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Habitat use by the invasive exotic Eurasian Collared-Dove (*Streptopelia decaocto*) and native dove species in the Chamela-Cuixmala region of West Mexico

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ABSTRACT—Invasive species are one of the main threats to biodiversity, and anthropogenic disturbance facilitates their entry and establishment. In this study, we assessed the presence and abundance of the invasive Eurasian Collared-Dove (*Streptopelia decaocto*) along a habitat gradient where this species interacts with native doves and pigeons. We found Eurasian Collared-Doves only in habitats modified by human activities, occurring more frequently in urban areas than agricultural fields. Sites with Eurasian Collared-Doves were highly dominated by this species, displaying less diverse dove communities, suggesting that the presence of this invasive species could be a factor contributing to a reduction of dove diversity. Effective management actions are essential to preserve biodiversity in human-modified habitats such as urban areas, and even more so if exotic invader species are present. Controlling Eurasian Collared-Doves' further dispersion could be beneficial to native dove communities in a wide range of habitats. *Received 21 June 2017. Accepted 11 June 2018.*

Key words: biodiversity conservation, dominance, doves, pigeons, *Streptopelia decaocto*, urban invaders.

Uso del hábitat de la paloma invasora Euroasiática y de la comunidad de palomas nativas en la región Chamela-Cuixmala en México

RESUMEN (Spanish)—Las especies invasoras son una de las principales amenazas a la biodiversidad. El disturbio antropogénico facilita su entrada y establecimiento. En este estudio evaluamos la presencia y abundancia de la paloma invasora de collar Eurasiática (*Streptopelia decaocto*) en un gradiente de hábitat donde esta especie interactúa con palomas nativas. Encontramos palomas de collar Eurasiática solo en hábitats modificados por actividades humanas, siendo más frecuentes en áreas urbanas que en áreas agrícolas. Los sitios donde la paloma Eurasiática estaba presente estaban dominados por esta especie y contenían comunidades menos diversas. Esto sugiere que la presencia de esta especie invasora puede ser un factor que contribuye a la reducción de la diversidad de palomas. Se requiere llevar a cabo acciones apropiadas de manejo para conservar la biodiversidad en hábitats modificados por el hombre, tales como áreas urbanas. Controlar la dispersión de la paloma Eurasiática sería muy beneficioso para las comunidades de palomas nativas.

Palabras clave: biodiversidad, conservación, dominancia, invasores urbanos, palomas, pichones, *Streptopelia decaocto*.

Natural habitat transformation by human activities facilitates the entry and establishment of introduced species (Niemela 1999, McKinney 2008, Kowarik 2011). By altering natural environments, humans are creating new niche opportunities; for example, urbanization reduces biotic resistance and provides resources that otherwise would be inaccessible to some species (Sol et al. 2017). Agricultural activities and urbanization generate changes in habitat structure that can decrease species richness and increase the abundance of a few dominant species because of the low number of taxa that can adapt to areas altered by humans (Shochat et al. 2010, Sol et al. 2014).

The Eurasian Collared-Dove (*Streptopelia decaocto*) is originally from India, and in <100 years it has become a successful invader in several regions of the world (Smith 1987). In America, it was introduced to the Bahamas during the 1970s and has spread rapidly through the United States in North America (Hengeveld 1993). The species reached Mexico at the end of the 20th century, first observed on the island of Cozumel along the Caribbean coast (JES, 2017, pers. comm.). However, the Eurasian Collared-Dove has entered Mexico mostly from the north, moving through the US–Mexico border and arriving at localities in central Mexico as early as 2006 (Sullivan et al. 2015). Today, the species is widely distributed in Mexico (Pineda-Lopez and Malagamba Rubio 2011, Chable-Santos et al. 2012, Pineda-Lopez et al. 2013, Blancas-Calva et al. 2014, Tinajero and Rodriguez-Estrella 2014, Lopez et al. 2015, Sullivan et al. 2015). The recent arrival of this nonnative species provides a unique opportunity to explore biodiversity dynamics during the first stages of a biological invasion.

Given that agricultural and urban environments have the potential to host diverse animal communities (Cornelis and Hermy 2004, Aronson et al. 2014, Camacho-Cervantes et al. 2018), understanding how invasive species exploit the resources and how they might affect native communities

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is crucial for improving biodiversity management. In this study, we examined the effect of the Eurasian Collared-Dove presence on the species richness and abundances of native doves in different habitats of the Pacific Coast of México. We hypothesized that Eurasian Collared-Doves should be more abundant in urban areas because they are known to exploit urban resources successfully.

Methods

We surveyed dove communities in tropical dry forest sites, agricultural fields, and towns of the Chamela-Cuixmala region along the coast of Jalisco, Mexico (19°29′46″N, 104°59′48″W). This region is considered critical for biological conservation at a continental level because of its high biological diversity and high number of endemic species (Noguera et al. 2002). We designed a sampling scheme that included sites in a gradient of human-modified habitats: urban, active crop fields, inactive crop fields, and conserved forest. We sampled conserved tropical dry forest within the Chamela-Cuixmala Biosphere Reserve. Urbanized areas were sampled in the towns of Zapata, Villa, Careyes, San Mateo, La Fortuna, and Perula, all of which have key features of urban environments such as concrete buildings, paved and unpaved streets, electricity, sewage, schools, churches, and a central square. Additionally, we conducted surveys in active and inactive crop fields located around these towns. We surveyed 25 independent point counts in urban areas, 16 in active crop fields, 16 in inactive crop fields, and 20 in conserved tropical dry forest.

We conducted fieldwork between 0900 and 1200 h (GMT -5) in May 2015. We used 5 min unlimited radius point counts; each point was separated from the closest other point by at least 250 m to minimize the probability of counting the same individuals (Ralph et al. 1996). We recorded all doves seen and measured the distance to each bird with a Nikon Forestry Pro laser rangefinder. Our analysis was restricted to birds recorded within a distance of 50 m to relate bird species presence and abundance with habitat characteristics (Ralph et al. 1996). This method represented a 60.47 ha sampled area within all of our point counts.

To characterize our sampling points, we recorded 3 sets of habitat variables: (1) geographic distance to the nearest crop field, dry forest, and urban border (using Google Maps software); (2) vegetation structure (i.e., proportion of canopy, shrub, and grass cover); and (3) urbanization features (i.e., number of doors as a proxy of human density, electricity or light posts, and people, cars, bicycles, dogs, and cats located or passing through the 50 m radius area of our point count during the 5 min bird survey period).

Data analysis

We evaluated differences in species richness and abundance for the dove community among sampled habitats using a Morisita-Horn dissimilitude index (range 0 to 1), with 0 indicating sites are identical and 1 indicating sites are completely different (Magurran 2004). To determine this index, we calculated the proportional abundance of individuals for each species in each of the natural and human-modified habitats. Because the Eurasian Collared-Dove was never found in the forest, and because the forest habitat had a Morisita-Horn dissimilitude index of 1.0 (meaning it is completely different from the other sampled habitats), we performed further analyses without this habitat. Given that active and inactive crop fields had a Morisita-Horn index of 0.02 and that the Eurasian Collared-Dove was present at almost the same proportion in both habitats ($Z = 0.816$, $P = 0.412$), we combined the point counts from these 2 habitats into a single crop-field category.

To assess the difference in species dominance, we calculated the Berger-Parker index (Magurran 2004) of point counts where the Eurasian Collared-Dove was present and absent. We also produced rank/abundance plots using the average number of individuals per species for each habitat.

We performed Z-tests using the proportion of point counts where the Eurasian Collared-Dove was present in relation to the total number of point counts conducted in each habitat to determine whether the presence of the Eurasian Collared-Dove differed among human-modified habitats. We also assessed differences in habitat features between point counts where Eurasian Collared-Doves were present and absent for both urban areas and crop fields using a Wilcoxon-Mann-Whitney U test with a Bonferroni correction for each set of variables (Shaffer 1995). Alpha was divided by 3 for the geographical and vegetation structure variables and by 5 for the urbanization variables.

Results

The pigeon and dove communities of the Chamela-Cuixmala region were composed of Inca Doves (*Columbina inca*), Ruddy Ground Doves (*C. talpacoti*), Common Ground Doves (*C. passerina*), Mourning Doves (*Zenaida macroura*), White-winged Doves (*Z. asiatica*), White-tipped Doves (*Leptotila verreauxi*), and 2 invasive exotic species: Eurasian Collared-Dove and Rock Dove (*Columba livia*). Species richness and abundances in the forest differed from the other habitats, with a Morisita-Horn dissimilitude index of 1. We recorded no doves in most of the forest point counts, with the sole exception of the White-tipped Dove (Fig. 1). Urban was the next distinct habitat, with a dissimilitude index of 0.49, with the Eurasian Collared-Dove recorded in most of the point counts (Fig. 1). Active and inactive crop fields showed no significant differences in species richness and abundance of doves (Fig. 1). The highest number of dove and pigeon species was found in crop fields, followed by urban areas.

The Eurasian Collared-Dove was present in a significantly greater proportion of point counts in urban areas than in crop fields ($Z = 2.046$, $P = 0.04$). When present, the Eurasian Collared-Dove was the most abundant species in both urban and agricultural habitats, with a Berger-Parker index of 0.78 in urban areas and 0.81 in crop fields. In point counts where Eurasian Collared-Doves were absent, Rock Doves were the most abundant species in urban areas, and White-winged Doves the most abundant in crop fields. Urban areas had highly dominated dove communities; point counts where the Eurasian Collared-Dove was present had more dove-dominated communities than those where this invasive species was absent (Fig. 2).

In urban areas, the Eurasian Collared-Dove was present in 16 of the 19 points were doves where found (Fig. 1). The 3 urban points without Eurasian Collared-Doves were mostly surrounded by tropical dry forest; thus, these points were closer to the nearest dry-forest border than the 16 point counts where the Eurasian Collared-Dove was present (Wilcoxon-Mann-Whitney $U_{17} = 48$, $P = 0.002$; Bonferroni corrected $\alpha = 0.017$) and more distant to the nearest crop field border (Wilcoxon-Mann-Whitney $U_{17} = 0$, $P = 0.002$; Bonferroni corrected $\alpha = 0.017$) than the 16 urban point counts where the Eurasian Collared-Doves were present (Table 1). Furthermore, the 3 urban point counts where the Eurasian Collared-Dove was absent had a higher percentage of canopy cover (Wilcoxon-Mann-Whitney $U_{17} = 0.5$, $P = 0.009$; Bonferroni corrected $\alpha = 0.017$) and grass cover (Wilcoxon-Mann-Whitney $U_{17} = 0$, $P = 0.007$; Bonferroni corrected $\alpha = 0.017$) and had a lower number of posts/light poles (Wilcoxon-Mann-Whitney $U_{17} = 48$, $P = 0.006$; Bonferroni corrected $\alpha = 0.007$).

We also found that point counts where Eurasian Collared-Doves were absent in the agricultural habitat were closer to the dry-forest border than those where the species was present (Wilcoxon-Mann-Whitney $U_{18} = 78$, $P = 0.011$; Bonferroni corrected $\alpha = 0.017$); point counts where we found the Eurasian Collared-Dove were statistically closer to an urban border (Wilcoxon-Mann-Whitney $U_{18} = 13$, $P = 0.008$; Bonferroni corrected $\alpha = 0.017$). We found no differences in vegetation structure or urban features between point counts where the Eurasian Collared-Dove was present or absent in the agricultural habitat (Table 1).

Discussion

The Eurasian Collared-Dove reportedly prefers habitats modified by human activities that create a low canopy cover (Hengeveld 1988, Bonter et al. 2010), a finding supported by the absence of this dove in the conserved tropical dry forest. However, we found no difference in vegetation characteristics and urban features for human-modified sites where the Eurasian Collared-Dove was present or absent. Previous studies with this species in the United States and Europe have demonstrated its association with human-modified habitats (Coombs et al. 1981, Fujisaki et al. 2010), and our results provide support for this idea in the Neotropics. A possible explanation for this association would be that invaders might find it more difficult to spread and establish in pristine locations because these areas might have a higher

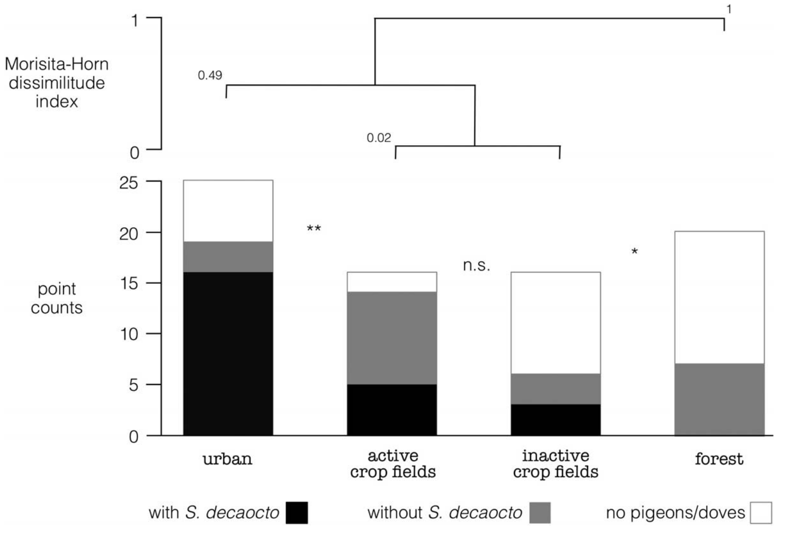

Figure 1. The occurrence of the Eurasian Collared-Dove (*Streptopelia decaocto*) in point counts along a human-modified habitat gradient. Asterisks show significant differences among habitats in the proportion of point counts where the Eurasian Collared-Dove was present (drawn from *Z*-tests).

biotic resistance, and food might be less available (Sol et al. 2017).

The dominant role of the Eurasian Collared-Dove in the dove communities where it is present is consistent with findings for other taxa where invaders tend to homogenize ecological communities. For example, the presence of the Asian Ladybird (*Harmonia axyridis*) is linked to the decline in native ladybird populations where it establishes (Roy and Brown 2015, Camacho-

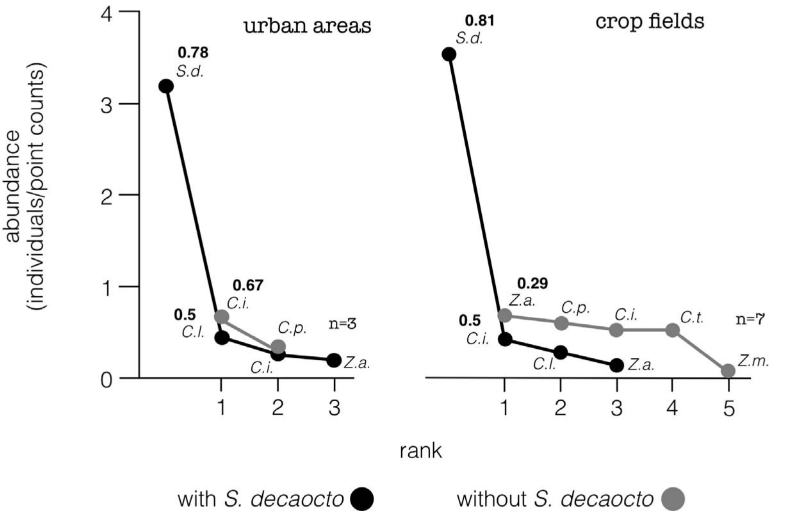

Figure 2. Rank/abundance plots of dove communities in urban areas and crop fields for point counts where the Eurasian Collared-Dove (*Streptopelia decaocto*) was present and absent. Bold numbers represent the Berger-Parker dominance index. In dove communities present at sites with *S. decaocto*, a second Berger-Parker index value was calculated for the community excluding *S. decaocto* individuals. In urban areas, there were 16 points with and 3 points without *S. decaocto*. In crop fields, there were 13 points with and 7 points without *S. decaocto*. Species found at sampling sites were: *S. decaocto* (*S.d.*), *Columba livia* (*C.l.*), *C. inca* (*C.i.*), *C. passerina* (*C.p.*), *C. talpacoti* (*C.t.*), *Zenaida asiatica* (*Z.a.*), *Z. macroura* (*Z.m.*).

Table 1. Habitat differences between points where the Eurasian Collared-Dove (*Streptopelia decaocto*) was present and points where it was absent. Probability values drawn from Wilcoxon-Mann-Whitney U tests. Bonferroni corrected α for each set of variables.

	Urban	Crop fields	Bonferroni corrected α
Geographic variables			$\alpha = 0.05/3 = 0.017$
distance to crop fields	0.002*		
distance to urbanization		0.008*	
distance to the forest	0.002*	0.011*	
Vegetation structure variables			$\alpha = 0.05/3 = 0.017$
canopy cover	0.009*	0.262	
bush cover	0.562	1	
grass cover	0.007*	0.422	
Variables related with urbanization			$\alpha = 0.05/7 = 0.007$
doors	0.008	0.175	
posts/light poles	0.006*	0.016	
people	0.059	0.026	
cars	0.017	0.044	
bicycles	0.074	0.648	
dogs	0.143	0.057	
cats	0.773	0.529	
Number of points with *S. decaocto*	16	13	
Number of points without *S. decaocto*	3	7	

Cervantes et al. 2017). Some avian invaders also out-compete native species that use similar resources. In central Mexico, the presence of the invasive exotic House Sparrow (*Passer domesticus*) reduces native bird diversity by up to 35% (MacGregor-Fors et al. 2009). Hence, our results support the hypothesis that the presence of the Eurasian Collared-Dove modifies the structure and function of native dove communities.

Our results show no differences in habitat variables between human-modified sites (crop fields) where the Eurasian Collared-Dove was present and those where the species was absent, suggesting that the greater dominance found in dove communities invaded by the Eurasian Collared-Dove was caused by the influence of this invasive species on native species rather than differences in habitat characteristics. However, bird invasions in urban areas tend to be better explained by invaders' ability to exploit resources unavailable to established native species rather than outcompeting natives (Sol et al. 2017).

The absence of the Eurasian Collared-Dove in conserved tropical dry forest sites suggests that this invasive species might be unable to exploit the resources available in the dry forest and other native habitats, and that its invasion could be limited to human-altered habitats at the Chamela-Cuixmala region. This idea is supported by the expansion of the Eurasian Collared-Dove range following human-altered landscapes; for example, this species is found only in human-modified areas in the United States (Fujisaki et al. 2010). An alternative and complementary hypothesis would be that the Eurasian Collared-Dove is in the lag phase of its invasion of Mexico. Further research could be implemented to test this hypothesis and to determine the phase of the biological invasion of this species in tropical sites.

The results of our study demonstrate that the Eurasian Collared-Dove has heavily invaded urban areas but is not as abundant in crop fields, the environment that supports the highest species richness of doves in our study region. Biodiversity can be preserved in urban and agricultural habitats, even if many invasive species are also present (Guenard et al. 2015), but populations of the Eurasian Collared-Dove need to be controlled to prevent the homogenization of dove communities. Management of invasive species requires complex and multidisciplinary approaches that involve understanding the processes and mechanisms behind the biological invasions of urban sites and the appropriate integration of this information into urban planning (Niemela 1999, Rosenzweig 2003, Kowarik 2011).

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