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How do seasonality and host traits influence the distribution patterns of parasites on juveniles and adults of *Columba livia*?

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ABSTRACT

Parasites may influence host fitness and consequently exert a selective pressure on distinct phenotypes of the host population. This pressure can result in an evolutionary response, maintaining only individuals with certain traits in the population. The present study was aimed at identifying the morphological characteristics of juveniles and adults of *Columba livia* that may influence the distribution patterns of lice, *Pseudolynchia canariensis* and *Haemoproteus columbae* and how the populations of these parasites vary throughout the seasons of the year. Between July 2012 and July 2014, 377 specimens of *C. livia* were captured. We observed a significant increase in the mean intensities of infestation by pigeon flies and lice, as well as in species richness of ectoparasites during the warmest seasons, suggesting a reproductive synchrony between ectoparasites and host species. Bill length, body mass, and body length did not affect the infestation levels of ectoparasites on adults and juveniles of *C. livia* with three distinct plumage colors. In juveniles, plumage color affected only the mean intensity of infestation by lice, with Spread individuals as the most infested. This indicates that melanin in feathers was not an effective barrier against ectoparasites.

1. Introduction

Parasitism, similar to predation and competition, is an important selective force on populations, as it reduces the energy available to physiological processes of their hosts (Loye and Carrol, 1995; Sorci et al., 1996). In birds, feathers form a complex environment that allow the occurrence of many groups of arthropod ectoparasites (Janovy, 1997). Ectoparasitism on birds is determined by different factors, including biological aspects, such as susceptibility, and ecological components that include social, reproductive, and foraging behaviors (Begon et al., 1990; Marini et al., 1996; Heeb et al., 2000).

Parasites, in general, affect the fitness (reproductive capacity) (Clayton, 1990) and survival (Clayton et al., 1999) of their hosts. Parasitism levels in animal populations involve a delicate relationship between host immunity and life history traits (Dawson and Bortolotti, 2000; Sol et al., 2003). They are influenced by the abundance and transmission efficiency of vectors (Bennet and Cameron, 1974; Dufva, 1996), as well as by the susceptibility and physiology of the host species (Applegate, 1970; Bennet and Cameron, 1974) and may vary in time in the host population (Atkinson, 1988; Weatherhead and Bennett, 1991) and geographically (Tella et al., 1999; Moyer et al., 2002). Within a host population (;), parasitism levels may also vary causing in some cases, a decrease in the survival rates of individuals of a certain age (Bennet and Cameron, 1974; Merino and Potti, 1995; Waldenström et al., 2002; Sol et al., 2003). Thus, parasites may exert a selective pressure on distinct phenotypes of the host population that in turn can respond in an attempt to control parasite populations (Haldane, 1949).

Host morphological traits may also influence parasite diversity. For instance, host body size may determine how much resources can be exploited by ectoparasites, as well as the number of available niches. Studies have demonstrated a positive relationship between host body size and parasite richness (Poulin, 1997), as well as parasite abundance (Poulin and Rohde, 1997).

Some studies have reported that many parasite groups synchronize

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their reproduction with that of their host species (Marshall, 1981). According to Foster (1969), this synchronization is the result of a close coevolutionary relationship that favors the colonization of new hosts. For some groups with limited mobility, such as mites (Acari) (Jovani et al., 2001) and lice (Insecta: Phthiraptera) (Johnson and Clayton, 2003), this reproductive synchronization is very important, since dispersion and consequently colonization of new habitats occurs only by direct contact among hosts (Marshall, 1981) or in some cases, by phoresy (Jovani et al., 2001). Because of this synchronization between the reproduction of ectoparasites and hosts, spring and summer are expected to be the periods with the highest infestation rates by lice and Pigeon fly *Pseudolynchia canariensis* Macquart, 1840 (Diptera: Hippoboscidae). Also, juveniles hosts are expected to have higher infestation levels by *P. canariensis* due to their close proximity with pupae and low efficiency in the control of ectoparasites when compared to adults.

Recent studies have demonstrated that the health condition of some bird species may be assessed based on the color of feathers. Bird coloration is a result of the physical structure of feathers or the pigments in them (Gill, 1995). This pigmentation has several functions, such as camouflage, thermoregulation, and inter and intraspecific communication (Savalli, 1995). In the last decade, the first studies on the effect of plumage colors of birds on ectoparasites were conducted. Kose et al. (1999) reported that *Machaerilaemus malleus* Burmeister, 1838 (Amblycera: Menoponidae), a louse that parasites *Hirundo rustica* Linnaeus, 1758 (Aves: Hirundinidae), remained significantly longer on white feathers of their hosts than black ones. A few years earlier, Møller (1991) found that the quantity of lesions on white feathers on this host bird caused by the same species of louse was higher than on black feathers. These results support the hypothesis that the melanin present in the feathers of birds may be considered a protection against lice, by making feathers more resistant. Ducrest et al. (2008) demonstrated that some of the genes that express melanin pigmentation have pleiotropic effects on the expression of other physiological processes in several taxa, in particular immunological functions. This suggests that the amount of melanin present in hair or feathers of animals may be an adaptation directly associated to environmental variables (Roulin, 2004), including parasitism (Gasparini et al., 2011).

The wide range of coloration in *Columba livia* Gmelin, 1789 (Aves: Columbidae) resulted from the artificial selection of domestic stocks makes this species an ideal model for studies on the influence of plumage colors on ectoparasites. This species has a gradient of melanin-based colors (Johnston and Janiga, 1995), which can be easily distinguished by the human eye. These various types of plumage colors are genetically determined (Johnston and Janiga, 1995; Jacquin et al., 2013) but are also associated with variables such as behavior, reproductive rate, and resistance to parasites (Johnson and Johnston, 1989; Jacquin et al., 2011). Interestingly, previous studies have shown a relationship between urbanization level and frequency of melanic morphotypes, with darker individuals as the most abundant (Johnston and Janiga, 1995; Obukhova, 2011). Thus, we hypothesize that these individuals have higher immune response (Jacquin et al., 2011) and lower parasite load when compared to individuals with other plumage colors.

Based on this information, this study was aimed at examining the seasonal variation of the richness and abundance of lice, *P. canariensis* and *Haemoproteus columbae* Kruze, 1890 in juvenile and adult specimens of *C. livia* of three distinct plumage colors.

2. Material and methods

Specimens of *C. livia* were classified into three distinct types of plumage colors according to Johnston and Janiga, (1995): (1) “Wild-type” – gray-bluish specimens with two dark blue stripes on wings; (2) “Checker” – individuals with several triangular-shaped dark spots, and (3) “Spread” – black or almost entirely black specimens (Fig. 1). These plumage colors do not differ between sexes and can be identified from the sixth week of life of birds (Johnston and Janiga, 1995).

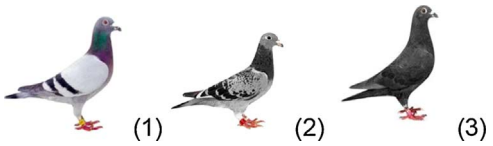

Fig. 1. Wild-type (1), Checker (2), and Spread (3) plumage colors in juvenile and adult specimens of *Columba livia* captured between July 2012 and July 2014 in the municipality of Pelotas, RS, Brazil. *Columba livia* figures:.
(1) https://br.pinterest.com/pin/30188259975188920/https://br.pinterest.com/pin/30188259975188920/
(2) http://www.theoweytjens.be/kuypers-240.htmlhttp://www.theoweytjens.be/kuypers-240.html
(3) https://br.pinterest.com/pin/30188259975188920/https://br.pinterest.com/pin/30188259975188920/

2.1. Study site

Specimens of *C. livia* were collected between July 2012 and July 2014 in three distinct sites in the municipality of Pelotas, in southernmost Rio Grande do Sul – storage sheds in the Port of Pelotas (31°46′55”S; 52°20′01”O), the facade of the Grande Hotel (31°46′55”S; 52°20′01”O), and inside the old building of the Finance Department of the city of Pelotas (31°46′13”S; 52°20′31”O). The city is located in the Coastal Plain, a geomorphological region located at the banks of the São Gonçalo Channel, a navigable waterway linking the Patos and Mirim Lagoons, the largest lagoons in Brazil. Its population is approximately 330,000 inhabitants, with an area of 1609 km^2 (Instituto Brasileiro de Geografia e Estatística-IBGE, 2010). The city is inserted in the Pampas Biome, in the Pioneiras Formation (vegetation associated with fluvial and/or lacustrine environments) and receives the influence of the semideciduous seasonal forest to the west (Instituto Brasileiro de Geografia e Estatística-IBGE, 1986).

The climate of southern Rio Grande do Sul is moist temperate, according to the classification proposed by Maluf (2000). The mean annual temperature in the urban area of Pelotas is 17.5 °C and the average annual rainfall is 1405 mm, evenly distributed throughout the year (Maluf, 2000).

2.2. Data collection

In the three study sites, a three-day field trip was carried out per season, with sampling activities starting at 08:00 and ending at 18:00. Adult individuals of *C. livia* were captured with the aid of mist nets, while juveniles individuals were captured by hand, since they were located on or near the nests (Permit SISBIO # 38447-1).

Each captured bird was individually placed in cotton bags until the collection of ectoparasites. First, *P. canariensis* specimens were collected manually by inspecting the feathers of each host bird. With the aid of forceps, flies were individually placed in Eppendorf microtubes with 70% alcohol, and later identified with the aid of a stereo-microscope, according to Bequaert (1955) and Graciolli and Carvalho (2003)

After the collection of hippoboscid flies, lice were collected by dust-ruffling (Walther and Clayton, 1997). A pyrethroid composed of 0.25 g of permethrin, 2.5 g of precipitated sulfur, and excipient q. s. P. 100.0 g (Piolhaves – ProvetS Simões Laboratory Ltda.) was applied in between the feathers of each bird. Lice of each bird were placed in plastic containers with 70% alcohol, mounted in permanent preparations, following Palma (1978), and identified according to Price et al. (2003) and Adams et al. (2005).

To avoid the contamination of samples, the materials used to remove and collect ectoparasites, such as brushes and tweezers, were washed in running water after each use. The surface used to collect lice, consisted of a 50 cm x 30 cm tissue paper sheet, placed under each captured specimen was discarded after use. Each captured specimen of *C. livia* was tagged with colored rings to maintain the independence of ectoparasite samples.