

Birds of prey of a semi-arid ecosystem in Falcón State, Venezuela: Diversity and ecological patterns

Aves rapaces de un ecosistema semiárido en el estado Falcón, Venezuela: diversidad y patrones ecológicos

Luis A. Saavedra¹, Belkis A. Rivas¹ & Carla I. Aranguren D.²

¹*Departamento de Biología, Facultad de Ciencias, Universidad de Los Andes, Mérida 5101, Venezuela.*

²*Laboratorio de Ecología Animal A. Departamento de Biología, Facultad de Ciencias, Universidad de Los Andes, Mérida 5101, Venezuela.*

Correspondence: belalirodri62@gmail.com

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ABSTRACT

Notes are presented on the species richness, diet, and reproduction of birds of prey in a semi-arid ecosystem of north-western Venezuela, based on nine months of daytime observations. A total of sixteen resident and two migratory species, belonging to four orders and five families, were recorded. Nests of eight species were observed and described. The diets of five species were determined through analyses of pellets and other prey remains collected around nests. The Eastern Cottontail Rabbit, *Sylvilagus floridanus* (J. A. Allen, 1890), was the most frequent prey item. Additionally, negative interactions between rural communities and raptors are reported, including the use of pesticides by local residents to control species perceived as threats to domestic animals.

Keywords: bird nests, human-wildlife conflict, raptor diets, species richness.

RESUMEN

Se presentan notas sobre la riqueza de especies, la dieta y la reproducción de aves rapaces en un ecosistema semiárido del noroeste de Venezuela, basadas en nueve meses de observaciones diurnas. Se registraron un total de dieciséis especies residentes y dos migratorias, pertenecientes a cuatro órdenes y cinco familias. Se observaron y describieron nidos de ocho especies. La dieta de cinco especies se determinó mediante el análisis de eagrópilas y otros restos de presas recolectados alrededor de los nidos. El Conejo de Florida, *Sylvilagus floridanus* (J. A. Allen, 1890), fue la presa más frecuente. Además, se reportan interacciones negativas entre las comunidades rurales y las aves rapaces, incluyendo el uso de plaguicidas por parte de los residentes locales para controlar especies percibidas como amenazas para los animales domésticos.

Palabras clave: conflicto humanos-vida silvestre, dieta de rapaces, nidos de aves, riqueza de especies.

INTRODUCTION

Arid and semi-arid environments in Venezuela are primarily located in the northern and western regions of the country, covering less than 4.5% of the national territory. These areas are characterized by low rainfall and high temperatures, which result in vegetation types such as deciduous and semi-deciduous forests, xerophytic plants, and

thorny shrubs (Matteucci 1982, Rodríguez *et al.* 2010, Nassar *et al.* 2013). There are only a few studies that have assessed the avifauna in these environments, and even fewer that focus on birds of prey, a group typically mentioned only in supplementary lists or in a limited number of reproductive studies (Barnes & Phelps 1940, Bosque & Lentino 1987, Ramoni-Perazzi *et al.* 2001, Morales *et al.* 2004, Rodríguez-Ferraro & Blake 2008).

Raptors are defined as those species of birds that have evolved from a common raptorial landbird ancestor that have maintained a raptorial lifestyle; they include all species within the orders Accipitriformes, Cathartiformes, Falconiformes and Strigiformes (McClure *et al.* 2019). In Venezuela, this functional group is represented by 90 species of the families Accipitridae, Cathartidae, Falconidae, Pandionidae and Strigidae (Miranda *et al.* 2024). However, raptors remain one of the least studied bird groups in the country. Therefore, this study aims to contribute to the understanding of raptors in a semiarid ecosystem of northwestern Venezuela through field observations focused on species richness, diet, reproduction, and interactions with local communities.

MATERIALS AND METHODS

The observations were made in a semi-arid ecosystem located 15 km southeast of Pedregal, Falcón State, Venezuela (10°56'15"N 70°00'41"W). The relief of the study area consists of a continuum of small depressions surrounded by hills. The vegetation, which includes cactus and dry forest elements, is dominated by *Prosopis juliflora* (Sw.) DC. (Fabaceae), *Bourreria exsucca* (L.) Jacq. (Boraginaceae) and *Bulnesia arborea* (Jacq.) Engl. (Zygophyllaceae) (Matteucci *et al.* 1982). The region has a dry, bi-seasonal climate, characterized by a dry season from December to March and rainfall peaks in May and October. Average annual temperatures range from 24.5 °C to 28.6 °C, with a total annual precipitation between 992 and 1,200 mm (Matteucci *et al.* 1982).

Unrestricted, non-systematic daytime surveys were conducted to record and identify raptor species between August 11 and 30, 2022, and between March 24 and April 19, 2023. Observations were made using 8.5×32 Raptor binoculars and photographs taken with a Canon EOS Rebel T7 camera. Taxonomic classification follows Clements *et al.* (2023). Additionally, the nests of raptors were identified and described (in terms of place of construction, type of material, size and height, and presence/absence of eggs. The description of the nests follows Simón & Pacheco (2005). The diet was characterized based on the collection of pellets and remains of prey found around or inside the nests. The samples were placed in paper envelopes, which were labeled and transferred to the laboratory of the Vertebrate Collection of the University of Los Andes (CVULA) for analysis. Each pellet was moistened and washed with water, and its contents (bone fragments, hair, scales, and insect exoskeletons) were separated using tweezers to facilitate identification. Mammalian remains (mandibles and skulls) were compared with reference

specimens of known species deposited in the CVULA collection.

To identify which raptor species have negative interactions with rural communities, local residents were asked whether they considered any of them to be a threat to domestic animals.

Finally, our species list was compared with those reported in the literature (Barnes & Phelps 1940, Ramoni-Perazzi *et al.* 2001, Rodríguez-Ferraro & Blake 2008) using the qualitative Sørensen Similarity Index (Moreno 2001).

RESULTS

For the semi-arid environments of Venezuela, the presence of 30 species of raptors, including 28 resident and two migratory species, has been documented (Barnes & Phelps 1940, Bosque & Lentino 1987, Ramoni-Perazzi *et al.* 2001, Morales *et al.* 2004, Rodríguez-Ferraro & Blake 2008). In the present study, 18 species were recorded, including 16 resident and two migratory species (Table 1). Four orders and five families were represented. At the family level, the Accipitridae showed the greatest species richness, followed by the Falconidae, Cathartidae, Strigidae, and Pandionidae.

Comparison with previous studies carried out in Venezuela revealed moderate similarity levels: 51.9% with the raptor assemblage of the Paraguana Peninsula (Barnes & Phelps 1940) and 50% with six arid sites in northern Venezuela (Rodríguez-Ferraro & Blake 2008). However, a similarity of only 24.4% was found with the raptor assemblage from the arid enclave of Lagunillas, in the Mérida Andes (Ramoni-Perazzi *et al.* 2001).

A total of 20 dietary samples were collected, corresponding to five raptor species: Black Vulture, *Coragyps atratus* (Bechstein, 1793), Zone-tailed Hawk, *Buteo albonotatus* (Kaup, 1847), Harris's Hawk, *Parabuteo unicinctus* (Temminck, 1824), Great Horned Owl, *Bubo virginianus* (Gmelin, 1788), and Crested Caracara, *Cara-cara plancus* (J. F. Miller, 1777). Eight prey categories were identified—one bird, three reptiles, and four mammals (Table 2). The Eastern Cottontail, *Sylvilagus floridanus* (J. A. Allen, 1890) was recorded in the diet of four species, whereas the Green Iguana, *Iguana iguana* (Linnaeus, 1758) appeared in three.

Regarding negative interactions between humans and birds of prey, several poisoned animals were found during the surveys. These carcasses were located a few meters from bait poisoned with carbofuran, as confirmed by local residents. The affected birds included two Turkey Vultures, *Cathartes aura* (Linnaeus, 1758), one Crested Caracara,

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Table 1. Raptor species recorded for the semiarid ecosystems of Venezuela. **R:** resident species. **M:** Nearctic migratory species.

Family	Species	Status	Barnes 1940	Ramoni-Perazzi <i>et al.</i> 2001	Rodríguez-Ferraro & Blake 2008	This study
CATHARTIDAE	<i>Sarcorampus papa</i>	R				x
	<i>Coragyps atratus</i>	R	x	x		x
	<i>Cathartes aura</i>	R	x	x		x
PANDIONIDAE	<i>Pandion haliaetus</i>	M	x	x		x
ACCIPITRIDAE	<i>Gampsonyx swainsonii</i>	R		x	x	x
	<i>Elanus leucurus</i>	R		x		
	<i>Chondrobierax uncinatus</i>	R		x		
	<i>Elanoides forficatus</i>	R		x		
	<i>Rostramus sociabilis</i>	R		x		
	<i>Accipiter striatus</i>	R		x		
	<i>Geranoospiza caerulescens</i>	R				x
	<i>Buteogallus urubitinga</i>	R				x
	<i>Buteogallus meridionalis</i>	R				x
	<i>Buteogallus solitarius</i>	R				x
	<i>Parabuteo unicinctus</i>	R	x			x
	<i>Parabuteo leucorrhous</i>	R			x	
	<i>Rupornis mgnirostris</i>	R			x	x
	<i>Geranoaetus albicaudatus</i>	R	x			x
	<i>Geranoaetus melanoleucus</i>	R			x	
	<i>Buteo brachyurus</i>	R				x
<i>Buteo albonotatus</i>	R				x	
STRIGIDAE	<i>Megascops choliba</i>	R	x	x		
	<i>Bubo virginianus</i>	R				x
	<i>Athene cunicularia</i>	R	x			
	<i>Glaucidium brasilianum</i>	R				x
FALCONIDAE	<i>Daptrius chimachima</i>	R		x	x	
	<i>Caracara planchus</i>	R	x		x	x
	<i>Herpetotheres cachinnans</i>	R			x	x
	<i>Falco sparverius</i>	R	x	x	x	x
	<i>Falco columbarius</i>	M				x

Table 2. Prey species found in the diet of four raptors in a semiarid ecosystem, Falcón state, northwestern Venezuela. COA *Coragyps atratus*. PAU *Parabuteo unicinctus*. BUJ *Bubo virginianus*. CAP: *Caracara plancus*. BUA *Buteo albonotatus*.

Prey	COA	PAU	BUJ	CAP	BUA
REPTILIA					
<i>Iguana iguana</i>		x	x	x	
Unidentified snake			x		
Unidentified lizard			x		
MAMMALIA					
<i>Rhipidomys venezuelae</i>			x		
<i>Sylvilagus floridanus</i>	X	x	x	x	
<i>Marmosa xerophila</i>			x		
<i>Capra aegagrus hircus</i>				x	
AVES					
<i>Melanerpes rubricapillus</i>					x

Caracara plancus (J. F. Miller, 1777), and one Black Vulture, *Coragyps atratus* (Bechstein, 1793) (Fig. 1). According to local residents, carbofuran is used to control birds of prey considered harmful to domestic animals, as these raptors may kill or cause serious injuries to small or newborn chicks, as well as young goats and sheep.

Nesting by nine raptor species was documented through direct observations. The characteristics and general features of the nests of eight species are presented here, following the classification system of Simón & Pacheco (2005). A species-specific description of the nests observed in this study is provided below.

CATHARTIDAE

Black Vulture, *Coragyps atratus* (Bechstein, 1793)

An inactive Black Vulture nest was documented; however, it showed evidence of recent use. Feces and fragments of white eggshells with small brown spots were present on the sandy substrate. The nest had been observed on March 29, 2023, and local residents reported seeing juveniles in it approximately one month earlier. The simple, unlined nest was located in a cave-like cavity at ground level, beneath the roots of a *P. juliflora* tree (Fig. 2f). Bone remains of *S. floridanus* were found a few meters from this nest.

ACCIPITRIDAE

Zone-tailed Hawk, *Buteo albonotatus* (Kaup, 1847)

On 31 March 2023, a nest was observed on the top of a *B. arborea* tree at a height of 12 m, where two white eggs

were found (Fig. 2e). One year later, on 14 April 2024 the nest was revisited, and was found to be active and possibly reused by the same pair, behavior that has been observed in other populations (Johnson *et al.* 2020). The nest was of the simple/platform type, measuring 75 cm in diameter, 40 cm in height, and 10 cm in depth. It was built with thin branches of the same tree and lined with a shallow layer of leaves. In both years, one parent remained in the nest while the other stayed nearby. In 2023, one individual was observed vigorously chasing away a Turkey Vulture. In 2024, the remains of a Red-crowned Woodpecker (*Melanerpes rubricapillus* Cabanis, 1862) were found beneath the nest.

White-tailed Hawk, *Geranoaetus albicaudatus* (Vieillot, 1816)

On April 17, 2023, a White-tailed Hawk was observed carrying a branch in its talons to a nest located in a *Handroanthus* sp. tree (Bignoniaceae) at approximately 4 m above ground. On April 16, 2024, another nest under construction was observed in a *P. juliflora* tree at 3 m above ground. Both nests were situated atop a hill, belonged to the simple/platform category, were exposed to direct sunlight, and were constructed with thin branches (Fig. 2d). Identified nest materials included branches of *P. juliflora* and *Vachellia tortuosa* (L.) Seigler & Ebinger (Fabaceae).

Harris's Hawk, *Parabuteo unicinctus* (Temminck, 1824)

Three nests were documented during the sampling period: The first, observed on March 8, 2023, was inactive, while the second and third, observed on March 23, 2023, and April 14, 2024, respectively, were active. In the active

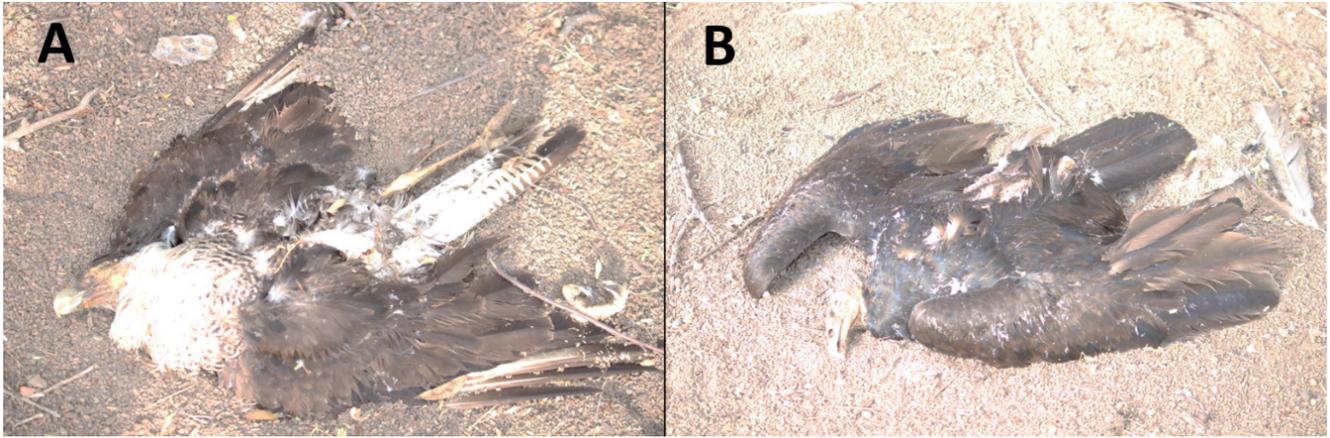


Figure 1. Birds of prey poisoned by consumption of carbofuran bait in a semi-arid environment in Falcón state, northwestern Venezuela. A. *Caracara plancus*. B *Cathartes aura*.

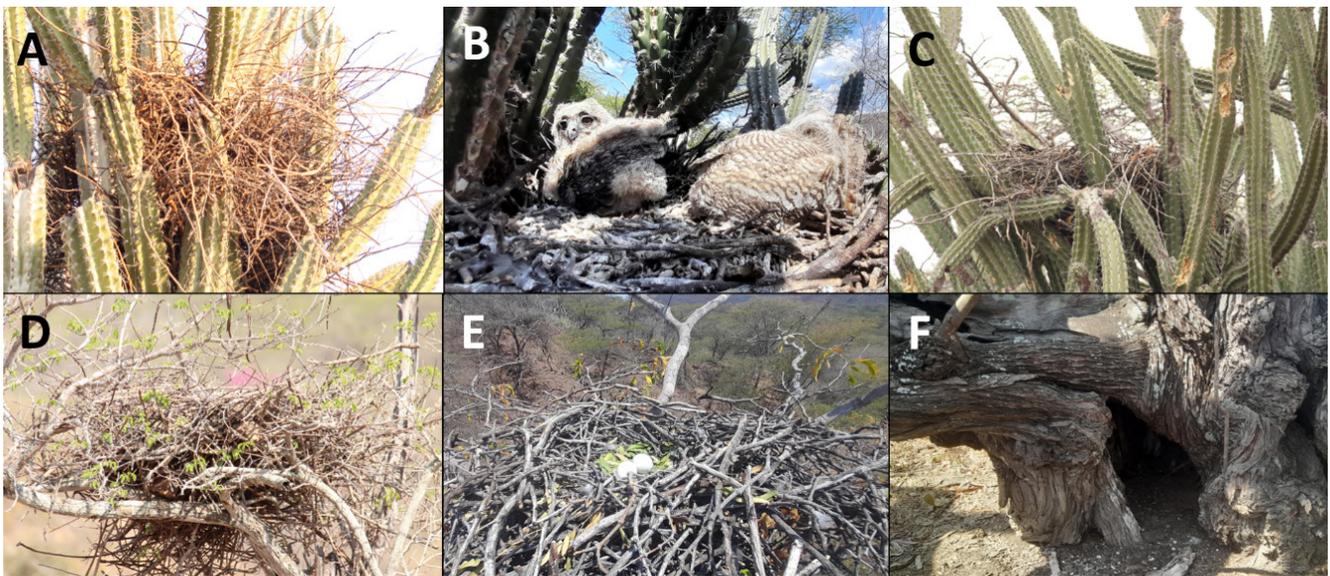


Figure 2. Nests of birds of prey found in a semi-arid environment in Falcón state, northwestern Venezuela. A. *Caracara plancus*. B. *Bubo virginianus*. C. *Parabuteo unicinctus*. D. *Geranoaetus albicaudatus*. E. *Buteo albonotatus*. F. *Coragyps atratus*.

nests, one parent was observed incubating eggs, while the other remained perched a short distance away. The inactive nest was located on a columnar cactus, *Stenocereus griseus* (Haw.) Buxb. LC. at a height of 2.5 meters. The active nest of 2023 was found 4 m above another columnar cactus of the same species, while the active nest of 2024 was located on a *B. arborea* tree at a height of 10 meters. All nests belonged to the simple/platform category, were bulky, and were constructed within the branches of *P. juliflora* tree (Fig. 2c). A skull of *S. floridanus* was found beneath the inactive nest. At the 2024 nest site, one of the adult birds was observed flying over the nest carrying a preyed *Iguana iguana*.

STRIGIDAE

Great Horned Owl, *Bubo virginianus* (Gmelin, 1788)

During sampling on April 14, 2023, two nestlings of different sizes were observed in a nest located among the branches of the columnar cactus, *S. griseus*, at a height of 2 m. This was a simple platform-type nest that measured approximately 67 cm in diameter and 56 cm in height, and was composed primarily of branches of *P. juliflora* (Fig. 2b). Remains of prey and pellets were found in, under, and around the nest. On April 14, 2024, another nest with similar characteristics was recorded on another *S. griseus*, at a height of 3 m. The nest contained a nestling, and

one of the parents observed from a distance. The structural characteristics of the nests, along with the documented behavior of nest reuse by the Great Horned Owl (Artuso *et al.* 2022), suggest that both may have represented previously abandoned nests of the Harris's Hawk.

FALCONIDAE

Crested Caracara, *Caracara plancus* (Miller, 1777)

On March 30, 2023, an inactive simple platform-type nest was found on a columnar cactus, *S. griseus*, at a height of 2 m and exposed to direct sunlight. The nest was primarily composed of branches of *P. juliflora* and *V. tortuosa* (Fig. 2a). Two adult Crested Caracaras were observed nearby, and local residents confirmed that the nest belonged to these birds and had been occupied since a few months earlier. Below and around the nest, there were abundant feces, pellets, and prey remains.

Laughing Falcon, *Herpetotheres cachinnans* (Linnaeus, 1758)

On August 13, 2023, a cavity-type nest was discovered in a stone wall along the banks of a seasonal stream at a

height of 3.5 m. The nest measured 60 cm deep and 25 cm wide, with a cavity height that tapered toward the bottom. Its interior consisted of a rocky, sandy substrate forming a concave space. The nest was occupied by a juvenile with remains of light-colored down (Fig. 3b). On April 17, 2024, another nest was located in a cavity approximately 3 m high in a *B. arborea* tree. An adult was observed nearby, vocalizing energetically, suggesting that the pair was brooding or that chicks were present inside the nest. Direct inspection was not possible because a honeycomb of meliponine bees was situated about 1 m below the nest.

American Kestrel, *Falco sparverius* (Linnaeus, 1758)

On March 30, 2023, a cavity-type nest with a diameter of 23 cm was discovered in a *Bulnesia arborea* (Jacq.) Engl. tree at a height of 2.5 m and a depth of 1 m (Fig.3a). The nest contained four cream-colored eggs with brown spots, resting on a layer of small branches, *B. arborea* leaves, and some feathers. Upon revisiting the nest on April 14, 2024, two chicks and one unhatched egg were observed. On both occasions, one parent remained in the nest while the other kept watch from a distance.

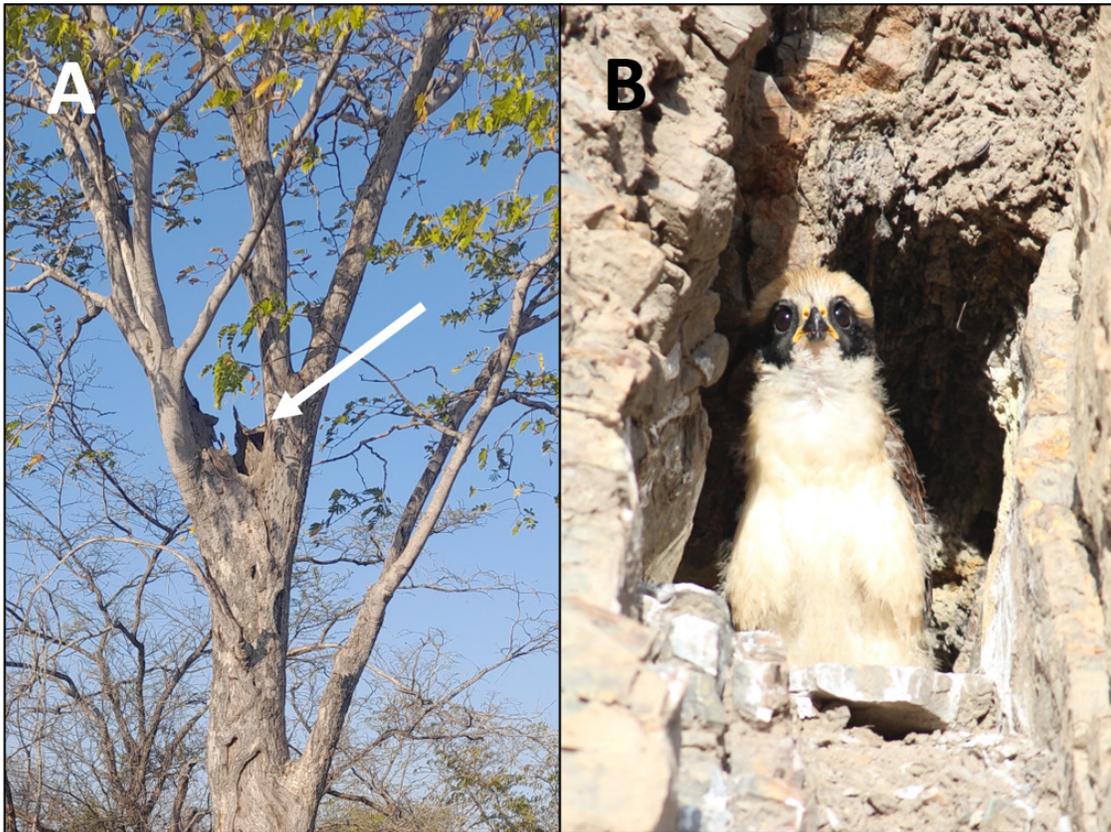


Figure 3. Nests of birds of prey found in a semi-arid environment in Falcón state, northwestern Venezuela. **A.** *Falco sparverius*. **B.** *Herpetotheres cachinnans*.

DISCUSSION

The high species diversity of birds of prey recorded in the present study, along with the moderate to low similarity compared to other lists from semiarid environments in Venezuela, reflects the success of our survey in inventorying birds of all raptorial families (Accipitridae, Cathartidae, Falconidae, Pandionidae, and Strigidae) occurring in the country.

The Lara-Falcón ecosystem complex comprises the largest region of arid and semi-arid environments in Venezuela (16,000 km²), encompassing a variety of vegetation types, including cactus, shrubs, and desert forests (Matteucci *et al.* 1982, Schubert 1988, Rodríguez-Ferraro & Blake 2008). This environmental heterogeneity likely contributes to a relatively high species richness (20 species) and a moderate similarity in species composition when compared with other semi-arid areas in the region, such as the Paraguaná Peninsula, and other continental semi-arid regions of Venezuela (Barnes & Phelps 1940).

Although the arid enclave of Lagunillas covers a small area (350 km²), it supports a relatively high raptor diversity (15 species). This may be attributed to the heterogeneity of surrounding non-arid ecosystems, which allows many species not typically associated with semi-arid environments to enter and leave the enclave easily (Ramoni-Perazzi *et al.* 2001). For this reason, this enclave shows the lowest similarity in species composition to the community that we studied.

Compared with other ecosystems in Venezuela, arid and semi-arid environments are less diverse. For example, in the Llanos region of Venezuela, 28 species of diurnal raptors have been reported, despite the genera *Cathartes* and *Coragyps* being excluded from the list (Jensen *et al.* 2005). Similarly, 25 species of diurnal and nocturnal raptors have been reported for a cloud forest in the Andes of Mérida (Rengifo *et al.* 2005), and 23 species for the Catatumbo River region of the Maracaibo Lake basin (Pirela *et al.* 2009). The reduced diversity of arid ecosystems is possibly due to their lesser primary productivity and environmental complexity, which cause the fauna of these regions to have lower population densities and species richness (Soriano & Ruíz 2003).

Birds of prey are a challenging group to study owing to their relatively low population densities, wide geographic ranges, high mobility, avoidance of areas with intense human activity, and, in some species, pronounced crepuscular or nocturnal behavior (Fuller & Mosher 1981). Accurate identification of raptors, particularly in flight, is of paramount importance, as are the observer's experience,

the methodological design, and the intensity of sampling, since these factors influence species detection and, consequently, the quality of inventories.

Regarding the diet of some of the species analyzed, the Great Horned Owl has been described as an opportunistic predator, consuming a wide range of vertebrates and invertebrates, particularly nocturnal animals (Artuso *et al.* 2022). However, our observations highlight the inclusion of *I. iguana*, a diurnal species, in its diet. In contrast, the Harris's Hawk primarily preys on rabbits and lizards in populations studied in the United States (Mader 1975), which coincides with the observations reported in the present study.

Regarding the Crested Caracara, our samples indicate that, in addition to species native to the semi-arid ecosystem, domestic species such as goats, *Capra aegagrus hircus* Linnaeus, 1758, are included in its diet. The consumption of domestic species no doubt owes to the scavenging habits of the species (Morrison & Dwyer 2023); however, locals claim that the species may kill and eat newborns, which creates a potential human-wildlife conflict. With respect to the diet of four of the five species, the presence of *S. floridanus* stands out, suggesting a key role of this lagomorph in the food chain.

In the study area, the wet season extends from April to November, with two rainfall peaks, the first in May and the second in September–October (Matteucci *et al.* 1982). Regarding reproductive activity, breeding was observed between March and April, with only one record in August. In the Venezuelan plains, the highest number of raptor nests has been recorded during the wet season, although some nesting also occurs in the dry season (Mader 1981). The synchronization of reproduction in semiarid environments may be directly related to rainfall patterns, which influence the leafing, flowering and fruiting seasons of most plant species and, consequently, the availability of prey (Guevara *et al.* 1992).

Conversations with local residents revealed negative interactions between rural communities and birds of prey. Local farmers often perceive certain raptor species as threats to their domestic animals, including goats, young sheep, and poultry. Among the raptors, the Crested Caracara is perceived most negatively, being considered a major threat to small domestic ruminants. Similarly, the Crane Hawk [*Geranospiza caerulescens* (Vieillot, 1817)] and the Harris's Hawk are regarded as threats to poultry. These perceptions often lead local residents to adopt retaliatory measures such as nest destruction, direct hunting with firearms or slingshots, and poisoning with pesticides like carbofuran. Such attitudes toward raptors have also been reported in other regions (Salom *et al.* 2021).

Carbofuran is a neurotoxic pesticide that poses a significant risk to raptors, particularly those that are scavengers, due to the high susceptibility of birds to this pesticide, and to their propensity to both direct and secondary poisoning (Wiemeyer & Sparling 1991, Mineau *et al.* 2012, Richards 2012, Krone *et al.* 2017). Although carbofuran poisoning has been documented in several raptor species across the Americas (de Almeida & de Almeida 2011, Krone *et al.* 2017), there are currently no specific records for Venezuela, highlighting the need for further research in the country.

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