N O T E   F R O M   T H E   E D I T O R

NOTE FROM THE EDITOR

Dear Friends, Colleagues and Otter Enthusiasts!

I am sorry that the start of issue 38/3 was delayed compared to the original planning. So finally, we start this issue for which I already have all manuscripts ready in their final form so stay tuned, come back regularly and you will soon see them going online as time allows. I also do have already enough manuscripts for issue 38/4 but not all manuscripts are already in the final layout, but this work will start on my side as soon as my other activities allow.

Lesley uses so much time not only for getting manuscripts online but also for the extra work to double-check the manuscripts for typos and the one always missing reference. Lesley, I thank you for this on behalf of the whole otter community!

R E P O R T

PAST HOLOCENE EXPLOITATION OF EURASIAN OTTERS (*Lutra lutra*) IN ROMANIA, BASED ON ARCHEOZOOLOGICAL DISCOVERIES

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Abstract: The current paper aims to present archeozoological and historical data about the Eurasian otter (*Lutra lutra*) distribution and its exploitation in Romania from the Mesolithic to the Middle Ages. Little is known about Eurasian otter ancient history, because most attention is given to study of the present populations. In order to be able to give information about the past exploitation of otters in Romania, literature reviews were used as a tool to provide answers, and more than 200 literature titles about faunal samples found in the area comprising modern Romania were consulted. This study is based on archeozoological data concerning 16 archeological sites dating from the Mesolithic to the Middle Ages, where Eurasian otter remains were identified in ancient settlements and cemeteries. The otter was not hunted solely for fur as today, but also for ceremonial and religious reasons and for its meat. In addition, data suggests that various cultures that lived in the present territory of Romania knew the Eurasian otter and its ecology. It has to be highlighted that it was difficult to coordinate the disparate data. Under these conditions the aim was to present a state of knowledge, avoiding generalization.
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Keywords: otter history, archeozoology, past Holocene mammals, otter exploitation

INTRODUCTION

At the current time, *Lutra lutra* has one of the largest population distributions of all otter species in the world (Kruuk, 2006). Its range extends from the cool damp climate of West Ireland to the humid tropical forests of Asia, and from the hot dry lands of North Africa to the cold lands of northern Russia and Finland (Chanin, 2013). The presence of the otter in Romania has been reported for all regions of the country, mainly along the large rivers and their tributaries, from the Danube Delta to the

Carpathian Mountains (Botnariuc and Tatole, 2005). But what about its past distribution and habitats?

Little is known about the ancient history of the Eurasian otter (Kruuk, 2008), as most of the attention is given to present *Lutra lutra* populations. In order to be able to answer the above question, a literature review was chosen as the best methodological tool to provide answers.

This paper aims to bring together, for the first time, archeozoological and historical data about Eurasian otter distribution and exploitation in Romania from the Mesolithic to the Middle Ages.

The interests of ancient human populations living in the territory of today`s Romania, and their knowledge of the Eurasian otter, is driven by interest hunting them for fur and meat, but also because of competition for fish resources.

MATERIAL AND METHODS

The exploitation of the natural environment by humans in ancient societies is mainly through fishing and hunting. The list of species of wild animals determined in an archaeological site can illustrate the exploitation of a certain type of biotope from an ecological point of view (Bejenaru, 1998).

When one wants to find information about the past fauna, a literature review of domains like paleontology and archeozoology may be a good methodological tool to provide answers. This study is based on archeozoological data concerning 16 archeological sites where Eurasian otter remains were identified, dating from the Mesolithic to the Middle Ages, located on the present-day territory of Romania (Fig. 1), found in a review of more than 200 published documents covering archeological sites where animal bones were identified.

RESULTS

The presence of the otter in archaeological sites confirms that the otter has been known and exploited by people living in the present territory of Romania, since the Mesolithic period.

Eurasian otter remains were found at 16 archeological sites from the present territory of Romania in four different historical regions. Fauna samples, excavated from archaeological sites, that contain remains of Eurasian otter belonged to different cultures that used the territory of present-day Romania and used Eurasian otters in different ways, as will be detailed later.

The main uses of otter as a resource were for meat and fur. It is interesting that some archaeological evidence confirms the continuity of the presence of the otter in the vicinity of human settlements from the Mesolithic period to the Middle Ages.

Of course, the archeozoology studies carried out for the 16 settlements where Eurasian otter remains were identified, do not cover the entire area of distribution of Eurasian otter during the Mesolithic to the Middle Ages, and do not give a general picture of the situation, due to the lack of data. In many of the sites, the otter remains have been ignored or not determined. In addition, there are differences in methodology, both at the archaeological level of sampling the organic remains, and at the archeozoological level of processing and interpretation. We refer here to the lack of sifting of the sediment for the complete recovery of material from the complexes, to the lack of biometrics, and the determination of the species. In the consulted studies, there is a significant percentage of undetermined mammal remains. These are major impediments to a complete faunal study. Therefore, the main aim of this paper is to present all the archeozoological material studied so far, and to show the sites where remains of the Eurasian otter have been positively identified, taking into account the limits presented above.

Table 1. Eurasian otter discoveries in the archeological sites

No.	Region	Period	Culture/Epoch	Archeological site	County	City	Data source
1	Banat	Mesolithic 8000 – 6500 BC	Lepenski Vir - Schela Cladovei	Ostrovul Banului	Mehedinți	Gura Văii	Boroneanţ, 2011
2	Banat	Mesolithic 8000 – 6500 BC	Lepenski Vir - Schela Cladovei	Ogradena	Mehedinți	Eşelnița	Bolomey, 1973
3	Banat	Mesolithic 8000 – 6500 BC	Lepenski Vir - Schela Cladovei	Ostrovul Corbului	Mehedinți	Ostrovu Corbului	Boroneanţ, 2011
4	Banat	Neolithic 6600 – 3000 BC (including Chalcolithic)	Vinča 5500 – 4500 BC	Uivar,	Timiș	Uivar	El Susi, 2017
5	Muntenia	Neolithic 6600 – 3000 BC (including Chalcolithic)	Boian 5200 – 4600 BC	Tangâru	Teleorman	Stoeneşti	Bălăşescu and Radu, 2001
6	Muntenia	Neolithic 6600 – 3000 BC (including Chalcolithic)	Boian 5200 – 4600 BC	Măgura	Teleorman	Măgura	Bălăşescu and Radu, 2001
7	Muntenia	Neolithic 6600 – 3000 BC (including Chalcolithic)	Boian 5200 – 4600 BC	Lăceni	Teleorman	Magura	Balasescu et al., 2005
8	Dobrogea	Neolithic 6600 – 3000 BC (including Chalcolithic)	Boian 5300 – 4600 BC	Isaccea	Tulcea	Isaccea	Balasescu et al., 2005
9	Dobrogea	Neolithic 6600 – 3000 BC (including Chalcolithic)	Hamangia 5200 – 4800 BC	Cernavodă	Constanța	Cernavodă	Voinea, 2009
10	Dobrogea	Neolithic 6600 – 3000 BC (including Chalcolithic)	Gumelnița 4600 – 3500 BC	Luncavița	Tulcea	Luncavița	Bălășescu, 2003
11	Muntenia	Neolithic 6600 – 3000 BC (including Chalcolithic)	Gumelnița 4600 – 3500 BC	Chitila Farm	Ilfov	Chitila	Balasescu et al., 2003
12	Muntenia	Neolithic 6600 – 3000 BC (including Chalcolithic)	Cernavodă 4200 – 3700 BC	Radovanu – Gorgana	Călărași	Radovanu	El Susi, 2016

13	Moldova	Neolithic 6600 – 3000 BC (including Chalcolithic)	Foltesti 3700 – 3500 BC	Foltești	Galați	Foltești	Haimovici, 2009
14	Dobrogea	Antiquity	IV-VII centuries	Murighiol	Tulcea	Murighiol	El Susi, 2008
15	Dobrogea	Middle Ages	XI – XIII centuries	Isaccea	Tulcea	Isaccea	Bejenaru, 2003
16	Dobrogea	Middle Ages	X–XI centuries	Garvan - Dinogetia	Tulcea	Garvăn	Haimovici, 1989

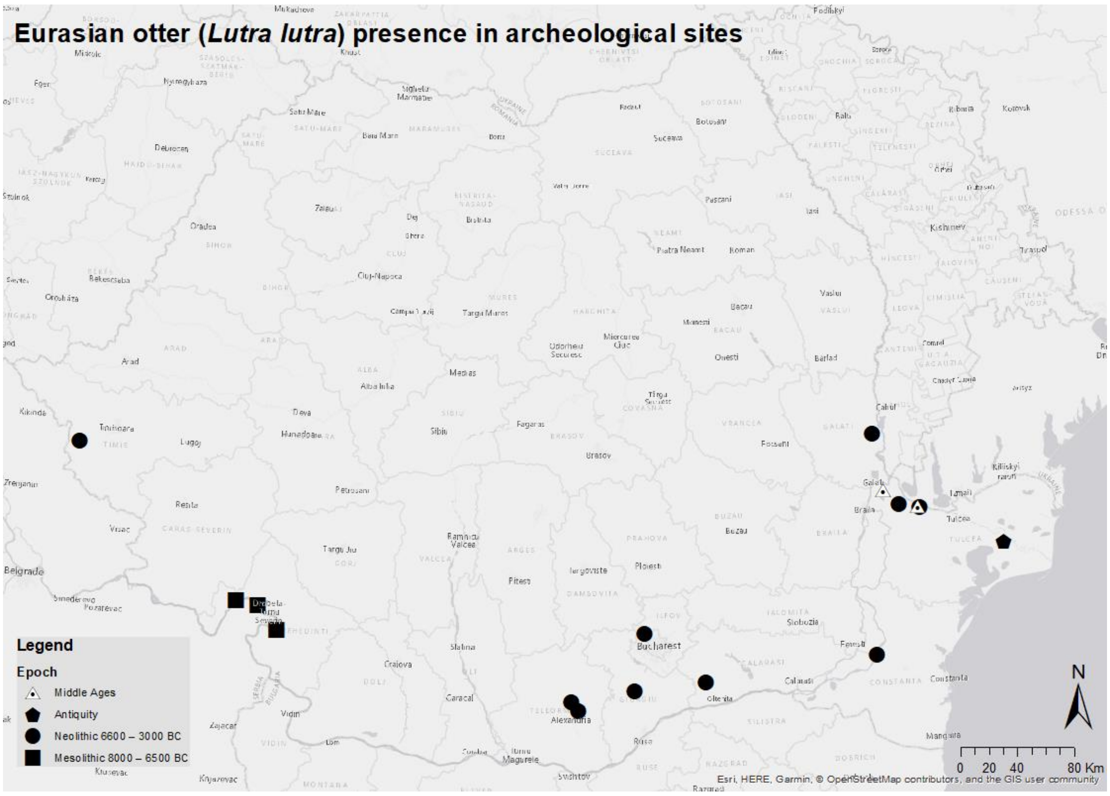

Figure 1. Map of the Eurasian otter (*Lutra lutra*) presence at archeological sites from Romania

DISCUSSION

Among the oldest remains of the Eurasian otter (*Lutra lutra*), discovered so far in the present-day territory of Romania, are those found in the Danube Gorge, in the Iron Gates area of Mehedinți County, in Eșelnița village; it is at an archaeological site (Ogradena - Icoana), which represents one of the oldest human settlements in Europe (about 9,000 years ago), belonging to the Lepenski Vir - Schela Cladovei culture, which developed at the beginning of the Holocene (Bolomey, 1973; Boroneanţ, 2011). The representatives of this culture, which was named after the localities of Schela Cladovei and Lepenski Vir, inhabited the area called today the Iron Gates on both banks of the Danube, both inside and outside the Danube Gorge.

Remains of Eurasian otters dated to the Mesolithic period (8,000-6,500 BC) were also found at other archaeological sites, belonging to the same culture (Lepenski Vir - Schela Cladovei) in the area of the Danube Gorge, Ostrovul Banului and Ostrovul Corbului, near the current localities of Gura Văii and Ostrovu Corbului (Boroneanţ, 2011). The archaeological remains of this culture prove the importance of the aquatic environment for this Mesolithic culture. They practiced intensive fishing, due to the richness of the waters in fish species, and were harvesting mussels and snails. Thus, the otter might be hunted both as competition for fish resources and also for increasing the surplus of meat in their diet. Hunting was also an important practice of this population; however, as one would expect, it was not the otter that was of greatest interest, but large species that can be captured relatively easily such as aurochs (*Bos primigenius*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*). To supplement the diet of these populations, gathering fruits, seeds and roots was another strategy (Rusu, 2014). The Mesolithic people from the Lepenski Vir - Schela Cladovei culture developed hunting weapons made from stone, wood, ropes, antlers, bones and wild boar tusk, and various tools were identified in the archeological sites in the Danube Gorge area (Rusu, 2014).

The exploitation of otters continued and intensified in the Neolithic epoch (6,600-3,000 BC), with the emergence of new cultures and settlements in what is now Romania.

The Neolithic Vinča culture (5,500-4,500 BC) were hunting otters: otter bone remains and a whole otter humerus were discovered at Uivar village, in Timiș county, south-west of Romania. The presence of the otter at this site is linked to the rich hydrographic network of the Bega River from the Banat Plain. In prehistory, the site was apparently surrounded on the eastern, northern and western sides by an ancient tributary of the River Bega, in an area with large swamps (El Susi, 2017).

Amongst the Neolithic cultures that were present in Romania, a particular culture called Hamangia (5,200-4,800 BC) is characterized by the practice of animal offerings. Bone remains of Eurasian otter were found in an ancient cemetery near Cernavodă town, in south-eastern Romania, located on the right bank of the Danube (Bălăşescu and Radu 2004). The Hamangia culture is present only in the south-eastern European area in the Dobruja region (Romania and Bulgaria); the practice of animal offerings is present both in settlements and, especially, in cemeteries. The animal offerings made by Hamangia culture indicate totemic ancestral beliefs, the fauna individuals killed as offerings representing only species present in the normal diet of Hamangia culture communities.

The practice of depositing cranial fragments (skulls / dentition) of wild fauna was found not only in Cernavodă necropolis, but also in other Hamnagia culture sites. The authors of the findings state “the practice of depositing with the dead human a rich supply of animal meat, snails and shells. Symbolically, in almost every grave a wild boar tusk and sometimes fragments or entire jaws or skulls of wild carnivores was deposed” (Berciu et al., 1959).

The large number of animal remains found in Cernavodă archeological site, means that Hamangia culture sites provide the richest assemblage of Neolithic European fauna (Voinea, 2009).

Despite *Lutra lutra* remains being at a low percentage in faunal samples discovered, and having little chance of the bone fragments being collected during archaeological excavations, and after that being recognized as belonging to *Lutra lutra*, Eurasian otter remains were identified in four Neolithic settlements belonging to the Boian culture (5,200- 4,600 CAL BC), in Isaccea, Lăceni, Măgura and Tangâru (Bălăşescu and Radu, 2001).

In the Neolithic period, humans begun to keep domestic animals, and thus hunting lost some of its importance, becoming a supplementary source of meat, which is probably the reason why wildlife remains are rare in Neolithic archaeological sites.

However, prehistoric communitieswhich belonged to the Boian culture hunted reptiles, birds and mammals, fished and continued to gather fruits, seeds and building materials. Boian culture settlements were located close to the riverbanks, in habitats that were used by Eurasian otter: the Isaccea settlement is located on the right bank of the Danube, Tangâru on Câlniștea river, and Lăceni and Măgura were located on Teleorman river.

Hunting was a more important activity for settlements located in the valleys of the larger rivers such as Teleorman and the Danube, where the fauna was much richer and more varied. However, the Neolithic cultures appear to have had a reduced anthropic pressure on the environment, if we consider the rich fauna that was identified in most settlements of the Boian culture.

The Neolithic population exploited all the environmental resources surrounding their settlement, starting with gathering fruits, seeds, and mollusks, fishing, raising animals and continuing with hunting. All this information is revealed to us by the discoveries made at the archaeological sites belonging to another Neolithic culture, the Gumelnița culture (4,600-3,500 BC), that occupied the southeastern part of today's Romania, the eastern half of Bulgaria and northern Greece.

Among remains of wildlife at two sites belonging to the Gumelnița culture, archeologists have been identified a small number of otter remains, at Chitila and Luncavița (Bălășescu, 2003; Bălășescu et al. 2003). It is worth noting that in the vicinity of these settlements there were also fish-rich water sources: in Chitila, the Colentina river and in Luncavița, the Danube river. Given that there are not many otter bones remains in these sites, they may represent by-catches or may have been intentionally hunted due to competition for fish resources, which were very important to these prehistoric communities.

A new culture then replaced the previous ones: the Cernavodă culture (4,200-3,700 BC). This seems to represent nomadic migration from the north Pontic steppes to southeastern Romania: Dobrogea and eastern Muntenia and northeastern Bulgaria (Mallory et al., 1997).

From a house belonging to this culture, an otter femur belonging to an adult specimen was found (El Susi, 2016). The Neolithic settlement of the Cernavodă culture was discovered in the present Radovanu village, in the south-east of Romania, located on the right bank of the Argeș river. Based on bone distribution, the settlement was characteristic of an animal economy focused more on the exploitation of domestic mammals and less on hunting. The bones of domestic species prevail in proportion of 92% compared to those of the game species (8%) (El Susi, 2016), which reflects species caught not necessarily for food, but probably for fur.

This culture was followed by an Eastern European culture: Foltești (3,700-3,500 BC). At a site in Foltești village, located on the right bank of the Prut river, numerous animal remains were identified, including bone remains of two otters (Haimovici, 2009). It seems that this Neolithic culture, at the period of transition from the Neolithic to the Bronze Age, knew *Lutra lutra* and hunted it occasionally for fur or/and meat.

The otter was also known as a game species during the Roman period in the province of Dacia, and was hunted especially for fur, but the possibility of consumption of meat cannot be excluded (Bunoiu, 2010). At the fortress of Halmyris, dating from the late Roman era (Sec. IV - VII), numerous faunal remains have been discovered, including those from at least 3 different otters (El Susi, 2008). The ancient harbour of Halmyris is located near Murighilol village in south-eastern Romania, on the right side of the Danube branch. The inhabitants of the Halmyris fortress hunted a lot of big and medium sized-mammals such as wild boar, red deer, roe deer, and aurochs, either to supplement the meat of domestic animals, or to procure raw materials as furs, bones or antlers. Small aquatic and terrestrial animals as marten, otter, fox and beaver were also hunted, for fur. Some of the animals identified in this site may have been hunted for amusement or practice by the soldiers. According to El Susi (2008) ten bones of Eurasian otter - two humerii, three radii, two ulnae, one tibia, one pelvis and a fragment from skull - were found. The Eurasian otter is abundant in the Danube Delta nowadays and most likely it was the same during the Roman period.

In the medieval period we find the use of otter for both fur and meat, especially in the Christian period. During the Middle Ages, there were numerous discussions and disputes over the nature of certain animals based on the morphology of their bodies (Delaunay, 1997). Those which were partially covered with "scales" were by some considered to be completely fish, while others considered only the "scaly" part was fish. In this way, several disputes arose over whether the beaver was to be considered a fish only in its posterior part or for the entire body, since it has scales only on its tail. Some leaders of the church considered beavers and otters as fish and some naturalists as Guillaume Rondelet and Pierre Belon agreed with this opinion in their classification. In any case, the uncertainty regarding the nature of these animals allowed many religious communities to decide whether or not to eat these animals on fast days, such as Lent (de Grossi Mazzorin and Minniti, 1999). The otter was therefore considered together with the beaver as part of the class of *Aquatilia* and their consumption was allowed on days of abstinence from meat for certain Christian religious communities.

The first evidence of otter consumption by the Christians from the present territory of Romania comes from the archaeological site of Garvăn – Dinogetia, a Roman-Byzantine settlement (9th-12th centuries). Bone remains and a skull fragment discovered in the Medieval settlement were identified as belonging to Eurasian otter (Haimovici, 1989).

In another nearby medieval settlement, animal remnants identified as Eurasian otters (based on archaeozoological analysis) were found at the medieval settlement of Isaccea – Noviodunum, active during the XI-XII centuries. The material comes mainly from animals used as food, as shown by the numerous traces of butchery identified on the bone remains (Bejenaru, 2003).

CONCLUSIONS

This paper focuses on the past exploitation of the Eurasian otter in Romania, and reveals that hunting otters was a popular practice from the Mesolithic to the Middle Ages. The reasons for otter hunting were different from culture to culture: fur, meat, practice, competition for fish resources or religious reasons.

We have shown that the otter was not only hunted for fur, as it is today, but also for ceremonial reasons, religious reasons and for meat. In addition, we showed that various cultures that lived in the present territory of Romania knew the Eurasian otter and its ecology. The people of the past Holocene had much more in-depth knowledge about the fauna and the natural environment that surrounds them than people today; in the period to which we refer, people were not only hunter-gatherers, but also farmers with more or less temporary settlements, and hunting was not the primary activity.

Finally, it should be emphasized that it is difficult to coordinate disparate data, which come from different sources and which are approached in different ways. In these conditions we have only tried to present a stage of research, without being able to generalize further.

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RÉSUMÉ

Exploitation De La Loutre Eurasienne (*Lutra lutra*) Basée Sur Des Découvertes Archéozoologiques Durant L'holocène En Roumanie

Le présent article vise à présenter des données archéozoologiques et historiques sur la distribution de la loutre eurasienne (*Lutra lutra*) et son exploitation en Roumanie du Mésolithique au Moyen Âge. On sait peu de choses sur l'histoire ancienne de la loutre eurasienne, tandis que la plupart des efforts sont consacrés à l'étude des populations actuelles. Afin de pouvoir donner des informations sur l'exploitation passée de la loutre en Roumanie, des synthèses bibliographiques ont été utilisées comme outil destiné à fournir des réponses et plus de 200 titres de publication sur des échantillons faunistiques trouvés sur le territoire actuel de la Roumanie ont été consultés. Cette étude est basée sur les données archéozoologiques de 16 sites archéologiques allant du Mésolithique jusqu'au Moyen Âge, où des restes de loutres eurasiennes ont été identifiés dans d'anciennes habitations et cimetières. La loutre n'était pas chassée uniquement pour sa fourrure, comme on le sait déjà, mais également pour des raisons cérémoniales et religieuses et pour sa viande. En outre, les données suggèrent que diverses cultures qui étaient présentes sur le territoire actuel de la Roumanie, connaissaient la loutre eurasienne et son écologie. Il convient de souligner qu'il fut difficile de regrouper les données dispersées. Dans ces conditions, l'objectif était de présenter un état des connaissances en évitant toute généralisation.

RESUMEN

EXPLOTACIÓN PRETÉRITA (HOLOCENO) DE NUTRIAS EURASIÁTICAS (*Lutra lutra*) EN RUMANIA, EN BASE A DESCUBRIMIENTOS ARQUEOZOOLÓGICOS

Este trabajo presenta datos arqueozoológicos e históricos sobre la distribución de la nutria Eurasiática (*Lutra lutra*) y su explotación en Rumania desde el Mesolítico hasta la Edad Media. Se conoce poco acerca de la historia antigua de la nutria Eurasiática, y la mayor parte de la atención se dirige a las poblaciones actuales. Para poder dar información acerca de la explotación pasada de las nutrias en Rumania, he utilizado revisión bibliográfica como herramienta para proporcionar respuestas, y consulté más de 200 títulos de bibliografía acerca de muestras faunísticas en lo que es hoy el territorio de Rumania. Este estudio se basa en datos arqueozoológicos relativos a 16 sitios arqueológicos que datan desde el Mesolítico hasta la Edad Media, en los que se identificaron restos de nutria Eurasiática en asentamientos y cementerios antiguos. La nutria era cazada no solamente por su piel -como ya sabíamos-, sino también por razones ceremoniales y religiosas, y por su carne. Además, los datos sugieren que varias culturas que vivieron en el actual territorio de Rumania conocían a la nutria eurasiática y su ecología. Debe destacarse que fue difícil coordinar datos tan diversos y dispersos. Bajo estas condiciones, el objetivo fue presentar un estado del conocimiento, evitando la generalización.

SHORT COMMUNICATION

A RARE PHOTOGRAPHIC RECORD OF A GROUP OF SMOOTH-COATED OTTERS *Lutrogale perspicillata maxwelli* IN HAWR OL-AZIM WETLAND IN SOUTHWESTERN IRAN WITH NOTES ON THEIR SOCIAL AND FORAGING BEHAVIOR

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Abstract: The Smooth-coated otter (*Lutrogale perspicillata maxwelli*) is endemic to the Mesopotamian wetlands of southeastern Iraq and it has been recently recorded in southwestern Iran. In April 2019, a rare photographic record of a large group of Smooth-coated otter gathering at one location in Hawr ol-Azim Wetland in southwestern Iran was obtained for the first time. In addition, the social and foraging behavior of the Smooth-coated otter group was carefully observed.

Citation: Al-Sheikhly, O.F., Gutleb , B. and Mousavi , S.B. (2021). A Rare Photographic Record of a Group of Smooth-Coated Otters *Lutrogale perspicillata* maxwelli in Hawr Ol-Azim Wetland in Southwestern Iran with Notes on their Social and Foraging Behavior. *IUCN Otter Spec. Group Bull.* **38** (3): 129 -132

Keywords: distribution range; endemic; mammals of Iran; Maxwell’s otter; rare species

The Smooth-coated otter (*Lutrogale perspicillata*: the subspecies *L. p. maxwelli* is endemic to the Mesopotamian marshes of southern Iraq and southwestern Iran (Al-Sheikhly et al., 2020). It was first described from Abusakhair village of Faraijat tribe along the Tigris River in southeast of Amara, and from Daub village (terr. typ.) in northwest of Al-Azair in southeastern Iraq in 1956 (Hayman, 1956). It was believed that the Iraqi population had faded due to disturbance and habitat destruction by the Iran-Iraq conflict in the 1980s and the subsequent drainage of the Mesopotamian marshes in the 1990s (Scott and Evans, 1993; Bedair et al. 2006). Later surveys confirmed the persistence occurrence of this species in the Iraqi marshes (e.g. Al-Sheikhly and Nader, 2013; Al-Sheikhly et al., 2015, 2017). Due to excessive poaching, trapping and habitat destruction and fragmentation, the species is listed as Vulnerable by the International Union for Conservation of Nature (IUCN) Red List (de Silva et al., 2015).

The Smooth-coated otter is suggested to be possibly found in the rivers of southern Iran (Gutleb et al., 1996). Two skin specimens were obtained from the Hawr “Hoor” ol-Azim Wetland, at the border to Iraq in 1972 and another skin specimen in 1974 (Ziaie and Gutleb, 1997). Moreover, it had been recorded from the marshes adjacent to the Iraq borders (presumably Hawr ol-Azim) in Khuzestan Province but field expeditions conducted in 2007–2008 did not confirm its occurrence in southwestern Iran (Firouz, 2000; Ziaie, 2008; Mirzaei et al., 2010). Hawr ol-Azim Wetland is trans-boundary monotonic marshlands situated in southwestern Iran and extends to southeastern Iraq where is called Hawizeh Marsh and bisected by the Iran-Iraq international borders (Al-Sheikhly and Al-Azawi, 2019). It is situated in the north of Azadegan Plain, ca. 80km to the southwest of Ahvaz city in Khuzestan Province in the southwestern Iran. The occurrence of *L. p. maxwelli* has been recently confirmed for the first time in Iran at Al-Ma'aish and Shatt Ali areas in Hawr ol-Azim Wetland in November 2017 and April 2019, respectively (Al-Sheikhly et al. 2020).

On 10th of April 2019, four Smooth-coated otters have been observed at Shatt Ali area (31°21'24.44"N 47°42'41.06"E) in Hawr ol-Azim Wetland (Al-Sheikhly et al. 2020). However, the significance and behavioral events of that record have not been discussed. It is worth mentioning that all available records from Iran and Iraq were based on sporadic and brief observations of mainly 1–2 individuals wondering in scattered places within Hawr ol-Azim Wetland and Hawizeh Marsh (e.g. Al-Sheikhly et al. 2015, 2017, 2020). In addition, reports from local fishermen had claimed that large groups of (8-12) otters were occasionally seen; however, such reports in both Hawr ol-Azim Wetland or Hawizeh Marsh had never been verified or properly documented. Therefore, our current observation represents the first photographic documentation of a large group of the Smooth-coated otters from the endemic population in Iran-Iraq foraging at one location has ever made.

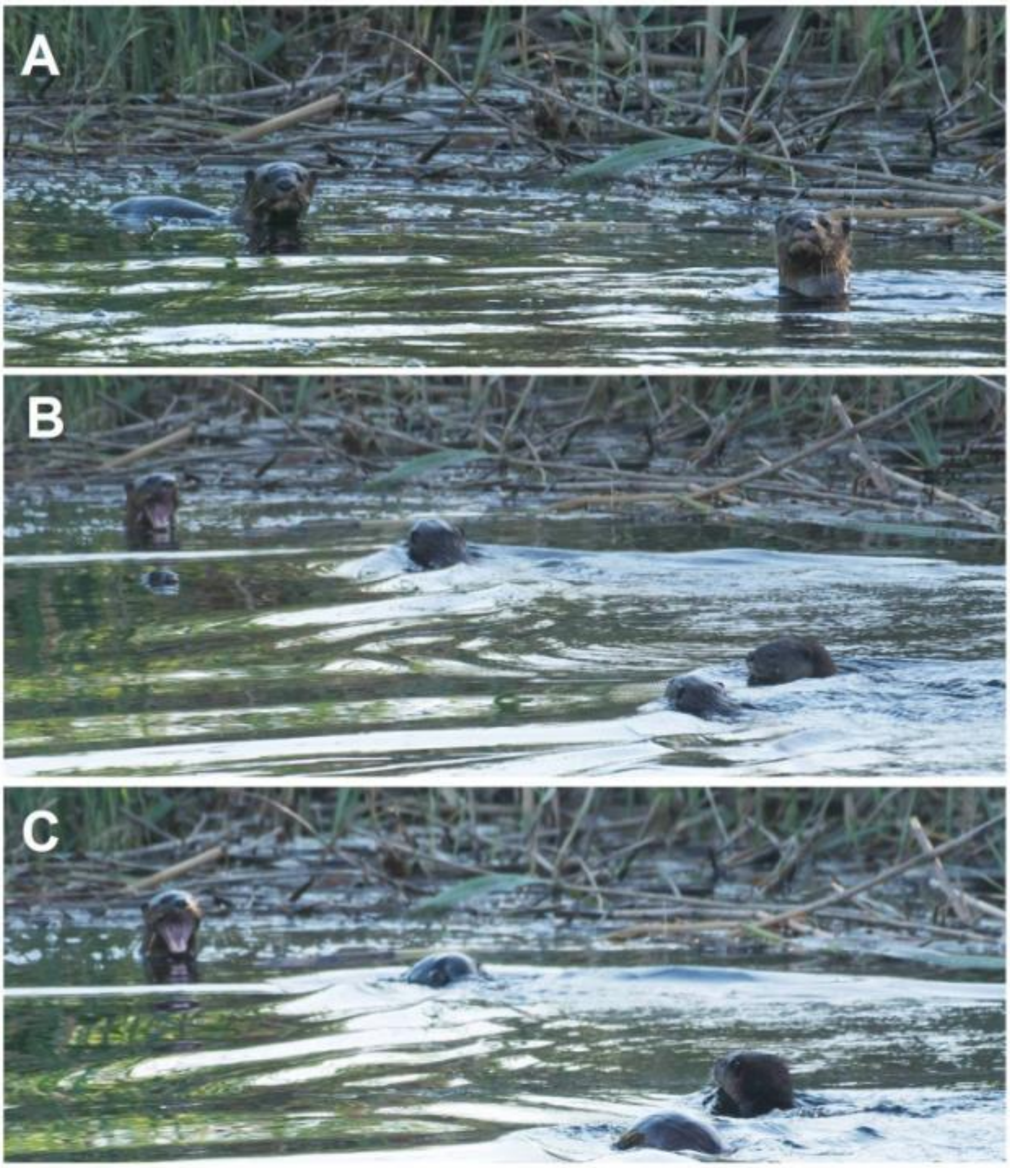

Figure 1. The social and foraging behavior of a family of Smooth-coated otter *Lutrogale perspicillata maxwelli* in Shatt Ali area in Hawr ol-Azim Wetland, southwestern Iran. A: adult otters, B & C: younger otters are swimming behind guarding adult. Photos © Seyed B. Mousavi 2019.

The group was apparently a Smooth-coated otter family consisting of two adults and two younger adults/juveniles which were swimming and foraging in a dense vegetated marsh mainly with Common reed *Phragmites australis* at Shatt Ali Area for 20-30 minutes. Adult otters were recognized by their heavy bodies, large heads, dark-rusty grayish fur inside water, with loud “whistle-like” anxious calls of “*psi-psi-psi*” in repeated rhythm (Fig. 1A). The younger otters (*c.* ≥ 12 months) were smaller in size, had smaller heads, chocolate-brown fur inside water, and led behind the adults (Fig. 1B). The family seemed well controlled and coordinated by the adult otters; both were performing intermittent dives to catching fish alternated with guarding fits to protect the family (Fig. 1C). So far, the foraging behavior of the Smooth-coated otters has not been described. On different occasions in the Hawr ol-Azim Wetland, adult otters were observed catching *Tilapia* sp., an abundant exotic fish species (e.g. Al-Faisal et al. 2014) which may represent the main prey for the Smooth-coated otters in Hawr ol-Azim Wetland and Hawizeh Marsh. However, Smooth-coated otters were observed taking other vertebral preys such as Binni *Mesopotamichthys sharpeyi*, Tigris Asp *Leuciscus vorax*, Tigris Catfish *Silurus triostegus*, Striped-necked Terrapin *Mauremys caspica*, and Little Grebe *Tachybaptus ruficollis* but in rare occasions. Moreover, the Smooth-coated otter family seems to avoid crossing dense reed beds, as they were observed swimming through narrow watercourses.

The current population size of ca. 930 Smooth-coated otters has been recently estimated in the Hawizeh Marsh and trans-boundary populations were suggested to be found in the Hawr ol-Azim Wetland (Al-Sheikhly et al., 2020). The increased over-exploitation and anthropogenic disturbance pressures mainly through poaching and trapping will possibly push away much of the Iraqi Smooth-coated otter populations toward new refuges in the Iranian Hawr ol-Azim Wetland. It is more likely; however, our current rare observation of the Smooth-coated otter family may represent the first documented evidence to support this claim; yet, further field monitoring is required.

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RÉSUMÉ ENREGISTREMENT PHOTOGRAPHIQUE RARE D'UN GROUPE DE LOUTRES À PELAGE LISSE *Lutrogale perspicillata maxwelli* DANS UN MILIEU HUMIDE DE L'HAWR OL-AZIM AU SUD OUEST DE L'IRAN, INCLUANT DES OBSERVATIONS SUR LEUR COMPORTEMENT SOCIAL ET ALIMENTAIRE

La loutre à pelage lisse (*Lutrogale perspicillata maxwelli*) est endémique des zones humides mésopotamiennes du sud-est de l'Irak et a été récemment signalée dans le sud-ouest de l'Iran. En avril 2019, nous avons réalisé pour la première fois un enregistrement photographique rare d'un groupe important de loutres à pelage lisse, se rassemblant en un lieu dans la zone humide de Hawr ol-Azim au sud-ouest de l'Iran. De plus, nous avons pu observer consciencieusement le comportement social et alimentaire du groupe de loutres à pelage lisse.

RESUMEN RARO REGISTRO FOTOGRÁFICO DE UN GRUPO DE NUTRIAS LISAS *Lutrogale perspicillata maxwelli* EN EL HUMEDAL HAWR OL-AZIM, IRÁN SUROCCIDENTAL, CON NOTAS SOBRE SU COMPORTAMIENTO SOCIAL Y DE ALIMENTACIÓN

La nutria lisa (*Lutrogale perspicillata maxwelli*) es endémica de los humedales Mesopotámicos del sudeste de Iraq, y ha sido recientemente registrada en el sudoeste de Irán. En Abril de 2019, se obtuvo por primera vez un raro registro fotográfico de un gran grupo de nutrias lisas que se congregaban en una localidad en el Humedal Hawr ol-Azim, en el sudoeste de Irán. Además, fue cuidadosamente observado el comportamiento social y de alimentación del grupo de nutrias lisas

الخلاصة

تسجيل صوري نادر لمجموعة من القضاعات ناعمة الفراء *Lutrogale perspicillata maxwelli* في مسطح هور العظيم في جنوب غرب أيران مع ملاحظات حول سلوكياتها الأجتماعية والبحث عن الغذاء

تستوطن القضاعة ناعمة الفراء (*Lutrogale perspicillata maxwelli*) الأراضي الرطبة مابين النهرين في جنوب شرق العراق وقد سجلت حديثا في جنوب غرب أيران. في نيسان **2019**, تم الحصول لأول مرة على تسجيل صوري نادر لمجموعة كبيرة من القضاعات ناعمة الفراء متجمعة في مكان واحد في مسطح هور العظيم في جنوب غرب أيران. أضافة الى ذلك, تم مراقبه السلوك الأجتماعي والبحث عن الغذاء لمجموعة القضاعات ناعمة الفراء بعناية.

ARTICLE

RIPARIAN RESERVES SERVE AS A CRITICAL REFUGE FOR ASIAN OTTERS (*Aonyx cinereus* and *Lutrogale perspicillata*) IN OIL PALM DOMINATED LANDSCAPES OF SABAH, MALAYSIAN BORNEO

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Abstract: We determined the occupancy of otter species and assessed several habitat features influencing their occurrence in four different land-use types: continuous logged forests (CF), heavily degraded forest (DF), riparian reserves within oil palm plantation (RR), and oil palm plantations without riparian reserves (OP). Our aim was to ascertain the usefulness of retaining riparian reserve in oil palm dominated landscape for otter conservation. This study was conducted in the Malaysian state of Sabah, northern part of Borneo. We surveyed 36 stream sub-transects across all of the different land-use types and detected otter presence based on their tracks and spraints. Overall, two out of the four otter species found in Sabah were detected within the surveyed areas, i.e., the Asian Small-clawed Otter, *A. cinereus* and Smooth-coated Otter, *L. perspicillata*. Streams in agricultural sites were found to have significantly higher otter occupancy compared to forested areas: RR (*psi* = 0.97), OP (0.83), DF (0.44), and CF (0.37). Using Generalised Linear Modelling (GLM), we identified that otter occupancy in oil palm landscapes was positively influenced by the availability of large trees and other vegetation along the banks. Deeper streams were also more preferred by otters. Interestingly, streams in oil palm plantations located nearer to human settlements recorded higher detection of otter signs. In general, this study suggests that streams in oil palm plantation with riparian vegetation are useful habitat for otter species. Hence, retaining riparian reserves within oil palm plantations is a useful management strategy to improve biodiversity conservation in an agricultural landscape.
Citation: Pianzin, A., Wong, A. and Bernard, H. (2021). Riparian Reserves serve as a Critical Refuge for Asian Otters (*Aonyx cinereus* and *Lutrogale perspicillata*) in Oil Palm Dominated Landscapes of Sabah, Malaysian Borneo. *IUCN Otter Spec. Group Bull*. **38** (3): 133 - 154
Keywords: riparian reserves, oil palm, land-use changes, otter, occupancy, sustainable oil palm plantation.

INTRODUCTION

Land-use changes particularly the conversion of tropical forests into agricultural plantations, i.e. oil palm, have been known to affect riparian habitats and have a strong negative influence on the freshwater ecosystem, due to the destruction of distinct vegetation community and structure of the riparian zones affecting every trophic level (Feld et al., 2011; Thomas et al., 1979). Habitat modifications as a result of agricultural plantation development and logging directly influence the semi-aquatic otters (Order: Carnivora; Family: Mustelidae) since these activities lead to changes in the structure of their habitats on land from spatially complex into a much simpler structure (Danielsen et al., 2009; Foster et al., 2011). In turn, this degrades stream quality and subsequently affects many aquatic organisms and other aquatic resources that the otters depend on for their survival (Bedford, 2009; Struebig et al., 2008).

Previous studies have shown that biodiversity within cultivated lands could be sustained to some extent through the development and management of riparian reserves (Bernard et al., 2014; Giam et al., 2015; Gray et al., 2014; Gray et al., 2015; Luke et al., 2017a; Mitchell et al., 2018; Peel, 2018; Seaman et al., 2019; Şekercioğlu et al., 2015; Wilkinson, 2018). Riparian reserves themselves are not only critical habitats for numerous species of animals, but at the same time they maintain critical ecological functions such as filtering agricultural chemicals and protect against soil erosion (Lamb et al., 2006; Luke et al., 2017b; Sabo et al., 2005; Turner et al., 2008). The threats affecting riparian carnivores in highly modified tropical landscapes are poorly understood (Laws, 2016), and there is limited information on habitat requirements of semi-aquatic vertebrates, such as the otters, especially in oil palm dominated landscapes. Regarded as an important indicator of the wetland environment, otters are sensitive to changes in the quality of their preferred habitats including both the aquatic environment and the associated riparian habitats (Shenoy et al., 2003). In agricultural landscapes across Asia, past studies revealed a relationship exist between otter presence and certain environmental features such as the river bank vegetation, canopy cover, substrate type, prey availability, river depth and width, disturbance intensity, and distance from human settlements (Aadrean and Usio, 2017; Laws, 2016; Pillai, 2015; Prakash et al., 2012; Prakash et al., 2014).

The preservation of native vegetation bordering water bodies has been widely adopted as a useful mitigation strategy in reducing the negative impacts of land-use changes in monoculture agriculture. In fact, it is one of the criteria of certification for sustainable palm oil production under the Roundtable on Sustainable Palm Oil scheme (RSPO, 2013). The legislation of Sabah presently requires riparian buffers with a minimum of 20 m and up to 30 m wide to be retained on all streams with a width of 3 m and 10 m, respectively (EPD, 2011; SWRE, 1998). Its purpose is to preserve water volume and flow, prevent degradation of water quality, and subsequently destruction to the aquatic ecosystem (SWRE, 1998). With proper management and planning of habitats in modified agriculture landscapes, they have a potential be a vital habitat for biodiversity in their own merit (Mendenhall et al., 2012). The establishment of sustainable oil palm plantation might be able to offer protection on otter habitats by ensuring suitable buffer widths along water bodies to be preserved, and by practicing good management for handling of wastes, protection of slopes, and agricultural conversion in degraded lands instead of forests.

In the present study, we aim to ascertain the value of retaining riparian reserves in oil palm plantation for otter conservation. We compare otter occupancy between riparian reserves in continuous logged and heavily degraded forested areas, and in oil palm plantations (with and without riparian reserves) located in Sabah, northern part of Malaysian Borneo. We investigate several environmental variables that may influence the occurrence of otters in both forested areas and agricultural sites. We hypothesized that otter occupancy would be higher in forested habitats compared to in oil palm plantations. Whereas within the oil palm plantations, we expected that otter occupancy would be higher in the oil palm with riparian reserves compared to oil palm without the riparian reserves.

METHODOLOGY

Study Area

Specifically, the present study was conducted in and around the 'Stability of Altered Forest Ecosystems' (SAFE) Project (117.50°N, 4.6°E) area in Sabah, Malaysian Borneo (Figure 1). The study area is approximately 80,000 ha comprising twice-logged lowland dipterocarp rainforest, acacia plantations, and oil palm plantations, the latter was established between 1999 and 2014 (Gray et al., 2015; Mitchell et al., 2018; Wilkinson *et al*., 2020). The area has a high annual rainfall of 2,925 mm, 2017–2018 (Malaysian Meteorological Department, 2019). There is little climate seasonality in the study area where drought only occurred during major El Niño Southern Oscillation years (Luke et al., 2017b).

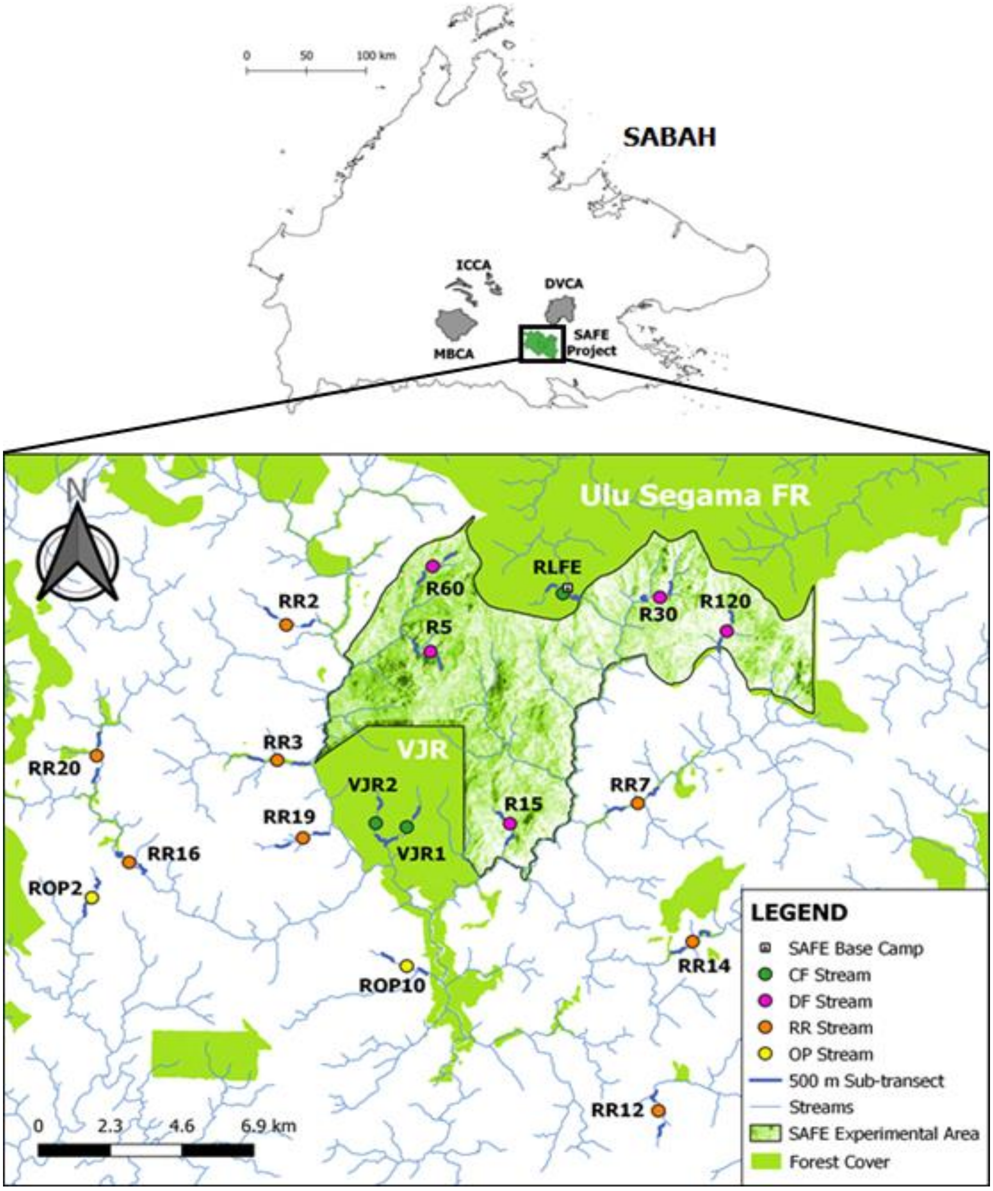

Figure 1. An oil palm dominated landscape in SAFE Project, Kalabakan, Sabah, Malaysian Borneo where 36 stream segments were surveyed for otter tracks and spraints on four occasions. Forest cover in the experimental area was based on Hansen et al. (2013) which was updated to 2018 to precisely represent the landscape change. Plantations (mostly oil palm) and clearings are shown in white.

The SAFE Project is a large-scale, long-term ecological experiment to explore the effect of forest degradation and fragmentation and oil palm plantation development on the biodiversity and ecosystem functions (Ewers et al., 2011). The SAFE Project experimental area was part of an area that has been gazetted for the conversion to agricultural plantation, mainly oil palm, by the Sabah state government since more than 20 years. At the time of the present study, the vegetation in the study area comprised mainly of heavily degraded forests which have been selectively logged multiple times (Ewers et al., 2011). Despite the high level of habitat degradation, the richness of animal community in this area was very high (Bernard et al., 2016; Wearn et al., 2017). Two of the common otter species of Sabah (*A. cinereus* and *L. perspicillata*) have been reported to occur in streams of the study area (Laws, 2016).

We selected streams in this study to represent the norm of the main habitat changes found within this region of Sabah and consisted four general categories of land-use types: continuous logged forest (CF), heavily degraded forests within heavily logged area planned for oil palm conversion (DF), forested riparian reserves in oil palm plantation (RR), and oil palm without riparian reserves (OP) (Fig 2).

Continuous Logged Forests (CF)

This land-use type was represented by three streams located immediately outside the SAFE experimental area. Two streams (VJR1 and VJR2) were located in old-growth forest sites within the Brantian-Tantulit Virgin Jungle Reserve (VJR) and one stream (RLFE) in the continuous forest adjoining the Ulu Segama Forest Reserve. The 2,200 ha VJR area underwent minimal illegal logging around the edges for road construction in the 1970s and 1990s but not to the extent of commercial selective logging (Ewers et al., 2011; Luke et al., 2017b; Struebig et al., 2013). Most of the old-growth forest characteristics in this site remain undisturbed (Struebig et al., 2013). RLFE stream is located within a twice-logged forest where it was selectively harvested in the 1970s and late 1990s to early 2000s, although 71% of its forest cover remains intact (Struebig et al., 2013).

Heavily Degraded Forests (DF)

The heavily degraded forests were represented by five streams (R5, R15, R30, R60, and R120). The experimental area where all heavily degraded forest streams were located consisted of 7,200 ha of lowland dipterocarp rainforest. It is situated neighbouring the VJR and to a large forested area (greater than 1 million ha) encompassing three large conservation areas: Danum Valley (DVCA), Maliau Basin (MBCA), and Imbak Canyon (ICCA), where all three have never been logged (Ewers et al., 2011). This area has undergone multiple rounds of selective logging in the 1970s, followed by multiple further rounds from the late 1990s to 2000s. All commercially valuable trees were removed between 2013 and 2016 (Seaman et al., 2019). The forest remnants within the experimental area only hold a small number of mature trees; however, some areas are less disrupted and are protected by law (Struebig et al., 2013). The area is extremely heterogeneous with forest patches of closed-canopy intermixed with regrowth, gaps, and roads (Luke et al., 2017b).

Riparian Reserves within Oil Palm Plantation (RR)

The riparian reserves in oil palm plantations were represented by eight streams (RR2, RR3, RR7, RR12, RR14, RR16, RR19, and RR20) that were retained within mature oil palm plantations planted between 1999 and 2014 (Mitchell et al., 2018; Wilkinson *et al*., 2020). The width of the riparian reserves along each of the eight streams was approximately 50 m on average with a range between 10 to 470 m (Mitchell et al., 2018).

Oil Palm Plantation without Riparian Reserves (OP)

The oil palm plantations without riparian reserves (ROP2 and ROP10) were represented by two streams. The oil palm estates in this study site were planted in 2009 and were located immediately outside the experimental area but adjacent to the streams selected in the oil palm with riparian reserves explained above.

Figure 2. Images of sampling transect showing streams by land-use types: A. continuous logged forests (CF), B. heavily degraded forest (DF), C. oil palm plantation with riparian reserves (RR), D. oil palm plantation without riparian reserves (OP)

Otter Survey Methods

We surveyed otter species in a total of 18 riparian sites, each of which were divided into 2 independent sub-transects. Therefore, the overall number of sub-transects surveyed for otter was 36 sub-transects. Each riparian site consisted of two km line transect divided into two 500 m sub-transects separated by a one km gap. This was to minimise the possibility of counting the same individual in multiple segments of the same riparian sampling site (Laws, 2016). Each sub-transects were further divided into 100 m segments to facilitate systematic data recording in the field. Site visitations for otter survey were done at random with an interval between two days to three months apart between sites visitations. The sampling sessions were completed for the first 14 streams (VJR1, RLFE, R15, R30, RR2, RR3, RR7, RR12, RR14, RR16, RR19, RR20, ROP2, and ROP10) in July-August 2017, September-October 2017, November 2017, and March 2018. The remaining four streams (VJR2, R5, R60, and R120) were sampled in May-June 2018.

During the surveys, we conducted searches for otter signs on foot on both sides of the stream banks (up to 13 m from stream edge), as well as on the rocks and boulders in the streams. A minimum of two observers was involved in the survey, i.e., one at each stream bank. The survey was conducted in the mornings to afternoons (8.30 - 14:00 hrs.) and concluded between late mornings to late afternoons (10:00 - 16:30 hrs.), depending on weather condition and proximity of the SAFE Project base camp to streams. Detected otter signs were recorded throughout the 500 m sub-transects. Indirect signs were comprised of spraints, tracks, and grooming areas. Direct observations of otters were recorded when they were encountered. Otter species identity from indirect signs were categorised as belonging to either species based on specific features.

Smaller tracks with partial webbing and without prominent claws was classified as *A. cinereus*, whereas larger tracks with full webbing and prominent claws was classified a *L. perspicillata* (Francis, 2008; Hussain, 2016; Wai, 2018). Likewise, spraints were categorised as belonging to either one of the species based on undigested prey content, appearance, and habitat. Spraints with higher content of crustaceans were classified as *A. cinereus* and spraints with higher fish content was classified as *L. perspicillata* (Foster-Turley, 1992; Hussain, 2016; Wai, 2018). Uncertain spraints were identified with the aid of an experienced otter researcher. During every survey, the occurrence of otters based on indirect and direct signs was documented as ‘1’ to indicate otter presence and ‘0’ for absence. The location coordinates of the otter signs were recorded using a handheld GPS.

Habitat characterisation

To predict the potential habitat features influencing otter occurrence, we measured a total of 13 environmental variables (Table 1) on the stream and stream bank at regular intervals along each 100 m segment within the 500 m sub-transects at all riparian sites. Vegetation plots of 5 x 5 m were established at each bank to determine bankside vegetation condition both at canopy and ground level. In addition, 3 disturbance variables were also recorded at each 500 m sub-transect to observe their influence on otter occurrence.

Data Analysis

The habitat variables measured were grouped by land-use types. Bank substrates were converted into proportion in sub-transects as soil/sand, rocks, or a combination of both. Data containing proportion and percentages were transformed using the ‘arcsine’ transformation for data normalization and to stabilize the variance. Average of averages of habitat variables were used to approximate habitat characteristics as mean ± SE for each land-use type. All analyses were performed using RStudio version 1.1.463 (R Core Team, 2019). The occupancy of otters dependent on land-use types was modelled with the package ‘unmarked’ (Fiske and Chandler, 2011) for each land use types, by individual otter species and combined. The smallest independent sampling unit was the 500 m sub-transects, of which only signs detected within them were included in the analyses. Site occupancy and detection probability of an individual were calculated based on Mackenzie et al. (2006), which accounts for the likelihood of an individual inhabiting the area and being detected during a survey. Detection histories of otters in each land-use types were based on whether otters or their signs were detected in each temporal replicate. Single-season, single-species occupancy modelling was used, and analysis was run when occupancy (*psi*) and detection probability (*p*) were held at constant. Further analysis was conducted to investigate the effect of land-use types on *psi* when *p* was held constant using the "aictab" function ("AICcmodavg" package, Mazerolle, 2020), and the best model, i.e., with delta AICc ≤ 2 was selected as the most parsimonious model explaining otter occupancy in the study site.

Table 1. Habitat and disturbance variables with method of measurement during survey.

Habitat Variables	Method of measurement
Stream Edge	Distance (m) of water edge to edge of bank vegetation measured by metric tape. Mean was calculated.
Stream Width	Distance (m) measured between two points where water is in contact with each stream bank by metric tape stretched across the stream. Mean was calculated.
Stream Depth	Depth (m) measured at the middle and both banks with metric tape. Mean was calculated.
Altitude	Distance above sea level (m) measured with a handheld GPS. Mean was calculated.
Stream Canopy Cover	Photograph of canopy was captured directly above water and percentage of the canopy cover was calculated using the program ImageJ version 1.50i (Rasband, 2018). Mean was calculated.
Bank Canopy Cover	Photograph of canopy was captured at the center of the vegetation plots at both stream banks and percentage of the canopy cover was calculated using ImageJ. Mean was calculated.
Bank Undergrowth Cover	Visual estimation by percentage within the 5 x 5 m vegetation plot at each bank. Mean was calculated.
Bank Substrate	Visual observation by substrate categories (1 = rock, 2 = soil, 3 = combination of both). Converted into proportions according to the 100 m segments within the 500 m sub-transect.
Number of Trees	Visual counting of all standing trees within the 5 x 5 vegetation plot at each bank. Mean was calculated.
Number of Logs	Visual counting of fallen trunks (only logs > 10 cm) on stream banks or across the stream (within 10 m from the 100^{th} m segment mark). Mean was calculated.
Forest Quality	Visual observation using standardized scale of SAFE Project (0 = oil palm, 1 = very poor, 2 = poor, 3 = okay, 4 = good, 5 = very good) (Ewers et al., 2011).
Bank Tree Height	Visual estimation of tree height (m) of all trees > 10 cm in GBH within the 5 x 5 m vegetation plot at each bank. Mean was calculated.
Bank Tree GBH	Measured with metric tape of trees > 10 cm in circumference within the 5 x 5 vegetation plot at each bank. Mean was calculated.
Distance to human settlements	Nearest distance (km) estimated using the "distance" function on Google Maps (2019).
Distance to oil palm plantations	Nearest distance (km) estimated using the "distance" function on Google Maps (2019).
Disturbance History	Last major disturbance incident in years in regards to the period when survey was last conducted (last logging endeavours for continuous logged and heavily degraded forests, and time since the establishment of oil palm plantations).

Stream and bank variables that were highly correlated with one or more variables (correlation coef. r > 0.50) were eliminated based on Pearson's Correlation Coefficient. The retained habitat variables were used as site covariates in the Generalised Linear Models (GLMs) to model otter occurrence, by taking the presence and absence of spraints and tracks as the response variable with binomial distribution family and logit link function. All predictor variables were standardised by using the "scale" function ("base" package, R Development Core Team, 2019). Next, the "dredge" function under the "MuMIn" package (Barton, 2016) was used on the global model to select the best set of candidate models and evaluated the relative importance of variables based on delta (Δ) AICc (Burnham and Anderson, 2002). The second-order Akaike information criterion (AICc) was used due to the small sample size of this study. The "dredge" function was performed to generate all possible combination of models by taking into account the set of predictor variables in the global model. The 95% confidence interval with averaged coefficients and the relative importance for each predictor variables from the selected set of candidate models with ΔAICc ≤ 2 was calculated by using the "model.avg" function ("MuMIn" package, Barton, 2020). Models were compared by ΔAIC_C and Akaike weight (w_i) to assess model fit, where the model selection was prioritised for each species and combined with a minimum of ΔAICc ≤ 2, and model with $w_i \leq 0.05$ were dismissed (Burnham and Anderson 2002).

RESULTS

Visual signs survey through the presence of spraints and tracks confirmed the presence of two otter species, *A. cinereus* and *L. perspicillata*, in 13 out of the 18 streams surveyed (Figure 3). A total of 87 otter signs were detected in 36 sub-transects during the study, where 34 signs belonged to *L. perspicillata* (39.0%) and 53 signs to *A. cinereus* (60.9%). Otter signs were mainly found within RR streams (49 signs; 56.32%), followed by DF (23; 26.44%), OP (8; 9.19%), and CF (7; 8.05%). The average of signs detection in the 500 m sub-transects per land-use types were 3.06, 2.03, 2.00, and 1.17, respectively. Out of the otter signs detected, 52 (59.77%) were footprints and 35 (40.23%) were spraints. Overall, the total accumulated sampling effort was over 72 days of survey occasions was 205 hours and the cumulative distance travelled in all survey transects combined across 18 streams was 144 km.

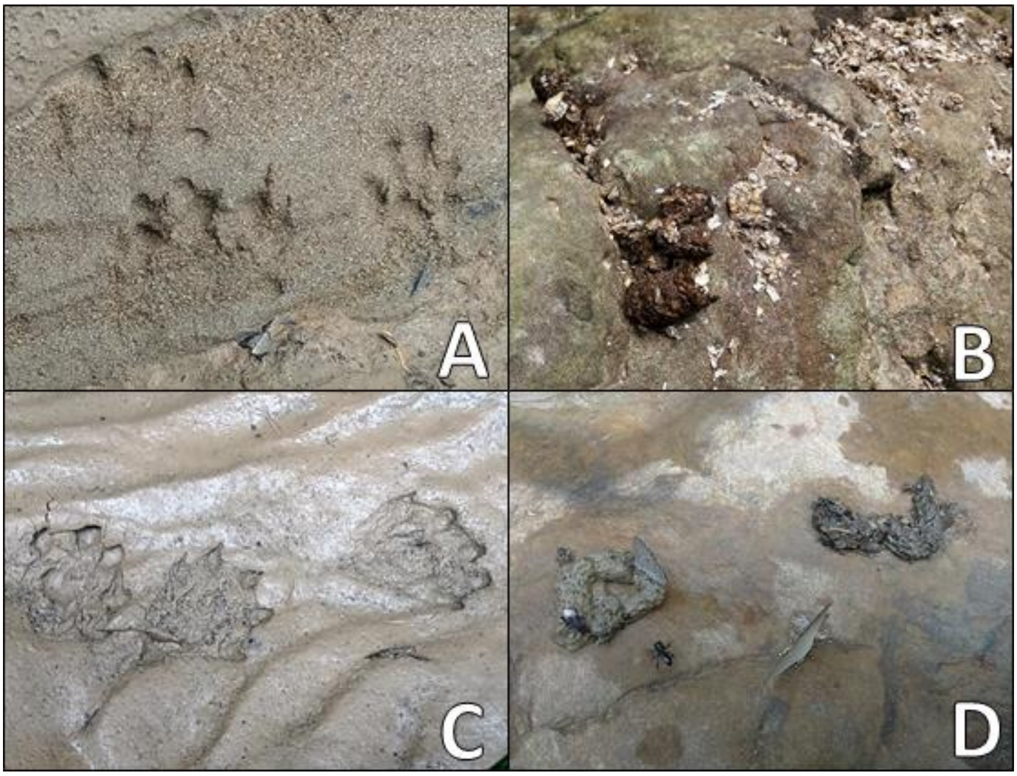

Figure 3. Signs of the two otter species occurring at SAFE Project: A. tracks of *A. cinereus*; B. latrine site of *A. cinereus* containing fresh and old spraints; C. tracks of *L. perspicillata*, D. fresh spraints of *L. perspicillata*

Otter Occupancy

Overall, otter signs were detected in 23 of the 36 sub-transects surveyed within four land-use types resulting in a naïve occupancy of 0.64. When modelled occupancy (*psi*) and detection probability (*p*) were constant across land-use types, otter occupancy at the landscape level was 0.71 ± 0.10 (SE), with an estimated overall *p* of 0.44 ± 0.06. Signs of *A. cinereus* were detected in 17 of the 36 sub-transects surveyed, which resulted in a naïve occupancy of 0.47. The *psi* of this species was 0.59 ± 0.12, and *p* was 0.33 ± 0.07. While the signs of *L. perspicillata* were detected in 13 of the 36 sub-transects surveyed, resulted in a naïve occupancy of 0.36. The *psi* of this species was 0.49 ± 0.14, and *p* was 0.28 ± 0.08. Because the main objective of this study was to investigate the effect of land-use on otter presence, occupancy was assessed by species and combined, and separately for each land-use types – continuous logged forest (CF), heavily degraded forest (DF), oil palm plantation with riparian reserves (RR), and without riparian reserves (OP).

By taking into account the type of land-use changes across the landscape, *A. cinereus* was detected the highest in RR, followed by CF, DF, and OP. Signs were detected in 11 out of the 18 sub-transects (naïve occupancy = 0.69) in RR, 2 out of the 6 (0.33) sub-transects in CF, 3 out of the 10 (0.30) sub-transects in DF, and 1 out of the 4 (0.25) sub-transects in OP. When corrected for detection probability, *psi* in the four land-use types were marginally higher compared to naïve estimates at 0.86 ± 0.17, 0.42 ± 0.24, 0.38 ± 0.19, and 0.31 ± 0.27, respectively. The *p* was comparable in both CF and DF (0.17 ± 0.11, 0.18 ± 0.09, respectively), and was remarkably higher in RR (0.38 ± 0.08) and lower in OP (0.08 ± 0.08).

Meanwhile, *L. perspicillata* was detected the highest in both RR and OP, followed by DF and CF. Signs were detected in 8 out of the 16 (0.50) sub-transects in RR, 2 out of the 4 (0.50) sub-transects in OP, 3 out of the 10 (0.30) sub-transects in DF, and 0 out of the 6 (0.00) sub-transects in CF. Since there was no detection in CF for this species, the *psi* and *p* were excluded from the following details and the effect of land-use types on otter occupancy (Table 2). The *psi* was slightly higher than naïve occupancy at 0.68 ± 0.20, 0.68 ± 0.36, and 0.41 ± 0.21, respectively. The *p* for each land-use type was 0.27 ± 0.09, 0.30 ± 0.17, and 0.34 ± 0.20, respectively.

Table 2. Overall occupancy for the two otter species detected in the study area across different land-use types. *Ac* and *Lp* refer to *A. cinereus* and *L. perspicillata*, respectively.

Land-Use Type	Species	Naïve Occupancy	Modelled Occupancy	SE	Detection Probability	SE
CF	*Ac*	0.33	0.37	0.21	0.17	0.10
DF	*Ac* + *Lp*	0.40	0.44	0.17	0.52	0.22
RR	*Ac* + *Lp*	0.88	0.97	0.10	0.49	0.07
OP	*Ac* + *Lp*	0.75	0.83	0.24	0.29	0.13
Overall	*Ac* + *Lp*	0.64	0.71	0.10	0.44	0.06

The effect on land-use types was analysed in regards to *psi* when *p* was held at constant, and the best model with ΔAICc ≤ 2 was selected as the best model explaining otter occupancy in the study site is shown in Table 3. For *A. cinereus*, *p*(.), *psi*(RR) emerged as the best predictor for land-use type whereas for *L. perspicillata*, the null model, *p*(.), *psi*(DF), and *p*(.), *psi*(RR) were the best predictor explaining occupancy of the species in the study area.

Table 3. Models on the effect of individual land-use types as site covariates on otter occupancy based on species, arranged in order of increasing AICc and ΔAICc values.

Model	AICc	ΔAICc	Akaike Weight (wi)	Cumulative Weight	df	logLik
A.cinereus						
p(.), *psi*(RR)	137.53	0.00	0.65	0.65	3	-65.39
p(.), *psi*(.)	140.63	3.10	0.14	0.78	2	-68.13
p(.), *psi*(DF)	141.33	3.80	0.10	0.88	3	-67.29
p(.), *psi*(OP)	142.08	4.55	0.07	0.94	3	-67.67
p(.), *psi*(CF)	142.45	4.92	0.06	1.00	3	-67.85
L. perspicillata						
p(.), *psi*(.)	109.30	0.00	0.45	0.45	2	-52.43
p(.), *psi*(DF)	110.67	1.37	0.23	0.68	3	-51.87
p(.), *psi*(RR)	111.16	1.85	0.18	0.86	3	-52.12
p(.), *psi*(OP)	111.70	2.40	0.14	1.00	3	-52.39

Otter Presence Identified Important Habitat Features in Oil Palm Dominated Landscapes

Generalized linear models (GLMs) were used to model the occurrence of otters by species and combined as a response variable on habitat features which included stream and banks variables, as well as disturbances. Non-correlated variables were selected based on a correlation matrix and were then used to create the global model. The variables selected were stream width and depth, altitude, stream edge, undergrowth cover, bank substrate based on the proportion of soil, or combination of soil and rocks, number of trees, bank tree GBH, distance to human settlements, and disturbance history. The habitat variables for the global model remained unchanged for all analyses. Since otters are known to travel over long distances due to the linear nature of their habitat and the proximity between forested areas and oil palm plantation taken into consideration, the analyses were run at the overall landscape level.

Table 4. Summary statistics for the effect of land-use types on occupancy for *A. cinereus* and *L. perspicillata*.

Land-Use Types	Estimate	SE	z Value	*P*
A. cinereus				
psi(RR)	1.51724	1.64669	0.921	0.3568
psi(DF)	-0.11987	0.47491	0.252	0.8007
psi(OP)	-0.08660	0.47706	0.182	0.8560
psi(CF)	-0.04704	0.32607	0.144	0.8853
L. perspicillata				
psi(DF)	-0.25769	0.70701	0.364	0.7155
psi(RR)	0.14559	0.54787	0.266	0.7904
psi(OP)	0.06162	0.63241	0.097	0.9224

Both species

The final model selected – Otter presence ~ Bank tree GBH + Proportion of bank with soil and rocks combination + Stream depth + Distance to human settlements + Bank undergrowth cover

In the model consisting of both species occurring in the study area, the final model selected based on AIC_C scores comprised of bank tree GBH, the proportion of bank with soil and rocks combination, stream depth, distance to human settlements, and bank undergrowth cover (AIC_C=38.06, ΔAIC_C=0.00). Bank tree GBH had a positive relationship with the presence of otters and was significant at 0.05. Three variables, namely the proportion of bank with the combination of soil and rocks, stream depth, and bank undergrowth cover, had positive relationships to otter presence and were significant at 0.01. The distance to human settlements had a negative relationship and was significant at 0.01 (Table 5).

Table 5. The model-averaged estimates of the five selected habitat variables through the "dredge" function for both *A. cinereus* and *L. perspicillata*.

Variables	Estimate	SE	z Value	*P*	Lower CI	Upper CI
(Intercept)	-1.9139	1.3747	-1.392	0.1639	-5.04	0.59
Bank tree GBH	1.4715	0.7932	1.855	0.0636	0.21	3.65
Proportion of bank with combination of soil and rocks	2.5040	1.0851	2.308	0.0210	0.78	5.26
Stream depth	2.0516	0.9703	2.114	0.0345	0.43	4.40
Distance to human settlements	-1.7987	0.7401	-2.430	0.0151	-3.66	-0.61
Bank undergrowth cover	9.2504	3.8974	2.373	0.0176	2.60	18.37

The Asian-small clawed otter *(Aonyx cinereus)*
Final model selected – Otter presence ~ Altitude + Proportion of bank with soil + Distance to human settlements

For this species, the best-fit model consisted of three habitat variables which were altitude, the proportion of bank with soil, and distance to human settlements (AIC_C=42.74, ΔAIC_C=0.00). There was a positive relationship to altitude and was highly significant at 0.001 level. The proportion of bank with soil showed a positive relationship and was significant at 0.05. The distance between streams to human settlement had a negative relationship and was significant at 0.01 (Table 6).

Table 6. The model-averaged estimates of the three selected habitat variables through the "dredge" function for *A. cinereus*.

Variables	Estimate	SE	z value	*P*	Lower CI	Upper CI
(Intercept)	-0.1242	0.4402	-0.282	0.7779	-1.02	0.77
Altitude	1.5044	0.5739	2.621	0.0088	0.53	2.84
Proportion of bank with soil	0.9497	0.5519	1.721	0.0853	0.08	2.33
Distance to human settlements	-1.3221	0.6081	-2.174	0.0297	-2.74	-0.32

The smooth-coated otter (*Lutrogale perspicillata*)
Final model selected – Otter presence ~ Stream depth + Number of trees + Bank undergrowth cover + Stream width

For this species, the final model selected consisted of four habitat variables which were stream depth, number of trees, bank undergrowth cover, and steam width (AIC_C=43.96, ΔAIC_C=0.00). Stream depth had a positive relationship with the response variable and was significant at 0.01. There was a positive relationship with stream width and was significant at 0.05. The non-significant variables included in the final model were the number of trees and bank undergrowth cover (Table 7).

Table 7. The model-averaged estimates of the four selected habitat variables through the "dredge" function for *L. perspicillata*.

Variables	Estimate	SE	z value	*P*	Lower CI	Upper CI
(Intercept)	-2.5500	1.3117	-1.944	0.0519	-5.60	-0.29
Stream depth	1.6687	0.8000	2.086	0.0370	-0.37	3.56
Number of trees	-1.1772	0.8289	-1.420	0.1555	-3.18	0.13
Bank undergrowth cover	4.0330	2.6498	1.522	0.1280	0.72	10.03
Stream width	1.2285	0.6478	1.896	0.0579	0.19	2.81

DISCUSSION

The occupancy of otters in this study varied across land-use types in a sustainably-managed oil palm dominated landscapes of Sabah. Streams located in agricultural sites: with riparian reserves (*psi* = 0.97) and without riparian reserves (0.83) have higher otter occupancy compared to forested areas: heavily degraded forest (0.44) and continuous logged forest (0.37). This indicates that they can persevere in a variety of habitat quality and that riparian reserves serve as crucial refuges for otters even in such modified landscapes. The result obtained contrasted with the initial hypothesis tested of sites in forested areas having higher otter occupancy compared to oil palm plantations. Despite that, it corresponds to several studies where otter occupancy was found to be somewhat insensitive towards human-modified landscapes for *A. cinereus* and *L. perspicillata* (Cho et al., 2009; Foster-Turley, 1992; Jo et al., 2017; Kamjing et al., 2017; Laws, 2016; Ottino and Giller, 2004; Pillai, 2015; Prakash et al., 2012; Prakash et al., 2014). When occupancy was observed by species, both *A. cinereus* and *L. perspicillata* have the highest occupancy in riparian reserves at 0.86 and 0.68, respectively. With consistent finding of high otter occupancy in riparian reserves on multiple occasions in various streams, it supports the previous claim that otters are residents in reserves instead of transient individuals or groups (Laws, 2016).

The main reason why otters can persist in a wide range of habitat quality is due to the linear nature of their habitats, which permits them to travel over long distances to meet their demands (Prakash et al., 2012). They may also have core areas spread across multiple land-use types because of specific habitat characteristics preferred. Some preferred habitat characteristics include dense bankside vegetation for holt placement (Anoop and Hussain, 2004; Prakash et al., 2014; Shenoy et al., 2006), and areas with sparse to no vegetation, low canopy cover, and loose sand for basking and grooming sites (Anoop and Hussain, 2004; Shenoy et al., 2006). Areas containing loosely packed sand with a small amount of rock but lacking in canopy cover, dense vegetation and stony or gravely substrate were chosen as sprainting sites (Shenoy et al., 2006). The proximity between plantations with and without riparian reserves suggests that higher otter occupancy in the latter might because of suitable habitat features available in mature riparian reserves neighbouring agricultural sites. These reserves contain ample vegetation cover, suitable streamline substratum, and various prey species important for otter activities such as denning, grooming, sprainting, foraging, and travelling. Without the maintenance of riparian reserves in plantations providing these important habitat features, there is a high chance that otter may not survive in this monoculture environment alone.

Since otters are usually infrequent visitors in extremely small rivers, they are used as feeding grounds or migratory pathway given that they are unable to support sedentary breeding population (Romanowski et al., 2012). This is applicable to streams without riparian reserves in plantations as their sizes were exceptionally smaller compared to any other land-use types. Thus, they cannot sustain otters long term due to their narrow and shallow stream, low canopy cover, and limited vegetation diversity for the security of holt placement. Both heavily degraded forests and riparian reserves recorded the highest detection probability at 0.52 and 0.49, respectively because of sandy banks availability in most streams which permit tracks to be detected and identified without difficulty. Spraints were strongly tied to the presence of rocky substrate detected in continuous logged and heavily degraded forests, as well as riparian reserves. However, most were located outside of the surveyed sub-transects and therefore were excluded from the analyses. Similar to the previous reason, occupancy was lower in continuous logged and heavily degraded forests may be influenced by signs found in the catchments within land-use types but were located outside of the sub-transects. Furthermore, the terrain of streams greatly influenced the detection of otter signs, where streams in agricultural sites were easily traversed compared to forested streams with rugged topography.

Otters can utilise whatever resources available within their habitat due to their opportunistic nature, which has been recorded in terms of prey and habitat availability. Otters commonly respond to the presence of habitat characteristics they use over the presence of anthropogenic structures or activities in an area (Aadrean and Usio, 2017; Gallant et al., 2009; Kamjing et al., 2017; Khoo and Sivasothi, 2018; Shenoy et al., 2003; Theng et al., 2016). Although, not all species of otters have a high resilience towards human-modified landscapes. In Borneo, *A. cinereus* and *L. perspicillata* are relatively common where they are often sighted, whereas both the *L. lutra* and *L. sumatrana* are rarely seen. This might be because of social otters dominate major habitats, while the two solitary otter species are forced into marginal habitats (Phillipps and Phillipps, 2016). One possible reason why the two rare species were not sighted in the study area was because it is located within a highly disturbed environment. They are known to occur in intact undisturbed or minimally disturbed forests, or in mangroves and swamp areas from recent discoveries which were absent or limited in the surveyed streams.

Since each otter species has different habitat preferences and needs, it is important to identify important habitat features to facilitate protection and conservation on the respective species and their environments. The GLM analysis identified one model that best explains the presence of both otter species at the landscape level which includes bank tree GBH, the proportion of bank with soil and rocks combination, stream depth, distance to human settlements, and bank undergrowth cover which were all significant. Another model which explained the presence of otters equally ($\Delta AICc \leq 2$) includes all the habitat variables above, with addition to altitude. The ability of observers to identify otter signs are highly influenced by the type of bank substrate which had a positive correlation to presence. The detection of tracks was easier on sand since they imprint well on the substrate, but difficult on rocks or pebbles since signs were normally unclear or do not imprint at all. Both rocky and sandy substrates are suitable mediums for the detection of spraints. Even though higher undergrowth cover is important for otters as a shelter during travel and placement of holt, they impede the detection of signs.

Bank tree GBH and bank undergrowth cover had positive correlations to the presence of otters showing that otters prefer areas with mature vegetation and well-covered banks. Trees that are taller and have bigger diameter provide stream banks with ample canopy cover and smaller, immature tree saplings and shrubs provide undergrowth cover vital for protection against predators. Stream depth too had a positive correlation. Streams within riparian reserves were deeper compared to other land-use types, although the streams in reserves were not deep enough to hinder hunting sessions. Conversely, the distance between streams to human settlements had a negative correlation to otter presence. This indicates that both otter species in the study area are highly adaptable and can tolerate moderate to high level disturbances. As otters need water as foraging and travelling sites, and humans tend to build settlements nearby water sources for their daily needs, both of them will inevitably share the same space. It may cause conflicts to arise when they compete for food resources as they are known as pests to fishermen and pond owners, and as a result are susceptible to being killed (Duplaix and Savage, 2018; Kruuk, 2006; Prakash et al., 2014).

The best-fit model explaining the presence of *A. cinereus* in oil palm dominated landscapes retained altitude, the proportion of bank with soil, and distance to human settlements, and were all significant. Altitude was positively correlated to otter presence. Although *A. cinereus* was found in all land-use types, only this species was found to reside in smaller hilly, rocky streams located at higher altitude. The main factor for this occurrence would be the type of main prey species they consume, i.e., crustaceans which can be found in streams with rocky substratum (Foster-Turley, 1992; Kruuk, 2006). The proportion of bank with soil had a positive correlation. Otter detection rate was higher when there was higher proportion of exposed soil. Soil, especially sandy substrate, is known to be an important feature of the otter habitat because it is associated with grooming activity and an important substrate for sprainting site (Anoop and Hussain, 2004; Shenoy et al., 2006). The distance between streams and human settlements had a negative correlation. As mentioned previously, otters usually share space with humans due to the same resources needed for livelihood. However, they will avoid humans by coming out when there are fewer disturbances. Other models that seemed to explain presence of this species equally across the landscape included vegetation variables such as stream edge, bank undergrowth cover, and bank tree GBH. All these are important as security during travelling, resting, and holt placement, as well as to screen disturbances between surrounding land-use and the stream (Prakash et. al., 2014).

The GLM analysis identified one model that best explains the presence of *L. perspicillata* in the study area. The model retained stream width and depth as significant variables and had positive correlations. Two other non-significant variables included into the final model were number of trees and bank undergrowth cover. *L. perspicillata* usually inhabit medium to large water bodies containing high fish productivity and tends to hunt for larger preys compared to other otter species sharing the same habitat (Kruuk et al., 1994; Anoop and Hussain, 2005). Higher altitude streams possess less diversity of the fish community, and fish biomass is less abundant (Ruiz-Olmo, 1998). Wider streams were mainly situated in riparian reserves located at low to moderate altitudes, where fishes are plentiful. Stream depth, again, showed a positive correlation. As mentioned earlier, deeper streams were mostly located in riparian reserves contain a higher congregation of prey items. Even though the number of trees and bank undergrowth cover were not significant, they are vital features of an otter’s habitat as they act as a buffer to disturbances and contribute to bankside diversity. Other models which described *L. perspicillata* presence equally across the landscapes included the proportion of bank with soil, altitude, stream edge, distance to human settlements, and bank tree GBH which has been explained.

The approach of preserving riparian reserves within oil palm plantation was a successful strategy in mitigating impacts of land-use changes for otters. Otters show resilience and possess the ability to adapt to modified habitats when they are present in oil palm dominated landscapes (Laws, 2016). One contributing factor to lower occupancy in forested areas was due the recent disturbance in heavily degraded forests, where the fragments were salvage-logged between 2013 and 2016 (Seaman et al., 2019). Therefore, otters may have prioritized riparian reserves as their habitat since the vegetation buffer had enough time to recover following previous disturbances during plantations establishment. This allows trees to mature and complexity of surrounding vegetation to be established, providing ample denning site, protection against predators, and prey stock to recover from disturbances (Laws, 2016).

Next is the availability of prey items in streams in oil palm dominated landscapes. This offers sustenance to otters as they travel across the landscape and was confirmed by numerous observations of spraints in riparian reserves. An extensive study on freshwater fishes discovered 28 species present in and around the SAFE Project area (Wilkinson, 2018), where up to 25 are known as focal food items to humans: primary forest (n=10), logged forest (n=13), heavily degraded forest (n=17), oil palm plantation with riparian reserves (n = 22), and oil palm plantation without riparian reserves (n=15). Focal fishes to local communities had an unexpected resilience to severe disturbance from land-use changes as the area was observed to have a relatively high level of species richness (Wilkinson, 2018; Wilkinson et al., 2018). Laws (2016) analyzed invertebrate abundance, where it was significantly lower in heavily degraded forests resulting in a limiting factor to otters there. There was a relationship between disturbance history and invertebrate abundance, implying that abundance might be negatively affected by the recent salvage-logging events. Since mature plantations had enough recovery time after the previous disturbances, it allows associated invertebrate communities to recuperate after the initial establishment of the plantation.

The influence of selective logging is still evident in stream environmental conditions even after 10 to 15 years following logging, when logged forests were compared to old-growth forests (Luke et al., 2017b). Streams in riparian buffers of oil palm plantations maintained more natural stream conditions compared to streams without buffers, displaying the value of preserving or restoring riparian buffers for the management of freshwater in these catchments. Although, it is not enough to fully protect streams from the impacts of oil palm agriculture. Another factor for otter resilience in agricultural site is because plantations without reserves can act as a corridor for otters to travel between reserves possessing better quality forests across the matrix (Bhagwat et al., 2008; Luskin and Potts, 2011). Mature plantations possess enough undergrowth cover to provide protection during movement. There is also more active roads between plantations and forests (continuous logged and heavily degraded), which might potentially cause an increased chance of conflicts between humans or transportation.

CONSERVATION IMPLICATIONS

The present study shows that otters have a high occupancy in agricultural sites. It suggests that oil palm plantations with riparian reserves have a potential as functional habitats for otters which are underestimated in the past. The establishment of sustainable oil palm plantation management might have greatly played a role in the preservation of otter habitats within an extremely modified landscape. The maintenance of riparian reserves in plantations given enough time to recuperate after past disturbances managed to mitigate the damaging impacts of agricultural intensification on freshwater habitats for otters.

Even though they can survive in these habitats, it should not replace the importance of intact forested habitats as they lack proper vegetation communities and are susceptible to extreme fluctuations in abiotic variables such as temperature and humidity, especially in streams without any vegetation buffer. The detection of signs across land-use types was highly influenced by the stream topography, bank substratum, and weather conditions. Therefore, supplementary sampling methods using advanced technologies, e.g. camera trap, eDNA analysis, radiotelemetry, are greatly needed to cover the limitations of traditional methods.

Since there is a limited suitable habitat for otters, especially within the monoculture landscape, this study highlights the importance of preserving riparian buffer strips adjoining water bodies. The two otter species detected during the study show a high resilience towards changes and managed to thrive well in agricultural sites and areas where humans are present as long as there are ample food and shelter. The evaluation of prey species stocks, especially in water bodies located adjacent to plantations, needs to be monitored appropriately. Wastes from both nearby palm oil mills and human settlements directly impact prey items. Therefore, it is important to observe the health of the riverine system as this will not only impact otters but also humans living within the area.

As otters are living nearby to humans, especially in plantations and urban areas, more cases of human-otter conflicts have been reported multiple times over the past years (Danau Girang Field Centre, 2020; Duplaix and Savage, 2018; Elankovan, 2019; Gomez and Bouhuys, 2018; Lokman, 2020; Lubis, 2005; Ottercity, 2020; Prakash et al., 2012; Prakash et al., 2014; Shenoy et al., 2003; Tan, 2015; Tan, 2020; Wai, 2019; Woo and Bakar, pers. comm., 2020). Therefore, these conflicts between both parties need to be addressed appropriately. Education and awareness programs amongst the local communities and plantation workers are a priority to educate on the importance of otters in the environment. State-wide social survey with fishermen and aquaculture pond owners should be conducted to identify the conflict intensity between human and otters within the fishery industry, and by creating a program to work alongside them in the future to reduce potential conflicts. The hunting intensity of otters is not known in Sabah, but it is essential to investigate how severe it is as Southeast Asia has the highest contribution towards illegal hunting and pet trades (Gomez et al., 2016; Gomez and Bouhuys, 2018). Negative perception towards otters should be reversed, and mitigation of human-otter conflict must be implemented throughout the state to aid in recovering the populations of Bornean otters.

Restoration and preservation of vegetation buffers strips, controlling pollution, and limiting extraction activities are vital in ensuring otter population survival in oil palm dominated landscapes. There is a need for enforcement for better monitoring of riparian buffer widths in plantations. Priority should be given to ensure oil palm plantation managements adhere to the regulations given that it is poorly applied at the moment. Retaining connectivity between reserves and intact forests through corridors should be an approach used in creating a wildlife-friendly plantation to reduce conflict between wildlife and humans during movement and to ensure genetic flow. The conversion of oil palm plantations from previously degraded landscapes should be a priority above intact forests, and that method to lessen the effects of conversion towards wildlife in logged forests must be established.

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RÉSUMÉ

LES RÉSERVES RIVULAIRES SERVENT DE REFUGE AUX LOUTRES ASIATIQUES (*Aonyx cinereus* ET *Lutrogale perspicillata*) DANS LES PAYSAGES DOMINÉS PAR LE PALMIER À HUILE AU SABAH, SUR L'ÎLE DE BORNÉO EN MALAISIE

Nous avons déterminé l'occupation des espèces de loutres et évalué plusieurs caractéristiques de l'habitat influençant leur présence dans quatre types différents d'utilisation du sol : Forêts exploitées en Continu (FC), Forêts fortement Dégradées (FD), Réserves Riveraines dans des plantations de palmiers à huile (RR) et Plantations de palmiers à huile Sans réserves riveraines (PS). Notre objectif était de vérifier l'utilité de conserver une réserve rivulaire dans un paysage dominé par le palmier à huile pour la protection de la loutre. Cette étude a été menée dans l'État malaisien de Sabah, au nord de Bornéo. Nous avons étudié 36 sous-transects de cours d'eau dans tous les différents types d'utilisation du sol et avons détecté la présence de loutres en fonction de leurs trajectoires et de leurs pentes. Dans l'ensemble, deux des quatre espèces de loutres trouvées au Sabah ont été détectées dans les zones étudiées, à savoir la loutre cendrée, *A. cinereus* et la loutre à pelage lisse, *L. perspicillata*. Nous avons constaté que les cours d'eau des sites agricoles avaient une occupation de loutres significativement plus élevée que les zones boisées : RR (psi = 0,97), PS (0,83), FD (0,44) et FC (0,37). En utilisant la Modélisation Linéaire Généralisée (MLG), nous avons identifié que le territoire occupé par les loutres dans les paysages de palmiers à huile était positivement influencé par la disponibilité de grands arbres et toute autre végétation le long des berges. Les cours d'eau plus profonds étaient également davantage préférés par les loutres. Fait intéressant, une détection plus élevée d'indices de présence de loutre a été enregistrée le long des cours d'eau des plantations de palmiers à huile proches des habitations. D'une manière générale, cette étude suggère que les cours d'eau des plantations de palmiers à huile avec une végétation rivulaire sont un habitat favorable aux espèces de loutres. Par conséquent, le maintien des réserves rivulaires dans les plantations de palmiers à huile est une stratégie de gestion utile pour améliorer la conservation de la biodiversité dans un paysage agricole.

RESUMEN

LAS RESERVAS RIBEREÑAS SIRVEN COMO REFUGIO CRÍTICO PARA LAS NUTRIAS ASIÁTICAS (*Aonyx cinereus* y*Lutrogale perspicillata*) EN PAISAJES DOMINADOS POR PALMERA ACEITERA EN SABAH, BORNEO MALAYO

Determinamos la ocupación por las especies de nutria y evaluamos distintos rasgos del hábitat que influyen en su ocurrencia, en cuatro tipos de uso de la tierra: bosques explotados continuos (CF), bosques intensamente degradados (DF), reservas ribereñas dentro de plantaciones de palmera aceitera (RR) y plantaciones de palmera aceitera sin reservas ribereñas (OP). Nuestro objetivo fue evaluar la utilidad para la conservación de las nutrias, de retener una reserva ribereña en un paisaje dominado por palmera aceitera. Este estudio fue conducido en el estado Malayo de Sabah, porción norte de Borneo. Relevamos 36 sub-transectas en arroyos a lo largo y ancho de todos los tipos de uso de la tierra, y detectamos presencia de nutrias en base a huellas y fecas. En total, fueron detectadas en las áreas relevadas, dos de las cuatro especies de nutria que se encuentran en Sabah, concretamente la Nutria de Uñas Pequeñas Asiática, *A. cinereus* y la Nutria Lisa, *L. perspicillata*. Encontramos que los arroyos en sitios agrícolas tuvieron ocupación por nutrias significativamente más alta en comparación con las áreas forestadas: RR (*psi* = 0.97), OP (0.83), DF (0.44), y CF (0.37). Utilizando Modelado Lineal Generalizado (GLM) identificamos que la ocupación por nutrias en los paisajes de palmera aceitera estaba influenciada positivamente por la disponibilidad de grandes árboles y otra vegetación a lo largo de las barrancas. También fueron preferidos por las nutrias los arroyos más profundos. En forma interesante, en los arroyos en plantaciones de palmera aceitera ubicados más cerca de asentamientos humanos registramos más detección de signos de nutria. En general, este estudio sugiere que los arroyos en plantaciones de palmera aceitera con vegetación ribereña fueron útiles para las especies de nutria. Por lo tanto, retener reservas ribereñas dentro de plantaciones de palmera aceitera es una estrategia de manejo útil para mejorar la conservación de la biodiversidad en el paisaje agrícola.

RUMUSAN

RIZAB RIPARIAN BERFUNGSI SEBAGAI TEMPAT PERLINDUNGAN YANG KRITIKAL UNTUK MEMERANG ASIA (*Aonyx cinereus* DAN *Lutrogale perspicillata*) DALAM LANDSKAP YANG TELAH DIDOMINASI OLEH KELAPA SAWIT DI SABAH, BORNEO MALAYSIA

Kajian ini menentukan penghunian spesies memerang dan menilai beberapa ciri-ciri habitat yang menpengaruhi kehadiran mereka di dalam empat jenis penggunaan tanah yang berbeza: hutan berterusan yang telah dibalak (CF), hutan yang sangat terdegradasi (DF), rizab riparian dalam ladang kelapa sawit (RR), dan ladang kelapa sawit tanpa rizab riparian (OP). Tujuan kajian ini adalah untuk memastikan pentingnya rizab riparian dikekalkan di landskap yang telah didominasi oleh kelapa sawit untuk tujuan pemuliharaan memerang. Kajian ini dilakukan di negeri Sabah, Malaysia iaitu di bahagian utara Borneo. Sebanyak 36 sub-transek anak sungai telah ditinjau yang merentasi semua jenis penggunaan tanah yang berbeza dan kehadiran memerang dikesan berdasarkan bekas tapak kaki dan najis mereka. Secara keseluruhan, dua daripada empat spesies memerang yang terdapat di Sabah berada di dalam kawasan yang ditinjau, iaitu Memerang Kecil, *A. cinereus* dan Memerang Licin, *L. perspicillata*. Anak sungai di kawasan pertanian didapati memiliki penghunian memerang yang jauh lebih tinggi berbanding dengan kawasan hutan: RR (*psi* = 0.97), OP (0.83), DF (0.44), and CF (0.37). Dengan menggunakan *Generalised Linear Modelling* (GLM), kami mengenalpasti bahawa penghunian memerang di landskap kelapa sawit adalah dipengaruhi secara positif oleh kehadiran pokok-pokok besar dan vegetasi lain di sepanjang tebing. Anak sungai yang lebih dalam juga menjadi pilihan dan lebih disukai oleh memerang. Lebih menarik lagi, anak sungai di ladang kelapa sawit yang terletak berdekatan dengan penempatan manusia mencatatkan kehadiran tanda-tanda memerang yang lebih tinggi. Secara umum, kajian ini menunjukkan bahawa anak sungai di dalam ladang kelapa sawit yang mempunyai vegetasi riparian merupakan habitat yang berguna untuk spesies memerang. Oleh itu, dengan mengekalkan rizab riparian di dalam ladang kelapa sawit merupakan strategi pengurusan yang berguna dalam meningkatkan pemuliharaan biodiversiti di dalam landskap pertanian.

ARTICLE

KNOWLEDGE AND PERCEPTION OF THE NEOTROPICAL OTTER *(Lontra longicaudis annectens)* BY LOCAL INHABITANTS OF A PROTECTED AREA IN THE STATE OF CAMPECHE, MEXICO

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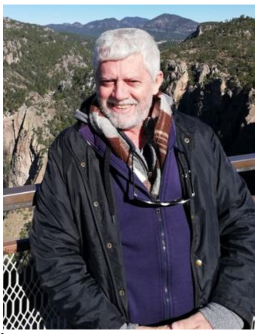

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ABSTRACT: The Neotropical otter is a protected species under the Mexican General law of wildlife listed as threatened (NOM-059-ECOL-2010); it is listed as near-threatened by the IUCN Red List of Threatened Species and in Appendix I of CITES. The Neotropical otter is mentioned in the management program for the *Laguna de Términos* federal protected area but is seldom mentioned in other management programs of protected areas of Mexico. As very few scientific studies conducted in the State of Campeche make reference to the Neotropical otter, we conducted a survey among the inhabitants of the margins of the *Laguna de Términos* system to learn about their perceptions of this species. Data were gathered from June to October 2015 through an *ad hoc* questionnaire applied to 101 local inhabitants. We asked questions about their empirical knowledge of the biology of the Neotropical otter and their perception of the status of the species. Data were summarized in terms of percentages and subjected to statistical analyses (Kruskal-Wallis tests) for comparison and interpretation. We found that the local inhabitants are familiar with Neotropical otters and provided candid and consistent information. They showed some ambivalence with regard to the protection of the species: although they recognized the conservation status of the species, they also admitted that otters are occasionally exploited (hunting for their fur) as a source of revenue. Most respondents (94-100%) supported establishing a conservation plan. This information should be taken into account when planning and implementing eco-tourism activities in the *Laguna de Términos* protected area.

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INTRODUCTION

The Neotropical otter, *Lontra longicaudis* (Olfers, 1818), is widely distributed in Mexico, where it can be found in almost all streams, lakes, dams, lagoons and large rivers on the coastal plains of the Atlantic and Pacific slopes (Gallo-Reynoso 1989, 1991; Ramírez-Bravo, 2010). It is a versatile species that can easily adapt to a wide range of riparian habitats, from arid regions with thorny scrub vegetation, oak-pine forests, to evergreen and deciduous tropical forests (Gallo-Reynoso, 1989, 1997; Cirelli, 2005; Botello et al., 2006).

Table 1. Studies focused on food preferences of the Neotropical otter in Mexico. Modified from Mariano-Mendoza (2019).

Author (Year)	FN	Locality	Prey (%)								
			Pla	Mo	Ins	Cr	Fis	Am	Re	Bi	Ma
Gallo-Reynoso (1989)	35	Sierra Madre del Sur (Nayarit, Jalisco, Colima, Michoacan, Guerrero, Oaxaca states)	+	-	11,6	34,8	46,9	2,1	1,7	1,7	1,2
Gallo-Reynoso (1996)	-	Yaqui River, Sonora	-	-	-	-	95,0	-	-	-	-
Macías-Sánchez and Aranda (1999)	474	Los Pescados River, Veracruz	-	-	7,5	30,8	54,1	-	6,2	1,4	-
Ramón (2000)	106	San Cipriano River, Tabasco	-	-	6,4	20,1	70,7	-	0,6	-	1,9
Arellanes-Licea and Briones-Salas (2003)	-	Zimatan River, Oaxaca	2,4	-	3,9	55,6	37,1	-	-	0,2	-
Casariego-Madorell (2004)	580	Three rivers in the State of Oaxaca	-	-	9,8	53,1	33,1	6,2	-	-	-
Soler-Frost (2004)	524	Four streams in the Lacandona tropical rian forest, State of Chiapas	7,7*	2,8	21,2	1,5	61,6	-	1,7	-	2,7
Díaz-Gallardo et al., (2007)	186	Ayuquila River, Jalisco	0,5**	-	23,1	35,1	36,1	-	1,6	1,6	1,8
Duque-Dávila (2007)	161	Grande River, Oaxaca	0,2	-	4,1	-	89,6	-	4,3	1,7	-
Rangel-Aguilar and Gallo-Reynoso (2013)	73	Bavispe-Yaqui River, Sonora	-	1,5	30,0	-	58,0	-	1,5	5,8	3,7
Grajales-García et al., (2019)	67	Coastal area of Tuxpan, Veracruz	-	8,6	4,9	55,5	22,2	1,2	-	6,2	1,2

FN = Number of sprints examined; * Plant fibers; ** Seeds; +Presence not quantifiable; Pla = Plants; Mo = Molluscs; Ins = Insects; Cr = Crustaceans; Fis = Fish; Am = Amphibious; Re = Reptiles; Bi = Birds; Ma = Mammals

The Neotropical otter, locally known as *perro de agua* (literally, water dog), is a polytypic species. The subspecies *L. l. annectens* (Major, 1897) is listed as near-threatened by the International Union for Conservation of Nature (IUCN) (Rheingantz and Trinca, 2015) and is included in Appendix I (endangered) of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2018).

In Mexico, it is listed as threatened by the official Mexican standard NOM-059-SEMARNAT-2010 (SEMARNAT, 2010).

This species is well-known in Mexico. Efforts to study the Neotropical otter have been increasing since the year 2000. Santiago-Plata (2009) compiled the studies on this species carried out in Mexico. His results and those obtained in more recent studies show that most studies have focused on evaluating the habitat of the otter, as well as on biological and ecological aspects related to its food preferences (Table 1) and relative abundance (Table 2) in different parts of Mexico, including the States of Campeche, Chiapas, Colima, Guerrero, Jalisco, Michoacan, Nayarit, Oaxaca, Quintana Roo, Sonora, State of Mexico, Tabasco, and Veracruz.

Table 2. Studies focused on the relative abundance of the Neotropical otter in Mexico (in chronological order). Modified from Santiago-Plata (2009).

Number	Estimated abundance (otters/km)	Distance traveled (km)	Method used	Study area	Reference
1	0.50	11.0	DR (3 spraints per day)	Catemaco Lagoon, Veracruz	Ruiz-Betancourt (1992)
2	0.34	73 000 *	DR (3 spraints per day)	Yaqui River, Sonora	Gallo- Reynoso (1996)
3	0.21	107.5	Traces, direct observations	Hondo River, Quintana Roo	Orozco-Meyer (1998)
4	2.45- 6.26	20.0	DR (3 spraints per day)	Los Pescados and Actopan rivers, Veracruz	Macías-Sánchez (2003)
5	1.22- 3.10	20.0	DR (6 cub spraints per day)	Los Pescados and Actopan rivers, Veracruz	Macías-Sánchez (2003)
6	0.42	707.1	Number of spraints or number of latrinas/km	Ayuta, Copalita and Zimatan rivers, coast of Oaxaca.	Casariego-Madorell (2004)
7	1.26	707.1	DR (3 spraints per day)	Ayuta, Copalita and Zimatan rivers, coast of Oaxaca.	Casariego-Madorell (2004)
8	0.38	68.0	DR (3 spraints per day)	Nayarit	Macías-Sánchez and Hernández (2007)
9	1.89	39.0	-Number of spraints/km	Tlacotalpan, Veracruz	Arellano-Nicolás (2008)
	0.38		-Number of latrinas/km		
	0.48		-DR (3 spraints per day)		
10	0.52	-	DR (3 spraints per day)	Yaqui River, Sonora	Rangel-Aguilar (2008)
11	3.70	60.5	DR (3 spraints per day)	Zimatan River, Oaxaca	Briones et al. (2008)
12	0.001-0.023	9.0	DR (3 spraints per day)	Temascaltepec River, State of México	Guerrero-Flores et al. (2013)
13	0.0005-0.011	9.0	DR (6 cub spraints per day)	Temascaltepec River, State of Mexico	Guerrero-Flores et al. (2013)
14	0.97	39.0	DR (3 spraints per day)	Catemaco Lagoon, Veracruz	González-Christen et al. (2013)
15	0.49	39.0	DR (6 cub spraints per day)	Catemaco Lagoon, Veracruz	González-Christen et al.

					(2013)
16	0.12	5.0	-DR (3 spraints per day) (Number of spraints/ storage time of spraints*)/km	Pantanos de Centla, Biosphere Reserve, Tabasco (RBPC) (San Pedrito)	Jiménez-Domínguez and Olivera-Gómez (2018)
17	0.4	5.0	-DR (3 spraints per day) (Number of spraints/ storage time of spraints*)/km	RBPC (Tabasquillo Stream, Tabasco)	Jiménez-Domínguez and Olivera-Gómez (2018)
18	0.93	5.0	-DR (3 spraints per day) (Number of spraints/ storage time of spraints*)/km	RBPC (La Gloria Stream, Tabasco)	Jiménez-Domínguez and Olivera-Gómez (2018)
19	0.02	-	DR (3 spraints per day)	Tampamachoco Lagoon, Tuxpan, Veracruz	Grajales-García et al. (2019)
20	0.14	-	DR (3 spraints per day)	Tumilco Stream, Tuxpan, Veracruz	Grajales-García et al. (2019)
21	0.94	-	DR (3 spraints per day)	Jácome Stream, Tuxpan, Veracruz	Grajales-García et al. (2019)

DR= Defecation rate * Distance traveled (l m-wide line)

The population of *L. l. annectens* (Major, 1897) in the State of Campeche is likely to have a wider distribution and higher abundance than what has been reported in the literature to date. However, the paucity of biological and ecological data collected in the State made it impossible to confirm this assumption. Fewer than 30 studies have been published since 1989, and some of those remained as gray literature (i.e., dissertations, thesis, technical reports and others), with limited distribution, or confirming the presence of the species in the State. Therefore, we first conducted an extensive review of the literature for the State of Campeche and found few scientific papers have been produced. The earliest report was by Gallo-Reynoso (1989) who in 1978 found indirect records (footprints and spraints) of the presence of the Neotropical otter in the Usumacinta River delta and in the upper areas of the Candelaria, Samaria, Chumpan, and Palizada rivers and Del Este Lagoon, whose waters flow into the *Laguna de Términos* (Términos Lagoon). Other records of the presence of the Neotropical otter were reported by Santiago-Plata (2009) and Santiago-Plata et al. (2013) for the *Laguna de Términos* federal protected area (APFFLT, for its acronym in Spanish). They found indirect records and documented sightings of *L. l. annectens* on the San Pedro-San Pablo River, which marks the boundary between the Campeche and Tabasco states, additional evidence of the presence of the otter was found subsequently (Table 3).

The *Centro de Estudios de Desarrollo Sustentable y Aprovechamiento de la Vida Silvestre* (Center for Studies on Sustainable Development and Use of Wildlife, CEDESU for its acronym in Spanish) at Universidad Autónoma de Campeche (UAC), hold three records of Neotropical otters: two skulls and one sighting in their mammal collection (Guzmán-Soriano et al., 2013). In addition, we visited Palizada Town in January 2015 to corroborate the presence of the Neotropical otter in the area; this was confirmed by Mr. J. Carvallo (*Comisión Nacional de Áreas Naturales Protegidas*, National Commission for Protected Areas, CONANP for its acronym in Spanish) and by managers of the San Román Ranch located near Palizada Town. Finally, we accessed at *Unidad Informática para la Biodiversidad*, specificaly the database of the *Colección Nacional de Mastozoología* (National Mammalogy Collection) of the Instituto de Biología, UNAM. We found a single record of this species for the State of Campeche, dated in 1986, with incomplete location data for the point of collection (Table 3) (Fig. 1).

Table 3. Record of the presence of the Neotropical otter in the State of Campeche, Mexico. Modified from Mariano-Mendoza (2019).

Locality	Evidence	Reference
Champoton River, 3 km East from Champoton City.	Tracks (footprints, latrines, spraints, throwers)	Gallo-Reynoso (1997)
Candelaria River, Candelaria Town.	Otter fur examined	
Samaria River, Samaria Village.	Interview with fishermen	
Chumpán River, Balchacah Lagoon (mouth of the *Laguna de Términos* Lagoon).	Tracks (footprints, latrines, spraints, throwers)	
Palizada River, Laguna del Vapor, 3 km Northeast from the El Vapor Town.	Tracks and dens	
San Pedro River, 1 km South of San Pedro Town.	Tracks (footprints, latrines, spraints, throwers)	
Not identified (SEDUE regional office).	Fur	CNMA, IBUNAM* (1986)
La Veleta road, between the Villahermosa-Cd. del Carmen federal highway and San Pedro-San Pablo River.	Footprints, sightings and tracks (typically wallows, latrines and spraints)	Santiago-Plata (2009) Santiago-Plata et al. (2013)
"La Esperanza", Calakmul Biosphere Reserve.	Skull	Guzmán-Soriano et al. (2013)
Venustiano Carranza River, 5 km Southeast from Candelaria town.	Skull	
Caribe River, 6 km from Ejido Pablo Torres Burgos, Candelaria.	Sighting	
Palizada.	Fur	Mammal Collection CEDESU** (2016)

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**Centro de Estudios de Desarrollo Sustentable y Aprovechamiento de la Vida Silvestre.

The presence at least one of the two species of river otters, *Lontra canadensis* and *L. longicaudis*, has been recorded in 23 of the protected areas of Mexico (Gallo-Reynoso et al., 2019). However, the management programs of most of those protected areas do not make any reference to otters. This is not the case of the *Laguna de Términos* protected area; its management program (INE, 1997) includes the Neotropical otter in the list of vertebrates inhabiting the reserve (p. 27) and describes its distribution in the fluival-lagoon and estuarine systems such as the Sabancuy, Panlao, Balchacah, and Puerto Rico lagoons and the Chumpan and Palizada rivers; the information included therein was provided by one of us (Gallo-Reynoso). The document also called for studies on the population dynamics of this species in order to support decisions regarding its protection and management (p. 43): *"Formulate and implement special protection measures for habitats of threatened, vulnerable, or endangered species including, among others: jabiru, manatee, otter, crocodile, sea turtles and fresh water* *tortoises"*. Unfortunately, no follow-up on the management program has been documented and, thus, the progress or implementation status of such actions is unknown.

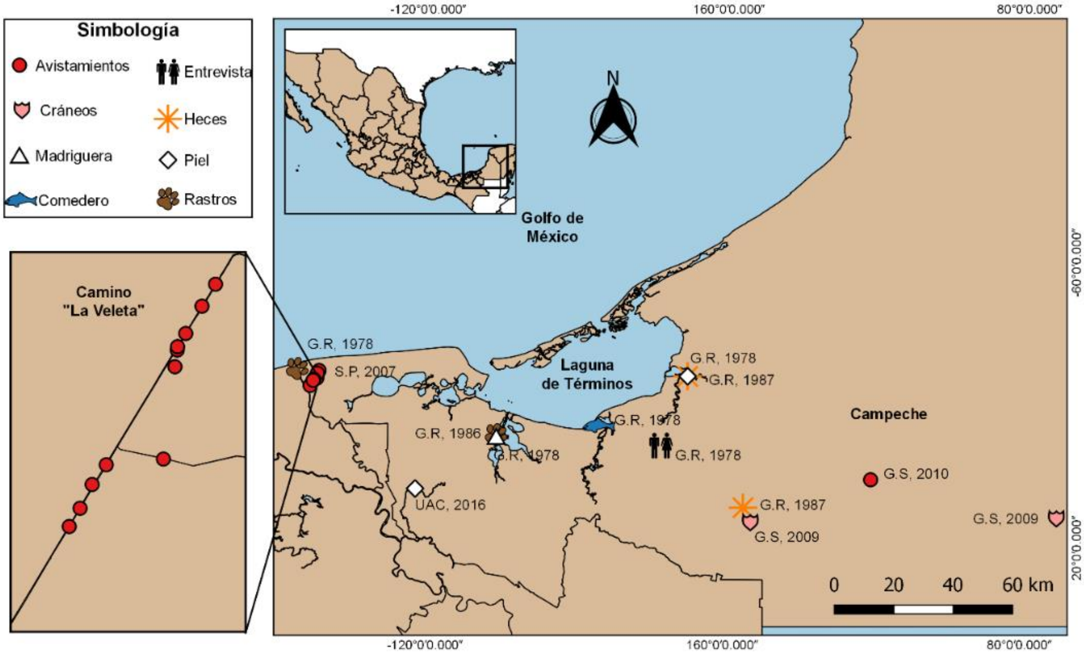

Figure 1. Historical-geographic distribution of direct or indirect records of the presence of the Neotropical otter in the State of Campeche, Mexico.

It is essential to design and implement strategies and policies for the study, protection, and monitoring of Neotropical otters. Information needs include determining their regional population trends; identify and evaluate the pressures affecting them; and, based on that, design actions to promote their conservation. Several surveys have shown that people, in general, regard otters as charismatic animals (Gallo-Reynoso, 1997; Macías-Sánchez, 2003; Kruuk 2006; Guerrero-Flores, 2007). This perception is advantageous, as it can facilitate public participation in conservation efforts for Neotropical otters. As otters are intimately linked to wetlands, such efforts would also result in the conservation of entire habitats, many of which are currently threatened and, consequently, of many other species inhabiting the same area and habitats (Guerrero-Flores et al., 2013).

There is a clear need to conduct further research to provide the necessary knowledge on the current situation of the Neotropical otter in the *Laguna de Términos* protected area, encompassing all the fluvial-lagoon systems therein. Part of this information can be gathered through more extensively surveys of local residents to learn about their views on this species; such information would provide the basis for designing and implementing applied research aimed to the conservation of this species.

STUDY AREA

The *Laguna de Términos* protected area for flora and fauna (APFFLT) is located in the Southwest part of the State of Campeche. It includes the entire *Laguna de Términos* Lagoon, and parts of the municipalities of Carmen, Champoton and Palizada (Fig. 2). The APFFLT is one of the largest protected areas of Mexico; it incorporates a total area of 706.147 ha, with 351.582 ha of terrestrial and 353.434 ha of aquatic areas, of which 200.108 ha correspond to the lagoon-estuarine ecosystems (INE, 1997). The coastal plain is part of the complex deltaic plain of the Grijalva-Usumacinta River, whose freshwater discharges is the largest in Mexico, and encompasses a variety of biodiversity-rich ecosystems that harbor a number of species listed as threatened, endangered, or under special protection by the Mexican official standard NOM-059-SEMARNAT-2010 (SEMARNAT, 2010).

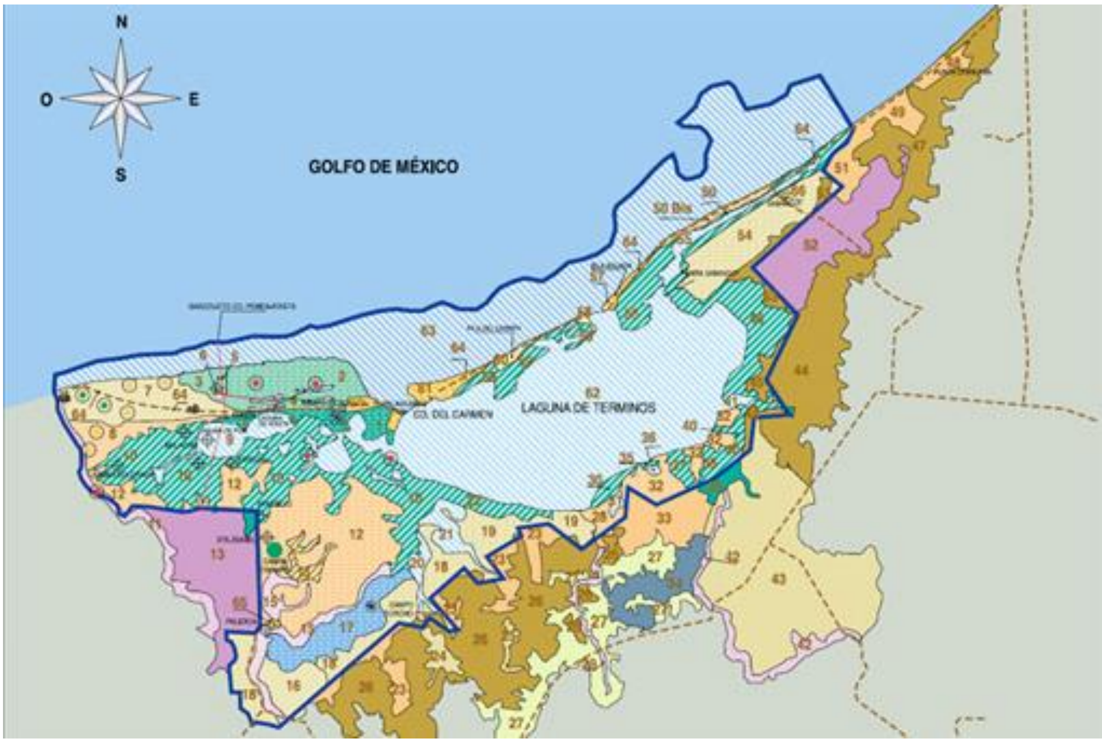

Figure 2. Location and boundaries of the *Laguna de Términos* protected area for flora and fauna (APFFLT); Mexico (taken from: INEGI-CONABIO-IMT-CONAGUA, 2015).

The prevailing climate in the area is humid tropical, with three well-marked seasons along the year (Yáñez-Arancibia and Day, 1988): 1. dry season (February to May), 2. rainy season (June to September) and 3. "nortes" or northern wind season (October to January); with February and May as transitional months when occasional "nortes" and rains occur, respectively (Villalobos-Zapata et al., 2002; Guerra-Santos and Kahl, 2018).

Freshwater inputs from rivers throughout the year play an important role in the dynamics of the lagoon system due to the mixing of water and the natural circulation of *Laguna de Términos*. Tides are semi-diurnal, with a 50-60 cm tidal range (Ramos-Miranda et al., 2006).

The main economic activities carried out within the protected area (as of 2017) are related to fisheries. There are fishermen (fishing being a men-only activity), fishing permit holders, president of fishing cooperative, government manager, and company manager; women participate in the last two activities (Crespo-Guerrero, 2017). Other activities that are carried out in the protected area, although to a lesser extent, include those related to the oil industry as well as commercial, services, and agricultural activities (INEGI, 2016). However, the 2015-2021 Development Plan of the State of Campeche stresses that the main economic activities in Campeche and in the *Laguna de Términos* protected area relate to the oil industry.

It is important to bear in mind that fishing activities in coastal wetlands of the Gulf of Mexico had a high economic impact in the past, when they accounted for up to 30% of the total catch of the country (Yáñez-Arancibia and Day, 2004). However, the activity declined from 2010 to 2015, with sporadic peaks when fishermen were hired on a temporary basis, depending on the fishing season (Secretaría de Pesca y Acuacultura, 2015). Coastal fisheries contribute with approximately 80% of the local economy in coastal towns. However, fisheries resources of the Gulf of Mexico have been overexploited and wetlands have been either destroyed or degraded by urban expansion and the construction of channels diverting water for irrigating crops (Yáñez-Arancibia and Day, 2004). The major issues affecting riverine fisheries in Mexico include illegal fishing, insufficient and unsupervised inspection, lack of organization and administrative order, poor practices in the sales and marketing of products (Secretaría de Pesca y Acuacultura, 2015). There is an urgent need for a comprehensive management program of the coastal areas of the reserve. Integrating cultural, economic, and ecological values, as well as reaching a balance between environmental protection and economic development, are key for a successful management program for the *Laguna de Términos* protected area.

METHODS

The management program of the *Laguna de Términos* protected area for flora and fauna (INE, 1997), describes the presence of the Neotropical otter on the margins of the fluvio-lagoon system of the protected area. However, the perception and knowledge of local residents about Neotropical otters were largely unknown. Thus, we conducted a perception survey among 101 local inhabitants in five localities within the *Laguna de Términos* protected area over a five-month period (Table 4).

Table 4. Number of interviews applied per locality within the *Laguna de Términos* protected area

Locality	No. of respondents	Completion Date (2015)
Palizada	16	June 30
Cd. del Carmen (La Puntilla)	20	June 20, 26 and 27 and July 4
Cd. del Carmen (Puerto Pesquero)	17	July 14, 17 and 18
Isla Aguada	22	August 28 and 30 and September 5
Atasta	26	Octuber 13 and 23
Total	101	

The questionnaire included 40 questions covering various aspects, from personal data such as gender, age, education level, and social-economic situation; knowledge about basic aspects of the biology of the Neotropical otter such as behavior and habitat use; and questions about their perception of the economic importance and conservation of the Neotropical otter.

The information thus gathered was sorted, percent frequencies of the responses were calculated, and statistical analyses (Kruskal-Wallis tests) were carried out for interpretation using Statistica Software version 7.0, p-values <0.05 were considered to be statistically significant.

RESULTS AND DISCUSSION

Overall, most respondents (62%) were men age 40 to 60 years old. Although several jobs or trades were mentioned, fishing was their primary economic activity. Most fishermen have basic educational level only, but a few of them (4% in Atasta and 8% at La Puntilla) have completed higher-level studies. All respondents had heard of the Neotropical otter, referring to it as *perro de agua* (literally, water dog).

Sightings of otters were frequent (50% of the respondents in Atasta and 56% in Palizada); the most recent sighting occurred less than one month before the survey in Palizada. Elsewhere, sightings of Neotropical otters had been sporadic, separated by at least one year. Respondents from all the localities surveyed have the perception that sightings used to be more frequent in the past than they are now.

Most sightings occurred in areas around households or in fishing grounds. For instance, anglers from La Puntilla and Puerto Pesquero spotted otters at Palizada; fishermen of Isla Aguada saw otters in the Candelaria-Panlao lagoon system and the Palizada River (Fig. 3). Sightings were most frequent during the dry season. The respondents demonstrated a fairly extensive knowledge of the species and were able to identify all the activities of Neotropical otters (swimming and feeding), the time of day when the otters are active (during the morning until noon) and what they eat (fish and crustaceans).

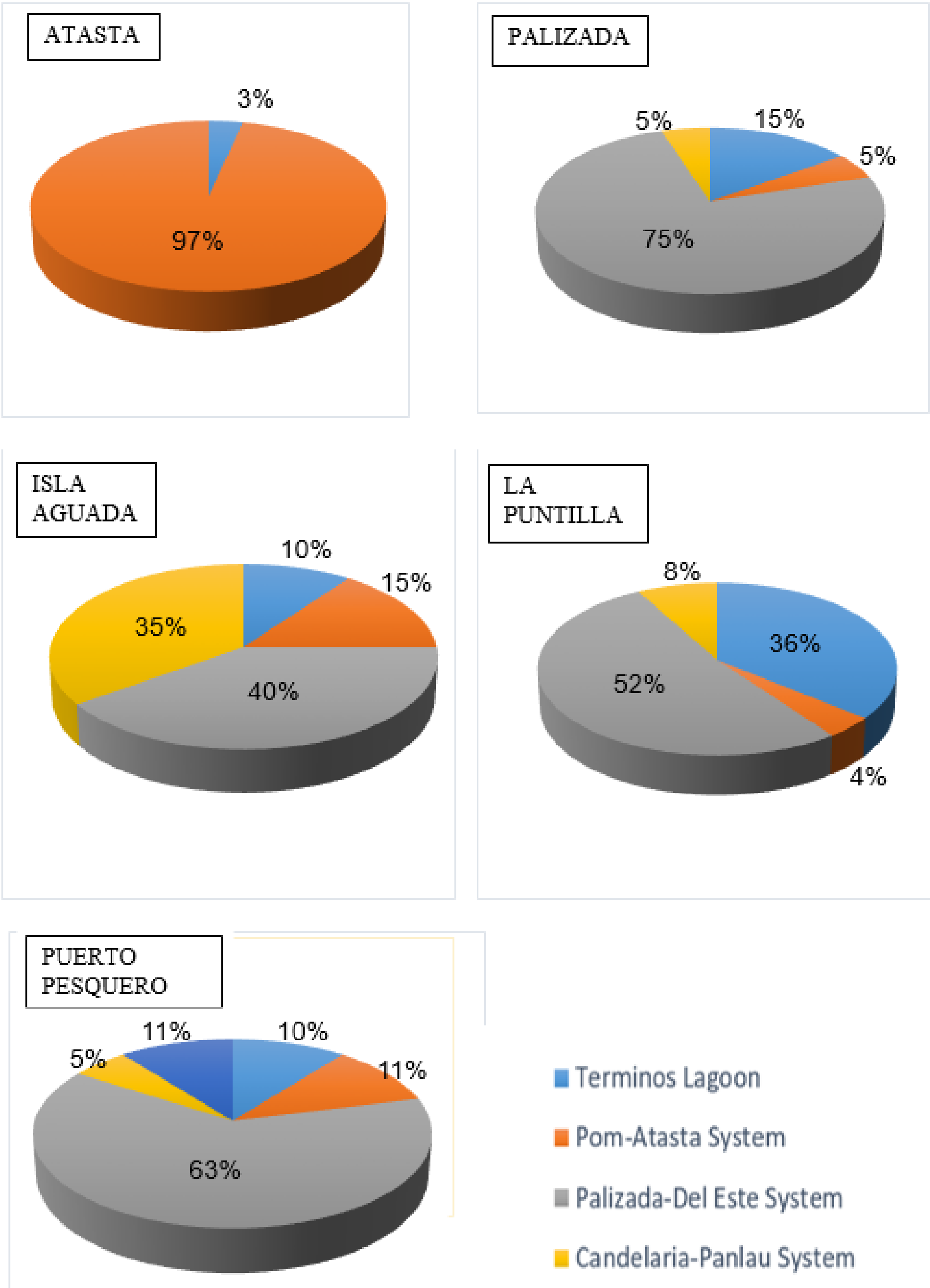

Figure 3. Localities where sightings of Neotropical otters have been recorded by local people in the *Laguna de Términos* protected area.

In most cases (56 to 73%), single otters were seen. Although groups of two or three individuals have been observed, in most cases females with calves were observed. Atasta (79%) and Palizada (62%) are the locations where group sightings have been recorded more frequently; there was a significant difference with the rest of the localities (H>0.05). Group sightings were recorded during the dry season.

Not all respondents were able to differentiate between otter sexes; however, those who were able (42%) took into account the following two criteria: body size and fur coloration, males are larger and darker than females (consistent with the criteria used by Gallo-Reynoso, 1989).

Respondents claimed to detect the presence of otters by their tracks (spraints and footprints) and by the location of the dens. This is consistent with reports in the literature describing that dens are usually constructed at the base of trunks (Gallo-Reynoso, 1989; Pardini and Trajano, 1999; Macías-Sánchez, 2003), in this case: mangrove swamp areas, amid the aerial roots of mangroves trees (Fig. 4).

Figure 4. Indirect evidence found in the *Palizada-Laguna de Términos* Lagoon within the APFFLT: Upper photographs, trunks used by the Neotropical otters. Lower photographs. spraints of Neotropical otters on tree trunks.

The majority of respondents (62% in Palizada, 96% in Atasta) live within the federal protected area and most of them (52% in Isla Aguada, 92% in Atasta) and are aware that the Neotropical otter is a species protected under the Mexican *Ley General de Vida Silvestre* (General Wildlife Law) for being a threatened species. However, there was a significant difference (H>0.05) between Isla Aguada and the other localities, where fewer people were aware of the conservation status of the otter (Fig. 5).

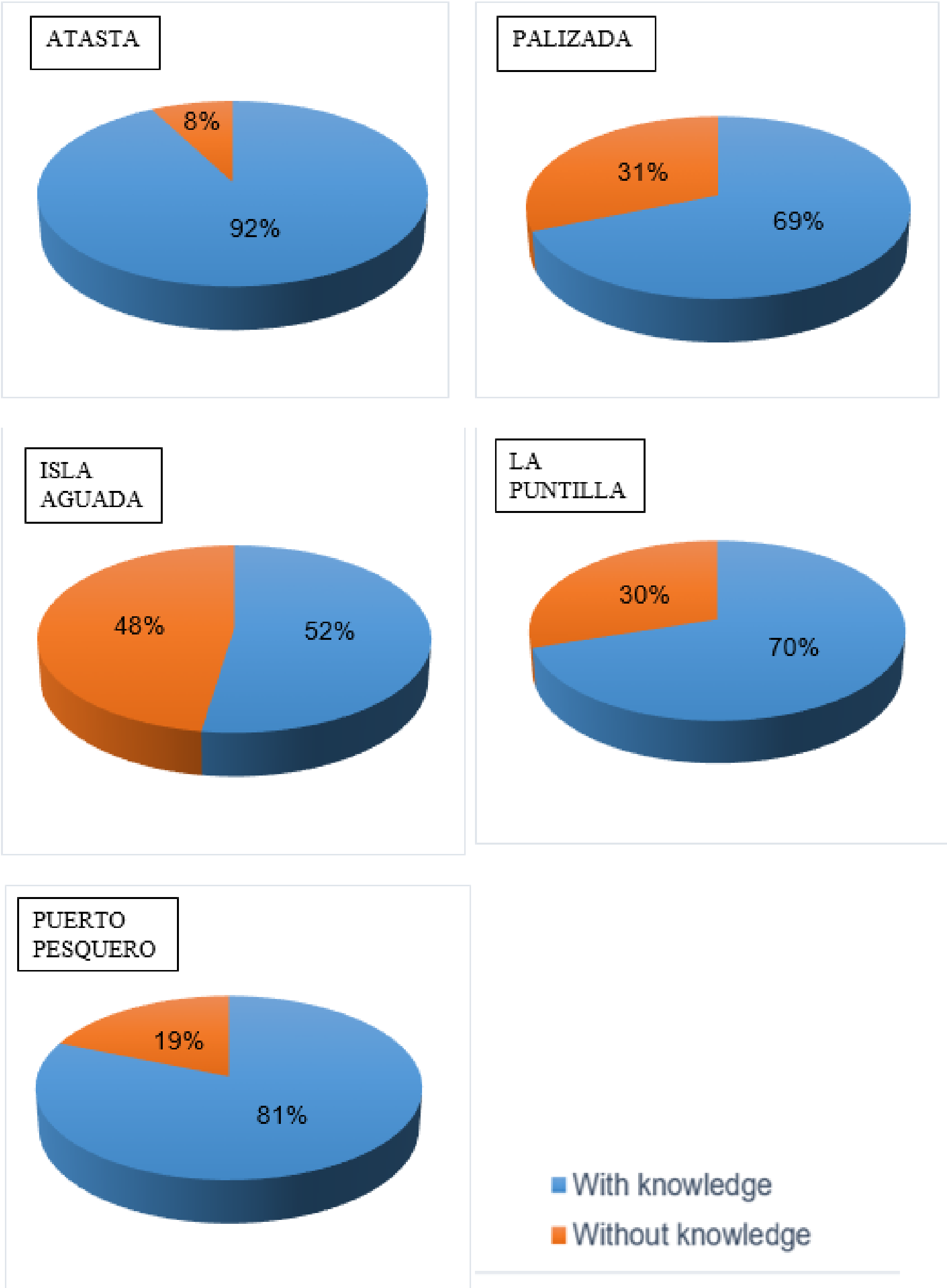

Figure 5. Knowledge on the conservation status of the Neotropical otter (Are you aware that this species is threatened with extinction?) in the four localities surveyed.

There was an ambivalent position on this regard, as this species is exploited as a resource to some extent in all localities. The respondents mentioned using the otter fur (94% in Palizada), having otters as pets (21 to 33 %), consuming the meat, or trading entire specimens (7% in La Puntilla and 11% in Puerto Pesquero). There are records of otter hunting, usually by shooting or setting traps with bow and bait hook.

Among the most significant finding of this surveys is that the majority of respondents (94 to100%) would support establishing a program for the conservation of the Neotropical otter, and they also expressed (45 to 92%) their willingness to attend workshops informing on otter conservation These findings can inform decision-making and actions to be taken for the protected area (APFFLT) to protect otters and their habitat. The respondents were also in favor (45 to 96%) of disseminating information so that the species can be protected in their locality and were willing (45 to 95%) to participate in the outreach efforts.

Isla Aguada was the locality that yielded the lowest percentages in all the aspects addressed in the questionnaire. When asked why they were in favor, the local respondents pointed out that there are a few otters (this locality is in a more coastal zone) and they cause no harm.

One of the factors assessed was whether the local community perceives a conflict of interest between their activities and the Neotropical otter. Interestingly, perception on conflict of interest ranged from nil to minor, with the highest percentage in Puerto Pesquero (25%). Some respondents mentioned that otters steal fish (37 to 50%) or break nets or traps (25 to 60%). In contrast, respondents from Isla Aguada reported 0% conflicts.

Another factor addressed that caught our attention was the perception of local residents on the actions to protect the Neotropical otter by the federal, state, or municipal authorities. In four of the five localities surveyed, it was mentioned that there is insufficient supervision (Atasta 54%; Palizada 56%; Isla Aguada 91%, and Puerto Pesquero 63%); Isla del Carmen-La Puntilla was the only location where 70% of respondents expressed that there is adequate supervision (Fig. 6). This information should be important for the authorities in charge of the reserve.

It is also important to know the characteristics of the local inhabitants, as these should be properly taken into account when designing strategies for the conservation of the Neotropical otters, particularly if environmental education activities are to be carried out as part of the otter conservation strategy. Most respondents have only elementary education; therefore, any documents to be used as part of environmental education activities should be easy to read and written in simple terms.

Since fishing is the main economic activity of the respondents and both humans and otters coexist in the same area, human interactions with otters are common. These interactions should be taken into account when updating the management program of the *Laguna de Términos* protected area, since both humans and otters exploit the same natural resources in the same fishing grounds.

One particular aspect that we aimed to investigate through the survey was whether there is any conflict of interest between humans and the Neotropical otter, as reported by Guerrero-Flores et al. (2013). This is an important aspect that should be addressed in any otter conservation program, as respondents consider that otters should be protected because they cause neither harm nor damages.

From the responses to the survey, it is clear that local inhabitants have a fair knowledge of otters; they provided candid responses and consistent information on the species. Many of them know some aspects of the otter biology: activities carried out by otters, time of the day when they perform them, what they eat, and places where they can be observed; local inhabitants are also able to detect the presence of otters through tracks (footprints). All the information provided was consistent with data reported by other authors for other regions within the distribution range of the Neotropical otter (Gallo-Reynoso, 1991, 1996, 1997; Casariego-Madorell, 2004; Briones et al., 2008; Briones-Salas et al., 2013; Duque-Dávila et al., 2013; Guerrero-Flores et al, 2013; Mayagoitia-González et al., 2013; Santiago-Platas et al., 2013). However, otter groups with more than two individuals were rarely seen.

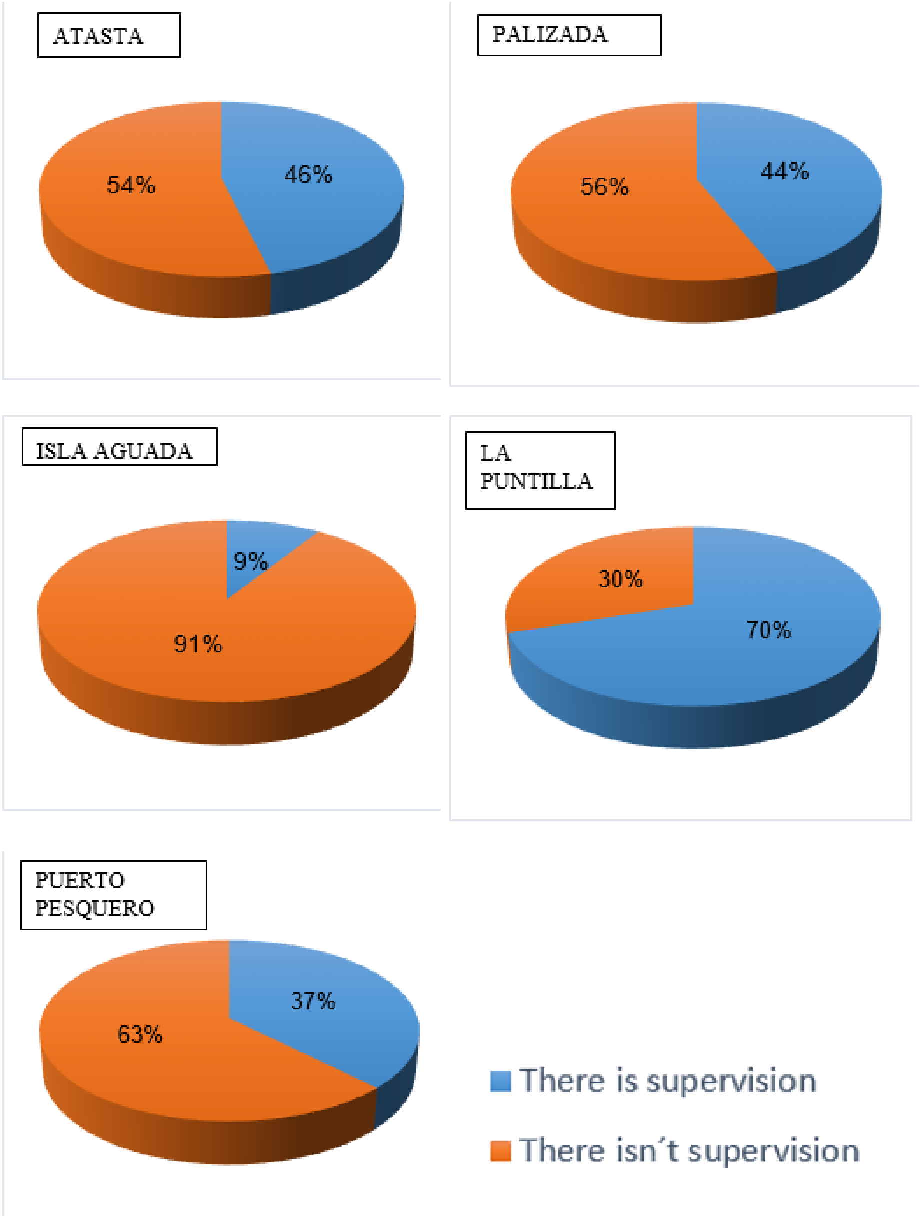

Figure 6. Perception of respondents about the enforcement of federal, state or municipal actions for the protection of the Neotropical otter, for each of the localities surveyed.

Gathering information on the Neotropical otter (*L. l. annectens*) in the *Laguna de Términos* protected area for flora and fauna by surveying local inhabitants helped to set the bases to formulate a comprehensive management program that strengthens the local conservation of the species and affects the conditions that should occur in the *Laguna de Términos* protected area to be considered for developing economic activities. Since 2003, the local government has been promoting tourism as a development economic activity alternative to oil production (Pat-Fernández and Calderón-Gómez, 2012).

The conditions in the *Laguna de Términos* protected area for developing ecotourism activities (such as boating, wildlife sighting, and kayaking) are very similar to those found in other areas such as the *La Vega Escondida* protected area in the State of Tamaulipas. In the latter, the approach proposed in the management program for conserving the Neotropical otter was to regard it as an "umbrella species" (Mayagoitia-González et al., 2013), emphasizing the functional links between otters and other species in the same ecosystem (Bifolchi and Lodé, 2005), because their presence is indicative of high energy availability and high biodiversity (Gallo- Reynoso et al., 2008). Mayagoitia-González et al. (2013) also highlighted the importance of convening outreach workshops to raise awareness on the importance of wetlands.

Macías-Sánchez (2003) mentions that otters are a bioindicator species of the ecosystems that can be used as tools for ecosystem conservation. In other words, a comprehensive management program should be formulated including the local inhabitants, where ecological benefits should include a viable habitat for the otter and social awareness on the Neotropical otter as an umbrella species for the conservation of entire ecosystems.

The Neotropical otter is also a charismatic species, attractive for zoos and considered as a keystone or flagship species (Soler, 2002). Flagship species enjoy sympathy of the general public; the intrinsic appeal of otters facilitate raising awareness about the importance for their conservation. The giant panda, seals, quetzals, and big cats are typical examples of flagship species. They are often included in the logos of organizations dedicated to wildlife conservation (INECC, 2013). A similar study carried out in the State of Veracruz focused on elucidating the conservation status of the species and proposed a program for the management of otter populations (Arellano-Nicolás, 2008).

The uses of the Neotropical otter in Campeche are mostly unknown. The few data available indicate that it has ornamental use (Gallo-Reynoso, 1997); there is also evidence of its use as pets, and its fur is used for manufacturing accessories such as wallets or belts (*obs. pers.*). Basic studies such as the one reported here provide useful information for planning and conducting further research on this species in the *Laguna de Términos* protected area.

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RÉSUMÉ

CONNAISSANCE ET PERCEPTION DE LA LOUTRE À LONGUE QUEUE (*Lontra longicaudis annectens*) PAR LES HABITANTS LOCAUX D'UNE RÉSERVE NATURELLE DANS L'ÉTAT DE CAMPECHE AU MEXIQUE

La loutre à longue queue est une espèce protégée en vertu de la loi Générale Mexicaine sur la faune sauvage des espèces menacées (NOM-059-ECOL-2010); elle est considérée comme presque menacée sur la Liste rouge de l'IUCN des espèces menacées et reprise à l'Annexe I de la CITES. La loutre à longue queue est mentionnée dans le programme de gestion de la réserve naturelle fédérale de *Laguna de Términos* mais est rarement mentionnée dans d'autres programmes de gestion des réserves naturelles du Mexique. Comme très peu d'études scientifiques menées dans l'État de Campeche font référence à la loutre à longue queue, nous avons mené une enquête auprès des habitants proches du réseau de la *Laguna de Términos* afin de connaître leurs avis sur cette espèce. Les données ont été récoltées de juin à octobre 2015 grâce à un questionnaire *ad hoc* appliqué à 101 habitants locaux. Nous avons posé des questions sur leurs connaissances empiriques de la biologie de la loutre à longue queue et leur perception du statut de l'espèce. Les données ont été résumées en termes de pourcentages et soumises à des analyses statistiques (tests de Kruskal-Wallis) comparatives et interprétatives. Nous avons constaté que les habitants locaux connaissent les loutres à longue queue et ont fourni des informations sincères et cohérentes. Ils ont montré une certaine ambivalence quant à la protection de l'espèce: bien qu'ils aient reconnu l'état de conservation de l'espèce, ils ont également admis que la loutre est parfois exploitée (chassée pour sa fourrure) comme source de revenus. La plupart des personnes interrogées (94-100%) ont soutenu le concept d'un plan de conservation. Ces informations devraient être prises en compte lors de la planification et de la mise en œuvre des activités d'écotourisme dans la réserve naturelle de la *Laguna de Términos*.

RESUMEN

Conocimiento Y Percepción De La Nutria Neotropical *(Lontra Longicaudis Annectens)* Por Los Habitantes Locales De Un Área Protegida En El Estado De Campeche, México

La nutria neotropical es una especie protegida por la Ley General de Vida Silvestre en la NOM-059-ECOL-2010 y está incluida en la Lista Roja de Especies Amenazadas de la UICN y en el Apéndice I de la CITES. Esta especie se menciona en el Programa de Manejo del Área de Protección Flora y Fauna Laguna de Términos, a diferencia de otros programas de manejo del país en que raramente se menciona. Una exhaustiva revisión bibliográfica para el Estado de Campeche mostró que hay poca investigación de esta especie, por lo que se hizo una encuesta entre los habitantes de las márgenes de la Laguna de Términos. La encuesta recopiló información sobre el conocimiento empírico de los residentes locales sobre la nutria neotropical, así como la percepción sobre su estado actual. La encuesta se aplicó de junio a octubre de 2015 a 101 residentes locales; los resultados se expresaron en términos de porcentajes y se hicieron análisis estadísticos (pruebas de Kruskal-Wallis) para su interpretación. Se encontró que los pobladores conocen ampliamente esta especie y proporcionaron datos verídicos y congruentes. Se detectó una posición ambivalente en cuanto a la protección de la especie, ya reconocen su estatus de conservación, pero ocasionalmente aprovechan la nutria neotropical como recurso (caza por piel). Sin embargo, la gran mayoría (94-100%) de los pobladores están a favor de establecer un plan para su conservación. Es importante considerar esta información al planificar e implementar actividades ecoturísticas dentro del Área de Protección de Flora y Fauna Laguna de Términos.

A R T I C L E

VASCULARIZATION OF THE AORTIC ARCH IN NEOTROPICAL OTTER (*Lontra longicaudis*, OLFERS 1818)

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Abstract: *Lontra longicaudis* is a semi-aquatic carnivorous mammal that belongs to the Mustelidae family and Lutrinae subfamily. It is found in South and Central America, from southern Mexico to Uruguay and up to 3,000 m altitude. In this study, vascularization of the aortic arch is described in the neotropical otter. Eight animals were studied, three puppies and five adults from the Otter Project of the Instituto Ekko Brasil. The results indicate that the brachiocephalic trunk and the left subclavian artery originated from the aortic arch in all animals studied. This pattern is similar to that found in wild and domestic carnivores. The brachiocephalic trunk arises three arteries, the left common carotid artery, the right common carotid artery, and the right subclavian artery, the latter two being emitted from a common trunk. The right and left subclavian arteries give origin to five vessels represented by the vertebral artery, the superficial cervical artery, the internal thoracic artery, the costocervical trunk, and the axillary artery.

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INTRODUCTION

Despite numerous publications on *Lontra longicaudis*, there is still little information about its anatomy, morphology and physiology. Most studies concern the diet (Quadros and Monteiro-Filho, 2001; Uchôa et al., 2004; Quintela et al., 2008; Carvalho-Junior et al., 2010a, 2010b; Rheingantz et al., 2011), conservation status (Rodrigues, 2013) or the geographic distribution (Carvalho-Junior et al., 2012).

Energy analysis and economic evaluation of the otter was carried out by Carvalho Junior (2016). Knowledge of morphological aspects is essential in determining diversity, adaptation, and intra-specific variability. This work aims to investigate the origin of the collateral branches of the aortic arch.

The circulatory system is responsible for transporting blood through tissues, bringing oxygen and nutrients to different areas of the body, and collecting the carbon dioxide that results from cellular metabolites. The aortic artery is the main vessel that distributes arterial blood to all systems. The head, neck, chest cavity, and chest organs are supplied with blood from the arteries that emerge from the aortic arch. Knowing the distribution and behavior of the arteries that originate from the aortic arch contributes to the understanding of the morphology, compared anatomy, and the clinic and surgery of wild animals.

The origin of the collateral branches that emerge from the aortic arch assumes a varied disposition between domestic and wild animals. These variations are already well described (Nickel et al., 1981; Sisson et al, 1975; Barone, 2010; Dyce et al., 2017; König and Liebich, 2020).

Studies with several species have shown a varied disposition in distributing the arteries that emerge from the aortic arch in wild animals. Among the species studied, *Agouti paca* (Oliveira et al., 2001), *Didelphis albiventris* (Reckziegel et al., 2003, Schimming et al., 2016), *Chinchilla lanigera* (Araújo et al., 2004), *Hydrochoerus hydrochaeris* (Culau et al., 2007), *Kerodon rupestris* (Magalhães et al., 2007), *Lepus europaeus* (Brudnicki et al., 2007), *Myocastor coypus* (Campos et al., 2010), *Mazama gouazoubira* (Schimming et al., 2012), *Tamandua tetradactyla* (Pinheiro et al., 2012), *Ozotoceros bezoarticus*, *Mazama gouazoubira* and *Axis axis* (Perez and Erdogan, 2014), *Galea spixii* (Oliveira et al., 2015), and *Callithrix penicillata* (Souza Neto et al., 2019).

Publications with *Procyon cancrivorus* (Santos et al. 2004), *Leopardus pardalis* (Martins et al., 2010), *Mustela* sp. (Quesenberry and Carpenter, 2012; Fox and Marini, 2014), *Cerdocyon thous* (Engel et al., 2013; Lima et al., 2016), and *Lontra canadensis* (Baitchman and Kollias, 2020), demonstrate that the origin of the collateral branches of the aortic arch maintains the same pattern observed for domestic carnivores. However, there are some variations between species, as Engel et al. (2013) mentioned for *Cerdocyon thous*.

METHODS

This study was conducted at the Animal Refuge Research Laboratory of the Instituto Ekko Brasil in partnership with the Wild Animals Research Laboratory at the Federal University of Santa Catarina (LAPAS/UFSC). The project's methodology for processing otters was authorized by the Animal Use Ethics Committee (CEUA/UFSC), process 23091.001975/10-24. Eight *Lontra longicaudis* were used, three female offspring, one adult male, and four adult females. All animals are part of the scientific collection of Instituto Ekko Brasil and were found dead by residents, run over by cars, drowned in fishing traps, or retaliation by fishermen, and stored at -20 °C until necropsies were performed.

The animals were thawed, and the left common carotid artery was cannulated to fill the arterial vascular system with Latex Neoprene 450, stained in red. Subsequently, the animals were fixed in a 10% aqueous formaldehyde solution. After fixation, specimens were dissected, and access to the thoracic cavity was done through the lateral opening of the ribs and the sternum's removal.

The adjacent structures were dissected, and the vessels were identified. Schematic drawings were made for each vascular system, and the most representative specimen photographed for documentation. The study was based on the nomenclature adopted by the International Committee on Veterinary Gross Anatomical Nomenclature (2017).

RESULTS

In the eight animals studied, the brachiocephalic trunk represented the first branch of the aortic arch, followed by the left subclavian artery as independent branches (Fig. 1). The branches originating from these arteries also did not show variations between the analyzed specimens.

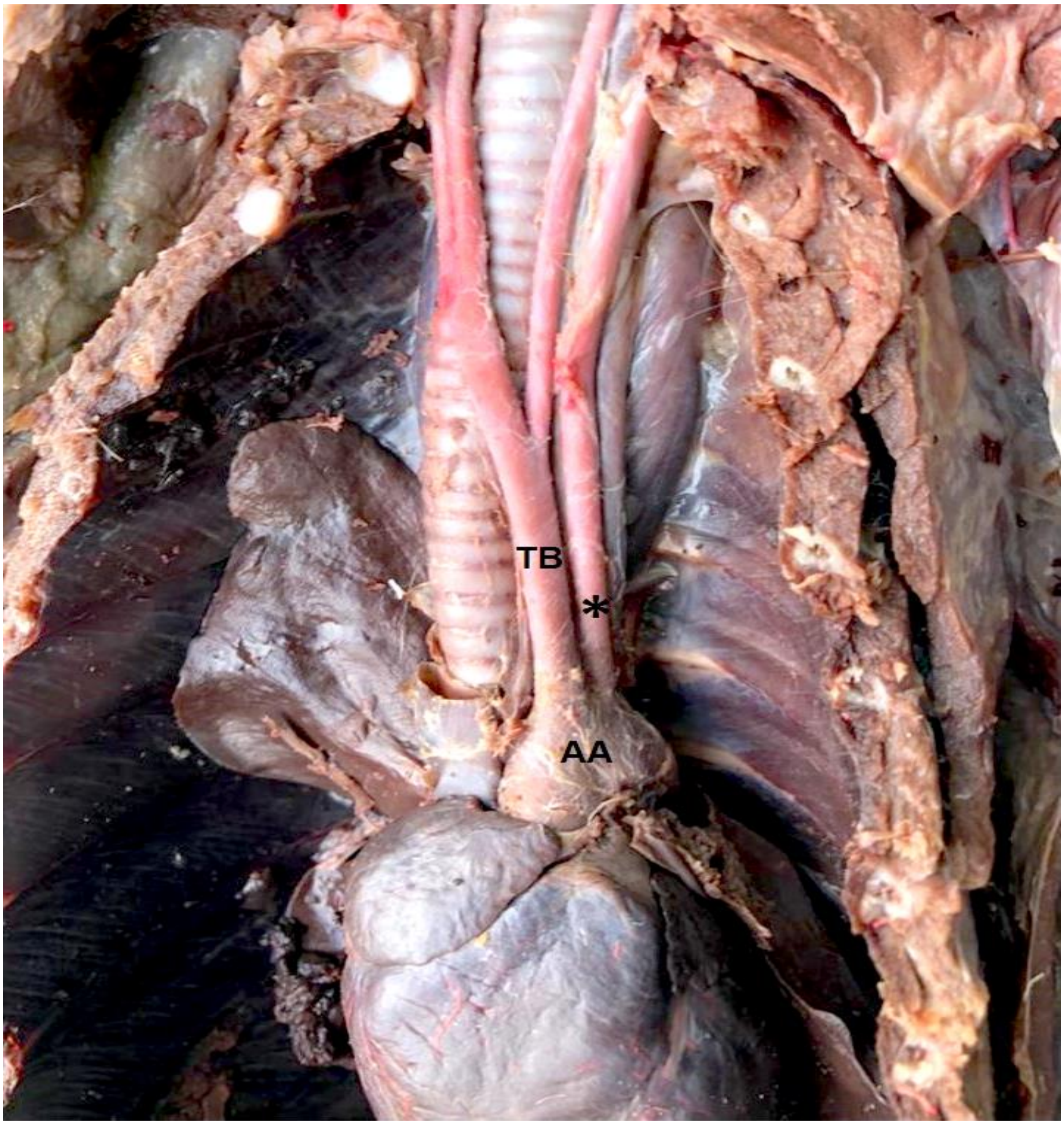

Figure 1. View of the aortic arch and its branches. AA - Aortic arch; TB - Brachiocephalic trunk; *Aa. Subclavian artery

The internal thoracic artery appeared at the level of the first intercostal space, inside the thoracic cavity, and advanced in the caudoventral direction towards the sternum and transverse muscle of the chest. At the chest entrance, the right and left subclavian arteries branched into two arteries, the superficial cervical artery that supplies the cervical musculature's ventrolateral surface, and the axillary artery that supplies the muscles of the thoracic limbs.

The brachiocephalic trunk followed cranially over the trachea's ventral face and emitted three branches, the left common carotid artery, the right common carotid artery, and the right subclavian artery.

In all specimens studied, the left common carotid artery was the first branch emitted by the brachiocephalic trunk, followed by the formation of a common trunk that originated the right common carotid artery and the right subclavian artery at the level of the first intercostal space, in the right antimere of the thoracic cavity (Fig. 2).

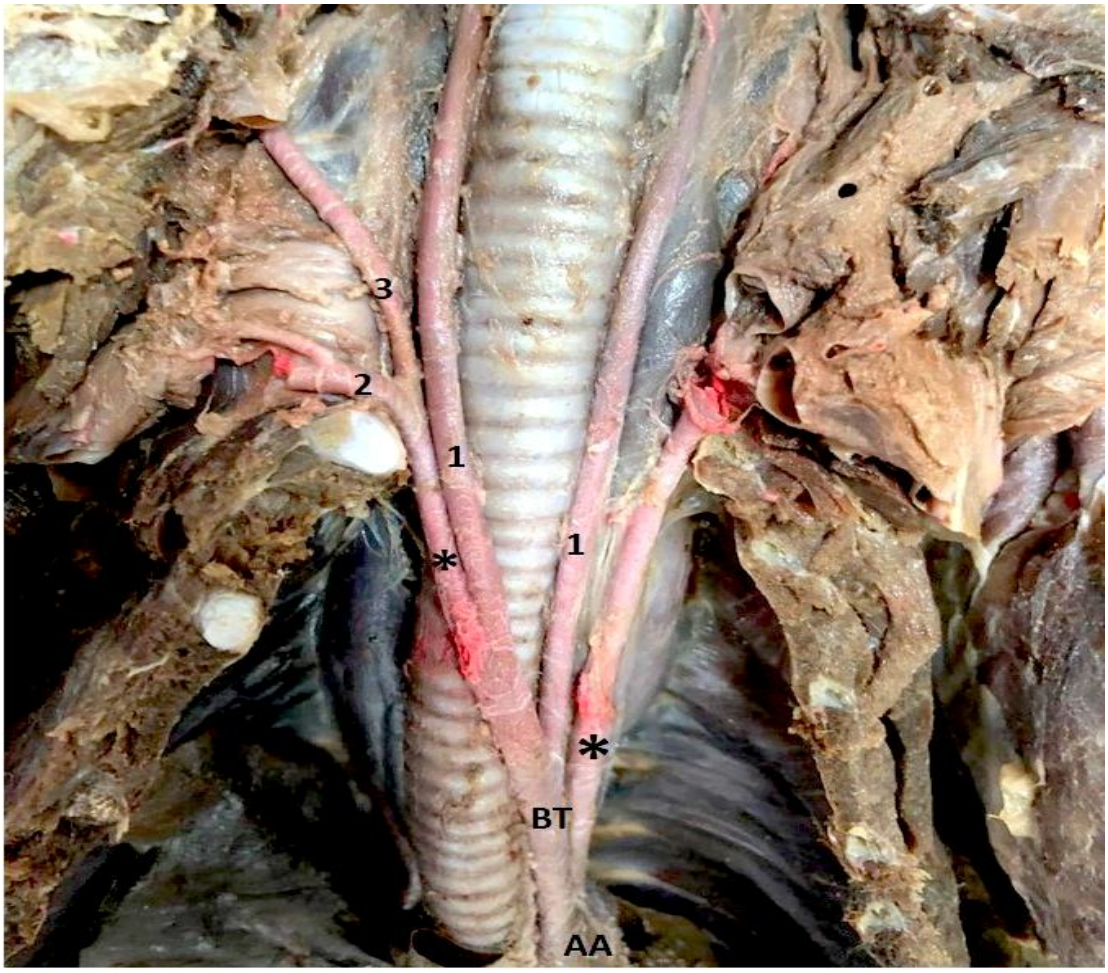

Figure 2. View of the brachiocephalic trunk and its branches. 1- common carotid artery; 2- axillary artery; 3 - superficial cervical artery; AA - aortic arch; BT - brachiocephalic trunk; * subclavian artery.

In the eight animals analyzed the right and left subclavian arteries emitted five branches: the vertebral artery, the costocervical trunk, the internal thoracic artery, the superficial cervical artery, and the axillary artery (Fig. 3).

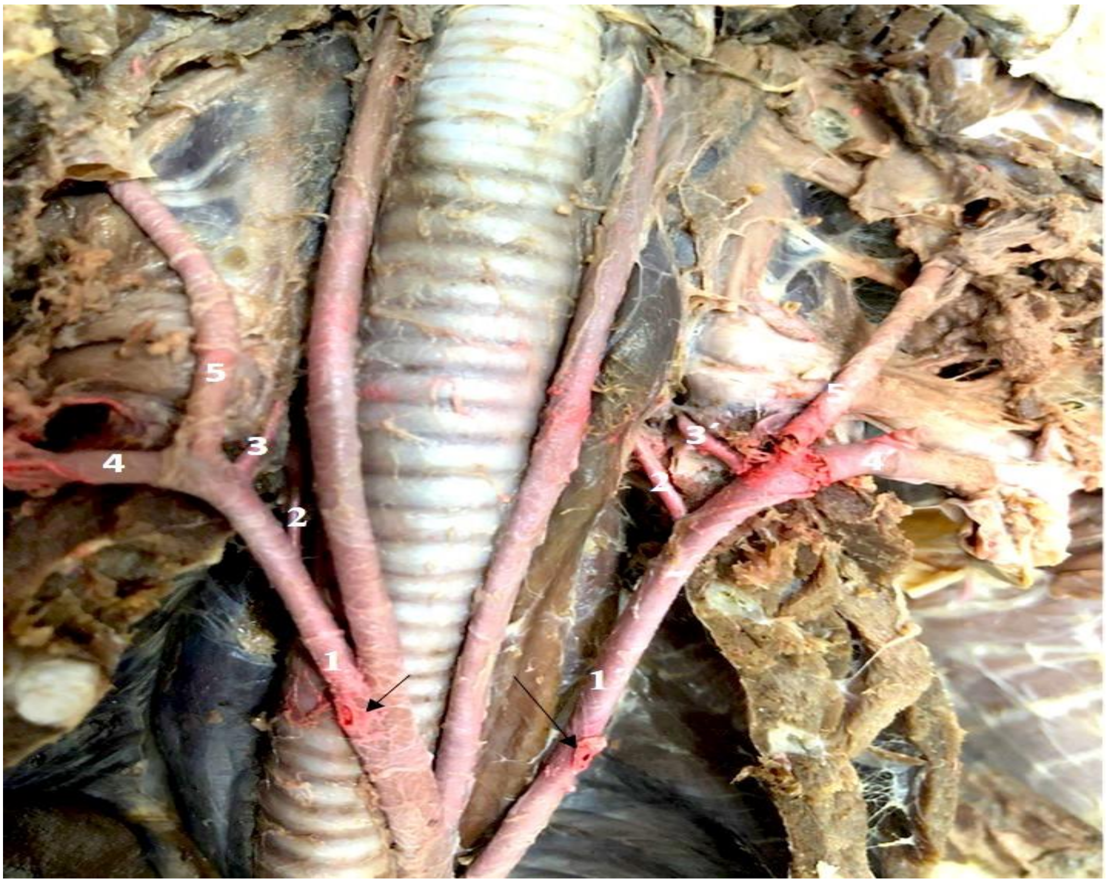

Figure 3. View of the subclavian arteries and their branches. 1 - right subclavian artery; 1' - left subclavian artery; arrows - right internal thoracic artery; 2 - right vertebral artery; 2' - left vertebral artery; 3 - right costocervical trunk; 3' - left costocervical trunk; 4 - right axillary artery; 4' - left axillary artery; 5 - right superficial cervical artery; 5' - left superficial cervical artery.

The vertebral artery went craniodorsally towards the cervical vertebrae. The costocervical trunk originated from the subclavian right after the vertebral artery and proceeded to the cervical region's dorsal muscles and the chest (Fig. 4).

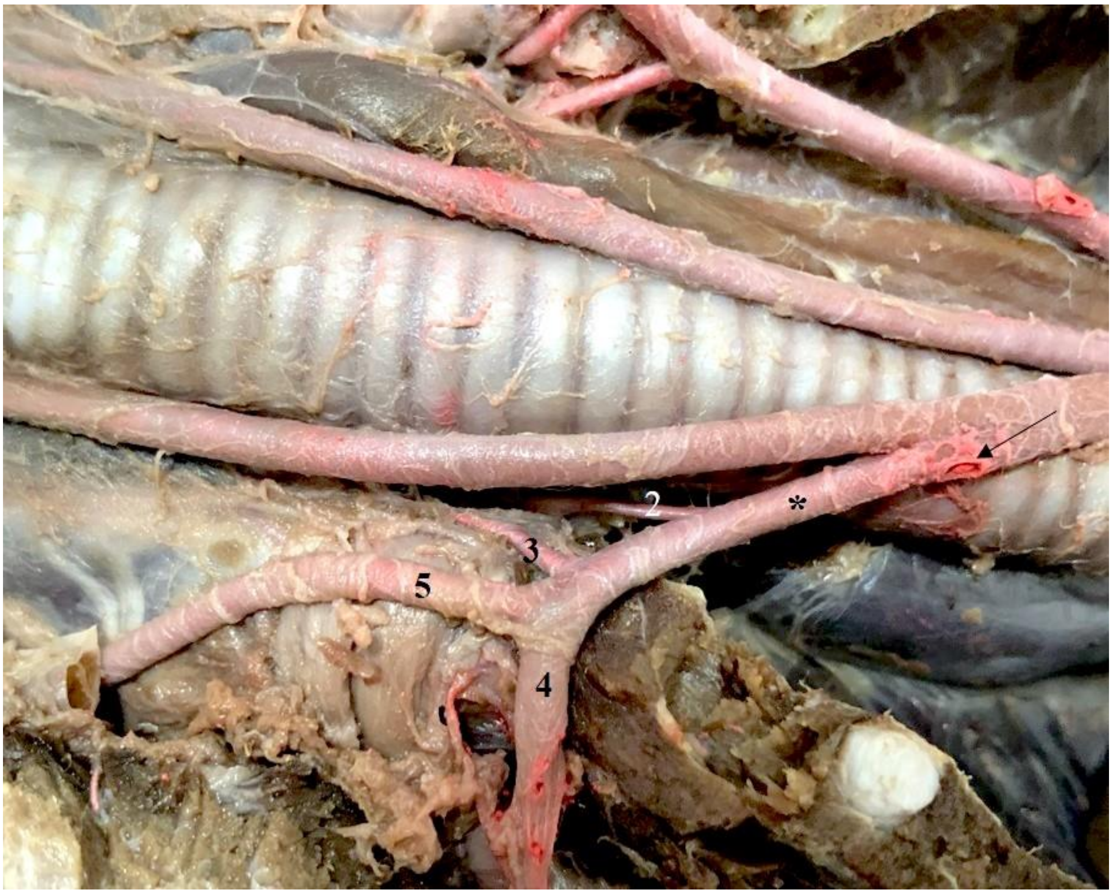

Figure 4. View of the right subclavian artery and their branches in the cranial part of the thoracic cavity. *1 - right subclavian artery; arrow - right internal thoracic artery; 2 - right vertebral artery; 3 - right costocervical trunk; 4 - right axillary artery; 5 - right superficial cervical artery.

DISCUSSION

The study of anatomy in domestic animals shows that the origin of the vessels that emerge from the aortic arch varies according to species, and the same occurs in wild animals. Considering the carnivorous order, the treatises on animal anatomy (Nickel and Seiferle, 1981; Sisson et al, 1975; Barone, 1996; Dyce et al., 2019; König and Liebich, 2020), describe that the aortic arch gives rise to the brachiocephalic trunk and then to the left subclavian artery. This same disposition was verified in this study, as well as in *Lontra canadensis* (Baitchman and Kolle, 2000), in *Procyon cancrivorus* (Santos et al., 2004), in *Mustela* sp. (Fox and Marini, 2014; Quesenberry and Carpenter, 2020) *Leopardus pardalis* (Martins et al., 2010), and in *Cerdocyon thous* (Lima et al., 2016).

With the results obtained in this work, it is possible to suggest a pattern in the origin of the vessels that emerge from the aortic arch in carnivores, whether wild or domestic, although variations may occur. Example for such variation are cases mentioned by Culau et al. (2004), when they reported the ectopic origin of the right subclavian artery and the bicarotid trunk in a dog, and by Engel et al. (2013) studying *Cerdocyon thous*, originating from a bicarotid trunk in the aortic arch.

In the neotropical otter, the origin and disposition of the arteries in the brachiocephalic trunk is following that described for domestic carnivores (Sisson et al, 1985; Nickel et al., 2010; Dyce, 2017; König and Liebich, 2020), where the brachiocephalic trunk first originates the common carotid artery left and posteriorly the right common carotid arteries and the right subclavian artery.

A study carried out with *Leopardus pardalis* (Martins et al., 2010) presented these same results. However, Santos et al. (2004), studying a specimen of *Procyon cancrivorus*, report that the brachiocephalic trunk of this species undergoes a trifurcation at the level of the first intercostal space, in the left antimere of the thoracic cavity, originating the left and right common carotid arteries, and the right subclavian artery. Indeed, Sisson et al (1975) mentions that the brachiocephalic trunk may present this trifurcation in domestic carnivores.

In *Cerdocyon thous* (Lima et al. 2016), the brachiocephalic trunk first originated the right subclavian artery and followed in a bicarotid trunk typical right and left carotid arteries. Filho and Borelli (1970), in a study with 240 cats (*Felis catus domestica*), reported that 75 animals showed the formation of the bicarotid trunk.

Wild carnivores work evidenced the dispositions described in the treatises of animal anatomy and comparative anatomy for the origin of the vessels' brachiocephalic trunk in domestic carnivores. The arrangement found in *Lontra longicaudis* and *Leopardus pardalis* were the same as those mentioned for domestic animals. These animals have a standard trunk between the right common carotid and right subclavian arteries after the left common carotid artery's origin.

In the carnivorous order such as *Lontra canadensis* (Baitchman and Kollias, 2020), *Leopardus pardalis* (Martins et al., 2010) and *Cerdocyon thous* (Lima et al., 2016), the subclavian arteries gave rise to the collateral branches: vertebral artery, costocervical trunk, internal thoracic artery, superficial cervical artery and axillary artery, the same branches found in our study. This same origin was also mentioned in *Mustela* sp. (Fox and Marini, 2014; Quesenberry et al., 2020). However, Santos et al. (2004) did not mention the vertebral artery and the axillary artery as branches originating from the subclavias in *Procyon cancrivorus*. Our results align with what is described in the literature for dogs and cats (Filho and Borelli, 1970; Sisson et al, 1975; Dyce et al., 2019; König and Liebich, 2020).

This work describes the organization of the branches that originate from the aortic arch in a neotropical otter and notes that the origin of these vessels is similar to that described for domestic carnivores, and for wild carnivores. In carnivores in general, the brachiocephalic trunk and the left subclavian artery emerge directly from the aortic arch. Thus, we can conclude that this pattern of origin of vascularization of the aortic arch is shared, both for domestic carnivores and wild carnivores.

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RÉSUMÉ

VASCULARISATION DE L’ARC AORTIQUE CHEZ LA LOUTRE À LONGUE QUEUE (*Lontra longicaudis,* OLFERS 1818)

Lontra longicaudis est un mammifère carnivore semi-aquatique appartenant à la famille des *Mustelidae* et à la sous-famille des *Lutrinae*. On la trouve en Amérique du Sud et en Amérique centrale, du sud du Mexique à l'Uruguay, jusqu'à 3000 m d'altitude. Dans cette étude, la vascularisation de l'arc aortique est décrite chez la loutre à longue queue. Huit animaux ont été étudiés, trois loutrons et cinq adultes du Projet Loutre de l'Institut Ekko Brasil. Les résultats indiquent que le tronc brachiocéphalique et l'artère sous-clavière gauche provenaient de l'arc aortique chez tous les animaux étudiés. Cet agencement est similaire à celui trouvé chez les carnivores sauvages et domestiques. Le tronc brachiocéphalique provient de trois artères: l'artère carotide commune gauche, l'artère carotide commune droite et l'artère sous-clavière droite, les deux dernières étant émises par un tronc commun. Les artères sous-clavières droite et gauche donnent naissance à cinq vaisseaux représentés par l'artère vertébrale, l'artère cervicale superficielle, l'artère thoracique interne, le tronc costocervical et l'artère axillaire.

RESUMEN

VASCULARIZACIÓN DEL ARCO AÓRTICO EN LA NUTRIA NEOTROPICAL (*Lontra longicaudis*, OLFERS 1818)

Lontra longicaudis es un mamífero carnívoro semi-acuático que pertenece a la familia Mustelidae y la subfamilia Lutrinae. Se encuentra en América del Sur y Central, desde Mexico hasta Uruguay y hasta 3.000 m de altitud. En este estudio, se describe la vascularización del arco aórtico en la nutria neotropical. Se estudiaron ocho animales, tres crías y cinco adultos, del Proyecto Nutria del Instituto Ekko Brasil. Los resultados indican que el tronco braquiocefálico y la arteria subclavia izquierda se originaron en el arco aórtico en todos los animales estudiados. Este patrón es similar al encontrado en carnívoros silvestres y domésticos. El tronco braquiocefálico origina tres arterias, la arteria carótida izquierda común, la arteria carótida derecha común, y la arteria subclavia derecha, siendo las dos últimas emitidas a partir de un tronco común. Las arterias subclavia derecha e izquierda dan origen a cinco vasos respresentados por la arteria vertebral, la arteria cervical superficial, la arteria torácica interna, el tronco costocervical, y la arteria axilar.

RESUMO

VASCULARIZAÇÃO DO ARCO AÓRTICO EM LONTRA NEOTROPICAL (*Lontra longicaudis*, OLFERS 1818)

Lontra longicaudis é um mamífero carnívoro semiaquático que pertence à família Mustelidae e à subfamília Lutrinae. É encontrada na América do Sul e Central, do sul do México ao Uruguai e até 3.000 m de altitude. Neste estudo, a vascularização do arco aórtico é descrita na lontra neotropical. Foram estudados oito animais do Projeto Lontra do Instituto Ekko Brasil, sendo três filhotes e cinco adultos. Os resultados indicam que, em todos os animais estudados, o tronco braquiocefálico e a artéria subclávia esquerda originam-se do arco aórtico. Este padrão é semelhante ao encontrado em carnívoros selvagens e domésticos. O tronco braquiocefálico origina três artérias, a artéria carótida comum esquerda, a artéria carótida comum direita, e a artéria subclávia direita, sendo as duas últimas emitidas a partir de um tronco comum. As artérias subclávias direita e esquerda dão origem a cinco vasos representados pela artéria vertebral, a artéria cervical superficial, a artéria torácica interna, o tronco costocervical e a artéria axilar.

OSG MEMBER NEWS

New Members of OSG

Since the last issue, we have welcomed 10 new members to the OSG: you can read more about him on the Members-Only pages.

Maila Cicero, Italy: Beginning with working with otters in Cumiana Zoo, Turin, and then surveying the small otter population in Calabria, I went to Mongolia to work on a camera trapping project in Arkhangai Forest. I plan to return to look at tter spatial behaviors in Northern Mongolia, with a focus on habitat requirements and the influence of anthropogenic disturbance

Dan Forman, UK: I am currently an Associate professor at Swansea University and a Senior Fellow of the Higher Education Committee. As well as my teaching and management leadership roles I also have a wide range of research interest including pollination, wildlife disease, animal welfare, wetland ecology and conservation, and carnivore ecology and conservation. I am particularly interested in the functional roles of otters in the landscape, niche partitioning, disease / parasites of otters, and the coastal ecology and conservation of Lutra lutra in Britain. I am working with Carol Bennetto on producing educational and outreach materials focussed on otters.

Simone Lampa, Germany: My area of interest is in using and developing genetic methods to receive important data about the otter such as population size, density, population dynamic, distribution, genetic origin, etc. to help to protect the species and to help in the conciliation process between species protection and stakeholder interests.

Twinamasiko Luke, Uganda: I am currently coordinating an otter project in Uganda, and am the Founder and CEO of Joint Efforts for Green Mountain Initiative Uganda, a non-governmental organization with an ultimate goal of promoting peaceful coexistence of people and wildlife through environmental conservation, climate change mitigation, adaptation, action to promote ecosystem integrity and resilience.

Carol Peterson, USA: As an artist focused on endangered species, the river otter has been the ideal symbol to influence and encourage societies to conserve the integrity and biodiversity of nature. I was the founder of The River Otter Alliance non-profit organization along with John C. Mulvihill Esq. and biologists Leslie Malville, Joe Powell and scientific advisor Paul Polechla Ph.D.in 1991, served as the first president and on the ROA board for 22 years. We published the River Otter Journal for 22 years with the extraordinary assistance of many research scientists, biologists, wildlife officials, rehabilitators, and otter enthusiasts. As well as my many artistic, interpretive and educational roles, I also participate in field studies and collecting camera data where needed.

Aurobindo Samal, India: I have been passionate about animal welfare, wildlife rescue and conservation since I was a child. My whole motto is co-existence with all wildlife. At first, my focus was snake rescue, but I and my friends soon branched out to help all animals, wild and domestic. Our non-profit organisation, ECO (Earth

Crusaders Organisation), is part of the Emergency Relief Network (ERN) launched by the Wildlife Trust of India (WTI) in partnership with the International Fund for Animal Welfare (IFAW), and also work with the Forest Department. We ran the first community-based conservation project in Odisha, and continue to engage local people on conservation; we have succeeding in mitigating or removing most of the otter-human conflict occuring, and convinced local people of the importance of smooth-coated otters.

Utthamapandian, India: I am currently working on the distribution, habitat selection, food and feeding habits, and mapping of hotspots, of Smooth coated otters in Tamil Nadu coastal ecosystems, particularly in the Cuddalore and Nagapattinam districts, and developing a GIS product identifying otter hotspots for targeting conservation efforts.

Andrew Upton, USA : I am a visual storyteller and a semi-professional wildlife conservation photographer. My long term project explores Japanese people's relationship with otters, and my current focus is on the recent "otter boom" and how otter cafes in Japan facilitate the global illegal otter trade. Professionally, I work as an assistant producer at the US office of one of Japan's leading animation studios developing projects for TV and Film. My photography and my work in the entertainment industry have given me a unique global perspective and visual storytelling skills that I am using to further otter conservation

Brendan Wenzel, USA: I am an author and illustrator of books for children (almost always about animals), and I would be more than happy to share my existing otter images, or create new work to suit your needs. Looking through a wider lens, however, I am also very interested in exploring the space where conservation overlaps with art, design, storytelling, and education. I am passionate about connecting people with animals on a deeper level, and I have some thoughts and projects in the works I'd be keen to connect about.

Clarence Wright, USA: I am a retired Zoo and Aquarium Industry man. In the late 1970s, I contributed to the development of the OSG Management Plans for captive otters. I had two non-releasable North American Otters in my home for 21 years and have always been involved with the conservation of otters where ever they are. Currently, I am working on a second master's degree at Oklahoma State University in Stillwater,Oklahoma, in the Department of Natural Resources Ecology and Management. My research focus is on assessing the current population of River Otters (Lontra canadensis) in eastern Oklahoma.