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ARTICLE

Comparative population densities of three species of doves (Columbidae) in disturbed landscapes in Northern Paraná State, Brazil

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ABSTRACT: Assessments of population density and contact number of individuals of the Eared Dove *Zenaida auriculata* were conducted in areas of the city of Londrina and were compared with those of two other species of the family Columbidae (*Columbina talpacoti* and *C. picui*). Data were collected from distance sampling in linear transects of 2,000 m. Analyses of density were calculated using the program DISTANCE. The results show that *C. talpacoti* and *C. picui* were recorded in all months in urban areas, and less frequently in rural and pasture areas. *Zenaida auriculata* was the most frequently recorded species in all areas, showing high rates of population density with seasonal variations; density peaks were observed during September and January in the urban area (coinciding with the arrival of warmer days in the region), while in rural areas, density peaks were also recorded during November/December, March and April/May — periods in which planting of soybean and maize, and the soybean harvest, and wheat planting in the region, occurred, respectively. The density of *Z. auriculata* during these months showed a value that was 93 times greater in November/December and 75 times greater in April/May, compared to the density in the other months of the year. Although *Z. auriculata* was considered uncommon a few decades ago, we suggest that the removal of the original forest and the expansion of agriculture in the region have provided a large amount of seeds in the environment, which might favor the increased density of *Z. auriculata* in the region. The high rate of population density achieved by the Eared Dove suggests that the species has found a favorable environment in the region. This includes the ease of obtaining resources, suitable sites for nesting, reproductive success and possible adaptive factors, such as the opportunist movement in search of distant food sources.

KEY-WORDS: *Columbina picui*, *Columbina talpacoti*, distance sampling, urbanization, *Zenaida auriculata.*

INTRODUCTION

Most Brazilian species of doves (Columbidae) inhabit the countryside and benefit from deforestation and the expansion of agricultural crops. This is true for the Ruddy Ground Dove, *Columbina talpacoti* (Temminck, 1811) and the Picui Ground Dove, *C. picui* (Temminck, 1813) (Sick 1997). *Columbina talpacoti* is also adapted to habitats altered by man and is generally found in all places where land is cultivated, roads, fields, parks and backyards (Carvalho 1957). *Columbina picui* inhabits natural open areas, and also occurs in rural areas and its distribution might be expanding, due to the alteration of natural areas and the creation of pastures (Andrade 1997, Sick 1997, Blamires 2002). Another species that is favored by the expansion of crops is the Eared Dove, *Zenaida auriculata* (Des Murs, 1847), which inhabits fields, cultured areas, pasture, and urban areas, with a naturally wide distribution in Brazil (Sick 1997, Souza *et al.* 2007).

These three species have similar ecological characteristics, such as diet composed primarily of seeds (Baptista *et al.* 1997) and the type of habitat they occupy. However, large quantities of seeds available in the environment have favored the population growth of *Z. auriculata* in regions of Argentina, Colombia, Uruguay, Bolivia and Brazil (Bucher & Ranvaud 2006). In the Brazilian states of São Paulo and Paraná, this species is considered a serious pest of germinating soybeans (Brannstrom 2003).

Columbina talpacoti, C. picui, and Z. auriculata are well adapted to anthropogenic environments and were considered common all year round in studies performed in the city of Londrina (Paraná State) by Westcott *et al.* (2002) and Lopes & Anjos (2006). Although it was uncommon for several decades, *Z. auriculata* is currently considered as possibly the most abundant species in rural and urban areas of Londrina (Lopes & Anjos 2006). Agricultural areas, combined with the mosaic formed in the fragmented landscape, provide a favorable environment for *Z. auriculata* individuals, including suitable sites for foraging, shelter and nesting. *Zenaida auriculata* has found possible sites of refuge and nesting in the urban area of Londrina (Lopes 2006).

Estimates of the number of individuals of *Z. auriculata* in the Londrina region are important to determine its abundance in different areas of the city. This could indicate the types of landscape where the species is more frequent in the region. Therefore, we assessed the population density of this species in three distinct areas located in Londrina, and compared it with that of the two other sympatric dove species with similar habits: *C. talpacoti* and *C. picui*. Additionally, we tried to document temporal changes in the number of contacts of these three dove species.

MATERIALS AND METHODS

Study area

The region of Londrina is located in the northern state of Paraná and currently is covered by only 7% of its original vegetation (Fundação SOS Mata Atlântica & INPE 2009), consisting of several Atlantic Forest fragments relatively isolated from each other. The main causes of deforestation in the region have been the commercial exploitation of wood and the implementation of agriculture (Santos-Filho 1980), particularly grain production. The cultivation of maize, wheat, and soybean during the year contributes to the ranking of Paraná state as one of the largest producers of these grains in Brazil (IBGE 2010).

Londrina has a mean annual temperature of 21ºC and mean rainfall of about 1,600 mm per year. December is considered the rainiest month, with a mean rainfall of 233 mm and August is the driest month with 52 mm (Soares-Silva & Barroso 1992). For this study, we selected three distinct areas (Figure 1) located within the municipality of Londrina. Area 1 is an urban area located in the southern part of the city (periphery), containing houses, empty lots, paved roads, afforestation and gardens; area 2 is characterized as a rural area formed by plantations, the edge of secondary forest, and built-up areas; and finally, area 3 is a pasture area with grasses, regenerating forest, secondary forest edge, and built areas (Figure 1).

Field procedures

Censuses were conducted between August 2011 and July 2012. We established a transect of 2,000 m at each sampling area and adopted the method of transect census proposed by Bibby *et al.* (1992), in which the observer walks the transect with low and constant speed to record all visual and aural contacts with species. When a species was detected, its perpendicular distance to the transect was estimated. Marks were established in these areas to facilitate distance calculations.

Samplings started at sun-rise and each transect was walked twice-monthly to obtain a replicate sample each month. Each sampling area was censused 24 times over the 12-months long study.

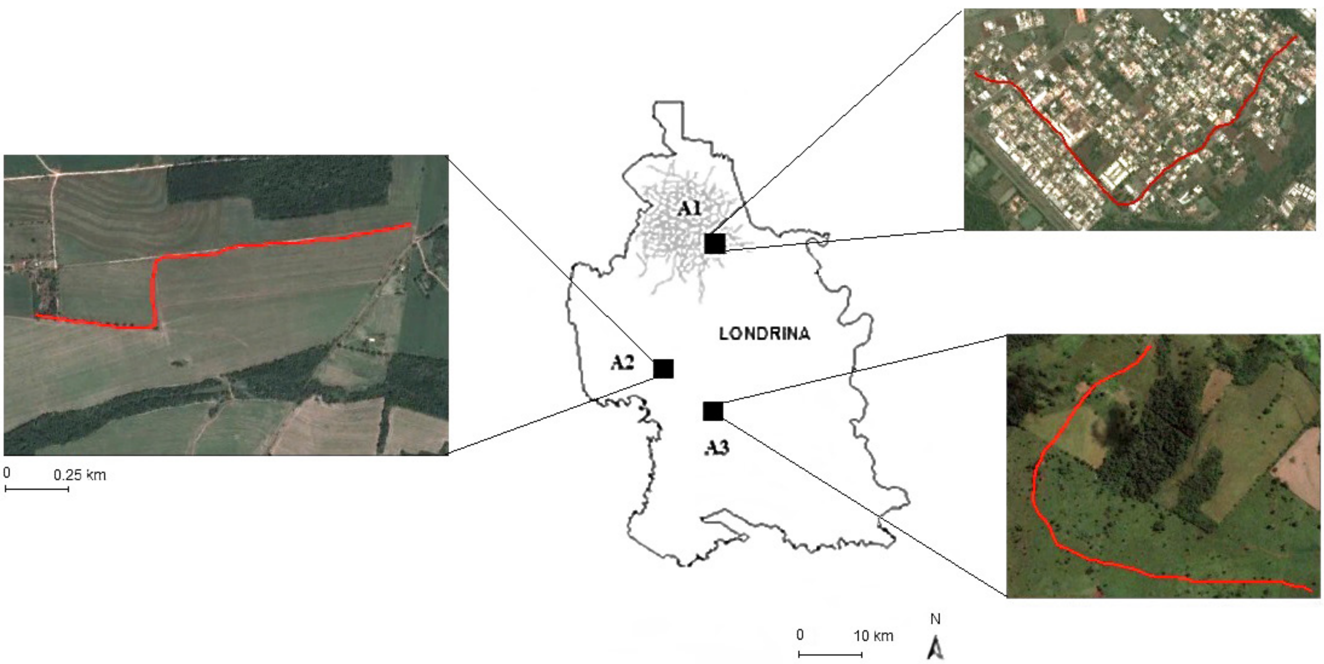

FIGURE 1. Map of the city of Londrina with the location and satellite images of transects in the three study areas. A1 – urban area (23º20'51.44"S and 51º10'01.63"W; 23°20'41.10'S and 51º09'12.90"W); A2 – rural area (23º25'40.25"S and 51º14'52.49"W; 23º25'20.15"S and 51º13'56.31"W); and A3 – pasture area (23°28'59.38"S and 51°14'38.03"W; 23°29'12.53"S and 51°14'00.10"W).

Data Analysis

Distance samplings were analyzed with the software DISTANCE version 6.0 (Thomas *et al.* 2009), based on the detection function g(x) for obtaining density values (D). The analyses used a detection model that allowed the extrapolation of the collected data for the region of study (Thomas *et al.* 2010). To ensure the validity of these analyses, three premises were assumed, following Buckland *et al.* (1993): 1) all individuals present along the transects were detected; 2) detections were made before evasive movements of individuals; and 3) the distances were estimated accurately. The data were modeled by "key function half-normal" followed by the "cosine" adjustments. The model that best represented the data analyzed was selected by the program from the minimum value of AIC (Akaike's Information Criterion). At least 5% of the data was truncated to eliminate "outliers", because these provide little information for estimating densities (Buckland *et al.* 1993). DISTANCE estimates used only contacts from transects where at least 40 contacts with a given species were obtained in each transect (Burnham *et al.* 1980). A two-way analysis of variance (ANOVA) ($P < 0.05$) was used to test for differences in the number of contacts obtained with each species among areas and months sampled.

RESULTS

Columbina talpacoti showed a density of 76.9 ind/km^2 in the urban area during the 12 months of study (Coefficient of variation, CV = 0.06); *C. picui* had a density of 28.0 ind/km^2 (CV = 0.10); and *Z. auriculata* a density of 1,501 ind/km^2 (CV = 0.03) for the same areas and period.

Due to the minimum number of contacts established for the analysis in DISTANCE, it was not possible to calculate the density for *C. talpacoti* and *C. picui* in rural and pasture areas, because the total number of contacts in each area for these species was fewer than 40. For *Z. auriculata*, the density value was 25.6 ind/km^2 in the pasture area (CV = 0.08) and 1,178 ind/km^2 in the rural area (CV = 0.03).

Monthly density estimates were only possible for *Z. auriculata* in the urban area (Table 1); the variation observed ranged from 626 ind/km^2 in July to 2,645 ind/km^2 in January (Figure 2). In the rural area, we obtained the following data for *Z. auriculata*: density of 3,161 ind/km^2 (CV = 0.04) for the months of November and December combined, 323 ind/km^2 (CV = 0.12) for March, 2,564 ind/km^2 (CV = 0.03) for the months of April and May combined, and 34 ind/km^2 (CV = 0.11) for the other seven months (August, September, October, January, February, June and July) combined (Figure 3).

Zenaida auriculata had the highest number of contacts in all three areas (Figure 4). In the urban area ($F_{2.69}$ =13.97; $P < 0.001$) and rural area ($F_{2.69}$ = 13.87; $P < 0.001$), significant differences were observed in the number of contacts obtained throughout the year. In these areas, the two *Columbina* species had a similar number of contacts, but *Z. auriculata* had a significantly higher number of contacts than the other two species (Tukey's pairwise comparisons, $P < 0.001$). All three species studied showed no significant differences in the number of contacts throughout the year in the pasture area ($F_{2.69}$=1.027; P=0.459).

Columbina talpacoti and *Z. auriculata* showed significant differences in the number of contacts throughout the whole study period in the different areas ($F_{2.69}$ = 1.989; P = 0.03 and $F_{2.69}$ = 13.25; $P < 0.01$, respectively). *Columbina talpacoti* had a significantly higher number of contacts in the urban area (Tukey's pairwise comparisons, $P < 0.001$), while *Zenaida auriculata* had significantly fewer contacts in the pasture area (Tukey's pairwise comparisons, $P < 0.001$). *Columbina picui* had a statistically similar number of contacts in all three areas ($F_{2.69}$ = 0.725; P = 0.785).

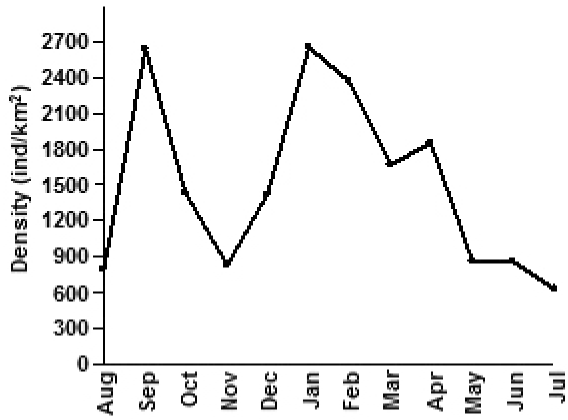

FIGURE 2. Density of *Zenaida auriculata* during the months of August 2011 to July 2012 in the urban area of Londrina, Southern Brazil.

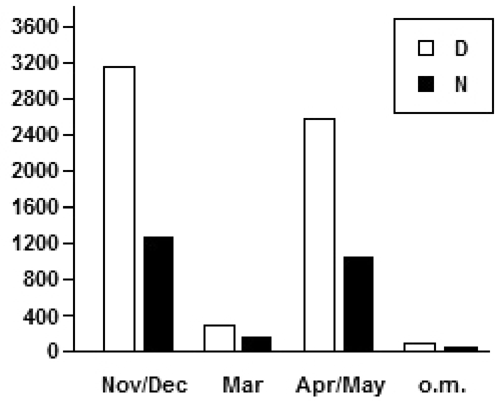

FIGURE 3. Density of ind/km^2 (D) and number of individuals (N) of *Zenaida auriculata* in the rural area in Londrina, Southern Brazil for November and December, March, April and May and the other months combined. Coefficient of variation (CV): Nov/Dec = 0.04; March = 0.03; Apr/May = 0.03; other months = 0.11.

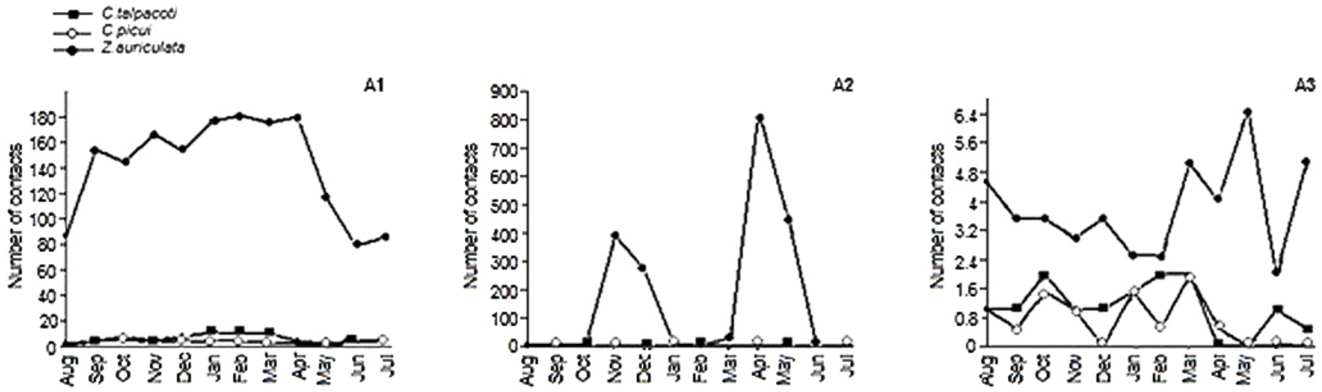

FIGURE 4. Mean number of contacts obtained for each of the three species of Columbidae in the urban area (A1), rural area (A2) and pasture area (A3) in Londrina, Southern Brazil, in the period of August 2011 to July 2012.

Months	D (ind/km^2)	N	CV
August	803	321	0.07
September	2634	1053	0.07
October	1437	575	0.1
November	840	336	0.09
December	1415	566	0.05
January	2645	1058	0.06
February	2375	950	0.05
March	1660	664	0.06
April	1842	737	0.06
May	867	347	0.08
June	864	346	0.1
July	626	251	0.09

TABLE 1. Density (D), number of individuals (N) and coefficient of variation (CV) of *Zenaida auriculata* during the months of August 2011 to July 2012 in the urban area in Londrina, Southern Brazil.

DISCUSSION

Although they share some similarities, *Z. auriculata* excelled compared to the other two *Columbina* species sampled, due to its high population density recorded in all months of the year in the urban area and for a few months in the rural area. The population peaks of the species in the rural area can be characterized by their opportunistic displacement during a period of large seed availability in the region.

The density of *Z. auriculata* was relatively high in all months in the urban area. The species had a high number of contacts even in months with a lower density. The low population density of *Z. auriculata* occurred in the same period as winter in the region (from June to August), characterized by low temperatures and low precipitation (Bianchini *et al.* 2006). The density peaks (months of September and January) of this species in the urban area (Figure 2) can be related to the appearance of warmer temperatures in the region and as a result of their reproductive success.

During the sampling, the collection of material for nesting by individuals of *Z. auriculata* was observed throughout the whole year, but more intensely in November. This observation suggests an increased reproductive activity of the species in this season, which coincides with the increased density rate of the species in January, a month in which many immature individuals were observed. According to Murton *et al.* (1974), *Z. auriculata* reproduces between October and April, which coincides with the rainy season and an abundance of seeds in Córdoba, Argentina. However, Bucher & Orueta (1977) reported active nests for the species during all months of the year in the same region. In southeastern Brazil, breeding peaks were observed in February to May, and August to November, and the breeding season of *Z. auriculata* might be influenced by the availability of grains cultivated in the environment (Menezes *et al.* 1998, Ranvaud *et al.* 2001). In Córdoba, Argentina, the availability of food, especially grain sorghum, appears to be the main factor that controls the reproduction of *Z. auriculata* in the region (Bucher & Orueta 1977).

The three dove species sampled had similar numbers of contacts over the sampling period in the pasture area. This area is characterized by an open area dominated by exotic grasses (e.g., *Brachiaria* sp. and *Panicum maximum*), the presence of some trees in the landscape, and isolated fragments in the surroundings. The pasture area is probably the most similar area to the natural environment selected by these species compared to the other areas studied. Nonetheless, the number of contacts of the three species was higher in the urban area. Therefore, the habitat selected by these species is highly influenced by the presence of anthropogenic environments (Fontoura & Orsi 2013).

Columbina picui was the species most commonly found in soybean fields in the region of Entre Rios in

Argentina, with a 40% frequency of occurrence (Goijman & Zaccagnini 2008). A different pattern was observed in this study, in which few *C. picui* and *C. talpacoti* individuals were recorded in rural areas. This agrees with data of Cintra *et al.* (1990), where an analysis of the composition of the diet of *C. talpacoti* found only 8.2% of cultivated grain, while 74% were seeds of other species. This suggests that this species is possibly not related to cultivated fields.

A considerable increase in the density of *Z. auriculata* was observed in the rural area during the period of the soybean harvest (March), which was about 10-fold higher than the density in other months of the year. However, this increase does not compare to the population peaks of *Z. auriculata* observed for the months of November/ December (approximately 93-fold higher than in other months, coinciding with the planting of soybean and maize) and April/May (75-fold higher than in other months, during the planting of wheat). In the other periods of the year, we found the permanent residence of a few individuals of *Z. auriculata* in the rural area. However, during the periods where cultivated seeds were available in the region, it was possible to observe the arrival of many individuals in the early morning. This suggests that individuals of the Eared Dove arrived in rural areas in search of grain wasted by agricultural practices and that they did not sleep in the area. Individuals of *Z. auriculata* also visit crop fields during different periods over the year in southeastern Brazil and widely explore different food sources according to the seasonal availability of resources (Ranvaud *et al.*2001). Nomadism in search of seeds was also recorded for this species in the Chaco of both Argentina and Paraguay (Murton *et al.* 1974), and in Córdoba, Argentina (Bucher & Ranvaud 2006). In northeastern Brazil, periodic migrations of *Z. auriculata* in search of food were recorded, in which the species moved great distances, following the rains that favor the fruiting seed of *Croton* sp. (Antas 1987).

The population explosion of *Z. auriculata* generates some concerns because it is unknown whether the maintenance of its current population density can threaten other species and even the local biodiversity as a whole. Broad control programs using toxic baits and other methods were not successful in Argentina (Bucher 1974, Murton *et al.* 1974) or Uruguay (Bucher 1985, Bucher & Ranvaud 2006); although the these programs caused high mortality and affected the reproductive potential of the species, the arrival of new individuals from other areas determined the recovery of these populations (Bruggers *et al.* 1998).

Besides the high density of *Z. auriculata*, our results also documented the predominance of *Z. auriculata* with respect to two species of *Columbina* in the study areas in Londrina. The high population density achieved by *Z. auriculata* every month in the urban area and in those in the rural area coinciding with the planting of soybean, wheat and maize, and the harvest of soybean, indicate that the species has found a favorable environment in the region. This includes the ease of obtaining resources, suitable sites for nesting, high reproductive success, possible adaptive factors, and its opportunistic displacement in search of distant food sources.

The replacement of forests by agricultural land and the consequent abundance of grain in the environment might contribute to the increased density of *Z. auriculata* in the region. We showed that the Eared Dove is the species most favored by deforestation and the expansion of agriculture in the region studied, although there is a lack of information that quantitatively compares all bird species in the Londrina region. Restriction measures on the food sources, to minimize the loss of grain in agricultural practices and during grain transport, the recovery of the forests and consequently the reestablishment of those elements of biodiversity that were part of the original landscape in the region, might result in interactions between competition and predation involving *Z. auriculata*. These could represent the most promising strategies to assist in controlling the population of the species.

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