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Increased presence of the invasive, exotic Eurasian Collared-Dove (*Streptopelia decaocto*) in the Chamela-Cuixmala Biosphere Reserve, Mexico, after hurricane disturbance

Incremento en presencia de la paloma turca de collar (*Streptopelia decaocto*) invasora en la Reserva de la Biósfera Chamela-Cuixmala, México, después de la perturbación por un huracán

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Abstract

Invasive species are a main cause of biodiversity loss, making it important to register their incursion into conserved, protected areas. We evaluated presence of the exotic Eurasian Collared-Dove (*Streptopelia decaocto*) in and around the Chamela-Cuixmala Biosphere Reserve, Jalisco, after hurricane disturbance. During March to May 2017 and 2018, we carried out 1 km transect surveys at three sites: Chamela Biological Station, Careyes town, and Cuixmala ranch, and conducted observations of the Eurasian Collared-Dove when detected. We also collected records from the eBird database to compare the number of Eurasian Collared-Doves reported before (2010-2015) and after (2016-2020) major hurricane disturbance. We recorded a total of 27 doves over 18 surveys, with the majority of records at the Chamela Biological Station within the reserve. Most sightings were of one dove, but we recorded a group of 4 doves at Chamela in May 2018. Doves spent significantly more time perched around buildings at Chamela in 2018 compared to 2017, and made occasional flights into trees at the dry forest border. The eBird data showed a significant increase in records of the Eurasian Collared-Dove outside the reserve after hurricane disturbance. Our results showed increased presence of the Eurasian Collared-Dove at sites within the biosphere reserve following major hurricane disturbance, possibly due to forest damage creating open-habitat and niche opportunities within the dry forest mosaic. We recommend continued monitoring to restrict establishment of this invasive species in forested areas of the reserve, and evaluate potential impacts on native species.

Keywords: eBird database, Exotic species, Invasive species, Hurricane disturbance, Tropical dry forest.

Resumen

Las especies invasoras son una de las principales causas de la pérdida de la biodiversidad, por lo que es importante registrar su incursión en áreas conservadas y protegidas. Evaluamos la presencia de la paloma turca de collar (*Streptopelia decaocto*) dentro y alrededor de la Reserva de la Biosfera Chamela-Cuixmala, Jalisco, después de la pertur-

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bación de un huracán. Durante marzo a mayo del 2017 y 2018, realizamos censos en transectos de 1 km en tres sitios: la Estación de Biología Chamela, el pueblo Careyes y rancho Ciuxmala, y llevamos a cabo observaciones de la paloma cuando fue detectada. Además, utilizamos la base de datos de eBird para comparar el número de registros de la paloma antes (2010-2015) y después (2016-2020) del huracán mayor Patricia. Registramos 27 palomas en 18 censos, con la mayoría de los registros en la Estación Chamela dentro de la reserva. La mayoría de los avistamientos fueron de una paloma, pero registramos un grupo de 4 palomas en Chamela durante mayo 2018. Las palomas permanecieron mayor tiempo en percha alrededor de los edificios de Chamela en 2018 comparado con 2017, éstas volaban ocasionalmente hacia los árboles en el borde del bosque seco. Los datos de eBird mostraron un aumento significativo del número de registros de la paloma turca fuera de la reserva después de la perturbación del huracán. Nuestros resultados mostraron mayor presencia de la paloma turca en sitios dentro de la reserva después de la perturbación de un huracán mayor, posiblemente debido al daño forestal que originó un hábitat abierto y oportunidades de nicho dentro del bosque seco. Recomendamos continuar con el monitoreo para restringir el establecimiento de esta especie invasiva en áreas boscosas de la reserva y evaluar los impactos potenciales sobre las especies nativas.

Palabras clave: base de datos eBird, especie exótica, especie invasiva, disturbio por huracán, Bosque tropical caducifolio.

Introducción

Invasive species are considered one of the main causes of biodiversity loss, and cause both economic and public health problems (Parker et al. 1999, Gurevitch and Padilla 2004, Mazza et al. 2014). The presence of invasive species is most often associated with human-modified landscapes (Bonter et al. 2010). However, in conserved habitats, modification caused by natural disturbances such as hurricanes can promote the establishment of exotic species. Some studies have demonstrated that invasive plants and small mammals are favored by alterations in forest structure following hurricane disturbance as this may create new niche opportunities (Wiley and Wunderle 1993, Bellingham et al. 2005, Shiels et al. 2020).

The Eurasian Collared-Dove (*Streptopelia decaocto*), native to India, Sri Lanka, and Myanmar, is a widespread exotic bird that is considered to have great potential for invasion (Fisher 1953). This dove arrived in Europe in the 1900's and in just 30 years it invaded the entire European continent (Fisher 1953). During the 1980's, the species was introduced to the United States of America, probably through escape from captivity in the Bahamas, and is now found throughout much of North America (Ramagosa and Labisky 2000, Fujisaki et al. 2010). In Mexico, the first records of the Eurasian Collared-Dove appeared in 2000 (Álvarez-Romeo et al. 2008), and the species is now distributed across most of the country (Chablé-Santos et al. 2012, Blancas-Calva et al. 2014, Tinajero and Rodríguez-Estrella 2014, Tinajero and Partida-Pérez 2016, eBird 2020). The successful range expansion of the Eurasian Collared-Dove has been attributed to its adaptive ecological plasticity in human-modified landscapes, high reproductive potential and aggressive competitive interaction (Bonter et al. 2010). Furthermore, clearing of natural habitats for agriculture and the creation of roads have facilitated its expansion (Fujisaki et al. 2010).

In this study, we evaluated presence of the Eurasian Collared-Dove in the Chamela-Cuixmala Biosphere Reserve and surrounding areas that recently experienced landfall by Hurricane Jova (category 2) in 2011, and Hurricane Patricia (category 5) in 2015. Both hurricanes affected vegetation types along the coast, with damage in mature forest consisting of uprooted trees, snapped trunks, or broken branches (Martínez-Ruiz and Renton 2018, Parker et al. 2018). This was more severe after the major Hurricane Patricia, which had maximum winds of 241 km/h (Kimberlain 2016). Hurricane landfall in the region reduced flowering and fruiting phenology during the first-year post-hurricanes, with a greater impact of Hurricane Patricia on fruit and flower abundance compared to the minor Hurricane Jova (Renton et al. 2018). Birds responded differently to these hurricanes according to their habitat preferences and functional groups. Raptors decreased in density in forests, but increased in richness and evenness in wetlands in areas impacted by maximum winds of Hurricane Patricia (Martínez-Ruiz and Renton 2018). The tropical dry forest and agricultural fields (orchards, pasture, crop fields) showed higher numbers of granivores and a reduction of carnivores compared to pre-hurricane conditions (Levey and McGregor-Fors 2021).

Previous avian surveys conducted in the Chamela-Cuixmala Biosphere Reserve have not

record presence of the Eurasian Collared-Dove (Hutto et al. 1985, Arizmendi et al. 1990, Ornelas et al. 1993). In addition, point count surveys to assess presence of the Eurasian Collared-Dove in the Chamela-Cuixmala region that were carried out in May 2015, prior to Hurricane Patricia, found that the species did not occur in conserved areas of tropical dry forest (Camacho-Cervantes and Schondube 2018). Here we evaluated the presence of the Eurasian Collared-Dove in the Chamela-Cuixmala Biosphere Reserve and surrounding area before and after major Hurricane Patricia. We also aimed to determine the time that doves spent perched in the area as a measure of their habitat use within and outside the reserve.

Methods

Survey sites

We evaluated presence of the Eurasian Collared-Dove in the Chamela-Cuixmala Biosphere Reserve (19°22'N, 104°56'W to 19°35'N, 105°03'W) on the western Pacific coast of Mexico (Figure 1). The reserve maintains high species diversity, many of which are endemic to the tropical dry forest of Mexico (Ceballos and Garcia 1995). The dominant vegetation in the reserve, and the region, is characterized as tropical deciduous forest, but small areas of semi-deciduous forest also occur in valleys and more humid areas (Lott 1993).

We documented presence of the Eurasian Collared-Dove at three sites (Figure 1): 1) the Chamela Biological Station (19°29'52" N, 105°02'39" W), 2) Careyes town (19°26'37" N, 105°01'22" W), and 3) Cuixmala ranch (19°23'14" N, 105°00'15" W). The Chamela Biological Station consists of nine small buildings surrounded by well-conserved continuous tropical dry forest within the reserve. Careyes town is a small, rural settlement of 7.5 ha, with 59 inhabitants (INEGI 2020), located at the boundaries of the reserve. This site is composed of small brick-building homes with large gardens, cobbled streets, and is surrounded by tropical deciduous forest to the North and East, and semi-deciduous forest along the Arroyo Careyes to the East, and next to Federal Highway 200 to the West (MacGregor-Fors and Schondube 2012). Cuixmala ranch, located at the boundary of the reserve, comprises areas of tropical deciduous forest, patches of semi-deciduous forest, secondary forest, wetlands, mangrove, palm plantations, and land devoted to organic agriculture (Martinez-Ruiz obs. per.).

Each month a transect was conducted along a different route at each survey site. At the Chamela site, surveys were conducted from the station buildings and along two forest trails (Eje Central and Tejón), and the paved entrance road. In Careyes town, the first transect was conducted from Federal Highway 200 through the town, the second transect from the center of town towards Arroyo Careyes, and the third transect along the Arroyo Careyes. In the Cuixmala ranch, the transects included edges of wetlands, open land and secondary vegetation.

Dove surveys

During March to May in 2017 and 2018, we conducted 1 km length transect surveys at each of the three sites, using a different route each month, for a total of 18 km surveyed over the two years. Surveys were conducted from 07:00 to 11:00 h, walking at a slow pace (0.5 km/h). When detecting presence of the Eurasian Collared-Dove, we recorded the number of birds, and whether they were observed in flight or perched in the habitat. On detecting a perched Eurasian Collared-Dove, one observer remained to conduct observations and record the time that doves spent perched in the area, while the other observer continued walking the transect to complete the survey. We measured the duration that doves spent perched at each location as the way in which individuals allocate their time in different habitats reflects their habitat use (Mysterud and Ims 1998).

In addition, we examined the eBird database (eBird 2020) to collate records of the Eurasian Collared-Dove in the region prior-to and after hurricane disturbance along the coast of Jalisco. For this, we delimitated a 5,200-ha polygon encompassing the area of the Chamela-Cuixmala Biosphere Reserve, and extending from the towns of Emiliano Zapata (19°22'58" N, 104°57'55" W) to the South and Punta Perula (19°35'24" N, 105°07'32" W) to the North (Figure 1). We obtained all eBird lists (n = 1854) corresponding to this area over the period from 2010 to 2020. Of these, 736 checklists (39.6%) were located within the Chamela Cuixmala Biosphere Reserve, and 1118 checklists (60.3%) were located outside the reserve. We found a total of 257 checklists that reported sightings of the Eurasian Collared-Dove in the area, and determined the number of records of the Eurasian Collared-Dove in checklists before and after major Hurricane Patricia, and within and outside the Chamela-Cuixmala Biosphere Reserve.

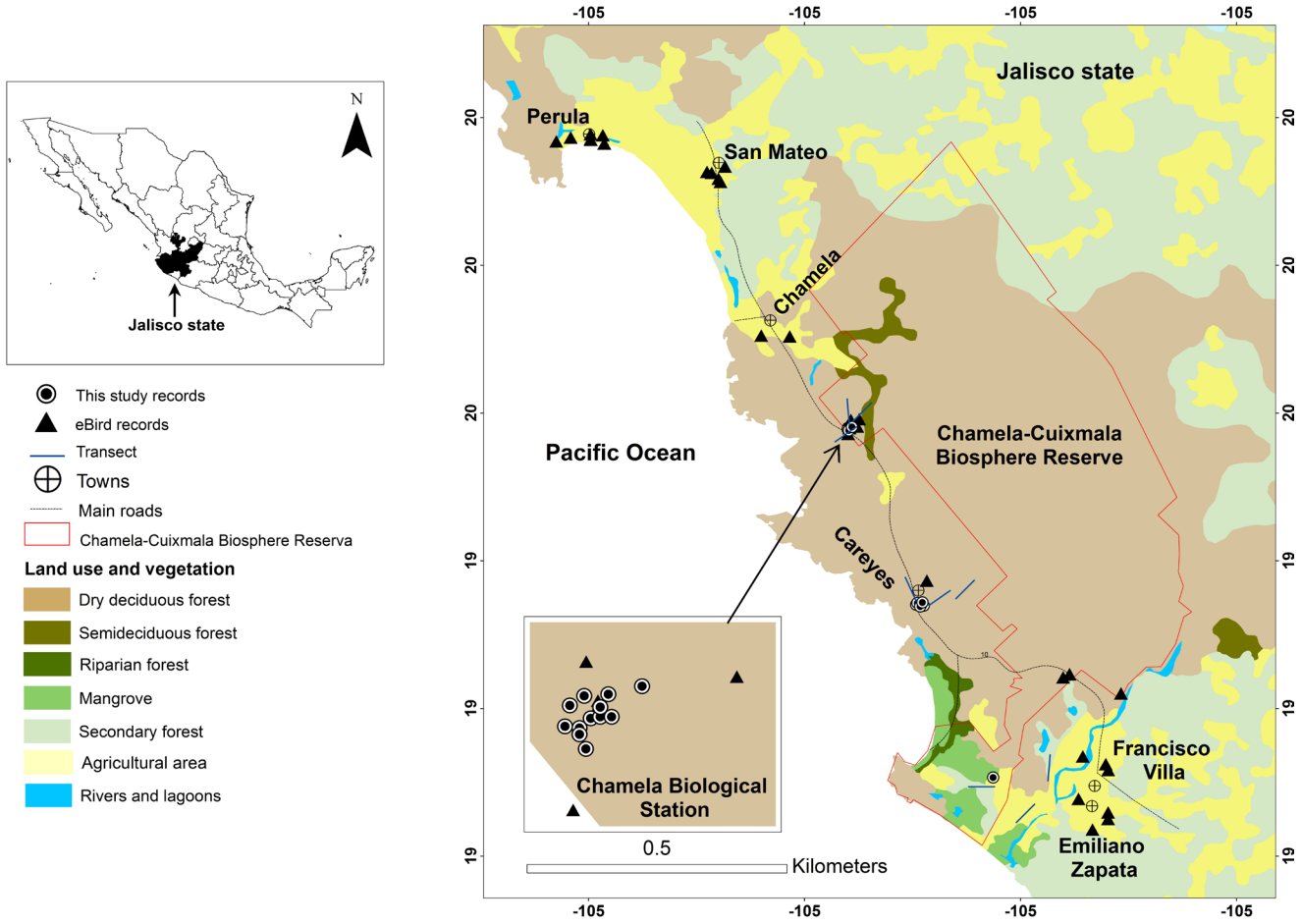

Figura 1. The study region along the western Pacific coast of Mexico showing the location of survey transects at three sites of the Chamela Biological Station, Careyes town and Cuixmala ranch, and records of the Eurasian Collared-Dove obtained in this study and from the eBird database.

Data analysis

Shapiro-Wilk analysis of normality determined that data on number of Eurasian Collared-Doves recorded and time spent perched in surveys had a normal distribution. Therefore, we applied paired *t*-tests to compare number of doves registered between years considering all sites, and to compare the time doves spent perched at the Chamela site between years, as well as a two-sample *t*-test to compare the time that doves remained perched at sites within and outside the reserve. Finally, we applied one-way analysis of variance (ANOVA) to test differences among months in the number of doves registered at the Chamela site, where more records were obtained. We also performed univariate linear regression to examine the relationship of time doves spent perched with distance to the nearest town and to Federal Highway 200. Data on eBird records did not present a normal distribution; therefore, we applied non-parametric Wilcoxon rank sum test for independent samples to compare the number of eBird records of the Eurasian Collared-Dove within and around the reserve, before and after major Hurricane Patricia (2015). All statistical tests were performed using the R statistical computing environment version 3.3.0 (R Development Core Team 2016).

Results

We recorded 27 Eurasian Collared-Doves in 18 transect surveys across both years, with a similar number of doves in 2017 (1.5 ± 1.1 doves/transect) and 2018 (1.4 ± 1.0 doves/transect; $t_8 = 1.3$, $P = 0.214$). Most records of the Eurasian Collared-Dove were obtained in surveys conducted at the Chamela site (Table 1), with all records obtained around the station buildings and the dry forest border. We did not register the Eurasian Collared-Dove within the conserved dry forest along trails at the Chamela site. We obtained a total of 12 records of the Eurasian Collared-Dove at the Chamela Biological Station (66.7% of all records) and counted a total of 19 doves (70.4% of all doves counted), recording the largest aggregation of 4 doves in May 2018. We recorded a higher number of 12 doves in the month

Table 1. Records of Eurasian Collared-Doves at three sites within and around the Chamela-Cuixmala Biosphere Reserve during March to May 2017 and 2018.

Month	Records	No. of birds	Site	Time	Activity	Habitat	Distance to forest (m)	Distance to town (m)	Distance to highway (m)
March-2017	1	1	Chamela	10:00	Perched	Building	25	4120	630
April-2017	2	2	Chamela	08:00	Flight	Dry-forest edge			
May-2017	3	7	Chamela	08:25	Perched	Building	20	4125	633
May-2017	1	1	Careyes	08:10	Perched	Building	70	35	280
March-2018	2	2	Chamela	08:40	Perched	Dry-forest edge	30	4115	625
April-2018	2	2	Chamela	10:30	Perched	Dry-forest edge	25	4120	635
May-2018	2	5	Chamela	09:45	Flight (1) Perched (4)	Building	10	4135	650
May-2018	4	4	Careyes	07:00	Flight (1) Perched (3)	Building	86	20	280
May-2018	1	3	Cuixmala	09:00	Perched	Secondary forest	150	2380	2600

of May (2.4 ± 1.5 doves/transect), compared to four doves in April (1.3 ± 0.6 doves/transect) and three doves in March (1.5 ± 0.7 doves/transect), although there was no significant difference among months ($F_{2,8}$ = 1.7, P = 0.234). In the town of Careyes, we obtained five records (27.8% of all records) and observed five doves (18.5% of all doves), one dove in 2017 and four doves in 2018 (Table 1). All sightings of the Eurasian Collared-Dove in Careyes town were recorded in house gardens. Finally, in Cuixmala ranch we obtained only one record of three Eurasian Collared-Doves perched in secondary forest (Table 1).

Our first observation of the Eurasian Collared-Dove within the Chamela-Cuixmala Biosphere Reserve was of one individual at the Chamela site on 29 March 2017. We observed the dove perched for 5-mins around the buildings of the Chamela Biological Station, but this individual was already present when we initiated the survey. In May 2017, we observed a total of 8 doves that spent a mean 24.5 ± 18.9 min (range: 18 – 50 min, n = 8) perched around the buildings of the Chamela Biological Station, with one individual perched for 50 min during the last sighting on 11 May 2017. Doves arrived at the station buildings during the morning (08:00 to 11:00 h), and were not present in the area at midday. During the last sighting of 2017, one dove vocalized for 15-min and performed short flights from the station buildings into the dry forest interior, although always coming back to the buildings. In 2018, doves spent a mean 61.4 ± 7.3 min (range: 51 – 70 min, n = 9) perched around the buildings and at the dry forest border (Figure 2). One of the doves vocalized for 12-min (16 May 2018), and two doves performed flights towards the dry forest interior, remaining within the forest for four minutes before returning to the vicinity of the buildings. The average time that doves remained perched at the Chamela site was significantly different between years (t_8 = 3.8, P = 0.006), with doves spending more time perched around the station buildings in 2018 (mean: 61.4 ± 7.3 min, n = 338 min) compared to 2017 (mean: 20.8 ± 19.5 min, n = 78 min; Figure 2).

At sites outside the reserve boundary, the Eurasian Collared-Dove appeared to spend longer periods of time perched and vocalizing compared to doves observed at the Chamela Station within the reserve, although this was not significantly different (t_{11} = 1.8, P = 0.101). In Careyes town, we observed one dove in May 2017 that was perched

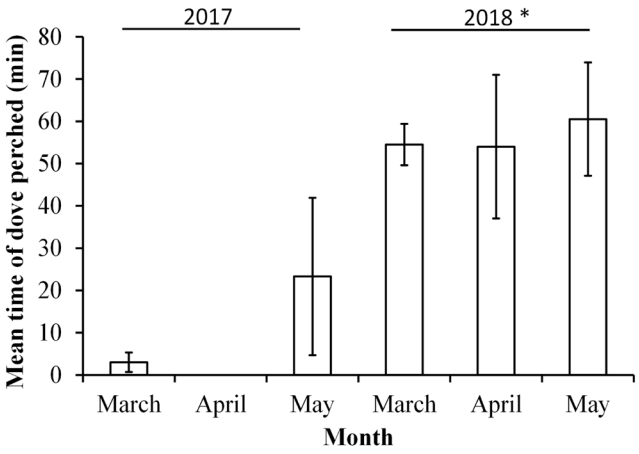

Figura 2. Mean (±SD) time that Eurasian Collared-Doves spent perched around the Chamela Biological Station within the Chamela-Cuixmala Biosphere Reserve, during March to May in 2017 and 2018. Asterisk shows significant difference between years.

and vocalizing for 50-min, and this individual also performed short flights into the forest. In May 2018, we observed another dove perched between a house garden and the dry forest border, and this individual vocalized for 16-min. In modified areas of the Cuixmala ranch outside the reserve, three Eurasian Collared-Doves were observed perched in secondary forest for 119-min.

Eurasian Collared-Doves registered in Careyes were closer to the nearest town (mean 27.2 ± 15.9 m, range 15 – 50 m, n = 4) and to the Federal Highway 200 (mean 25 ± 14.1 m, range 5 – 35 m, n = 5). While doves registered in Chamela Station were at a greater distance from the nearest town (mean 4117.2 ± 7.9 m, range 4105 – 4130 m, n = 12), and from the Federal Highway 200 (636.2 ± 9.3 m, range 625 – 655 m, n = 12). However, the time that doves spent perched was not related to distance from the nearest town (r^2 = 0.23; $F_{1,11}$ = 3.2, P = 0.10) or the Federal Highway 200 (r^2 = 0.24; $F_{1,11}$ = 33, P = 0.09).

Overall, the Eurasian Collared-Dove was reported in 13.8% (n = 257) of all eBird checklists (n = 1854) in the studied area. Outside the reserve, 184 checklists reported presence of the Eurasian Collared-Dove compared to 73 checklists within the Chamela-Cuixmala Biosphere Reserve. Prior to Hurricane Jova in October 2011, only 0.16% (n = 3) of all eBird checklists in the region included the Eurasian Collared-Dove, and these were all observed outside the reserve. This increased to 11.1% (n = 206) of all eBird checklists in the region that re-

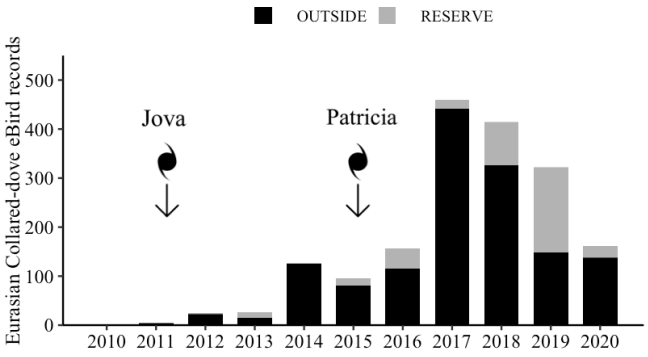

Figura 3. Number of eBird records of the Eurasian Collared-Dove within the Chamela-Cuixmala Biosphere Reserve and in nearby human settlements outside the reserve, during 2010-2020.

ported presence of the species from 2016-2020 after Hurricane Patricia (2015). Of the 257 checklists that recorded presence of the Eurasian Collared-Dove, on1y 1.2% (n = 3) occurred before Hurricane Jova (2011). Another 48 eBird checklists reported the Eurasian Collared-Dove between 2012-2015, representing an increase of 18.7% in checklists recording presence of the dove. However, it is notable that the majority of checklists (80.1%, n = 206) recorded presence of the Eurasian Collared-Dove in the years after Hurricane Patricia in 2015 (Figure 3). This increase in records of the Eurasian Collared-Dove after Hurricane Patricia was significant for checklists outside the reserve ($W_{57,143} = 2984.5$, $P = 0.001$). However, although there was an increase in checklists reporting presence of the Eurasian Collared-Dove within the Chamela-Cuixmala Biosphere Reserve after Hurricane Patricia (Figure 3), this did not differ significantly from records over the previous years of 2010-2015 ($W_{15,61} = 463$, $P = 0.676$).

Discusión

Our data demonstrated increased presence of the invasive, exotic Eurasian Collared-Dove at a site within a protected area. Previous records of the Eurasian Collared-Dove in Mexico have mainly occurred in urban, sub-urban and agricultural areas (Pineda-López and Malagamba 2011, Chablé-Santos et al. 2012, Blancas-Calva et al. 2014, Tinajero and Rodríguez-Estrella 2014, Tinajero and Partida-Pérez 2016), with few records in conserved habitats (Ortiz-Pulido et al. 2010). In this sense, we consider that our observations on the presence and behavior of this invasive species in the Chamela-Cuixmala Biosphere Reserve are relevant for monitoring the possible expansion of this dove into conserved forest areas.

Particularly for the Chamela Biological Station, results of this study indicate that the number of records and the duration that Eurasian Collared-Doves spent perched in the area, increased from one year to the next. Colonization by the Eurasian Collared-Dove is considered to occur in jumps from occupied sites to nearby unoccupied areas (Romagosa and Labisky 2000, Fujisaki et al. 2010). Previous studies in the Chamela-Cuixmala region have demonstrated higher numbers of the Eurasian Collared-Dove, and some active nests in several towns (Camacho-Cervantes and Schondube 2018) close to the Chamela Biological Station (Chamela town: 4.3 km; San Mateo: 9.5 km; Punta Perula: 13 km). It is likely therefore that excursions by the Eurasian Collared-Dove into the reserve are facilitated by the proximity of human settlements and the presence of paved roads.

Our results also demonstrated that records of the Eurasian Collared-Dove in the region increased following major Hurricane Patricia. We believe that the alteration of forest structure caused by landfalling hurricanes (Parker et al. 2018) could have created potential niches for the Eurasian Collared-Dove since similar trends have been observed for invasions of other exotic species (Bellingham et al. 2005, Shiels et al. 2020). In particular, the more severe damage and habitat modification caused by Hurricane Patricia may have affected native birds, forcing them to locally migrate to other habitats (Martínez-Ruiz and Renton 2018, Renton et al. 2018). Hurricane disturbance may also reduce abundance of some groups of forest birds (Will 1991, Wunderle 1992, Wiley and Wunderle 1993, Martínez-Ruiz and Renton 2018). In the Chamela-Cuixmala region, higher numbers of granivores and a reduction in carnivorous birds were recorded after hurricane disturbance (Levey and MacGregor 2021), and these changes could influence interspecific competition for the Eurasian Collared-Dove (Shiels et al. 2020). Moreover, previous studies demonstrate that while the dry forest may be resilient to low-category hurricanes, such as Jova, landfall by a major hurricane, such as Patricia, causes a level shift in fruiting cycles of forest trees (Renton et al. 2018). Lastly, the density decreases in local diurnal raptor populations following Hurricane Patricia (Martínez-Ruiz and Renton 2018) could result in reduced predation risk for birds and further promote incursion by the Eurasian Collared-Dove within the Chamela-Cuixmala Biosphere Reserve.

Thereby, the creation of potential niches, and lower risk of predation, could facilitate invasion by the Eurasian Collared-Dove to sites within the reserve.

Although we did not observe interactions of Eurasian Collared-Doves with other native dove species, we consider it important to monitor interspecific interactions of the Eurasian Collared-Dove with native avifauna in our study area. Studies have reported competition among the Eurasian Collared-Dove and other native Columbidae species (Romagosa and Labisky 2000, Poling and Hayslette 2006). Moreover, previous studies suggest that Eurasian Collared-Doves dominate dove communities and reduce their diversity (Camacho-Cervantes and Schondube 2018), having potential effects in community dynamics where they occur. Native birds could also be vulnerable to the presence of the invasive Eurasian Collared-Dove since the species carries diseases like Newcastle virus (Terregino et al. 2003), west Nile virus (Savini et al. 2012), and paramyxovirus (Schuler et al. 2012). Therefore, more information is needed on the possible establishment and interactions of doves and native birds in the reserve to apply specific conservation actions.

We recommend continued avian monitoring to determine whether the Eurasian Collared-Dove is increasing numbers within the Chamela-Cuixmala Biosphere Reserve. In particular, it would be important to monitor and control the possible establishment and nesting attempts in forested areas. It is likely that Eurasian Collared-Doves in towns were also affected by hurricane landfall, but due to their ecological plasticity and reproductive rate (Bonter et al. 2019) this species might not be severely affected in the long term by hurricane disturbance. On the contrary, the increasing intensity and frequency of hurricanes over the past few decades due to climate change (Emanuel 2005), along with the expected increase in the incidence of major hurricanes, may represent a risk of colonization by the Eurasian Collared-Dove not only within the Chamela-Cuixmala Biosphere Reserve, but in other conserved forest areas where this invasive species inhabits.

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