove captured birds. The collection period lasted three months in 1997, taking place in the coldest months of the year (May, June and July), and in the end of 1997 and beginning of 1998 new collections were made during the warmest months of the year (December, January and February).

Young and female individuals were excluded from the sample. The sex was determined by chromosome count from the blood feather. The measures analyzed were: *body mass*, using a precision balance (0.001g), and *total length* and *wing*

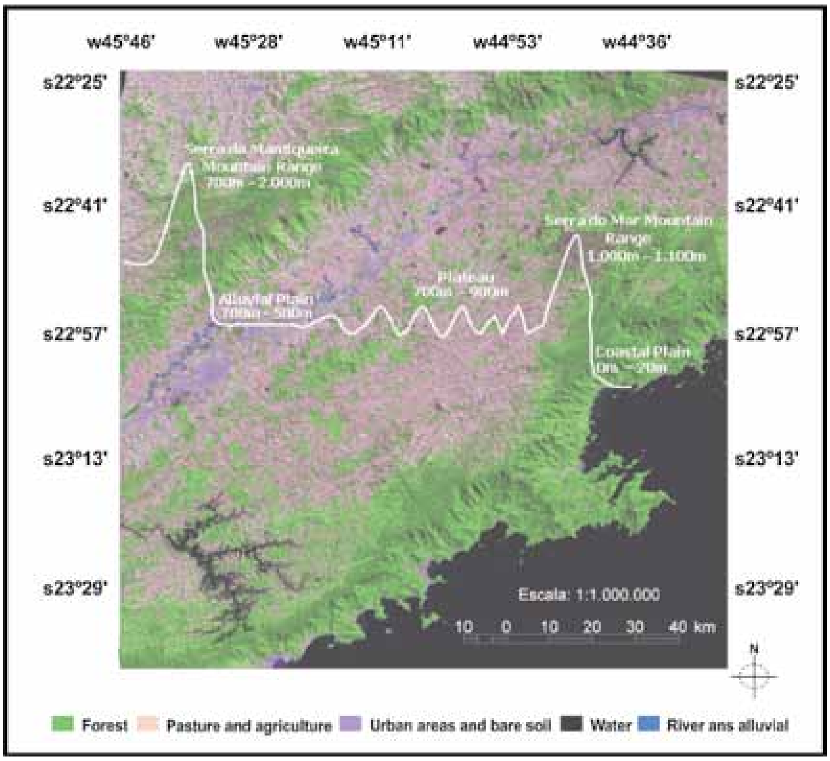


Figure 1: Satellite image of Vale do Paraiba, Serra da Mantiqueira and Serra do Mar, State of São Paulo. The region's altitude was drawn on the image.

length, with a vernier calliper (0.1cm nearest), being the last two used as surface measures. The *body mass* index (BMI) was established by dividing the mass by the surface. In order to calculate the BMI, the *total length* and the *wing length* were used separately.

The *total length* was measured from the tip of the beak to the distal end of the rectrices, the bird being spread, and the *wing length* – from the bend of the wing to the end of the longest primary (p8), in a closed and natural position. In order to avoid bias in the measurement, only one researcher carried out the measurements with 15 repetitions per each individual, alternating measurements between right and left wings. The birds were weighed 15 times to define the weight variation in function of the bird flouncing inside the bag. After the measurement, the individuals were marked with simple unnumbered leg rings to prevent the same individual from being measured more than once.

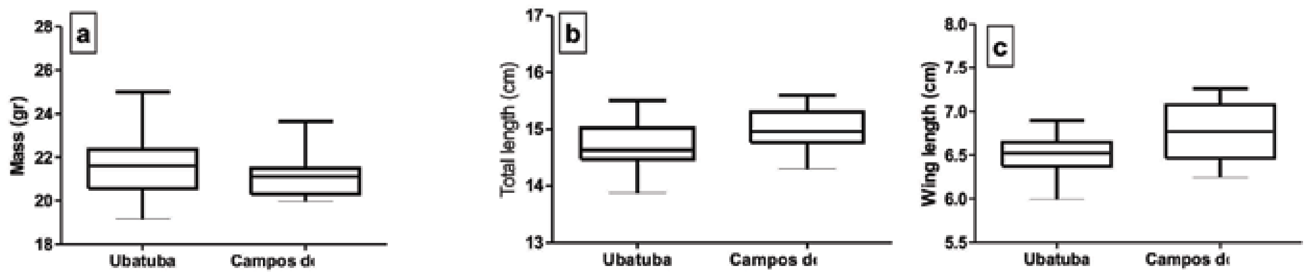
Data analysis started by the test for normality of the following variables: mass, *wing length* and *total length*. Results obtained showed that all data sets presented normal distribution for the Shapiro-Wilk Test. Parametric tests (t Test) were used to compare means and linear regression to define the behavior of variables in relation to mass (g), *total length* (cm) and *wing length* (cm).

Results

Body mass: In general, *body mass* not showed significant differences in among altitudes. However was observed a tendency to mean mass value higher for individuals living at 20 m of altitude (21.70±1.40cm) than at 1,700 m (21.22±1.0 cm) but these values were not significantly different (t = 1.36, gl = 21; p = 0.18) (Figure 2a). The intervals between maximum and minimum values were larger at 1,700 m, comprising 5.9 cm (min = 19.1 g and max = 25.0 g) than at 20 m, comprising 3.68 cm (min = 19.98 g and max = 23.66 g).

Total length: the mean value for individuals living at sea level was 14.7±0.41 cm and at 1,700 m of altitude was 15±0.38 cm. The sample populations were statistically different (t = 2.105, gl = 21; p = 0.048) (Figure 2b). The range between maximum and minimum values was 5.85 cm at 20 m (min = 19.16 g and max = 25.01), and 3.68 cm at 1,700 m (min = 19.98 g and max = 23.66 g).

Wing length: The wing measures were smaller for the group captured at 20 m of altitude (6.52±0.23 cm) than for those captured at 1,700 m (6.77±0.32 cm), being this difference statistically significant (t = 2.98; gl = 21; p = 0.007) (Figure 2c). The range between maximum and minimum values was 0.9 cm at 20 m (min = 5.99 cm and max = 6.89 cm), and



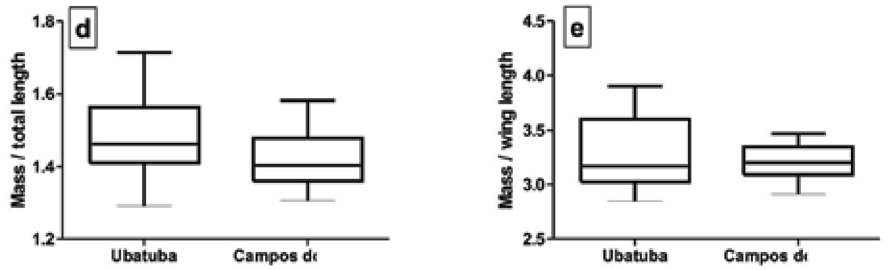


Figure 2: Mean, maximum and minimum values, and standard deviation of mass (a), *total length* (b), *wing length* (c), *total length* vs. mass (d), and *wing length* vs. mass (e) of *Zonotrichia capensis* individuals living at 20 m and 1,700 m of altitude in the Northeastern area of the State of São Paulo.

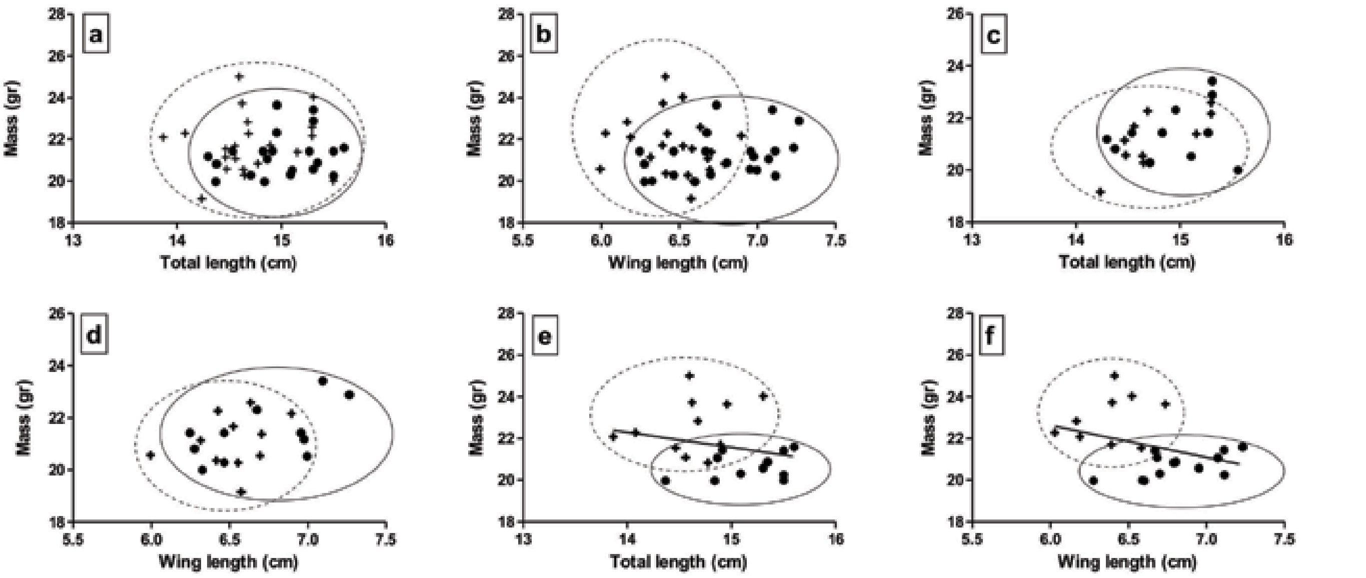


Figure 3: Distribution of mass/*total length* and mass/*wing length* values for individuals captured at 20 m of altitude (+) and at 1,700 m of altitude (●), being (a) *total length* vs. mass, (b) *wing length* vs. mass, (c) *total length* vs. mass in the summer, (d) *wing length* vs. mass in the summer, (e) *total length* vs. mass in the winter, and (f) *wing length* vs. mass in the winter. The bigger circles gather the sets of values obtained at 20 m (broken line) and at 1,700 m (solid line) of altitude.

1.02 cm at 1,700 m (min = 6.24 com and max = 7.26 cm).

BMI (*total length and wing length versus mass*): For the ratio *total length* x mass, the individuals captured at low altitude showed lower values (1.48±0.09) than the individuals captured at high altitude (1.42±0.07), being significantly different (t = 2.267, gl = 20; p = 0.034) (Figure 2d). The results of the ratio *wing length* x mass were not different between the two locations (t = 0.78, gl = 21; p = 0.43), the mean value for individuals captured at 20 m of altitude being lower (3.27±0.31) than for individuals captured at 1,700 m of altitude (3.22±0.15) (Figure 2e).

The mass/*total length* and mass/*wing length* ratios of individuals measured in the six months of capture (n = 44) did not evidence any significant behavior (figures 3a and 3b). However, the mass/*wing length* ratio showed a slight separation between the groups, being the cold climate individuals lighter and longer than the warm climate ones. When analyzing the mass/surface ratio by season (n = 22), the mass/*total length* ratio (r^2 = 0.21; p= 0.03) and mass/*wing length* ratio (r^2 = 0.22; p= 0.02) in the summer were positively correlated regardless of the capture site. The results showed an opposite relationship in the warm season as to mass/*total length* (r^2 = 0.12; p = 0,043) and mass/*wing length* (r^2 = 0.23; 0.01) values, showing weight loss in cold climate individuals (Figures 3e and 3f).

Discussion

There is evidence that body size variations provide some physiological advantages such as acclimatization (JAMES, 1970; GILL, 1994; DAWSON and WHITTOW, 2000). Results show that (1) there was no difference in mass between two sets of *Z. capensis* individuals; (2) mass variation was evident, when analyzing variation by season, when the individuals living in high altitude were lighter during the winter. A survival strategy observed in species living in cold regions is the storage of energy, increasing *body mass* for the periods of food shortage (EVANS, 1969; KLAASSEN, et al., 2004). The diet of *Z. capensis* consists of 80% of seeds, which are scarce especially during winter time, complemented with insects (NOVOA, et al., 1996) in periods of food shortage. In this way, a weight loss is expected for the individuals of Campos do Jordão during winter time, when both seeds and insects are scarce. However, this type of adaptive regulation may vary greatly according to food availability (WITTER, et al., 1995). We believe weight variation in individuals living in the most seasonal climate was a response to higher energy expenditure in colder days.

Among birds of temperate regions, the adjustment in basal metabolic rates has been documented, some species presenting high metabolic rate in the winter as compared to the summer (COOPER and SWANSON, 1994; DOWSON and WHITTOW, 2000). In this sense, Williams and Tieleman (2000) conducted a study in which the basal metabolic rates of (greater) Hoopoe-lark (*Alaemon alaudipes*) at 15ºC was 46.8 kJ/day and at 36ºC was 32.9 kJ/day, the intake of food of individuals also increasing at 15ºC. Therefore, the energy expenditure to keep body temperature in cold periods and with lower food availability may lead to decrease in mass, which can explain the mass loss in individuals living at 1,700 m of altitude in the winter time.

Other important avenue to discuss variation in *body mass* of an organism is the relation between predation risk and lack of food (LIMA, 1986). In the event of predation risk, smaller body size is preferred for being less conspicuous to the predator and more agile to escape, as opposed to fatter birds that become less agile and, consequently, more conspicuous (CRESSWELL, 1998). During winter the greater part of the trees loses the leaves and the birds become more susceptible to predators, thus slimmer individuals can realized faster scape maneuvers.

To *total length* and *wing length* the results showed that (1) the two groups of individuals were significantly different, the cold climate individuals being longer than the warm climate ones; (2) the difference in *wing length* was more outstanding than the *total length*. As for *wing length*, our results corroborate those obtained in a variation in altitudinal gradient in the Andes where the wings of individuals captured in high altitudes were significantly larger (HANDFORD, 1983; LOUGHEED and HANDFORD, 1993). The discussion about morphological characters variation at population level has evidenced three distinct groups that differ in their approaches: physiological, according to adjustments to energy conservation (MALDONATO, et al., 2009; HAMILTON. 1961), evolutionists (JAMES, 1970), and ecological (YOM-TOV, 1999, YOM-TOV, et al., 2006). Therefore, a discussion about the advantages of a larger wing in individuals living at higher altitudes may be related to a higher effectiveness in the flight, leading to energy saving in a region where the air is more rarefied and food is seasonal. According to Yom-Tov (2006), the type of habitat also tends to define functional morphological variations, especially in *wing length*. *Z. capensis* individuals living at the sea level where habitat is basically a forested one, with few open areas, do not need so much flying effort as those living in high altitudes where fields are more prevalent. Surface variation may also be associated to evaporative heat loss (SCHMIDT-NIELSEN, 2002). Weathers (1997) studied heat production and evaporative heat loss in 13 Sporophila minuta (Emberezidae) individuals in the region of Panama, and results showed that evaporative heat loss was directly and positively related to atmospheric temperature. In other words, birds living in warm areas would have a smaller surface to decrease heat loss through evaporation, conduction and radiation. James (1970) comments that the environment's influence on thermal equilibrium of the organism and can be represented by mean temperature of the dry bulb and vapor pressure. Therefore, there could be a tendency to an optimal body size, i.e., lower values in mass and *wing length* and a higher value of heat conduction are expected in a warm and humid climate.

The results to *BMI* (*total length* and *wing length*) showed that (1) both groups were significantly different, the warm climate group obtaining higher values of *BMI* than the cold climate one; (2) the difference was greater in the winter time, when cold climate individuals lost mass. According to James (1970) and White et al. (2007), mass vs. surface is not only related to temperature, but also to atmospheric humidity. This combination can lead to intraspecific variations, where warm and humid climate individuals are favored by smaller sizes and cold and dry climate ones by larger sizes. The *body mass* index was higher (mass / smaller surface = 32/2 = 16) in the individuals captured in warm and humid regions, and may be associated to greater food availability along the year and higher heat production to establish a thermoneutral condition, in which evaporative water loss decreases (BECH, et al., 1997; WEATHERS and GREENE, 1998; WHITE, et al., 2007). In contrast, individuals captured in the cold climate region showed a lower *BMI* (mass / larger surface = 32/4 = 4), which can be explained by a higher energy expenditure in low temperature periods and by the fact that a larger surface would help them get external heat through solar energy, as well as atmospheric and soil heat (PORTER, et al., 2000). Such variations showed a very strong genetic structure, according to Cheviron and Brumfield (2009), who carried out an analysis of mitochondrial haplotypes that showed two distinct populations of *Z. capensis* along an altitudinal gradient in the Andes. *Zonotrichia capensis* shows a wide geographical distribution favored by a high genetic plasticity (CHEVIRON, et al., 2008), and is subject to a strong directional selection pressure along different altitudinal/climate ranges from the decrease in gene flow, thus improving the performance of individuals adapted to distinct climates. Our results showed that there is variation in the body size of *Z. capensis* living in distinct climate areas in the Brazilian Atlantic coastal region, and that these variations help the acclimatization of individuals, widening the geographical distribution of the species.

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