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## Assessment of the relative abundance and habitat of Neotropical Otter *Lontra annectens* (Carnivora: Mustelidae) in Durango, Mexico


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### ABSTRACT

**Introduction:** Neotropical otter (*Lontra annectens*) is a widespread aquatic mammal in Mexico. Unfortunately, anthropogenic activities in Mexico have modified and polluted the habitat of this otter species, which has been listed as threatened. In Durango State, Neotropical otters thrive in preserved areas within the Sierra Madre Occidental. However, there are few scientific reports of their presence at the San Diego River.

**Objective:** To evaluate the habitat and compare the relative otter abundance over a 10 km section of the San Diego River using two widely used methods.

**Methods:** The habitat was characterized by measuring the river's physical structures, water physicochemical analyses, and plant species identification by strata and cover. Otter abundance was estimated by counting scats and latrines over 15 months. Data were analyzed with a stepwise regression to obtain the habitat variables significantly correlated with otter abundance.

**Results:** Vegetation was composed of a gallery forest with low deciduous forest associations. The highest plant cover corresponded to the herbaceous stratum (50.87 %), followed by the tree stratum (30.4 %) and the shrub stratum (18.71 %) and the species *Salix bomplandiana*, *Baccharis salicifolia*, *Sanvitalia ocyroides*, and *Muhlenbergia montana* had the highest Importance Value Index (IVI). Otter abundance was  $0.50 \pm 0.14$  otters  $\text{km}^{-1}$  using Method 1 (I) and  $1.12 \pm 0.30$  otters  $\text{km}^{-1}$  using Method 2 (E), with significant differences between them.

**Conclusion:** A model was constructed to predict the number of scats (SC) about otter abundance; the significant habitat variables were smaller rock diameter (SRD), a greater distance to the shoreline (DSL), turbidity (TB), and pH.

**Key words:** abundance; scats; *Lontra annectens*; conservation; Sierra Madre Occidental.



## RESUMEN

### Determinación de la abundancia relativa y evaluación del hábitat de la nutria neotropical *Lontra annectens* (Carnívora: Mustelidae) en Durango, México

**Introducción:** La nutria neotropical (*Lontra annectens*) es un mamífero acuático ampliamente distribuido en México. Desafortunadamente, las actividades antropogénicas han modificado y contaminado su hábitat, por lo que se encuentra enlistada como amenazada. En el estado de Durango se tienen registros de nutrias en zonas conservadas dentro de la Sierra Madre Occidental; sin embargo, se disponen de pocos trabajos científicos para el río San Diego.

**Objetivos:** Evaluar el hábitat, estimar y comparar la abundancia de la nutria en el río San Diego, mediante dos métodos utilizados ampliamente para esta especie, en una sección de 10 km del río.

**Métodos:** La caracterización del hábitat consistió en medir estructuras físicas del río, en realizar análisis fisico-químicos del agua, e identificar especies vegetales por estratos y cobertura. La estimación de la abundancia de nutrias se realizó por un periodo de 15 meses, mediante el conteo de heces y letrinas. Los datos se sometieron a una regresión paso a paso, para obtener las variables de hábitat significativas con la abundancia de nutrias.

**Resultados:** El hábitat de la nutria está compuesto por bosque de galería con asociaciones de selva baja caducifolia. La mayor cobertura fue la del estrato herbáceo (50.87 %), el estrato arbóreo (30.4 %) y el estrato arbustivo (18.71 %) y las especies *Salix bomplandiana*, *Baccharis salicifolia*, *Sanvitalia ocmoides*, y *Muhlenbergia montana* fueron las de mayor Índice de Valor de Importancia (IVI). La abundancia de las nutrias tuvo un promedio de  $0.50 \pm 0.14$  nutrias/ km<sup>-1</sup> para el método 1 (I) y de  $1.12 \pm 0.30$  nutrias/ km<sup>-1</sup> para el método 2 (E), presentando diferencias entre ellos.

**Conclusiones:** Se obtuvo un modelo para predecir el número de heces (SC por sus siglas en inglés) relacionado con la abundancia de la nutria, las variables de hábitat significativas fueron el diámetro menor de roca (SRD por sus siglas en inglés), distancia mayor del cauce (DSL por sus siglas en inglés), turbidez (TB) y pH.

**Palabras clave:** abundancia; heces; *Lontra annectens*; conservación; Sierra Madre Occidental.

## INTRODUCTION

Otters are carnivorous mammals from the Mustelidae family, adapted to the aquatic environment. There are three species in Mexico: *Enhydra lutris* (Linneo, 1758) (Sea otter), *Lontra canadensis* (Nearctic otter) (Nearctic otter), and *Lontra longicaudis* (Olfers, 1818) (Neotropical otter), the latter being the most widely distributed (Gallo-Reynoso, 1997; Larivière, 1999). Neotropical otter inhabits the Great Pacific and Gulf of Mexico slopes, from arid regions to tropical and mountainous forests (Gallo-Reynoso, 1997; Larivière, 1999). Despite its widespread distribution and being at the top of the trophic web in rivers, streams, lakes, lagoons, and dams, the Neotropical otter is currently listed as threatened according to the Official Mexican Norm NOM-059-SEMAR-NAT-2010 (Secretaría de Medio Ambiente y Recursos Naturales, 2019). Its low tolerance to pollution and its evasive behavior toward humans make it highly vulnerable to anthropogenic activities, such as poaching, alteration

of its habitats, and pollution of water bodies. Therefore, it is important to determine its current distribution and abundance to implement conservation strategies, as the Neotropical otter is an indicator of environmental quality in riparian ecosystems (Sánchez et al., 2007).

In Durango State, there are areas inhabited by the Neotropical otter. Historically, *L. annectens* has been recorded in the Mezquital River basin (Charre-Medellín et al., 2011), La Michilia Biosphere Reserve (Gallo-Reynoso, 1997); the Ramos River, in the municipality of Santiago Papasquiario (Charre-Medellín et al., 2011); El Aleman stream, in the Grande de Santiago River basin (Servín et al., 2003), and the Nazas River, in the Ocampo municipality (Pohle, 1920).

Baker and Greer (1962) reported the existence of numerous “water dogs” in the San Diego River, a finding subsequently confirmed by Barrón (2012), Rodríguez and Medrano (2015), and Cruz-García, Contreras-Balderas, Nava-Castillo and Gallo-Reynoso (2017).

This work aimed to estimate the population abundance and assess the habitat characteristics of *L. annectens* in the San Diego River, which comprises one of the best-preserved areas of the Sierra Madre Occidental, to produce valuable information about species conservation.

## MATERIALS AND METHODS

**Study area:** The study area covered a 10 km section of the San Diego River (23°44'08" N & 105°17'52" W; Fig. 1). This area is locally known as Quebrada de Galindo, in Adolfo Ruiz Cortines ejido, municipality of Pueblo Nuevo, Durango, which is located at 1 743 m.a.s.l. and belongs to the Cañones Duranguenses sub-province within the Sierra Madre Occidental Physiographic Province.

San Diego River is located within the hydrological region N° 11, classified as the Acaponeta River Basin (B). It originated Southeast of El Salto town, across 233 km, and ended in Nayarit state. It is also on the Pacific Ocean slope, draining an area of 5 092 km<sup>2</sup>

(Instituto Nacional de Estadística y Geografía [INEGI], 2015).

There are two types of climates described for this region. One is semi-humid subhumid (A) C (W1) with rain in summer. This climate has precipitation in the driest month of less than 40 mm and a percentage of winter rain between 5 and 10.2 mm. The other one is sub-humid temperate C (W2) with rain in summer, a percentage of winter precipitation between 5 and 10.2 mm, and rainfall relatively scarce. The highest rainfall occurs between June, July, August, and September, with an annual average of 940 mm. The mean annual temperature ranges from 10.8 to 11.8 °C (Cruz-García, Contreras-Balderas, Nava-Castillo, & Gallo-Reynoso, 2017).

Dominant plant communities belong to the mixed temperate forests with *Pinus* and *Quercus* species and some shrub species. The most representative vegetation types are pine forest, pine-oak forest, and riparian vegetation (INEGI, 2015). Riverbanks are home to trees of the genera *Salix*, *Populus*, *Bursera*, *Lysiloma*, and

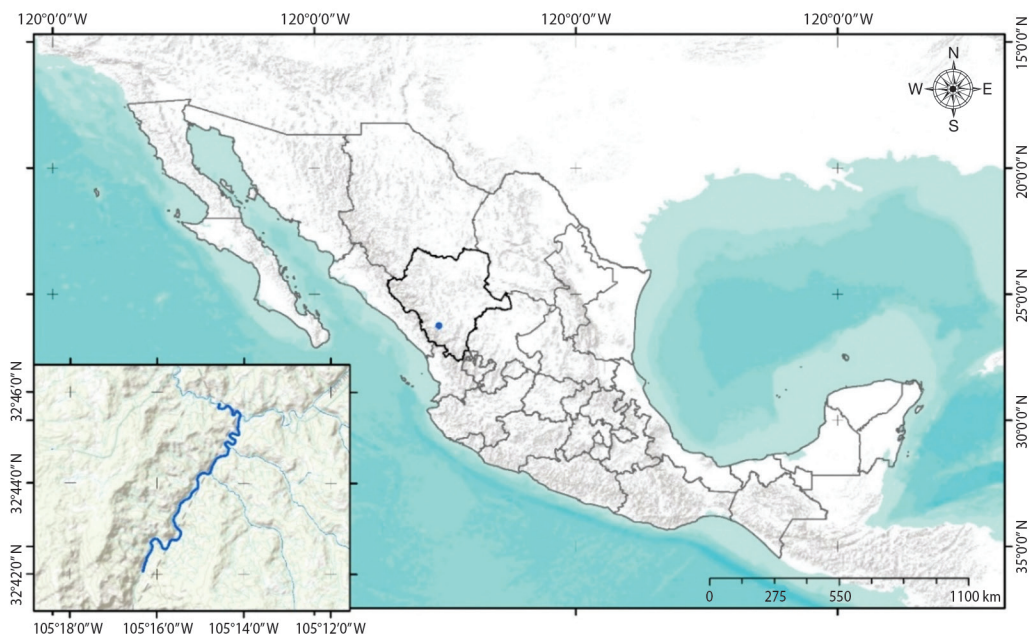


Fig. 1. Location of the San Diego River, segment of the river where a neotropical otter population is located.



*Pithecellobium* (Cruz-García, Contreras-Balderas, Nava-Castillo, & Gallo-Reynoso, 2017).

**Otter sampling:** Field sampling consisted of latrines counting and scats to estimate otter abundance. Scats were identified based on location, shape, size, and smell (Murie & Elbroch, 2005). According to Cruz-García, Contreras-Balderas, García-Salas and Gallo-Reynoso (2017), any habitat component having at least one otter scat was counted as a latrine. Samples were collected monthly from February 2013 to April 2014 along a riverbank strip measuring 10 km long by 5 m from the river's edge on both sides, this distance was adjusted on average along the riverbank to where it was possible to observe the excreta, based on the vegetation and terrain conditions. These sites were georeferenced with a Garmin® eTrex Venture GPS unit.

**Relative abundance:** Otter relative abundance was calculated monthly using two methods. The first method estimates the number of otters per river km ( $A_N$ ), dividing the scats number found by defecation rate and total distance traveled in km. In addition, the scats number indexes per river km ( $N_E$ ) and the latrines number per river km ( $N_L$ ) were estimated (Macías-Sánchez, 2003):

$$A_N = \frac{n_E}{T_D} / d$$

$$N_E = \frac{n_E}{d}$$

$$N_L = \frac{n_L}{d}$$

$N_E$  = number of scats per kilometer of river,  $n_E$  = number of scats,  $d$  = distance traveled (kilometers),  $N_L$  = number of latrines per kilometer of river,  $n_L$  = number of latrines,  $A_N$  = estimated number of scats per kilometer of river,  $T_D$  = defecation rate (number of scats per otter per day).

The second method used was the one described by Eberhardt and Van Etten (1956),

and modified by Casariego-Madorell et al. (2008):

$$E = \frac{(NK)(EA)}{(TP)(3)}$$

$E$  = number of otters per kilometer of river,  $NK$  = number of kilometers traveled,  $EA$  = number of scats in the area,  $TP$  = scat deposition time (days).

For both abundance indexes, an estimated defecation rate from three otter scats per day based on a study of two female otters in captivity was used (Gallo-Reynoso, 1997). We compared the mean number of otters per kilometer of river estimated with both methods through a one-way analysis of variance (Macías-Sánchez, 2003).

**Vegetation characterization:** Plant species were collected to build a floristic inventory to evaluate the otter riparian habitat's composition and structure. The samples collected were placed in a botanical press and transferred to the Botany Laboratory at Technological Institute of El Salto, where specimens collected were identified to species. Also, the coverage of the herbaceous, shrub, and tree strata was estimated on 10 transects with a length of 50 m each, running parallel to the riverbed on the bank. A series of five separate points were sampled at 10-meter intervals, on which a 3 m rod was supported. The vegetation intercepts number on the rod in each meter section was counted. To determine the respective stratum for different vegetation heights, the formula from Hays et al. (1981) was used:

$$\text{Cob}(x) = \frac{\sum I_x}{L} * 100$$

$\text{Cob}(x)$  = cover of species  $x$ , = number of intercepts (herbaceous, shrub, and arboreal) of species  $x$ ,  $L$  = transect length. This formula was multiplied by one hundred to get the result as a percentage.

Additionally, the Importance Value Index (IVI) of species was estimated to determine the composition of the dominant taxa that make up

the otter's habitat. The IVI, developed by Curtis and McIntosh (1951), consists of summing the relative values of density (Abr), dominance (Dr), and frequency (Fr). The general formula of the IVI is as follows:

$$IVI = Abr + Dr + Fr$$

**Channel physicochemical characterization:** Water quality was determined based on the pools and rapids' physicochemical characteristics (Cruz-García, Contreras-Balderas, Nava-Castillo, & Gallo-Reynoso, 2017), measured on-site with portable laboratory equipment (Hach®) and subsequently in the Technological Institute of El Salto laboratory. The parameters evaluated were water temperature, ambient temperature (mercury-column precision thermometer), pH, turbidity, total solids, nitrates, nitrites, phosphates and salinity (Hach® turbidimeter), and dissolved oxygen (estimated using the equation by Elmore and Hayes, 1960).

$$C_s = 14.652 - 0.41022T + 0.0079910T^2 - 0.000077774T^3$$

Where  $C_s$  is the dissolved oxygen saturation concentration (mg/L) and  $T$  is the temperature in degrees Celsius. These parameters were measured during the sampling period in the dry and rainy seasons.

River physical structures were characterized on the site where otter latrines were observed (Spínola-Parallada & Vaughan-Dickhaut, 1995). The variables measured for rocks were the emerged height (above the water surface) and the rock's most extensive and minor diameters used as a latrine (measured on the emerged part). The variables for the river were channel depth and width and the longest and shortest distance to the rock's shoreline used as latrines.

**Relationship of the habitat with otter abundance:** Based on the data obtained regarding floristic coverage, water physicochemical parameters, and river physical structures, the relationship between the habitat components and the presence of otters was analyzed. To

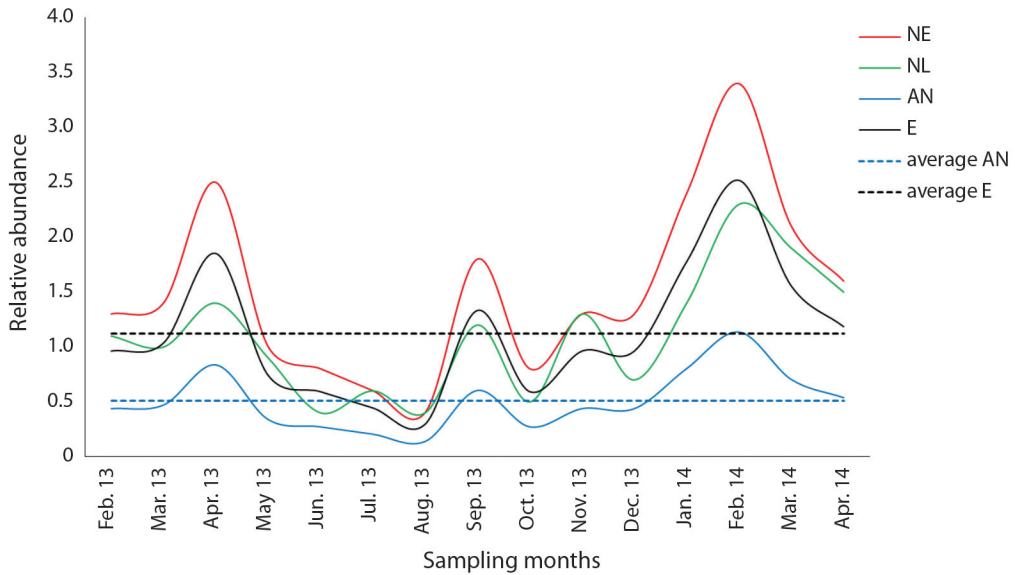
perform this analysis, a regression model was fitted including all the variables evaluated. Statistically significant variables ( $p < 0.05$ ) were selected using the Forward Stepwise Regression procedure. With the significant variables, a scat abundance model was constructed using a logistic regression. All analyses were performed using SAS (SAS, 2004).

## RESULTS

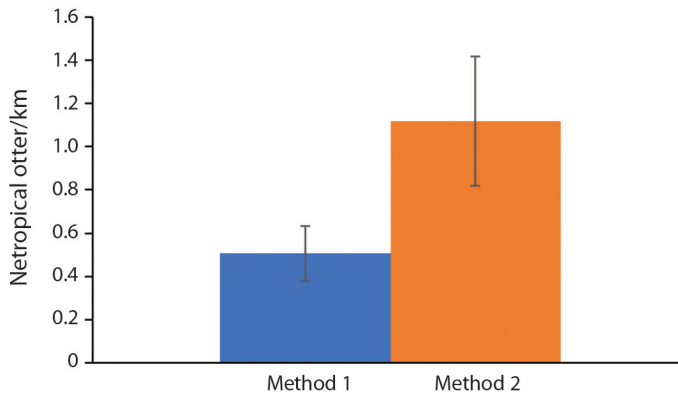
**Otter abundance:** 227 scats and 166 latrines were found along the 10 km river sampled. Within the 15month sampling period, April 2014 was the time point with the highest number of scats and latrines recorded, while October 2013 was the month with the lowest figures recorded (Fig. 2). Otter abundance showed significant fluctuations, mainly between the dry and rainy periods. The abundances estimated with Method 1 ( $A_N$ ) and Method 2 (E) averaged  $0.50 \pm 0.14$  otters  $\text{km}^{-1}$  and  $1.12 \pm 0.30$  otters  $\text{km}^{-1}$ , respectively. The latrine's average number per km was  $1.10 \pm 0.27$ , and the scat's average number per km was  $1.51 \pm 0.41$ . On the other hand, the  $A_N$  and E indexes showed a positive correlation (0.9) over the sampling period.

The variance analysis showed highly significant differences ( $p < 0.001$ ) in otter abundances per river km calculated with method 1 ( $A_N$ ) and method 2 (E) with 95 % confidence (Fig. 3).

**Vegetation characterization:** On the riverbank, 19 plant species were identified, most of them from the herbaceous stratum, which showed the highest coverage (50.87 %), followed by the tree stratum (30.4 %) and the shrub stratum with the lowest coverage (18.71 %). Out of the nine species identified in the herbaceous stratum, the creeping zinnia (*Santivitalia ocymoides*) and the mountain muhly (*Muhlenbergia montana*) had the highest coverage. In the tree and shrub strata, the species with a higher coverage percentage were the willow (*Salix bomplandiana*) and the seepwillow (*Baccharis salicifolia*) (Fig. 4).



**Fig. 2.** Relative abundance of otters per month. , feces/km of river ratio; , ratio of latrines/km of river; and E, number of otters/km of river (method 1 and 2, respectively).



**Fig. 3.** Otter abundance with method 1 ( $A_N$ ) and method 2 (E), and they error bars.

The species *S. bomplandiana*, *B. salicifolia*, *S. ocymoides*, and *M. montana* had the highest IVI values (Table 1), consistent with what is shown in Fig. 3 and Fig. 4.

**Physicochemical characterization:** The parameters measured displayed similar values in pools and rapids (Table 2). However, some parameters show differences. For instance, the pH was, on average, more acidic in pools than in rapids. Dissolved oxygen was higher in

rapids than in pools. Turbidity and total solids were higher in rapids than in pools.

Rocks used as latrines were larger in pools than in rapids, with average maximum diameters of 2.36 and 1.44 m, respectively. These rocks were generally located in the middle of the channel, both in slow-flowing waters and in rapids. The average (maximum and minimum) distance from the rock to the shoreline was 9.42 and 4.07 m in pools, and 12.08 and 5.28 m in rapids, respectively, with a channel width

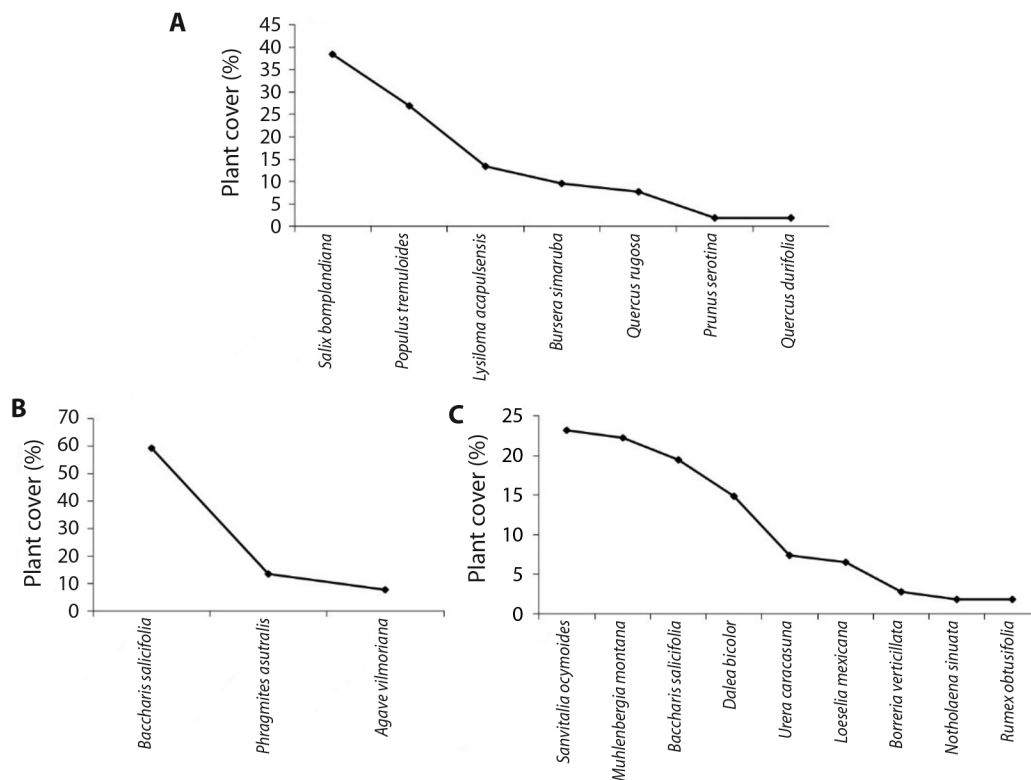


Fig. 4. Coverage of the species identified on the river bank by stratum. A. Arboreal. B. Shrubby. C. Herbaceous.

of 5.50 m in slow-water areas and 9.25 m in rapids. River depth ranged from 3.85 m in pools to 1.16 m in rapids. On the other hand, water temperature was lower in slow-flowing waters (15.4 °C) than in rapids (20.1 °C). Similarly, ambient temperature was lower in pool areas than in rapid areas (22 and 26 °C, respectively).

**Habitat and otter abundance relationship:** Only four had a significant relationship with the scat's presence from all the water quality variables and river physical structures analyzed. The final scat prediction model (Table 3) was as follows:

$$SC = 1.39829 + 3.28959 (DMIR) + -0.96637 (MADC) + -4.32372 (TB) + 2.69940 (pH)$$

SC = number of scats, DMIR = minor diameter of the rock, MADC = maximum distance from

the channel, TB = turbidity, pH = hydrogen potential.

## DISCUSSION

Otter abundance was 0.83 (AN) and 1.85 (E) otters km<sup>-1</sup> in April 2013 and only 0.13 (AN) and 0.30 (E) otters km<sup>-1</sup> in August of the same year. Except for the work of Santiago-Plata et al. (2013), most studies reported this pattern, in which otter abundance is considerably lower during rainy periods (Casariego-Madorell et al., 2008; Cruz-García, Contreras-Balderas, Nava-Castillo & Gallo-Reynoso, 2017; Duque-Dávila et al., 2013; González-Christen et al., 2013). This is likely due to the river flow increases in the rainy season, so scats can be removed by the heightened river flow from rocks used as latrines (Aranda-Sánchez, 2012). Melquist and Hornocker (1983) and Quadros and de



**Table 1**  
Ecological Importance Value Index of all plant species identified in the transects.

Especie	Denabs	Denrel	Cobabs (%)	Cobrel (%)	Freabs	Frerel	IVI
<i>Salix bomplandiana</i>	5	8.92	80	11.69	20	11.69	32.32*
<i>Populus tremuloides</i>	4	7.14	56	8.18	14	8.18	23.51
<i>Lysiloma acapulcensis</i>	3	5.35	28	4.09	7	4.09	13.54
<i>Bursera simaruba</i>	2	3.57	20	2.92	5	2.92	9.41
<i>Quercus rugosa</i>	2	3.57	16	2.33	4	2.33	8.25
<i>Prunus serotina</i>	1	1.78	4	0.58	1	0.58	2.95
<i>Quercus durifolia</i>	1	1.78	4	0.58	1	0.58	2.95
<i>Baccharis salicifolia</i>	4	7.14	84	12.28	21	12.28	31.70*
<i>Phragmites australis</i>	3	5.35	28	4.09	7	4.09	13.54
<i>Agave vilmoriana</i>	2	3.57	16	2.33	4	2.33	8.25
<i>Sanvitalia ocyroides</i>	5	8.92	100	14.62	25	14.62	38.16*
<i>Muhlenbergia montana</i>	5	8.92	96	14.03	24	14.03	36.99*
<i>Dalea bicolor</i>	5	8.92	64	9.35	16	9.35	27.64
<i>Urera caracasuna</i>	4	7.14	32	4.67	8	4.67	16.50
<i>Loeselia mexicana</i>	3	5.35	28	4.09	7	4.09	13.54
<i>Borreria verticillata</i>	3	5.35	12	1.75	3	1.75	8.86
<i>Notholaena sinuata</i>	2	3.57	8	1.17	2	1.17	5.91
<i>Rumex obtusifolia</i>	2	3.57	8	1.17	2	1.17	5.91
Total	56	100	684	100	171	100	300

Denabs = absolute density, Denrel = relative density, Cobsbs = absolute cover, Cobrel = relative cover, Freabs = absolute frequency, Frerel = relative frequency.

**Table 2**

Average values of the physical-chemical parameters of the channel in pools and rapids.

Low zone	Variables	Unit of measurement	Average	Min.	Máx.	SD
Pool	Major diameter of the rock	m	2.36	0.5	8	2.4
	Minor diameter of the rock	m	0.99	0.3	1.6	0.49
	Canopy coverage	m	0.9	0.3	1.8	0.6
	Maximum distance from the channel	m	9.42	1.5	14	3.89
	Minimum distance from the channel	m	4.07	0.5	8	2.72
	Total height of the rock	m	1.68	0.5	4.4	1.16
	Channel width	m	5.50	4	9.5	3.01
	Average depth	m	3.85	0.5	5.5	1.04
	Height above water surface	m	0.65	0.3	1.3	0.31
	Turbidity	NTU*	2.04	1.54	2.54	0.46
	pH	pH	5.82	4.71	7	0.51
	Ambient temperature	°C	22	12	25	6.31
	Water temperature	°C	15.4	9.34	18.2	6.2
	Dissolved oxygen	mg/L	7.81	1.7	12.25	2.97
	Nitrates	mg/L	0.23	0.1	0.5	0.12
	Nitrites	mg/L	0.22	0.1	0.4	0.12
	Phosphates	mg/L	2.97	2.93	3.5	0.68
	Salinity	mg/L	0.58	0.4	0.7	0.11
	Total solids	mg/L	0.73	0.67	0.96	0.11

Low zone	Variables	Unit of measurement	Average	Min.	Máx.	SD
Rapid	Major diameter of the rock	m	1.44	1	5.1	1.04
	Minor diameter of the rock	M	1.94	1	3	0.83
	Canopy coverage	M	1.22	0.8	1.7	0.31
	Maximum distance from the channel	M	12.08	9.5	15	1.59
	Minimum distance from the channel	m	5.28	1.5	7.5	2.05
	Total height of the rock	m	1.74	1.1	2.4	0.43
	Channel width	M	9.25	7.4	19.9	1.84
	Average depth	m	1.16	0.8	1.5	0.25
	Height above water surface	m	0.61	0.4	1	0.21
	Turbidity	NTU*	2.21	1.22	2.89	0.54
	pH	pH	6.82	5.34	8.2	1.10
	Ambient temperature	°C	26	17.23	28	1.54
	Water temperature	°C	20.1	8.67	22.2	4.9
	Dissolved oxygen	mg/L	8.2	1.2	11.68	3.08
	Nitrates	mg/L	0.35	0.2	0.6	0.17
	Nitrites	mg/L	0.36	0.1	0.8	0.27
	Phosphates	mg/L	2.45	1.29	3.5	0.78
	Salinity	mg/L	0.57	0.2	0.9	0.23
	Total solids	mg/L	0.83	0.6	0.93	0.11

\*Nephelometric turbidity units.

**Table 3**  
Estimated parameters of the scats presence model.

Variables	Degrees of Freedom	Parameters	Standard Error	t Value	Pr > t
CONSTANT	1	$b_0$	3.01642	0.46	0.652
DMIR	1	$b_1$	0.50716	6.49	< 0.0001
MADC	1	$b_2$	0.12375	-7.81	< 0.0001
TB	1	$b_3$	0.73929	-5.85	0.0001
pH	1	$b_4$	0.43498	6.21	< 0.0001

The model indicates that greater rock diameters and more neutral pH values tend to be associated with a larger number of otters; the opposite was observed with distance to the shoreline and higher turbidity, i.e., the presence of otters decreases when the values of these variables increase.

Araújo-Monteiro-Filho (2002) stated that otters can also defecate in water, especially when they have offspring, probably to avoid odors that would attract predators. Therefore, our results need to be interpreted with caution since the sites might be used more intensively than what can be estimated through indirect methods (Gallo-Reynoso et al., 2019). However, Spínola-Parallada and Vaughan-Dickhaut (1995) pointed out that the increased number of scats during the drought period was due to the seasonal variation in the otter's number

marking their territory. Waldemarin (2004) suggests that this increase occurs when the prey availability decreased and intraspecific competition increased. The latter was consistent with the findings reported by Cruz-García, Contreras-Balderas, García-Salas and Gallo-Reynoso (2017), who stated that the main otters diet (fish and aquatic insects) in this section of the San Diego River decreased in the dry season, which would lead otters to have most frequent encounters with other individuals of their own species in areas where prey was found.



On the other hand, average abundance indexes were not different from those observed in other studies. Mainly,  $A_N$  - one of the most used indexes in this type of research - yielded  $0.5 \pm 0.14$  otters  $\text{km}^{-1}$ , similar to the figures reported by Gallo-Reynoso (1996) for the Yaqui River (0.43), Casariego-Madorell et al. (2008) for the Ayuta River in Oaxaca (0.41), Arellano-Nicolás et al. (2012) for the Papaloapan River (0.43), and González-Christen et al. (2013) for Lake Catemaco (0.49), considering a defecation rate of six scats per day. In this same area, Cruz-García, Conteras-Balderas, Nava-Castillo and Gallo-Reynoso (2017) estimated an average of  $0.46$  otters  $\text{km}^{-1}$  with the  $A_N$  index. However, the value obtained with AN in this study was different from the figure reported by Macías-Sánchez (2003), who estimated two and six otters  $\text{km}^{-1}$  in Actopan and Los Pescados rivers in Veracruz, but was similar to the value obtained with Method 2 (E) ( $1.12 \pm 0.3$  otters  $\text{km}^{-1}$ ). Casariego-Madorell et al. (2008), using this same method, obtained lower values compared to the present study (0.005, 0.111, and  $0.154$  otters  $\text{km}^{-1}$  for rivers Ayuta, Copalita, and Zimatán, respectively). This difference might be due to the reduced number of scats  $\text{km}^{-1}$  found by Casariego-Madorell et al. (2008). Separately, Gallo-Reynoso et al. (2019) determined the relative abundance through camera traps ( $1.8$  otters  $\text{km}^{-1}$  in the San Pedro River in Chihuahua State for the Neartic otter, and  $2.2$  otters  $\text{km}^{-1}$  in the Bamochi stream in Sonora of the Neotropical otter), these values were similar to those obtained here with Method 2 (E) for the Neotropical otter.

Although both methods ( $A_N$  and E) use a defecation rate, the distance traveled, and the number of scats, the difference in the results yielded by these methods might be due to the time since scat deposition applied in Method E. The results of otter abundance tend to increase with shorter times since scat deposition. This work's time was 45 days, which might have overestimated the population size considering the few otter sightings in the area. Parera (1996) reported that high abundances can also occur when food abundance increases; this coincided

with the otter mating season onset during the dry season or spring from December to May, with births from April to June.

Local vegetation in this section of the San Diego River resembles a gallery forest with a dense herbaceous cover, which, although not influencing the otter's diet, was a major factor for other activities of this species, such as escape, rest, fur grooming, cub breeding, and thermoregulation (Bertonatti & Parera, 1994; Gallo-Reynoso, 1996; Gallo-Reynoso, 1997; Gallo-Reynoso et al., 2019). Important tree species, such as *Salix bonplandiana* and *Populus tremuloides*, were also found. These species provide trunks and roots that protect otter dens (Pardini & Trajano, 1999). However, although otters thrive in areas covered by this type of riparian vegetation, the tree and shrub strata in the study area were found to be below the herbaceous stratum, in which *S. ocyroides* and *M. montana* stand out as the dominant species in this ecosystem. This vegetation structure was consistent with the reported by Mayagoitia-González et al. (2013) in Tamaulipas, observing an herbaceous cover greater than 60 %, higher than the other two strata. Meanwhile, in the same area as in the present study, Cruz-García, Conteras-Balderas, Nava-Castillo and Gallo-Reynoso (2017) found dens in sites with trees and shrubs. However, the highest scat abundance was recorded in sites with scarce riparian vegetation, which were more suitable as feeding grounds for otters.

The pH values recorded corresponded with the range reported by Casariego-Madorell et al. (2008) and Guerrero-Flores et al. (2013), from 6 to 7. Although pH was close to 7 (neutral) in most river sites, it was acidic (4.34) in some pools, likely due to the presence of decomposing matter (Cruz-García, Conteras-Balderas, Nava-Castillo & Gallo-Reynoso, 2017). Dissolved oxygen values recorded in our study were above ranges reported in other works (Casariego-Madorell, 2013). However, García and Quintana (2005) agreed that otters preferred clean water with high dissolved oxygen levels. Total solids were higher than the  $0.054$  and  $0.046$   $\text{g l}^{-1}$  figures reported for two rivers

in Temascaltepec, State of Mexico, by Monroy-Vilchis and Mundo (2009). Turbidity was higher than the levels observed by Mayagoitia-González et al. (2013) in a protected area in Tamaulipas. These higher turbidity values were possibly related to the season when the measurement was recorded. In our study, turbidity was measured in the dry and rainy seasons; the latter might increase suspended solids in water from runoff (Ospina-Zuñiga et al., 2016). Water temperature was higher in rapids (20.1 °C) compared to pools (15.4 °C); these values were lower than those reported by Macías-Sánchez (2003) and Casariego-Madorell et al. (2008), with temperatures ranging between 21 and 27 °C for the rivers studied which were found in lower elevations. Nonetheless, they corresponded with the temperatures reported by Cruz-García, Conteras-Balderas, Nava-Castillo and Gallo-Reynoso (2017) in the same study area.

The scat prediction model was similar to those developed in other studies where it also associated the abundance of Neotropical otters with factors such as water pH and turbidity or with river physical structure characteristics (Cruz-García, Conteras-Balderas, Nava-Castillo & Gallo-Reynoso, 2017; Mayor-Victoria & Botero-Botero, 2010). However, it did not include variables that had been significant in predicting scat numbers, such as temperature and dissolved oxygen (DO) (Casariego-Madorell et al., 2008; Guerrero-Flores et al., 2013). This work recorded a positive, although not significant, relationship between the scat's number and dissolved oxygen (DO).

Similar to the present study, Mayor-Victoria and Botero-Botero (2010) reported a seasonal change in habitat preferences. In winter, a smaller rock diameter and rock total and emerged height were more relevant, while in summer, rock height, proximity to the shore, and canopy cover were most influential for rock use and marking.

Botero-Botero (2013) reported that otter inhabits rivers of medium and large flows in La Vieja river basin, Colombia; this author also observed a low positive correlation between

otter abundance and channel width ( $r = 0.241$ ,  $p = 0.0001$ ).

The model produced in this study and the results of similar studies showed the otter's preference for sites where the habitat characteristics, the abundance of Neotropical otter scats is related to physical characteristics of the river and habitat, such as pH, turbidity, rock size and position, as well as channel width.

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