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First record of the coexistence of two mesocarnivores in the Yucatán Peninsula, México

Primer registro de coexistencia de dos mesocarnívoros en la Península de Yucatán, México

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The simultaneous occurrence of two or more species in space and time (coexistence) is the initial condition for interspecific interactions. One example is the little known binomial of *Urocyon cinereoargenteus* and *Spilogale angustifrons*. Our objective is to contribute information on the coexistence of these mesocarnivores in Komchén de los Pájaros, in the north of Yucatán, an area covered by low deciduous tropical forest. We placed eight camera traps from 23 December 2019 to 20 June 2020 in eight sampling stations. We depicted the daily activity patterns using an hourly circular diagram based on the frequency of camera-trap records. We obtained 68 camera-trap records with a sampling effort of 4,320 trap-hours over 180 days, with three corresponding to the coexistence of *U. cinereoargenteus* and *S. angustifrons*. The activity of *U. cinereoargenteus* occurred all day during the dry season. The relative abundance index of the coexistence of *S. angustifrons* and *U. cinereoargenteus* was 0.7 and for *U. cinereoargenteus* alone was 15.74. We recorded the synchronized activity of *U. cinereoargenteus* and *S. angustifrons* on three occasions. These events occurred at night, early morning hours, and dawn, which confirmed the coexistence of both species in space (low deciduous tropical forest) and time (dry season). The photographic records showed no antagonistic events and the fact that one species followed the other suggests mutualism. We confirmed the coexistence based on the follow-up behavior of *U. cinereoargenteus* by *S. angustifrons*, and believe that these two species are mutualist in the dry season and in the low deciduous tropical forest.

Key words: Deciduous tropical forest; Dzemul; gray fox; Komchén de los Pájaros; mammals; private natural reserve; spotted skunk.

La ocurrencia de dos o más especies en espacio y tiempo (coexistencia) es la condición inicial para las interacciones interespecíficas. Por ejemplo, el binomio *Urocyon cinereoargenteus* y *Spilogale angustifrons* es poco conocido. Nuestro objetivo es contribuir con información sobre la coexistencia de estos mesocarnívoros en Komchén de los Pájaros, en el norte de Yucatán, dominada por selva baja caducifolia. Colocamos ocho cámaras-trampas del 23 de diciembre de 2019 al 20 de junio de 2020 distribuidas en ocho estaciones de muestreo. Representamos los patrones de actividad diaria mediante un diagrama circular por horas con base en la frecuencia de los registros fotográficos. Obtuvimos 68 foto-registros con un esfuerzo de muestreo de 4,320 hr-trampa en 180 días, tres corresponden a la coexistencia de *U. cinereoargenteus* y *S. angustifrons*. La actividad de *U. cinereoargenteus* ocurrió todo el día durante la temporada seca. El índice de abundancia relativa de la coexistencia de *S. angustifrons-U. cinereoargenteus* fue de 0.7 y solo para *U. cinereoargenteus* fue de 15.74. En tres momentos registramos la sincronización de la actividad de *U. cinereoargenteus* y *S. angustifrons*. Estos eventos ocurrieron en la noche, madrugada y al amanecer, lo que confirmó la coexistencia de ambas especies en espacio (selva baja caducifolia) y tiempo (temporada de seca). Los registros fotográficos no mostraron eventos antagónicos y el seguimiento de una especie por la otra sugiere un mutualismo. Confirmamos la coexistencia basada en el comportamiento de seguimiento de *U. cinereoargenteus* por *S. angustifrons* y planteamos que son especies mutualistas en temporada seca y en la selva baja caducifolia.

Palabras clave: Bosque tropical caducifolio; Dzemul; Komchén de los Pájaros; mamíferos; reserva natural privada; zorra gris; zorrillo manchado.

In the ecology of communities, interspecific interactions stand out, either between not taxonomic-related species (*e.g.*, plant-animal) or taxonomically related, as beween species in the order Carnivora (Donadio and Buskirk 2006). In theory, populations or individuals of two species interact in three basic ways: 1) neutral interactions, when any of the two species is affected by the other; 2) positive interactions, when both species benefit from the interaction; and 3) negative interactions, when both populations are inhibited or at least one is negatively affected (Odum and Barret 2006). In particular, carnivores can exploit a resource, such as space or food, in a similar way, forming guilds (Root 1967); these are classified according to their diet in hypercarnivores (diet > 70 % meat), mesocarnivores (diet between 50 % and 70 % meat, balanced by invertebrate consumption), and hypocarnivores (diet > 70 % invertebrates; Van Valkenburgh 2007). Accordingly, *Urocyon cinereoargenteus* Schreeber 1775 and *Spilogale angustifrons* Howell 1902 are species referred to as mesocarnivores.

At least 123 species of terrestrial mammals inhabit the Yucatán peninsula, of which 17 belong to the order Carnivora (Sosa-Escalante *et al.* 2013; Sosa-Escalante *et al.* 2014); these include the gray fox (*Urocyon cinereoargenteus*) and the southern spotted skunk (*Spilogale angustifrons*). *Spilogale angustifrons* is distributed from central México to northern Costa Rica (Helgen *et al.* 2016). In México, it can be found in south and southeast regions through the Yucatán peninsula and the State of Chiapas (Reid 2009; Hidalgo-Mihart *et al.* 2014). It feeds mainly on insects, small vertebrates, and occasionally fruits; therefore, it is considered a generalist and omnivorous species (Cantú-Salazar *et al.* 2005). *Urocyon cinereoargenteus* is distributed from southern Canadá through the United States of America, excluding the northwestern mountainous areas, to northern Venezuela and Colombia, as well as to eastern Central America. It is a species in the order Carnivora that feeds mainly on meat, supplementing its diet with fruits and insects, so it is considered omnivorous (Fritzell and Haroldson 1982; Reid 2009). In México, it has a potential distribution spanning virtually the whole national territory (Ceballos *et al.* 2006), including practically all vegetation types in the country (Fritzell and Haroldson 1982). Both *U. cinereoargenteus* and *S. angustifrons* have been reported based on isolated camera-trap records in the north of the Yucatán peninsula (Vu 2011; Hernández-Pérez *et al.* 2015).

The coexistence between *S. angustifrons* and *U. cinereoargenteus* was reported for the first time for México based on camera-trap records by Farías-González and Vega-Flores (2019) in a locality within the Tehuacán Cuicatlán biosphere reserve in the municipality of San José Miahuatlán, southeast State of Puebla, characterized by deciduous tropical forest at an altitude of 900 to 1,400 m. The objective of this note is to contribute to the record of coexistence between *U. cinereoargenteus* and *S. angustifrons* in the northern region of the State of Yucatán.

This work was carried out in Komchén de los Pájaros, a private protected area voluntarily dedicated to conservation, comprising deciduous tropical forest across 300 ha (21° 12′ 42.36″ N, 89° 19′ 16.36″ W; Figure 1), with registration pending with SEMARNAT. It is located at kilometer 1.5 of the Dzemul-Xtampú beltway, to the south of the munici-

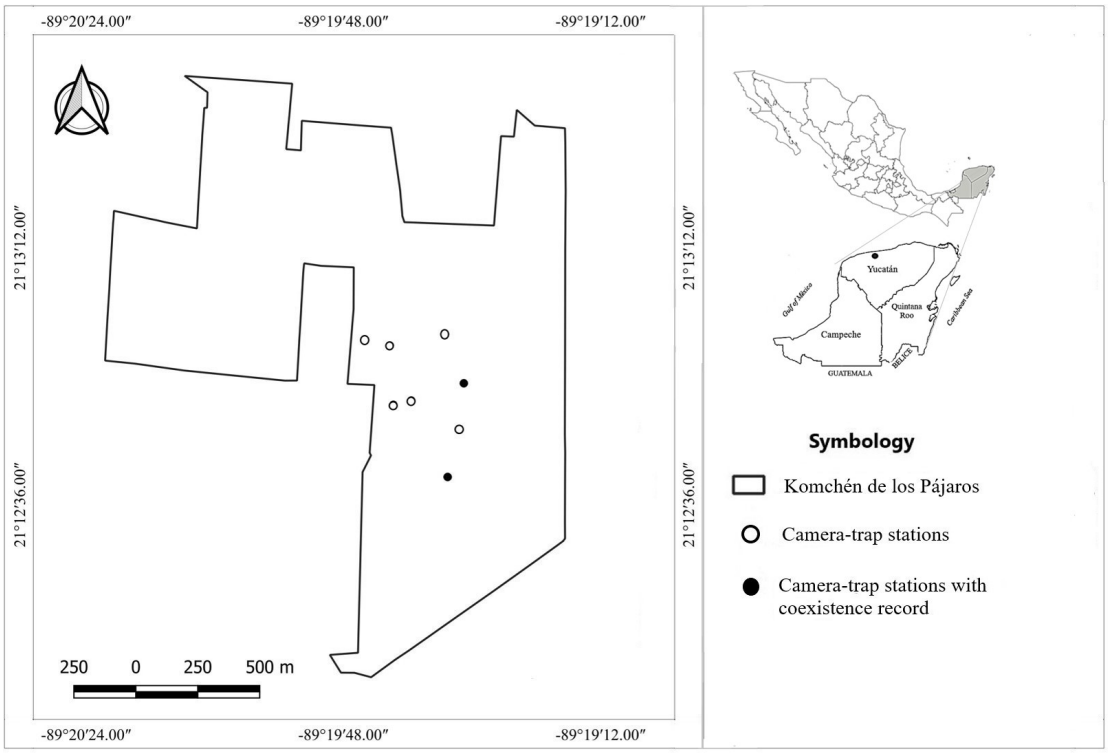

Figure 1. Location of camera traps across the private protected area voluntarily dedicated to the conservation named Komchén de los Pájaros, municipality of Dzemul, Yucatán, México.

pality of Dzemul and to the north of the State of Yucatán. The protected area has an altitude of zero meters (INEGI 2005). The climate is warm subhumid with summer rains; the drought in this area is quite severe, can last from seven to eight months (November to June) and is only slightly attenuated by "Norte" rains or winter storms. The soil type is Leptosol and the area includes two cenotes (wells) that contain water for most of the year (INEGI 2009).

As part of a monitoring study of medium-sized and large mammals in the private reserve, we placed eight camera traps (seven Bushnell camera traps, three of model 119636c and four of model 119447, plus one Cuddleback trap model H-1453) from 23 December 2019 to 20 June 2020. The camera traps were affixed to trunks of living trees, at a height of of approximately 50 cm from the ground, along paths created for both humans and wildlife; animals were attracted by water contained in drinkers made of concrete. Each camera was set to run 24 hr a day with three shots per second, operating for the duration of batteries, and camera cards were checked weekly. We determined the species captured by camera traps using field guides, based on the distinctive characteristics of *S. angustifrons, i.e.*, its white lateral and dorsal strips (Figure 2a), and on the physiognomy of *U. cinereoargenteus*, considering the shape of ears, body, and tail (Reid 2009; Aranda-Sánchez 2012). In addition, we use the term "following" when in the same camera station, *S. angustifrons* was recorded behind *U. cinereoargenteus* in the same image (Farías-González and Vega-Flores 2019). To identify the daily activity patterns of both species, we built a circular diagram based on the hourly photographic records with the software Oriana ver. 4 (Kovach 2011). We did not capture any photographic records of *S. angustifrons* alone, so neither comparative nor statistical analyses were conducted.

The total sampling effort (MS) was 4,320 trap-hours over 180 days, which was used to calculate the relative abundance index for each species (IAR; Maffei *et al.* 2002). The equation used for this purpose was: IAR = (C/EM)*1000 trap-days, where C is the number of camera-trap events and 1,000 camera-trap-days is the standard correction factor.

We obtained a total of 68 camera trap records in two of eight stations, including three observations of *S. angustifrons* in physical proximity of *U. cinereoargenteus*. The first observation was obtained on 21 January 2020 at 05:09:11 hr, recording a distance of 6 m between both species; the second, on 28 march 2020 with three photographs (two at 21:18:03 hr and one at 21:18:04 hr) with a separation of 2 m between the individuals of both species; the third record, on 30 march 2020 with three photographs (01:08:53, 01:08:54, 01:08:55 hr) where an individual of one species is virtually facing an individual of the other species at a distance of approximately 2 m between them (Figure 2a). The evidence of coexistence was recorded in the dry season.

We estimated the IAR of *S. angustifrons* from the three records along with *U. cinereoargenteus* (IAR = 0.7) and the records of *U. cinereoargenteus* alone including 68 photographs (IAR = 15.74), suggesting that *U. cinereoargenteus* is a dominant species for displaying greater activity in the study area (Figure 3).

Figure 2. Sequence of three photographs showing the gray fox (*Urocyon cinereoargenteus*) observing an individual of southern spotted skunk (*Spilogale angustifrons*); a) on 30 March 2020 at 01:08:53-55 hr (21°12"46' N, 89°19'32" W), which is moving around; b-c) 21 January 2020 and 28 March 2020, respectively, in Komchén de los Pájaros, municipality of Dzemul, Yucatán, México. The white arrow indicates the position of the southern spotted skunk (*S. angustifrons*).

Based on the 68 record captured, *U. cinereoargenteus* was active practically all day, mostly from 21:00 to 22:00 hr and from 03:00 to 04:00 hr. Besides, two additional activity periods were observed, namely from 00:00 to 02:00 hr and from 08:00 to 09:00 hr (Figure 3). Only on three occasions (21 January 2020, 28 March 2020, and 30 March 2020), we recorded the simultaneous activity of *U. cinereoargenteus* and *S. angustifrons* (Figures 2 and 3).

The synchronous activity of *U. cinereoargenteus* and *S. angustifrons* was recorded during the night, the early morning hours and at dawn, confirming the simultaneous spatial-temporal presence of both species. This note shows that both species coexist, where the individual of *U. cinereoargenteus* is observed sitting, waiting, in addition to being in front of *S. angustifrons*, which is moving (Figure 2a).

Urocyon cinereoargenteus is mainly a twilight and nocturnal species, and during the day it searches for resting places in the dense understory (Fritzell and Haroldson 1982; Fritzell 1987). Our data inform that *U. cinereoargenteus* is very active in morning hours in the deciduous tropical forest of northern Yucatán (Figure 3). By contrast, *S. angustifrons* is a nocturnal species; during the day, it rests on underground burrows and dens that may or may not share with other conspecifics (Verts *et al.* 2001; Lesmeister *et al.* 2008; Dragoo 2009). The activity of both species coincides at night, which we recorded on three occasions in this study (Figure 3).

Urocyon cinereoargenteus and *S. angustifrons* are mesocarnivorous and omnivorous mammals, respectively, that share predators, means of locomotion and habitat use (Fritzell 1987; Hunter and Caro 2008; Dragoo 2009). However, several factors related to the social structure and behavior of *U. cinereoargenteus* and *S. angustifrons* remain unclear due to the lack of information on their coexistence (Fritzell and Haroldson 1982; Dragoo 2009).

In carnivorous mammals, body size is considered to be the primary driver of the coexistence of species (Simberloff and Dayan 1991). For the above, we consider that *U. cinereoargenteus* may be a stronger competitor given its larger body size relative to *S. angustifrons*. However, the photo-

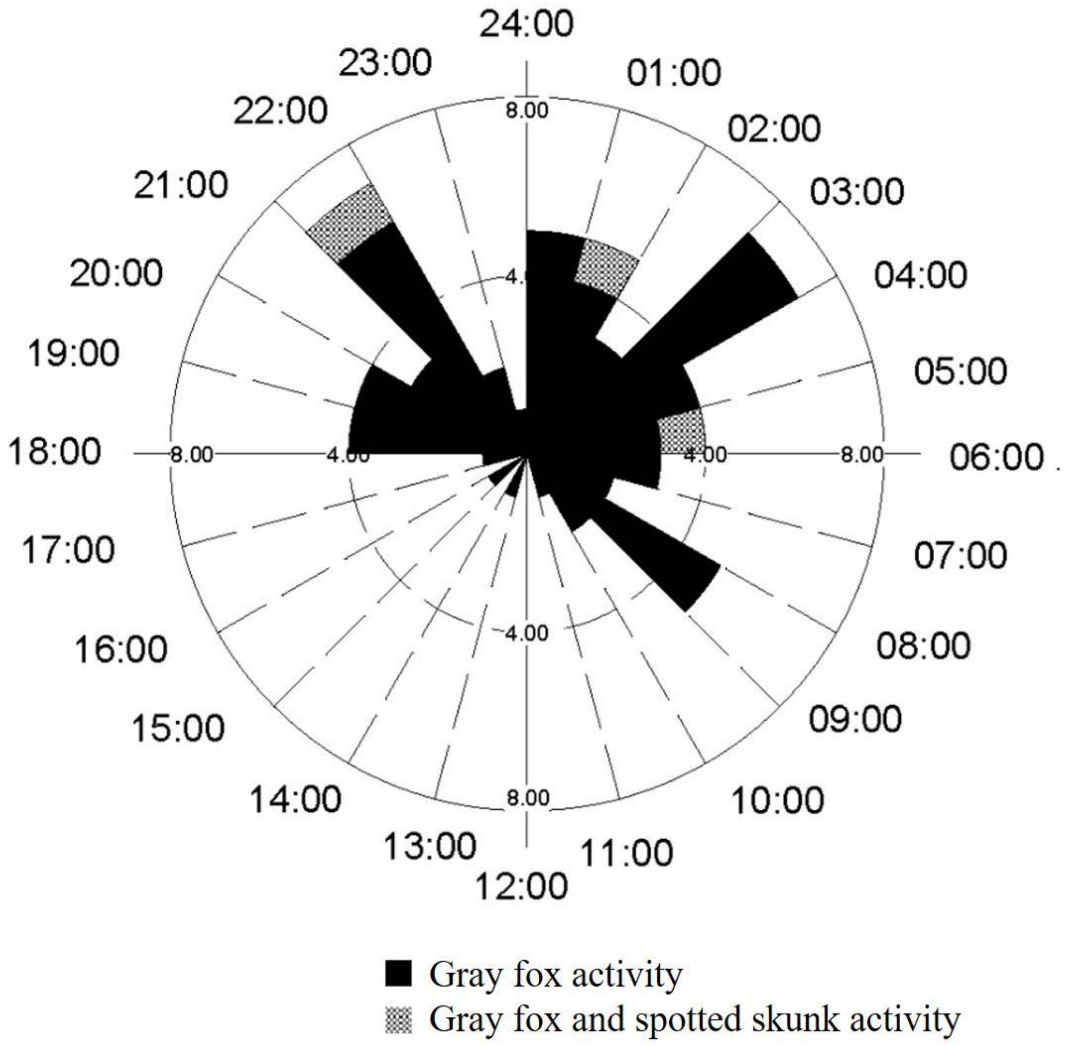

Figure 3. Daily activity based on 68 records, where 65 record only *Urocyon cinereoargenteus* (in black) and three record its coexistence with *Spilogale angustifrons* (in gray). The inner values 4 and 8 refer to the frequency of coexistence.

graphic records showed no evidence of antagonistic events. Thus, camera-trap records can be interpreted as illustrating two potential interactions: mutualistic, where both species benefit, or neutral, where one does not affect the other (Odum and Barrett 2006). *Spilogale angustifrons* has been found to walk behind *U. cinereoargenteus*, with camera-trap records during the dry season and in the deciduous tropical forest (Figure 2b, 2c; Farías-González and Vega-Flores 2019), as evidenced in this study. The fact that one species follows the other precludes the possibility of a neutral interaction. Therefore, it has been suggested that the behavior of *S. angustifrons* following *U. cinereoargenteus* aims to reduce the risk of predation and improve foraging (Farías-González and Vega-Flores 2019). From the closeness observed in the sequence of photographs in Figure 2 and the additional camera-trap records captured on 21 January and 28 March 2020, we consider the existence of a mutualistic relationship between these two species. We confirmed the coexistence based on the behavior of *S. angustifrons* following *U. cinereoargenteus* in the dry season, so this note contributes to the knowledge of the natural history of these mesocarnivores in México; therefore, long-term studies should be performed to broaden the knowledge of this interaction.

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