EXOTIC TREES FAIL AS A SUPPORT FOR RED-CRESTED CARDINAL (*PAROARIA CORONATA*) NESTS IN A NATIVE FOREST OF EAST-CENTRAL ARGENTINA

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Abstract.- Different tree species offer birds different types of bases for building the nests; those with thorns have been reported as important structural supports to contain and protect the nest from predators. We evaluate whether the tree used for nest support of the Red-crested Cardinal (*Paroaria coronata*) influences the durability and viability of the nests. Because the native forests of east-central Argentina are heavily altered by anthropic activity and coexist with a large number of exotic tree species, we assessed whether the frequency of broken-down nests before completing the nesting cycle varied between native and exotic trees. We monitored 207 nests in natural areas (all built on native trees) and 22 in modified habitats (seven on native trees and 15 on exotic trees). Among the nests built on native trees, the frequency of broken-down nests was lower in the Spiny Hackberry (*Celtis ehrenbergiana*) than in *Scutia buxifolia* and *Schinus longifolius* trees. Although all of them have thorns, we attribute this result to the tangled and zigzagging arrangement of *C. ehrenbergiana* branches that offer better support for the nests. On the other hand, the frequency of broken-down nests before completing the nesting cycle was higher in exotic trees, which raises concerns about the negative effect of the presence of exotic trees in the breeding areas of the Red-crested Cardinal. Considering the continuous invasion and expansion of exotic trees in these remnants of native forests, we suggest the authorities take measures to avoid new introductions and to control the progress of those that are already expanding, such as the worrying invasive tree *Gleditsia triacanthos*.

Key words: Celtis ehrenbergiana, Gleditsia triacanthos, *nest-tree support, invasive trees, native trees.*

Resumen.- LOS ÁRBOLES EXÓTICOS FALLAN COMO SOPORTE DE LOS NIDOS DEL CARDENAL COPETE ROJO (*PAROARIA CORONATA*) EN BOSQUES NATIVOS DEL CENTRO-ESTE DE ARGENTINA. Las diferentes especies de árboles ofrecen a las aves distintos tipos de bases para la construcción de los nidos, y los que tienen espinas se han reportado como importantes soportes estructurales para contenerlos y protegerlos de los depredadores. En este trabajo evaluamos si la especie de árbol-soporte para los nidos del Cardenal Copete Rojo (*Paroaria coronata*) tiene influencia en la durabilidad y viabilidad de los nidos. Debido a que los bosques de talares del centro-este de Argentina están fuertemente intervenidos por la actividad antrópica y conviven con un gran número de especies arbóreas exóticas, evaluamos si la frecuencia de nidos que se desarman antes de terminar el ciclo de nidificación varía entre árboles nativos y exóticos. Monitoreamos 207 nidos en el ambiente natural (todos construidos sobre árboles nativos) y 22 en el ambiente modificado (siete sobre árboles nativos y 15 sobre exóticos). Entre los nidos construidos sobre árboles nativos, la frecuencia de nidos desarmados fue menor en Tala (*Celtis ehrenbergiana*) que en Coronillo (*Scutia buxifolia*) y Molle (*Schinus longifolius*). Si bien todas ellas presentan espinas, atribuimos este resultado a la disposición enmarañada y zigzagueante de las ramas de Tala que podrían ofrecer un mejor soporte para los nidos. Por otro lado, la frecuencia de nidos desarmados fue mayor para árboles exóticos en relación a nativos, lo que enciende una alerta sobre el efecto negativo de la presencia de árboles exóticos en los sitios de cría del Cardenal Copete Rojo, y posiblemente otras especies de aves que usan los talares como sitios de cría. Considerando la continua invasión y expansión de árboles exóticos en los talares bonaerenses, sugerimos a las autoridades que tomen medidas para evitar nuevas introducciones y controlar el avance de las que ya están en expansión, como el caso preocupante de la invasora Acacia Negra (*Gleditsia triacanthos*).

Palabras clave: Celtis ehrenbergiana, Gleditsia triacanthos, *árbol-nido, árboles invasores, árboles nativos*

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Different tree species offer birds different types of bases for nest construction (Hansell 2000, Mezquida 2003, Collias and Collias 2014, Biddle et al. 2017). For some tree species with thorns on their branches, it has been claimed that the thorny branches provide important structural support for nest construction (Healy et al. 2015). For example, in dry forests of central Argentina, Marone et al. (1997) found that branch structure was associated with nest stability against wind or heavy rains, and Mezquida and Marone (2001) reported that the selection of some nest-tree species was more related to the structural characte-

ristics of the branches than to any benefit against nest predators. In the same way, Austin (1970) found that birds avoided nesting on thornless bushes in a North American desert, as these branches provided few suitable forks to support the nest (see also Mares et al. 1977). Apparently then, thorns can serve as an effective structural basis to increase the stability of nests (Janzen 1969, Biddle et al. 2017) and can also discourage the access of certain nest predators (Schmidt and Whelan 1999, Collias and Collias 2014, Healy et al. 2015; but see Vazquez and Farji-Brener 2018). For example, thorns can reduce the attacks of certain snakes (Quader 2006), but be neutral against birds or rodents, or even facilitate their access (Mezquida and Marone 2002, Borgmann and Rodewald 2004). Given this potential association between breeding success and the presence and characteristics of thorns that support the nests, studies on the availability of suitable nesting trees in breeding areas are especially relevant (Healy et al. 2015).

Tree species representative of the 'talares' (a type of native forest that grows in east-central Argentina, hereafter 'talares') commonly have thorns in their branches (except for *Sambucus australis* and *Phytolacca dioica*). The dominant tree species of the talares is *Celtis ehrenbergiana*, which has zig-zag branches with geminated axillary thorns that offer different angular and intricate surfaces for nest construction (Dawson 1967). *C. ehrenbergiana* is followed in abundance by *Scutia buxifolia* and *Schinus longifolius*, both with abundant thorns on their branches. Talares are one of the few native forest communities in east-central Argentina and are being progressively degraded due to urbanization, livestock activities, extraction of calcareous material and firewood and establishment of forest plantations (Arturi and Goya 2004). According to Di Giacomo et al. (2007), at least ten areas within these forests are critical for bird conservation. Talares are also used as effective nesting and feeding sites (Marateo et al. 2009). Due to the proximity to large urban centers, these forests have been invaded by a large number of exotic trees, mostly without thorns in their branches. In this contribution we study whether the tree species selected as a nesting support has an influence on the durability and viability of the nests of the Red-crested Cardinal (*Paroaria coronata*), a bird that frequently nests in these forests. In particular, we assess whether the frequency of broken-down nests before completing the nesting cycle (~28 days for this bird species, Segura et al. 2015) varies between native and exotic trees.

METHODS

Study area

The study was conducted in two different habitats in northeastern Buenos Aires Province, east-central Argentina: 1) a relatively well preserved area of native forest (Estancia 'La Matilde' and Estancia 'Luis Chico' in Punta Indio Department, Buenos Aires Province; 35° 20' S, 57° 11' W; hereafter 'natural habitat') and 2) four urban and semi-urban areas of forests strongly modified by human activity (hereafter 'modified habitat'): 1) outskirts of Verónica City, Punta Indio Department (35° 22' S, 57° 18' W), 2) outskirts of Villa Elisa City, La Plata Department (34° 53' S, 58° 04' W), 3) Parque Ecológico Municipal, La Plata Department (34° 51' S, 58° 04' W) and 4) outskirts of Facultad de Ciencias Naturales y Museo (National University of La Plata), La Plata department (34° 54' S, 57° 55' W) (Fig. 1). Talares are warm-temperate forests related to the Chacoan Domain (Cabrera and Willink 1980), with an average annual temperature of 16° C and annual rainfall of ~900 mm.

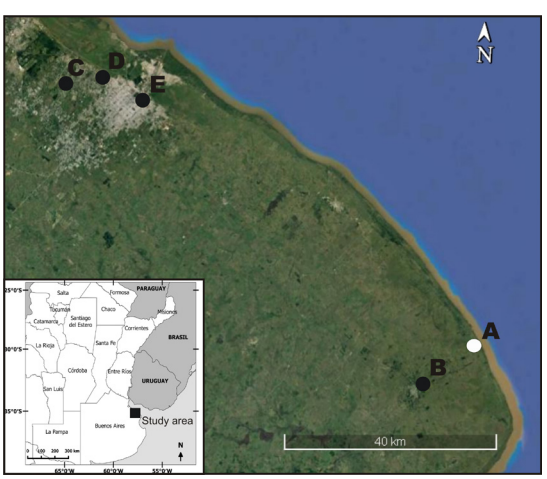

Figure 1: Map showing the location of the study site in east-central Argentina, with indication of natural (white circle, A) and modified habitats (black circles, B-E). A is a relatively well preserved area of native forest in Punta Indio department, Buenos Aires province and B-E are urban or semi-urban areas of forests strongly modified by human activity: outskirts of Verónica city, Punta Indio department (B); outskirts of Villa Elisa city, La Plata department (C); Parque Ecológico Municipal, La Plata department (D); and outskirts of Facultad de Ciencias Naturales y Museo (National University of La Plata), La Plata department (E).

The natural habitat is within the Biosphere Reserve 'Parque Costero del Sur' (UNESCO Natural Heritage) and, in turn, is within the Bahía de Samborombón Wildlife Refuge, under the jurisdiction of the Buenos Aires province. These forests have been moderately altered in recent decades, where clearing to increase crop areas and selective logging to extract firewood have been the main types of habitat alterations. The most represented native trees were *Celtis ehrenbergiana* and *Scutia buxifolia* (Segura and Arturi 2009), but other representative native species were also common in the study site, such as *Schinus longifolius*, *Sambucus australis* and *Phytolacca dioica*. In this habitat, ~5% of the forested area was covered by *Eucalpytus* sp. plantations, and another ~7% has been colonized by exotic tree species such as *Populus* sp., *Pinus* sp., *Melia azedarach*, *Morus alba*, *Ligustrum lucidum* and *Gleditsia triacanthos*, among others.

On the other hand, the modified habitat, represented by four different study sites (Fig. 1), is characterized by strong current and historical anthropic environmental alteration (Arturi and Goya 2004). In these forests there is a clear predominance of exotic tree species that have replaced native ones. The only native species present in these sitesare *Celtis ehrenbergiana* and *Schinus longifolius*, sparsely distributed over fences or road margins (in all cases it represents less than 5% of tree cover). The rest is mostly represented by ornamental trees introduced by humans, such as *Populus* sp., *Eucalpytus* sp., *Gleditsia triacanthos*, *Fraxinus americana, Celtis australis, Ligustrum lucidum*, among others.

Study species

The Red-crested Cardinal (Family Thraupidae) is a sexually monomorphic species (Segura and Mahler 2019) that inhabits semi-open areas with scattered trees and shrubs (Segura and Arturi 2012, Segura et al. 2014a) from east-central Argentina to southern Brazil, Paraguay, eastern Bolivia, and Uruguay. At the study site they breed from early October to late February, and build open-cup nests (Fig. 2). Nests are built with thorny twigs (usually of native trees as *Celtis ehrenbergiana*) and lined with stems, roots, bristles, and hairs (Segura 2011, Segura et al. 2015). The nests are typically placed in small forks or clusters of small branches in the tree-canopy (Segura 2011). External nest dimensions are ~13 cm in diameter and ~8 cm in depth, and inner nest cup dimensions are 8 cm in diameter and 4 cm in depth (Segura et al. 2015). Modal clutch size is 3 eggs (Segura and Reboreda 2012a, 2012b, Segura and Berkunsky 2012, Segura et al. 2012, 2015).

Nest monitoring and data analysis

We collected data during 11 consecutive breeding seasons (2006-2018), from October to February. We found nests by systematically searching potential nest sites and observing the behavior of territorial pairs (see details in Segura et al. 2015). Once we found the nest, we determined the nest stage (construction, egg lying, incubation or nestlings) and we visited it every 2-4 days until the nestlings flew or the nest failed (predation, abandonment, destruction by storms, among others). When the nestlings were 9-10 days of age, we inspected the nests from a distance of 1–3 m to minimize the risk of premature fledging. We considered a nest successful when at least one nestling left the nest. We considered a nest deserted if eggs were cold to the touch and no parental activity was observed near the nest during the visit (i.e., 15–20 min), or when all chicks died mainly as a result of botfly (*Philornis* spp.) parasitism (Segura and Reboreda 2011). We considered a nest predated if nest contents disappeared between two consecutive visits and

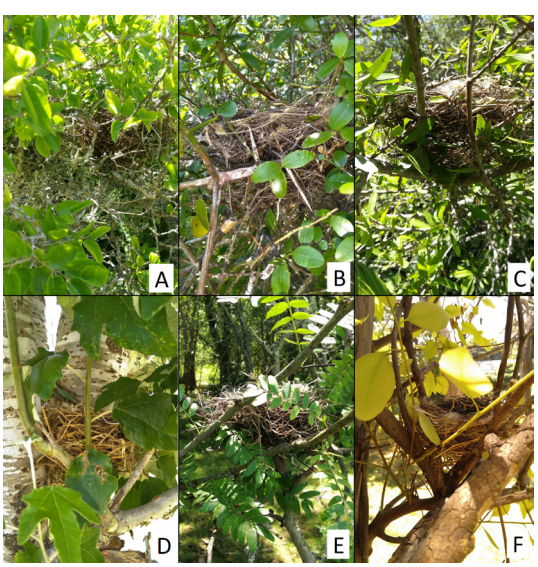

Figure 2: Red-crested Cardinal nests in different tree species used as support: *Celtis ehrenbergiana* (with thorns, A), *Scutia buxifolia* (with thorns, B), *Schinus longifolius* (with thorns, C), *Populus* sp. (without thorns, D), *Gleditsia triacanthos* (with thorns, E) and *Eucalpytus* sp. (without thorns, F).

no parental activity was detected near the nest. Nests abandoned before eggs were laid were not considered. For descriptive and data analysis purposes, we only considered successful nests and those that failed because they were broken-down or destroyed by wind or storms (i.e., we excluded all predated and deserted nests). We used chi-square tests to assess differences in frequency distributions (R Core Team 2019).

RESULTS

We monitored 207 nests in the natural habitat and 22 in the modified one. In the natural habitat, all nests were built in native trees: 143 in *Celtis ehrenbergiana* (Fig. 2A), 61 in *Scutia buxifolia* (Fig. 2B) and three in *Schinus longifolius* (Fig. 2C). In the modified habitat, seven nests were built in native trees (six in *Celtis ehrenbergiana* and one in *Schinus longifolius*) and 15 in exotic trees (three in *Celtis australis*; three in *Populus* sp., Fig. 2D; two in *Acacia melanoxylon*; two in *Prunus persica*; two in *Gleditsia triacanthos*, Fig. 2E; one in *Fraxinus americana*; one in *Eucalpytus* sp., Fig. 2F; and one in *Quercus* sp.). Among the nests monitored in the modified habitat, six were found in Verónica, 11 in Villa Elisa, three in the Parque Ecológico Municipal and two in the Facultad de Ciencias Naturales y Museo.

The frequency of broken-down nests before completing the nesting cycle varied between native and exotic trees (native: 8 of 214, exotic: 7 of 15; Chi = 52.42, *df* = 1, *P* <0.001; Fig. 3A). This frequency varied in relation to the tree species used as a support (*Celtis ehrenbergiana*: 2 of 149, *Scutia buxifolia*: 5 of 61 and *Schinus longifolius*: 1 of 4; Chi = 9.11, *df* = 2, *P* < 0.01; Fig. 3B). Among the nests built on exotic trees, seven (47%) were broken-down before completing the nesting cycle (two were in *Populus* sp., one in *Celtis australis*, one in *Acacia melanoxylon*, one in *Gleditsia triacanthos*, one in *Fraxinus americana* and one in *Eucalpytus* sp.).

Finally, among the nests broken-down before completing the nesting cycle (including native and exotic trees), six (55%) reached the nestling stage (nest failed when nestlings were 5-9 days of age) and the remaining five (45%) were broken-down during the incubation stage. The frequency of nests that reached the nestling stage did not vary between native and exotic trees (native: 3 of 4, exotic: 3 of 7; Chi = 0.29, *df* = 1, *P* = 0.58).

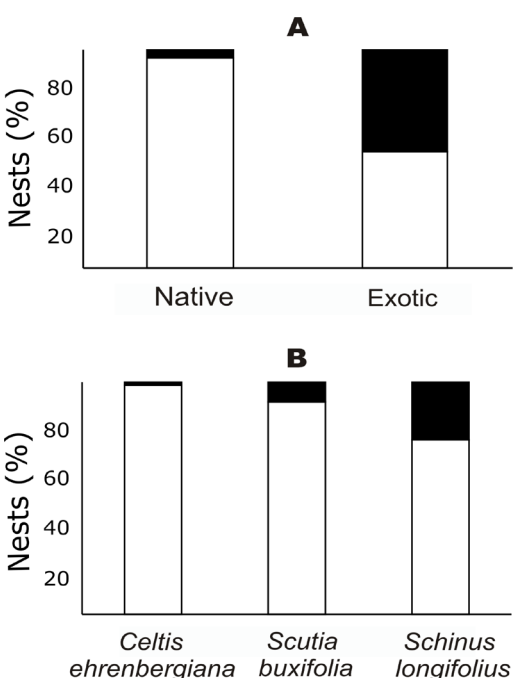

Figure 3: Percentage of broken-down nests before completing the nesting cycle (black area) and nests that managed to complete it (white area) in relation to native and exotic trees (A) and among native tree species (B) used as a support for Red-crested cardinal (*Paroaria coronata*) nests.

DISCUSSION

Our results indicate that the tree species used for nest support by the Red-crested Cardinal had an influence on the durability and viability of the nests. Nests built on exotic trees were broken-down before completing the nesting cycle more frequently than nests built on native trees. The number of monitored nests was clearly higher in natural habitats in relation to the modified ones, which is mainly explained by the greater sampling effort in natural habitats, but also to a greater abundance of Red-crested Cardinals in better preserved talares (Segura et al. 2014a). In addition, we found that the frequency of broken-down nests was lower in *Celtis ehrenbergiana* trees than in the rest of the native trees. Approximately 70% of the nests monitored were built on *C. ehrenbergiana* trees, coinciding with a previous study that reports a clear selection of this tree species over others available in the habitat (Segura and Arturi 2009). Because tree species such as *Scutia buxifolia* and *Schinus longifolius* also have thorns, our result would indicate that, in addition to the presence of thorns, the tangled and zigzagging arrangement of *C. ehrenbergiana* branches

offers better support for the nests (see also Ferguson-Lees et al. 2011). However, Segura (2011) reported that *C. ehrenbergiana* trees did not offer Red-crested Cardinals any advantage in terms of breeding success, as the highest nest success was associated with *S. buxifolia* instead of *C. ehrenbergiana*. The use of *C. ehrenbergiana* trees as a nest support, then, would be more linked to the structural characteristics of the branches than any benefit in breeding success (Lima 1990, Mezquida and Marone 2001, Segura 2011).

Despite the availability of exotic trees in the natural habitat (~12% of the forested area), the Red-crested Cardinals only used native trees to build their nests, highlighting the importance of nesting habitats that conserve native trees within the forest matrix. In the same sense, other passerines studied in these forests also exclusively used native trees to build their nests [i.e.; the Yellow-browed Tyrant *Satrapa icterophrys* (Gonzalez et al. 2019); Narrow-billed Woodcreeper *Lepidocolaptes angustirostris* (Jauregui et al. 2019); Masked Gnatcatcher *Poliptila dumicola*, Blue-and-yellow Tanager *Pipraeidea bonariensis*, Small-billed Elaenia *Elaenia parvirostris*, and Vermilion Flycatcher *Pyrocephalus rubinus*, Exequiel Gonzalez, unpubl. data]. Similarly, Mezquida (2002) also found that eight species of Tyrannidae in the central Monte desert of Argentina only used native trees as a nest support. Strikingly, *Gleditsia triacanthos* (a woody tree with abundant thorns that has invaded native forests of central Argentina, Fernández et al. 2017) was not used as a nest-tree in the natural habitat and was little used in the modified ones, despite its wide availability in both habitats. One possible explanation is that its foliage is not dense enough to allow hiding of nests (see Segura et al. 2012) or, alternatively, its large spines do not offer an effective anchor to contain the nests.

As an alternative explanation, a factor that could be associated with the frequency of broken-down nests is the type of material with which nests were built (Hansell 2000, Collias and Collias 2014, Healy et al. 2015), especially the external wall of the nest (Collias and Collias 2014). In this sense, for the nests monitored in the natural habitat, we are confident that the materials used for the nest's external wall were always dry thorny twigs of *Celtis ehrenbergiana*. Unfortunately, in the modified habitats, we do not have accurate information on the type of materials used to build the nest, although we believe that they mostly used dry thorny twigs of *Celtis ehrenbergiana* as well. Although the modified habitats had a large percentage of exotic trees and shrubs, *Celtis ehrenbergiana* was always present, but in a lower proportion in relation to the natural habitat (see 'Study area'). As mentioned above, the tangled and zigzagging arrangement of *C. ehrenbergiana* twigs in the nest's external wall offers a good support for the nest, which would lead Red-crested Cardinals to select them. However, our field data do not allow us to rule out an effect of nest material on the frequency of broken-down nests, mainly considering that the availability of dry thorny twigs of *Celtis ehrenbergiana* is lower in the modified habitats.

In addition to highlighting the continuous invasion and expansion of exotic trees in the native forests of east-central Argentina (Ghersa et al. 2002, Arturi and Goya 2004, Segura et al. 2014b), the results of this contribution are a warning about the negative effect of exotic trees in breeding sites for birds. Due to the proximity of these forests to the large urban centers and the homogeneous distribution of small rural towns that favor the propagation of ornate parks with numerous exotic plants, these natural habitats have been invaded by a large number of exotic tree species. In this context, as Red-crested Cardinal prefers native trees to nest in (Segura and Arturi 2009), we suggest that governmental authorities take urgent measures to stop the introduction of exotic trees in natural habitats and, in parallel, take measures to curb the rapid advance of invasive exotic species such as the worrying invasive *Gleditsia triacanthos* (Ghersa et al. 2002, Fernandez et al. 2017).

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