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# Ecological aspects of the Neotropical otter, *Lontra longicaudis annectens* (Major, 1897), in La Lagartera Lagoon, Campeche, Mexico

# Aspectos ecológicos de la nutria neotropical, *Lontra longicaudis annectens* (Major, 1897) en la laguna La Lagartera, Campeche, México

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## ABSTRACT

**Background**. Several works conducted in Mexico have addressed the Neotropical otter (*Lontra longicaudis annectens*), a protected subspecies (NOM-059-SEMARNAT-2010). **Objectives**. To know the abundance and distribution of the neotropical otter in the State of Campeche in La Lagartera Lagoon (Palizada River). **Methods**. During 2017 were searched the lagoon looking for indirect evidence on mangrove, collected and analyzed scats in order to identify preys. **Results**. Were traveled 1.49 km in each climatic season (nortes, dry, and rainy seasons), on board a small vessel, recording a total of 99 signs (85 scats, five feeding sites, five dens, and four vocalizations). We recorded the distribution of these signs across the sampling area and estimated a relative abundance of 0.30 otters/km. The analysis of 85 scats collected on logs or roots recorded six major prey groups: fish (40 %), crustaceans (26 %), reptiles (15 %), mollusks (11 %), mammals (4 %), birds (3 %) and other unidentified prey (1%). **Conclusions**. No evidence was found to suggest a variation in the consumption frequencies of the groups of prey by season. The presence and consumption of the "sailfin catfish" was also recorded in all seasons. The presence of four native species and five new records of prey fish was confirmed from otoliths contained in feces. This information highlights the ecological relevance of the species.

**Keywords:** distribution, feeding habits, Palizada river, relative abundance.

## RESUMEN

**Antecedentes**. En México, existen diversos trabajos sobre la nutria neotropical (*Lontra longicaudis annectens*), subespecie protegida (NOM-059-SEMARNAT-2010); sin embargo, son pocos los trabajos realizados en el estado de Campeche. **Objetivos**. Conocer la abundancia y distribución de esta especie en laguna "La Lagartera" (río Palizada). **Métodos**. Durante 2017 realizaron recorridos en la zona de estudio buscando evidencias indirectas de las nutrias en troncos de mangle analizando heces para conocer las presas. **Resultados**. Se recorrieron 1.49 km en cada temporada climática (nortes, secas y lluvias), a bordo de una embarcación menor, obteniéndose un total de 99 rastros (85 heces, cinco comederos, cinco madrigueras y cuatro vocalizaciones). Se registró la distribución de estas evidencias dentro del área de muestreo y se estimó una abundancia relativa de 0.30 nutrias/km. El análisis de 85 heces colectadas sobre los troncos y/o raíces, registró seis grupos principales de presas: peces (40 %), crustáceos (26 %), reptiles (15 %), moluscos (11 %), mamíferos (4 %), aves (3 %) y otros no identificados (1 %). **Conclusiones**. No se encontró evidencia que determine una variación en las frecuencias de consumo de los grupos presas por temporada. También se registró la presencia y consumo del pez diablo en todas las temporadas. Se confirma por medio de otolitos obtenidos en las heces, la presencia de cuatro especies nativas y cinco nuevos registros de peces presa. Con esta información se resalta el valor ecológico de la especie.

**Palabras clave:** abundancia relativa, distribución, hábitos alimentarios, río Palizada.

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## INTRODUCTION

Mexico is one of the countries harboring a huge biodiversity; it ranks first in the Americas and third worldwide in terms of the number of mammals (PROFEPA, 2020). However, mammals currently face conservation issues derived from the drastic disruption of ecosystems, pollution of tributaries, habitat destruction and fragmentation. These have affected multiple species by displacing them from their original habitats and even causing local extinctions when wildlife does not encounter suitable conditions for survival. Additional factors affecting wildlife include indiscriminate poaching, resulting in marked reductions in their populations. Therefore, natural ecosystems — and the species living in them — should be preserved, since each organism within populations and communities have a significant role in the functioning of ecosystems (Cruz-García *et al*., 2017).

The Neotropical otter, *Lontra longicaudis annectens* (Major 1897), also known as water dog *"perro de agua"* in Spanish (Gallo-Reynoso, 1989), is listed as a nearly threatened species on the Red List of the International Union for the Conservation of Nature (Rheingantz & Trinca, 2015) and as endangered of extinction in the Convention on International Trade in Endangered Species of Wild Fauna and Flora, Appendix I (CITES, 2018). In Mexico, it is listed as a "threatened" species in NOM-059-SEMARNAT-2010 (SEMARNAT, 2010).

The earliest records of this subspecies in the State of Campeche Gallo-Reynoso (1989, 1997), reporting its presence from indirect signs (tracks, skins examined, latrines, scats, resting sites, dens, and interviews with fishers in 1978 in the Usumacinta River Delta. The usumacinta delta is made up by the Champotón River and the high reaches of rivers such as Candelaria, Samaria, Chumpán, Del Este Lagoon, and Palizada, which flow into Laguna de Términos and by the San Pedro River, which forms the limit with the State of Tabasco. Later, Ramírez-Pulido *et al*. (2017) published a literature collection of mammals in Mexico during the period 2000-2010, stating that no scientific publications were available for *L. l. annectens* in the State of Campeche. Santiago-Plata *et al.* (2013) confirmed the presence of Neotropical otter at La Veleta road, between the federal highway between Villahermosa and Cd. del Carmen, and the San Pedro and San Pablo River, through indirect signs (footprints, grooming sites, latrines, and scats) and direct sightings of individual otters. In the same year, Guzmán-Soriano *et al*. (2013) recorded the presence of the subspecies from the finding of two skulls, one in the Calakmul Biosphere Reserve and the other in the Venustiano Carranza river southeast of Candelaria, in addition to one sighting in the Caribe River.

There are only four records of Neotropical otter presence in the Palizada River prior to this work. Corresponding to Gallo-Reynoso (1997), who found tracks and dens. Later on, an otter skin obtained in the Palizada area, was donated by a fisherman from Palizada town in 2016, to the Mammal Collection of the *Centro de Estudios en Desarrollo Sustentable y Aprovechamiento de la Vida Silvestre* (Center for Studies in Sustainable Development and Wildlife Use at Universidad Autónoma de Campeche (CEDESU-UAC). Vázquez-Maldonado *et al.* (2018a, 2018b), found scats, latrines, and obtained four observations of Neotropical otters in lagoons adjacent to the Palizada River (La Sangría, La Lagartera and Las Coloradas) and in Laguna de Términos.

In Mexico, several studies have been carried out to evaluate the habitat of the Neotropical otter and determine its biological and ecological features. *Lontra longicaudis annectens* is recognized as a carnivore, generalist, and top predator in riparian ecosystems (Gallo-Reynoso *et al*., 2008); its recorded diet is based primarily on fish and crustaceans (Gallo-Reynoso, 1997; Macías-Sánchez & Aranda, 1999; Monroy-Vilchis & Mundo, 2009). Sánchez & Gallo-Reynoso (2007) state that this subspecies is likely to be primarily a predator that prefers certain types of prey, displaying flexibility in feeding preferences according to prey abundance and availability. Whether this prey substitution can be sustained in the long term remains unknown; for example, foraging on plants, mollusks, insects, amphibians, reptiles, birds, and mammals has been recorded (Gallo-Reynoso, 1989, 1997; Macías-Sánchez & Aranda, 1999; Ramón, 2000; Santiago-Plata, 2009; Arellanes-Licea & Briones-Salas, 2003; Casariego-Madorell, 2004; Soler-Frost, 2004; Díaz-Gallardo *et al.,* 2007; Duque-Dávila, 2007; Monroy-Vilchis & Mundo, 2009; Rangel-Aguilar & Gallo-Reynoso, 2013; Grajales-García *et al*., 2019; García-Silva *et al*., 2021). Thus, feeding habits allow determining the diversity of prey in the area where Neotropical otter thrive (Casariego-Madorell *et al*., 2008; Rheingantz *et al*., 2017).

The above highlights the importance of conducting research on Neotropical otter in the State of Campeche, to contribute to the knowledge of this species in this riparian habitat that includes the deltaic system with the greatest flow in México (Cotler-Ávalos *et al*., 2010). The objective of this work is to contribute ecological knowledge on Neotropical otter in La Lagartera lagoon (located adjacent to the Palizada River), Campeche, within the Laguna de Términos Flora and Fauna Protection Area (APFFLT); particularly, this study estimated population density, distribution of indirect signs (scats, latrines, feeding sites, and dens, among others). An additional objective was to describe its feeding habits by analyzing scats and food residues collected in latrines and feeding sites. This information will support proposals on conservation strategies for the Neotropical otter within and outside the Laguna de Términos Flora and Fauna Protection Area.

## MATERIALS AND METHODS

The study comprised three climatic seasons during the year 2017, herein named as nortes, dry and rainy, as they are the main seasons in La Lagartera Lagoon, adjacent to the Palizada River, Campeche. Palizada River is the largest tributary of the Usumacinta River Delta (Coll de Hurtado, 1975); it is a long and narrow stream with multiple short-radius bends and a mean annual discharge volume of $11.9 \times 10^9$ $m^3$ (Soberón-Chávez & Yáñez-Arancibia, 1985). La Lagartera Lagoon is located between parallels 18° 22' 38.92" and 18° 22' 11.24" North, and between meridians 91° 51' 43.32" and 91° 51' 52.96" West (Fig. 1), comprising an area of approximately 0.38 $km^2$ calculated by GIS tools (QSIG 2.0 software), of which the entire perimeter of 1.49 km was surveyed. The "La Lagartera" lagoon is part of the Laguna de Términos Flora and Fauna Protection Area (APFFLT), which was decreed as a Natural Protected Area on 6 June 1994 (https://simec.conanp.gob.mx/ficha.php?anp=118&reg=5).

The Palizada-Del Este fluvial lagoon system has a salinity between 0 and 8 ‰, surface water temperature between 22 °C and 31 °C (Ayala-Pérez, 1989), and water transparency of 1.0 ± 0.23 m (Muciño-Márquez *et al*., 2017). The vegetation in the system includes submerged hydrophytic angiosperms, supralittoral hydrophytes typical of wetlands, reed, tulles, and annual and perennial grasses (Vera-Herrera *et al*., 1988a, 1988b). In addition, the surrounding vegetation includes well-developed riparian mangrove (10 - 25 m), dominated by black mangrove (*Avicennia germinans*), followed in abundance by red man-

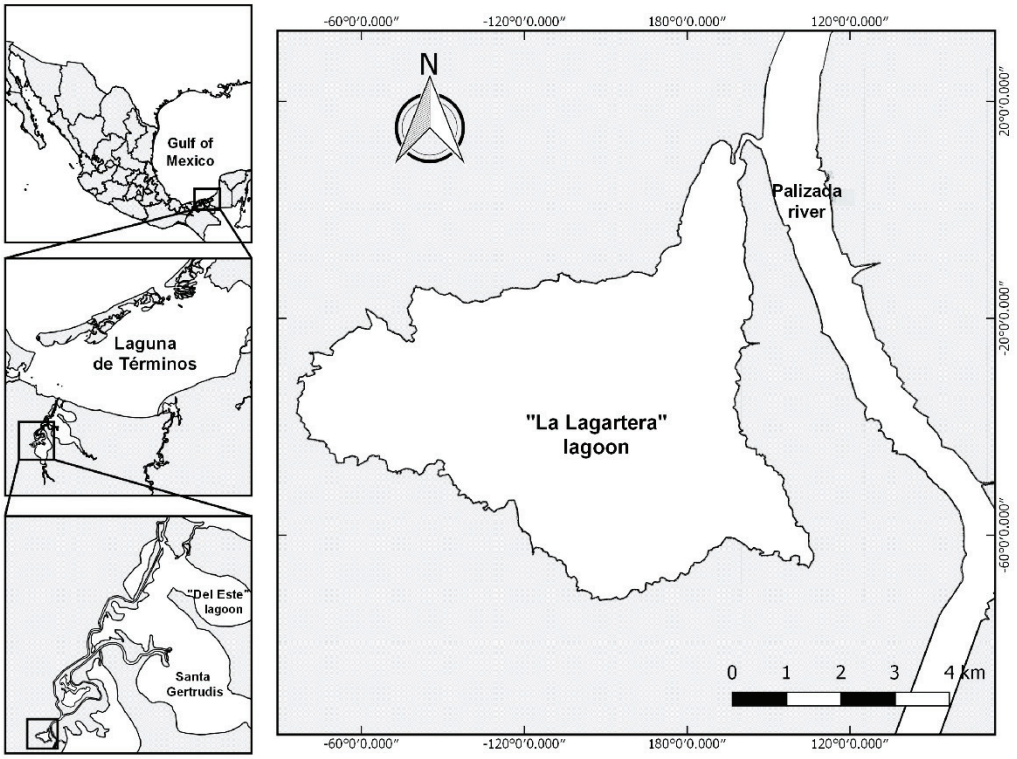


Figure 1. Location of the study area: La Lagartera Lagoon, adjacent to the Palizada River, Campeche, Mexico (APFFLT).

grove (*Rhizophora mangle*) and, in a smaller proportion, white mangrove (*Laguncularia racemosa*) (Jardel *et al*., 1987).

Field surveys in the study area comprised three visits, one per climatic season. Since the study area is regularly flooded and covered by dense vegetation, surveys were carried out onboard of a 7.6 m long fiberglass boat with a 50 HP outboard motor. A search for indirect signs of the presence of Neotropical otters was carried out on the shore of the lagoon and in areas that could be walked. Each evidence found was georeferenced (Garmin GPSMAP® 78s) and photographed (Ricoh WG-4 SR Adventure Proof digital camera with SanDisk 32GB memory card). Kayaks were used in shallow or closed vegetation areas where navigation with the boat was impossible. In sites where otter signs were found, surface water temperature, depth (Hawkeye manual echosounder), and salinity (ATAGO refractometer) were recorded.

Biological material was collected manually and placed in resealable Ziploc plastic bags labeled with the date, and sample number. All collected samples were placed in a cooler while transfer to "Laboratory No. 1" of the Faculty of Natural Sciences (Facultad de Ciencias Naturales) at Universidad Autónoma del Carmen (UNACAR), where they were kept refrigerated until their analysis. To collect potential prey, some fishes were caught by a fisherman in the study area at the end of sampling during the nortes season; potential prey collected were also placed in resealable bags and in a cooler for transfer to the laboratory.

Scats and food residues collected at feeding sites were washed with a soap solution (1:10) and left to stand for 24 hours to neutralize any bacterial activity and agglutinate organic matter residues. Afterward, these were washed with running water through a sieve (0.500 mm mesh) and the material retained was placed on aluminum paper trays and oven-dried (Felisa model FE-292AD) at 61 °C to dry; it was then placed in previously labeled manila paper envelopes. Identifiable components and structures in each sample were sorted out according to animal taxa under a stereo microscope (Iroscope model ES-24 PLIT), using dissection needles and forceps.

The food items found were sorted out as scales, bones, hairs, feathers, and other items, and were placed individually in properly labeled plastic vials. Structures larger than these vials (collected mainly from feeding sites) were stored in paper envelopes.

Once otoliths were separated from the rest of the scat components, they were cleaned with damp towels to remove any debris and determine whether their state of conservation allowed identification. Fish otoliths were identified, either individually or in pairs (left and/or right), based on characteristics such as shape, acoustic sulcus, and cauda. These were compared with four types of reference materials: 1) photographic catalogs contained in the *Anàlisi de formes d'Otòlits* (AFORO, for its acronym in Catalan) database (http://aforo.cmima.csic.es) and in the *"Catálogo de otolitos Sagitta de peces del Golfo de México"* (Catalog of *Sagitta* Otoliths of Fish from the Gulf of Mexico) by Martínez-Pérez *et al.* (2019); 2) list of fish species recorded for the Palizada-Del Este system and Laguna de Términos (Ramos-Miranda *et al*., 2006; Ayala-Pérez *et al*., 2015); 3) otoliths of the Collection of otoliths of the Faculty of Natural Sciences, UNACAR, obtained from the stomach content of stranded bottlenose dolphins (*Tursiops truncatus*); and 4) otoliths extracted from fish captured in La Lagartera Lagoon by us and identified to species. Once otoliths were identified to the extent possible, a unique key was

assigned for each otolith or pair of otoliths identified, which were integrated according to the guidelines of the Collection mentioned above.

Regarding the ecological aspects, we calculated the relative abundance of otters based in terms of number of fresh scats present in sampling sites per individual on sampling site (dark green to black scat, with a musk odor, soft consistency not disaggregated, sometimes moist pasty) (pers. obs.). The calculated figure was compared with the baseline relative abundance index (number of scats per kilometer [NE]), and the bounded abundance index (estimate of the number of otters per kilometer [AN]), respectively (Gallo-Reynoso, 1996; Macías-Sánchez, 2003) using a defecation rate of three defecation events (i.e., scats) per day (TD = 3) as established by Gallo-Reynoso (1989). The results on relative abundance were analyzed with the statistical program IBM SPSS Statistics 25 applying the Kruskal-Wallis and Chi square ($X^2$) non-parametric indices to determine the statistical significance of the difference between scat records and climatic seasons (nortes, dry and rainy), after testing the data for normality (Shapiro-Wilk) and homoscedasticity (Levene).

Ecological niche breadth was calculated using the Levins index (Levins, 1968; Jaksic & Marone, 2007), where *Pi* is the relative frequency of the species.

The feeding habits of the Neotropical otter were determined by estimating the Frequency of Occurrence (*FO*) of the different prey categories and the various structures within the same group, using the equation: $FO = fi/N \times 100$, where *fi* is the number of scats containing a given prey category and *N* is the total number of scats analyzed. Also, the Percentage of Occurrence (*PO* was calculated using the equation: $PO = fi/ft \times 100$, where *fi* is the number of scats containing a given prey category and *ft* is the total number of occurrences of all prey categories in all scats (Macías–Sánchez & Aranda, 1999). Last, a Kruskal-Wallis test was performed to determine the statistical significance of the differences in the consumption of prey groups between seasons (Díaz-Gallardo *et al*., 2007).

The location and spatial distribution of indirect signs (scats, latrines, feeding sites and dens) served to produce maps by climatic season using the software QGIS 2.0.

## RESULTS

A total of 99 indirect signs of Neotropical otter were recorded in the study area, of which 85 were scats; most were found over tree roots, branches and logs, the majority on white mangrove trees that were either fallen or on the lagoon shore (86 %), five were found in dens (5 %), and five in feeding sites (5 %), also we registered four vocalizations (4 %). The number of indirect signs by climatic season were 37% in nortes, 35 % in dry season, and 28 % in rainy season; there were no significant differences in the percentage of indirect signs between climatic seasons ($X^2 = 3.856$, *d. f.* = 98, $p = 0.696$).

The analysis of indirect signs observed by climatic season showed that the Percentage of Occurrence (*PO*) was mostly represented by scats (Table 1).

A total of 11 latrines were identified and 85 otter scats were recorded on them; only four fresh scats were found during rainy a nortes seasons on 4.47 kilometers surveyed. These records were used to estimate the relative abundance indices of *L. l. annectens* in La Lagartera lagoon area (Table 2). The analysis by climatic season considering only fresh scats revealed that the highest relative abundance occurred in the nortes season, with 0.67 otters/km (Td = 3), and the lowest in the rainy season, with 0 otters/km (Table 2). However, the Kruskal-Wallis analysis yielded no significant difference in relative abundance between climatic seasons ($X^2 = 6.592$, *d. f.* = 2, $p = 0.159$). Therefore, the estimation of relative abundance of Neotropical otter was based on the number of indirect signs: number of scats (nE = 85) and number of latrines (nL = 11); this led to the estimation of 6.34 otters/km corresponding to 19.02 scats/km and 2.46 latrines/km. The Kruskal-Wallis test revealed no significant differences in the number of scats between climatic seasons ($X^2 = 2.000$, *d. f.* = 2, $p = 0.368$). Finally, the analysis based on fresh scats yielded an overall estimate of 0.30 otters/km (TD = 3)

In this work, five feeding sites were recorded, one for the nortes season, two for the dry season and two for the rainy season. In such feeding sites, two genera were identified based on bone remains: first the genus *Pterygoplichthys* (sailfin catfish, "*pez diablo"* in Spanish) and second, *Cathorops melanopus* (the dark sea catfish, "*bagre*" in Spanish).

Table 1. Percentage of occurrence (*PO* %) of the different signs of Neotropical otter per climatic season.

| Indirect signs | Percentage of Occurrence (PO) Climatic season | | |
|---|---|---|---|
| | Nortes | Dry | Rainy |
| Scats | 86.49 | 85.72 | 85.19 |
| Dens | 8.11 | 5.71 | 7.41 |
| Feeding sites | 2.70 | 5.71 | 7.41 |
| Vocalizations | 2.70 | 2.86 | - |
| Total | 100 | 100 | 100 |

Table 2. Rates of relative abundance of Neotropical otter based on total and fresh scats, assuming a defecation rate of 3 scats per day (TD = 3).

| Climatic season (Total scats – Fresh scats) | Total scats otters/km | Fresh scats otters/km |
|---|---|---|
| Nortes (32 – 3) | 7.16 | 0.67 |
| Dry (30 -1) | 6.71 | 0.22 |
| Rainy (23 – 0) | 5.15 | 0.0 |
| Total (85 – 4) | 6.34 | 0.30 |

Six main prey groups were identified from the 85 scats analyzed: fish were the most frequently consumed group (40 %), followed by crustaceans (26 %), reptiles (15 %), mollusks (11 %), mammals (4 %), birds (3 %), and miscellaneous remains grouped under "other", including very small fragments of polychaetes and unidentified material (1 %).

Ten families of fish were identified: Batrachoididae, Gerreidae, Gobiidae, Paralichthyidae, Cynoglossidae, Cichlidae, Triglidae, Loricariidae, Poeciliidae, and Eleotridae. It should be mentioned that, from a total of 238 separate otoliths, only 145 (61 %) could be identified. In the case of the genus *Pterygoplichthys*, identification was achieved not only through otoliths, but also from other structures such as vertebrae, pectoral and dorsal fin spines, and dermal plates. As for crustaceans, two families were identified (Portunidae: *Callinectes*, and Palaemonidae: *Macrobrachium*); for reptiles, only the Squamata Order was identified, particularly the suborder Serpentes; for mollusks, two classes were identified: Bivalvia and Gasteropoda; finally, regarding birds and mammals, remains were determined only to class (Table 3).

The ecological niche breadth based on fish (the group where the largest number of species was identified) using the Levins index, indicate low dominance (0.14) and high diversity (0.86), that is, *L. l. annectens* is a generalist subspecies with a broad niche, consistent with the findings reported by other authors (Gallo-Reynoso, 1989, 1996, 1997; Macías-Sánchez & Aranda, 1999; Ramón, 2000; Arellanes-Licea & Briones-Salas, 2003; Casariego-Madorell, 2004; Díaz-Gallardo *et al.*, 2007; Duque-Dávila, 2007; Grajales-García *et al.*, 2019).

The consumption of prey groups was similar in the nortes and dry seasons, both with six well-defined groups: mollusks, crustaceans, fish, reptiles, birds, and mammals. However, in the rainy season, the prey groups consumed decreased from six to five, with mammals and the "other" group missing in this season. Fish, crustaceans, and reptiles were the groups with the highest percentage of occurrence in the three seasons. The statistical analysis of food preference according to climatic season showed no differences in prey consumption frequencies ($X^2$ = 9.775, *d.f.* = 6, $p$ = 0.636); fish was the main prey group consumed during the three seasons (59 % nortes, 58 % dry, and 78 % rainy) (Fig. 2).

Table 3. Types of prey found and identified, to the lowest taxonomical level possible, in Neotropical otter scats at "La Lagartera" Lagoon, Campeche. From: WoRMS (2018) and FishBase (Froese & Pauly, 2018).

| Phylum | Subphylum | Class | Family | Genus | Species |
|---|---|---|---|---|---|
| Mollusca | | Bivalvia | Unidentifiable | | |
| | | Gastropoda | Unidentifiable | | |
| Arthro-poda | Crustacea | Malacostraca | Portunidae | *Callinectes* | *Callinectes* sp. |
| | | | Palaemonidae | *Macrobrachium* | *Macrobrachium* sp. |
| Chordata | Vertebrata | Actinopterygii | Batrachoididae | *Opsanus* | *Opsanus beta* * (Goode & Bean, 1880) |
| | | | Gerreidae | *Eucinostomus* | *Eucinostomus melanopterus* * (Bleeker, 1863) |
| | | | Gobiidae | *Awaous* | Awaous sp. ** |
| | | | | | *Awaous banana* ** (Valenciennes, 1837) |
| | | | Paralichthyidae | Unidentifiable | |
| | | | Cynoglossidae | *Symphurus* | *Symphurus* sp. ** |
| | | | Cichlidae | *Cichlasoma* | *Cichlasoma* sp.** |
| | | | | | *Cichlasoma urophthalmus* * (Günther, 1862) |
| | | | | *Petenia* | Petenia sp. ** |
| | | | | | *Petenia splendida* * (Günther, 1862) |
| | | | | Oreochromis | *Oreochromis niloticus* ** (Linnaeus, 1758) |
| | | | Triglidae | *Prionotus* | *Prionotus* sp. ** |
| | | | | | *Prionotus rubio* ** (Jordan, 1886) |
| | | | Loricariidae | *Pterygoplichthys* | *Pterygoplichthys* sp. ** |
| | | | | | *Pterygoplichthys pardalis* ** (Castelnau, 1855) |
| | | | Poeciliidae | *Poecilia* | *Poecilia* sp. ** |
| | | | Eleotridae | *Gobiomorus* | *Gobiomorus dormitor* ** (Lacède, 1800) |
| | | Reptilia | Order: Squamata, Suborder: Serpentes | | |
| | | Aves | Unidentifiable | | |
| | | Mammalia | Unidentifiable | | |

* Native species (Ramos-Miranda *et al.*, 2016; Ayala-Pérez *et al.*, 2015).

** Potentially new records in the study area.

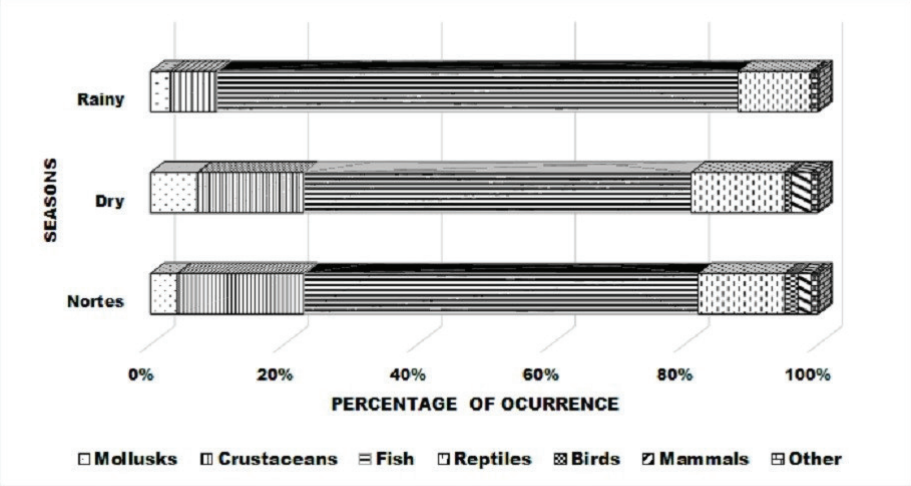


Figure 2. Variation in feeding habits of Neotropical otter according to the climatic seasons (nortes, dry, and rainy seasons).

## DISCUSSION

Scats were the most representative indirect signs found over the three climatic seasons, located mainly in branches, trunks, logs, root systems and on the shore; some of these were on white mangrove (*Laguncularia racemosa*) trunks or roots, being the first record of the use of this tree species by Neotropical otter in the study area. The lowest number of scats recorded, were found during the rainy season, likely because rain washes away the scats deposited on the logs. In the nortes and dry seasons, it was possible to walk along the lagoon shoreline, where several dens were found. Although these observations were conducted under harsh conditions, such efforts should be continued, as this type of observational sampling yielded the highest number of records of dens. Of the two dens recorded in the dry season, one could be classified as a nursery (Fig. 4), since a feeding site and scats were found in the vicinity; also, this record coincides with the breeding period for the species (Gallo-Reynoso, 1989). During the rainy season, the water level rose and flooded the study area, making impossible to record evidence on the use of dens by otters. The type of vegetation and soil in the sampling area did not allow obtaining evidence from footprints or tracks.

The total number of indirect signs and their geographic location allowed the estimation of the abundance of the Neotropical otter, and to determine their distribution range in La Lagartera Lagoon, also to identify the main zones used by the otters in each season.

It is important to mention that anthropogenic activities like the burning of vegetation for clearing to allow the growth of grass during the dry season were observed on the lagoon's banks; however, vocalizations (indirect signs of otters) indicated that they were still present after burning in the area. The distribution of these signs along the perimeter of the lagoon was similar between climatic seasons (Fig. 3-5) indicating the even distribution, availability and abundance of food resources along the year.

La Lagartera Lagoon present freshwater characteristics during the three climatic seasons, with a variation of surface water temperature between 30.7 °C – 33.9 °C; this information matches the data recorded in the technical information of the subspecies base on PROY-NOM-059-ECOL-2000 (Mexican mammals in danger of extinction) (Gómez-Nisino, 2006).

If the estimated relative abundance (6.34 otters/km based on the total number of scats) is compared with other works for neotropical otters, the estimate obtained in the present study is slightly higher than estimates reported for other regions. This difference may derive from the fact that our analysis considered any scats identified, regardless of its degraded condition, which may have led to an overestimation of the number of individuals in the study area. The abundance figure derived from fresh scats only (0.30 otters/km), lies within the abundance range calculated for other regions with similar evidence (Gallo-Reynoso, 1996).

Considering the total area of the lagoon (0.38 km$^2$) and fresh-scat records, an estimate of 1.17 otters/km$^2$ was obtained, which is also within the range of previous estimates for Neotropical otter (Gallo-Reynoso, 1996) and more realistic one.

The Neotropical otter diet included six groups: fish, crustaceans, reptiles, mollusks, mammals, and birds, confirming that *L. l. annectens* is a generalist predator that probably consumes any potential preys available (Duque-Dávila, 2007), with fish as the main type of prey consumed in most cases (Table 3). The presence and consumption of *Pterygoplichtys* sp. and *Pterygoplichtys pardalis* were recorded in the three climatic seasons, indicates that Neotropical otter probably contributes to regulate the population size of the sailfin catfish, as mentioned by Vázquez-Maldonado *et al.* (2018a) but a bigger research effort will be necessary, including isotopic analyses as Juarez-Sanchez *et al.* (2019) have done with scats in the rivers of Guatemala. The identification of fish to species based on otoliths was difficult because no reference catalog of otoliths is currently available for the region. Some otoliths could not be identified to family because of their highly degraded status due to the digestion process, or were not *Sagitta* otoliths, which are the otoliths commonly used for the identification of fish species.

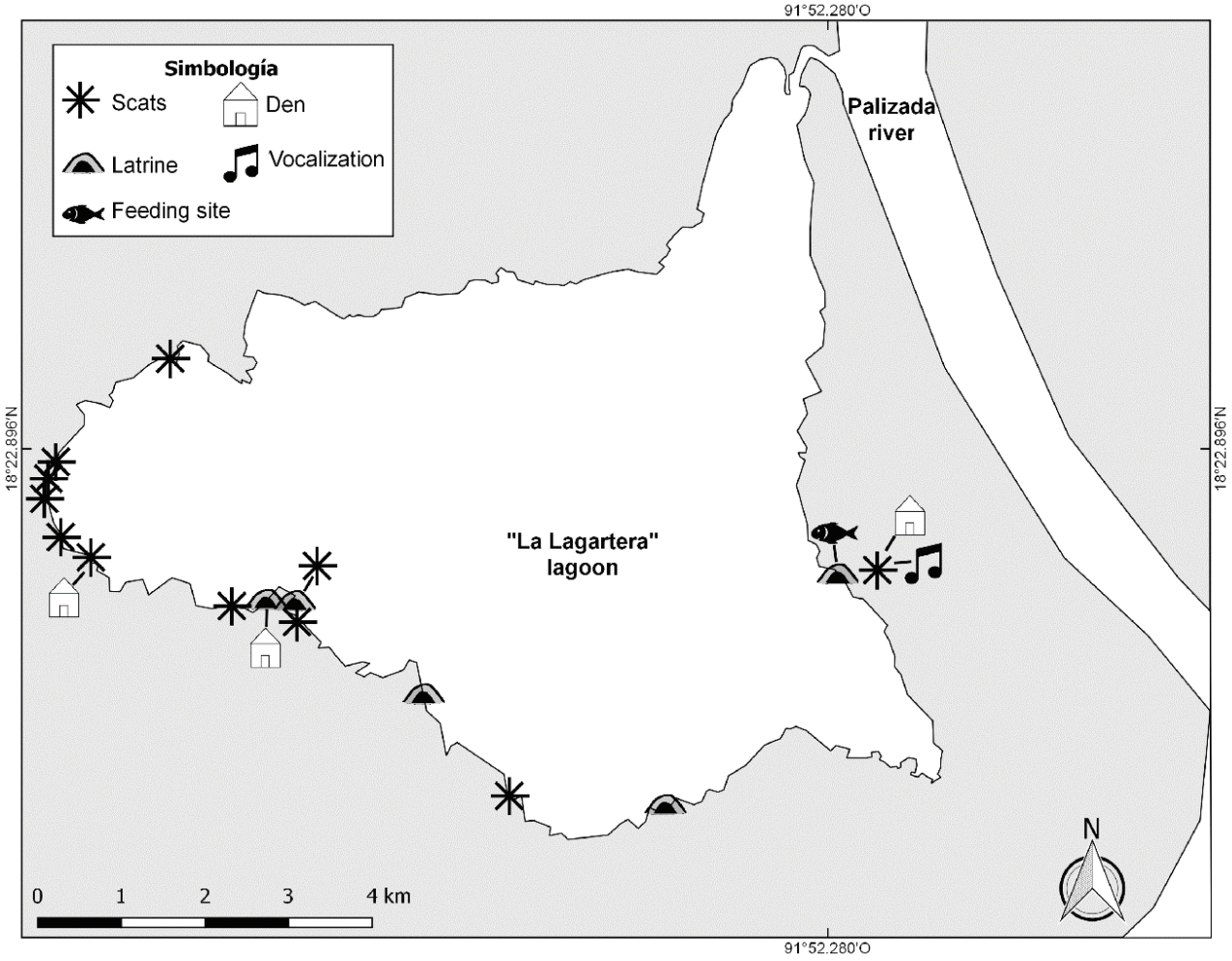


Figure 3. Distribution of Neotropical otter signs recorded for the study area in the nortes season.

Four of the prey fish species identified, (*Cichlasoma urophthalmus, Eucinostomus melanopterus, Opsanus beta*, and *Petenia splendada*) are native to the area according to the records of Ramos-Miranda *et al.* (2006) and Ayala-Pérez *et al*., 2015). Moreover, five new fish records were obtained for the study area: *Awaous banana, Gobiomorus dormitor, Oreochromis niloticus, Prionotus rubio*, and *Pterygoplichthys pardalis*; however, more analyses should be conducted for these species in the area, some of which are freshwater species not usually found in brackish environments.

Comparing the main groups of prey found in scats by other authors versus our findings in this study, the rank order in percentage of occurrence, in general and by climatic season, as recorded for La Lagartera Lagoon is the first report of its kind for the subspecies. In general, for the nortes and dry seasons, the rank order of frequency of consumption is: fish > crustaceans > reptiles; for the rainy season, the order is: fish > reptiles > crustaceans. These combinations of prey groups are different from those recorded in other regions of Mexico, such as the Sierra Madre del Sur (Gallo-Reynoso, 1989), Los Pescados River, Veracruz (Macías-Sánchez & Aranda, 1999), San Cipriano River, Tabasco (Ramón, 2000), Ayuquila River, Jalisco (Díaz-Gallardo *et al*., 2007), where the rank order is: fish > crustaceans > insects, or from the coastal zone of Tuxpan, Veracruz (Grajales-García *et al*., 2019), where the order is: crustaceans > fish > mollusks. However, this variation in the percentage of consumption of prey groups appears to be related to the type of river (narrow and rocky versus wide and muddy/sandy) or freshwater environment (river versus lagoon) (García-Silva *et al*., 2021), and even to anthropogenic pressures in the area, as well as to the time of the year when sampling was carried out and scats were collected. In La Lagartera Lagoon, no significant differences were found in the preference of prey by the Neotropical otter between climatic seasons.

Finally, otters showed certain tolerance to anthropogenic activities, as dens, scats, and vocalizations, were heard and recorded at the same sites where vegetation burning, and clearing was done in the previous season.

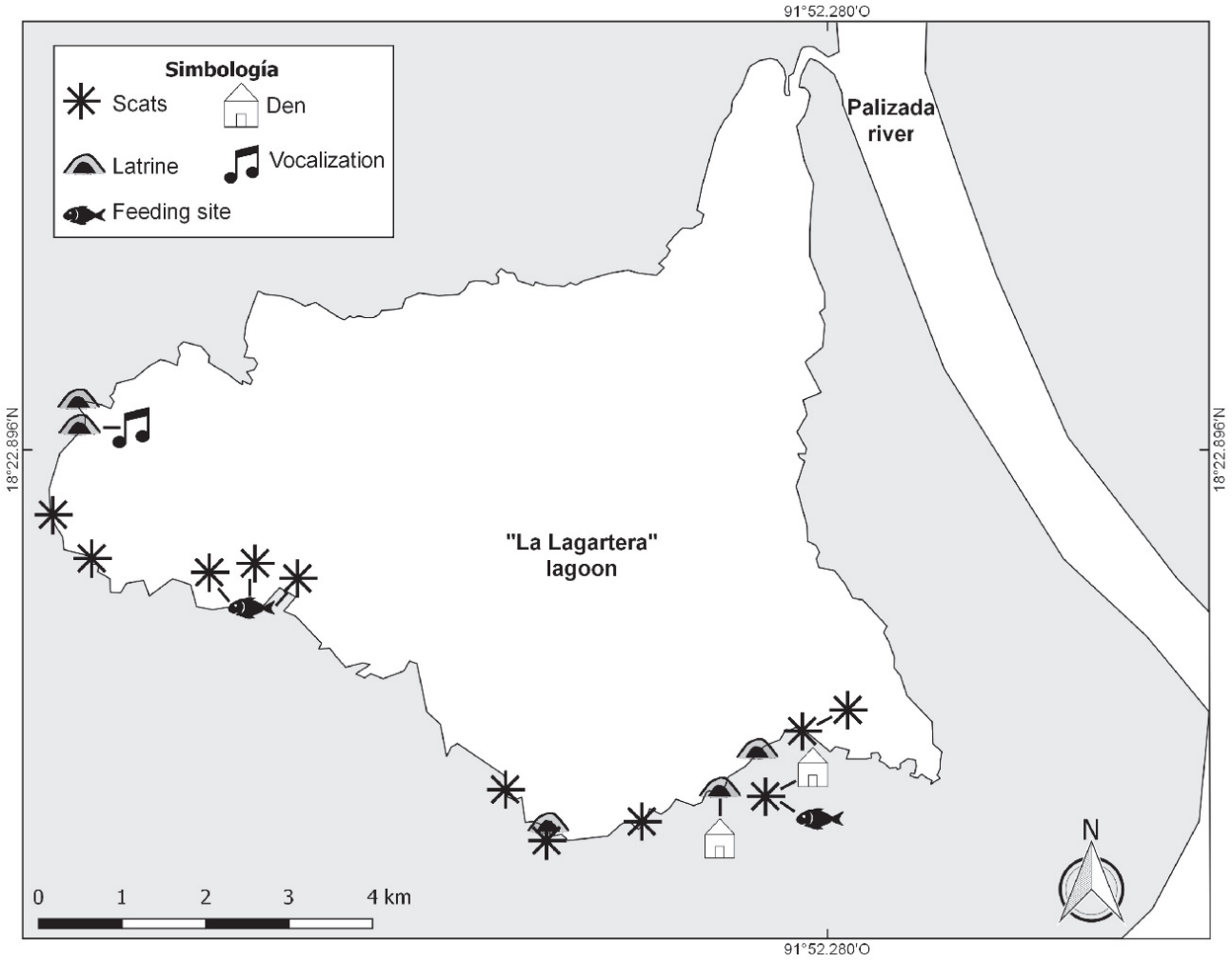


Figure 4. Distribution of Neotropical otter signs recorded for the study area in the dry season.

The species has been considered as an "umbrella species" (Gallo-Reynoso *et al.*, 2008) based on the conservation approach within the APFFLT Management Program. The efficiency of this strategy may be increased by including functional bonds between this species and other species in the same ecosystem (Bifolchi & Lodé, 2005), since this study shows that otters prefer sites with branches, root systems and logs. In addition, its position as a top predator highlights its important role in maintaining the functioning of ecosystems in aquatic environments (Grajales-García *et al.*, 2019), particularly, regarding the consumption of sailfin catfish, considered an invasive species. The results reported here indicate a central ecological role of the Neotropical otter in this transition zone between freshwater and brackish environments in the Laguna de Términos Flora and Fauna Protection Area.

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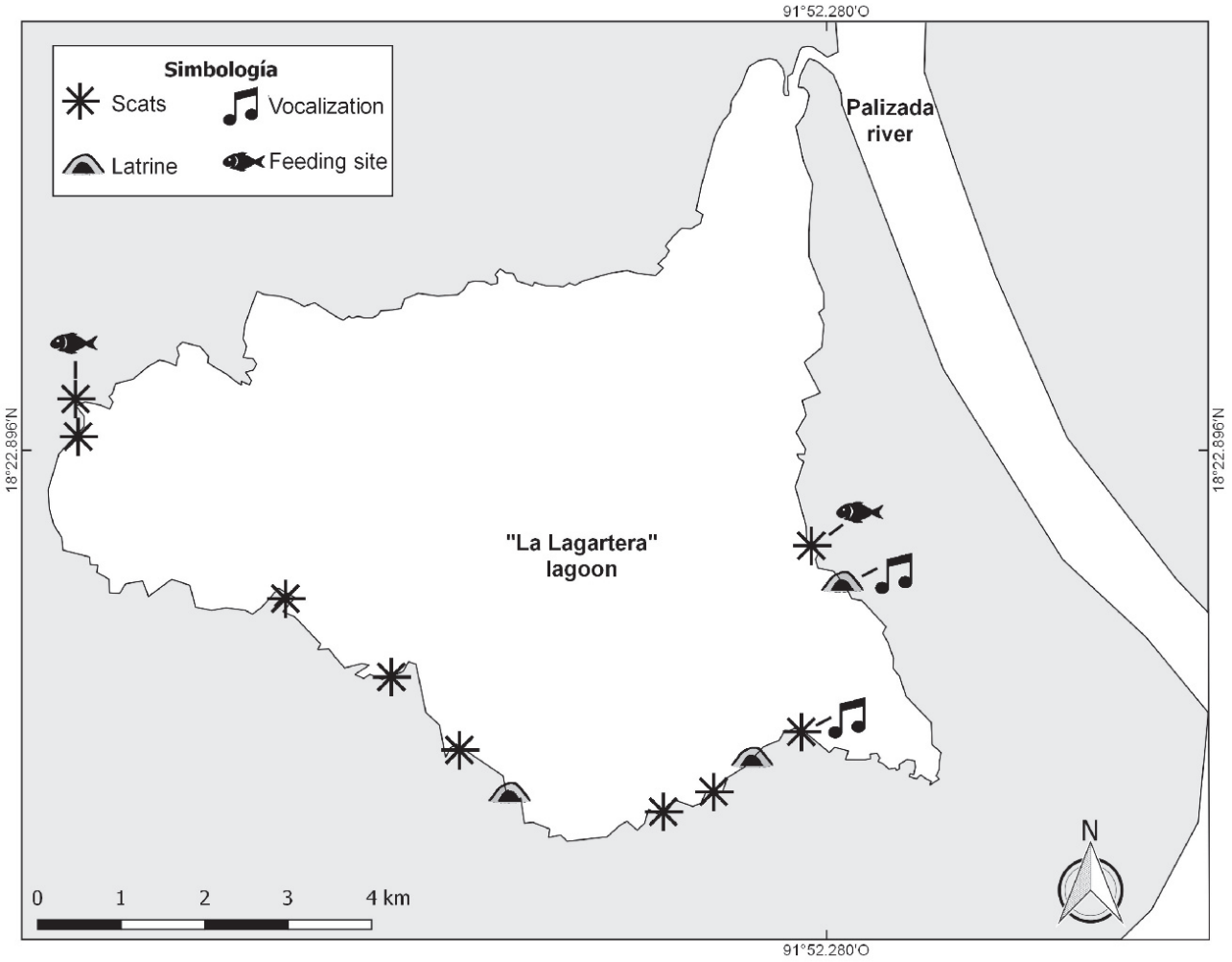


Figure 5. Distribution of Neotropical otter signs recorded for the study area in the rainy season.

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