NOTE FROM THE EDITOR

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Dear Friends, Colleagues and Otter Enthusiasts!

So, we have recently closed issue 41/4 of this year and open the last issue 41/5 which soon will be complete online. It will take a few weeks into 2025 to get this last issue online. We decided to keep the originally communicated issue number so as not to create issues for the authors that were already informed about this delay.

I want to again address one problem I have observed: once or twice every year, it seems that some manuscript submissions never reach me. They are not in the spam folder and not in my inbox. Therefore, I had already for some time adopted the habit of always sending a confirmation mail once I see a submission. I am online almost every day, checking the Bulletin e-mails. Please keep in mind that if you do not get a confirmation from me, please send a second mail without any attachment and ask me about the status. In the few days, we had a case in which the authors waited almost two months before they asked about their paper. I know that we all want our publications to go online as soon as possible, so please ask within a week maximum.

It is no surprise that I end my editorial by thanking Lesley for all the time and efforts she invests into this project, which is still growing and asks more and more time and dedication. We have the 5th issue this year so you can all imagine how much work this is.

R E P O R T

FORGOTTEN BUT NOT GONE: REDISCOVERY OF EURASIAN OTTER *Lutra lutra* IN LANTAU, HONG KONG

Michael Ka Yiu HUI[1], Aiko K.Y. LEONG[1], Huarong ZHANG[2], Feng YANG[2], Ho Yuen YEUNG[1], Yik Fui Philip LO[1], Jian-Huan YANG[1*]

[1]*Kadoorie Conservation China, Kadoorie Farm and Botanic Garden, Lam Kam Road, Tai Po, New Territories, Hong Kong SAR, China*
[2]*Flora Conservation Department, Kadoorie Farm and Botanic Garden, Lam Kam Road, Tai Po, New Territories, Hong Kong SAR, China*
**Corresponding author: jhyang@kfbg.org*

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Abstract: Since its rediscovery in the 1980s in Hong Kong, the Eurasian Otter (*Lutra lutra*) has only been recorded sporadically and mostly confined to the Inner Deep Bay area in northwestern New Territories. Here, we present a spraint record collected from an islet of the Brothers Marine Park in northern Lantau waters in February 2024, which has been subsequently confirmed by molecular analysis. Our discovery represents the first verifiable evidence of otter presence in Lantau waters and largely extends its current known range in Hong Kong, bringing new hope for this locally critically endangered species. This finding highlights the urgent need for a more extensive search of suitable habitats in a broader area in order to assess the current distribution and status of the otters in Lantau and wider Hong Kong.

Citation: Hui, M.K.Y., Leong, A.K.Y., Zhang, H., Yang, F., Yeung, H.Y., Lo, Y.F.P., and Yang, J.-H. (2024). Forgotten but not Gone: Rediscovery of Eurasian Otter *Lutra lutra* in Lantau, Hong Kong. *IUCN Otter Spec. Group Bull.* **41** (4): 235 - 240
Keywords: carnivores, conservation, endangered species, Pearl River Delta, South China, urban wildlife

INTRODUCTION

The Eurasian Otter (*Lutra lutra*) is a globally Near Threatened species that is widely distributed across the Palearctic and Oriental regions, from western Europe and North Africa to the North Pacific and Southeast Asia (Loy et al., 2022). During the past decades, the European population has been recovering to some degree from historical declines caused by water pollution and habitat degradation, but it is still threatened in most of Asia and accurate population data are lacking for many countries (Loy, 2018; Basnet et al., 2020).

In China, the species has undergone a severe reduction in range and abundance since the 1950s–1980s due to sustained nationwide hunting, habitat loss, water pollution and prey reduction (Han and Shi, 2019; Li and Chan, 2018; Zhang et al., 2018). Within the Hong Kong Special Administrative Region (hereafter Hong Kong), it was once widespread along the coastal lowlands but the numbers started to decline in the 1930s (Hui and Chan, 2024). Despite being legally protected since 1936 in Hong Kong, the otters have nonetheless faced increasing anthropogenic pressures and were once thought to be extinct because of rapid urban development and uncontrolled human disturbance (Marshall and Phillips, 1965; Lance, 1976). Since its rediscovery from Mai Po Nature Reserve in the 1980s, this elusive species has only been reported sporadically and confirmed records have mostly been confined to northwestern New Territories with the core habitats in the Inner Deep Bay Area (Hui and Chan, 2024). It has therefore been considered of regional conservation concern (Fellowes et al., 2002). A recent DNA-based otter population survey between 2018–2019 only identified seven individuals across its core habitats, indicating that it is now undoubtedly one of the rarest mammals in Hong Kong (McMillan et al., 2022).

In this study, we report the recent discovery of Eurasian Otter in Lantau waters based on a spraint collected and discuss its conservation implications.

MATERIALS AND METHODS

Study Area

Situated at the estuary of Pearl River in southern China, Lantau Island is the largest among the 263 outlying islands in Hong Kong, covering a land area of 147 km^2. The terrain is mostly rugged with the highest peak up to 934 m and supports a diverse range of habitats from mangroves to montane forest and grassland. There are several smaller islets and islands surrounding Lantau Island, such as Chek Lap Kok, Ma Wan, Peng Chau, Cheung Chau, Soko Islands and the Brothers Islands (Fig. 1). It is relatively less developed than other parts of the city, the human population is approximately 0.2 million with over half of them living around Tung Chung on the northern coast (Sustainable Lantau Office, 2023).

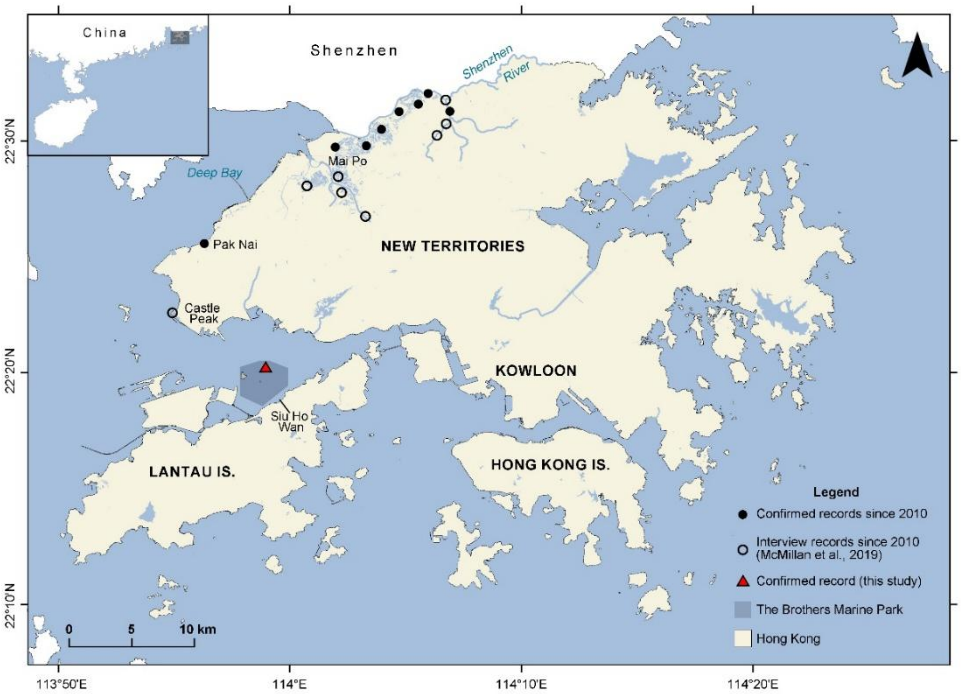

Figure 1. Map of the current distribution of the Eurasian Otter (*Lutra lutra*) in Hong Kong based on McMillan et al. (2019, 2022), Hui and Chan (2024) and KFBG unpublished data. Confirmed records refer to "hard fact" data including photos, spraint and anal jelly records; interview records refer to the observations of the locals collected through local ecological knowledge surveys.

The Brothers Marine Park was established in 2016 to protect the globally Vulnerable Indo-Pacific Humpback Dolphin (*Sousa chinensis*) in northeast Lantau waters. It comprises three islets - Tsz Kan Chau (Reef Island), West Brother Island (Tai Mo To) and East Brother Island (Siu Mo To) with the southern boundary extending to the shoreline of Siu Ho Wan of Lantau Island and has a total sea area of approximately 9.7 km^2 (Fig. 1). Since two of the islands were levelled in the 1990s for aviation safety and reclamation materials, original vegetation was largely removed and now only scattered small trees and shrubs exist.

Sign Surveys

An otter field survey was conducted in the Brothers Marine Park on 22 February 2024. Two experienced otter surveyors (JHY and YFPL) walked along the shore and searched for otter signs (e.g., tracks, spraints and anal jelly). A faecal sample was collected and preserved in a 5 ml sterile vial containing InhibitEX buffer (QIAGEN, Germany) and subsequently stored at -20°C until analysis.

Genetic Analysis

Genomic DNA was extracted using QIAamp Fast DNA Stool Mini Kit (QIAGEN, Germany), following the manufacturer's protocol with modifications of Coudrat et al. (2022) and McMillan et al. (2022) and the final elution was repeated once to obtain a total 400 µl of DNA sample. An otter-specific primer pair Lutcyt-F (5'-CCACAATCCTCAACAACTCGC-3') and Lutcyt-R (5'-CTCCGTTTGGGTGTATGTATCG-3') was used to amplify a 227 bp fragment spanning partial mtDNA cytochrome b region (Cytb) (Park et al., 2011). Polymerase chain reaction (PCR) was performed in a total volume of 25 µl reaction containing 3 µl of faecal DNA, 12.5 µl of Thermo Scientific™ PCR Master Mix (2X), 7.5 µl nuclease-free water and 1 µl of each primer. PCR was performed at 1 min at 95°C; 35 cycles of three steps (15 sec at 95°C, 15 sec at 55°C, 15 sec at 72°C), and a final extending step of 72°C for 3 min. PCR product of the sample was sent to BGI Bio-Solutions Hong Kong Co., Limited for Sanger sequencing by ABI 3730xl DNA Analyzer and using the forward primer Lutcyt-F. Sequences obtained were edited in Geneious Prime 2022.0.1 software (Kearse et al., 2012) and compared with GenBank sequences for species identification using BLAST. Apart from two sequences of *Lutra lutra* from Hong Kong and Sichuan (GenBank accession no. OR655422 and LC049952 respectively), additional sequences representing other 10 species of Lutrinae from GenBank were included in the phylogenetic analyses. Bayesian inference (BI) was performed using Geneious Prime 2022.0.1 software developed by Kearse et al. (2012) and MrBayes 3.2.6 software by Ronquist et al. (2012) with the HKY85+G+I model recommended by the Akaike Information Criterion as implemented in jModelTest 2.1.2 by Darriba et al. (2012). We also calculated the uncorrected pairwise genetic distances (*p*-distance) using Geneious Prime 2022.0.1 software.

RESULTS

A single dried faecal sample was collected from East Brother Island during the survey, which was laid on a bamboo branch left on the coast approximately 10 m away from the sea (Fig. 2). The fragment of the partial Cytb was successfully amplified from the sample, and the nucleotide BLAST (BLASTN) search showed the sequence generated share 99% sequence identity with a confirmed *Lutra lutra* sequence from Hong Kong (GenBank no. OR655422), and this sample was also grouped with the *Lutra lutra* sequences analysed with high support (BP 90) in the phylogenetic analysis (Fig. 3).

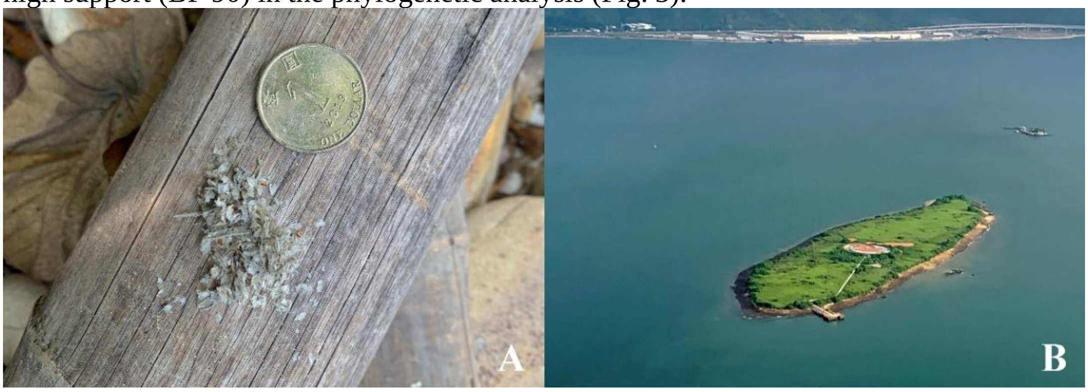

Figure 2. The dried spraint collected on 22 February 2024 (A); the East Brother Island and the coast of Siu Ho Wan in northern Lantau, Hong Kong (B).

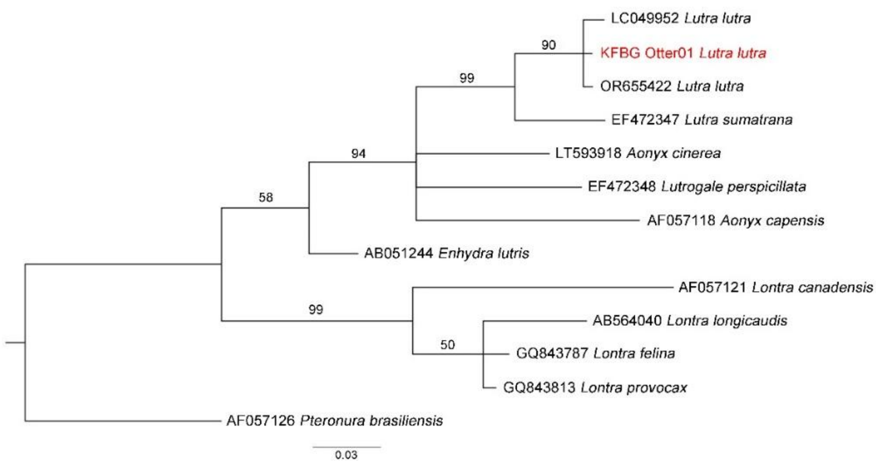

Figure 3. Phylogenetic relationships among the newly collected sample (KFBG Otter01) and other otter species shown in the BI tree result using partial Cytb.

DISCUSSION

Historically, otters had been documented around Lantau since, at least, the 1930s and thought to be extirpated around the 1960s (Hui and Chan, 2024). Our new finding represents the first verifiable evidence of otters in Lantau waters and largely extends its current known range in Hong Kong, with a range expansion up to approximately 10 km in straight line distance and >15 km when measured along coasts (Fig. 1). Such a distance is well within the known travel range of Eurasian Otter (see Kruuk and Moorhouse, 1991); however, it remains unclear whether this discovery represents a recent natural recolonisation of the existing known otter population from northwestern New Territories. We also cannot rule out the possibility that this elusive species has never been extirpated in Lantau waters and a remnant subpopulation managed to survive in this busy coastal area. In fact, our interview survey with local fishers and anglers also resulted in some otter sightings from northern Lantau within the past two decades (e.g., Siu Ho Wan) (KFBG, unpublished data), suggesting that the continued presence of otters in northern Lantau might have been long overlooked.

Eurasian Otters rely on freshwater for drinking and washing, an essential behaviour for coastal-dwelling otters to maintain the insulating properties of their fur (Kruuk and Balharry, 1990). However, there is no freshwater stream or pond on the islets of the Brothers Marine Park, while the closest freshwater sources are located approximately 2 km away on the northern coast of Lantau Island (see Fig. 1). Therefore, we believe that if a residential otter population exists in this area, they would live along the northern coast of Lantau Island where more suitable habitats (e.g., mangroves, estuary and river), shelters and freshwater sources are available, and utilise the offshore islets as part of their hunting and resting grounds.

CONSERVATION IMPLICATIONS

In this study, we present the first verifiable evidence of Eurasian Otter in Lantau waters, supporting the possibility that they may inhabit a wider area in Hong Kong and bringing new hope for this locally extremely rare species. The importance of marine habitats to local otters has long been neglected, our new discovery underlines the urgent need for a more extensive search of suitable habitats beyond the current known range in northwestern New Territories in order to assess the distribution and status of the otters in Lantau and wider Hong Kong.

The Hong Kong government has recently proposed various housing and economic developments in northern Lantau under the “Development in the North, Conservation for the South” principle (Development Bureau and Civil Engineering and Development Department, 2017). It is essential to evaluate the impact of all upcoming coastal construction projects on the otters, and other species of conservation concern using this area, and maintain the integrity and connectivity of the potential otter habitats and freshwater streams which are vital for their survival.

ACKNOWLEDGMENTS - We would like to thank our colleagues Daniel Hang and Craig Williams for the support with the field work.

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RÉSUMÉ: OUBLIÉE MAIS PAS DISPARUE : REDÉCOUVERTE DE LA LOUTRE EURASIENNE *Lutra lutra* SUR LANTAU, À HONG KONG

Depuis sa redécouverte dans les années 1980 à Hong Kong, la loutre eurasienne (*Lutra lutra*) n’a été observée que sporadiquement et principalement confinée à la région de « l’Inner Deep Bay », dans le nord-ouest des «New Territories». Nous présentons ici une épreinte prélevée en février 2024sur un îlot du « Brothers Marin Park » dans les eaux du nord de l’île de Lantau. Celle-ci a par la suite été validée par une analyse moléculaire. Notre découverte représente la première preuve tangible de la présence de la loutre dans les eaux de Lantau et étend largement son aire de répartition actuelle connue à Hong Kong, apportant un nouvel espoir pour cette espèce localement en danger critique d'extinction. Cette découverte souligne le besoin urgent d’une recherche plus approfondie d’habitats appropriés dans une zone plus large afin d’évaluer la répartition et le statut actuels des loutres à Lantau et sur l’ensemble du territoire de Hong Kong.

RESUMEN: OLVIDADA PERO NO AUSENTE: REDESCUBRIMIENTO DE LA NUTRIA EURASIÁTICA LUTRA LUTRA EN LANTAU, HONG KONG

Since its rediscovery in the 1980s in Hong Kong, the Eurasian Otter (Lutra lutra) has only been recorded sporadically and mostly confined to northwestern New Territories. Here, we present a spraint record collected from an islet of the Brothers Marine Park in northern Lantau waters in February 2024, which has been subsequently confirmed by molecular analysis. Our discovery represents the first verifiable evidence of otter presence in Lantau waters and largely extends its current known range in Hong Kong, bringing new hope for this locally critically endangered species. This finding highlights the urgent need for a more extensive search of suitable habitats in a broader area in order to assess the current distribution and status of the otters in Lantau and wider Hong Kong.

嶼海遺珠：歐亞水獺（*Lutra lutra*）重現香港大嶼山水域

摘要：在香港，歐亞水獺（*Lutra lutra*）過去曾被認為已經在本地滅絕，直至上世紀80年代才被研究人員在米埔自然保護區重新發現。過去數十年，歐亞水獺在香港的記錄依然非常之少，而且大部分都局限於新界西北部的内后海灣濕地範圍内。本研究報道2024年2月份於大嶼山北部水域的大小磨刀海岸公園所發現並經分子鑒定確認的歐亞水獺糞便。本次發現為歐亞水獺在大嶼山水域出沒提供了確切證據，並遠遠擴大了歐亞水獺在香港目前已知的現存分布範圍，為這一本地極度瀕危物種的保育帶來新希望。調查成果亦顯示未來仍需要加強和擴大野外考察的力度和範圍，覆蓋更多水獺潛在的分布區域和生境，以全面評估大嶼山區域乃至全港水獺的分布現狀。

REPORT

INVESTIGATING THE DIETARY COMPOSITION OF SMOOTH-COATED OTTERS (*Lutrogale perspicillata*) AT VADUVOOR BIRD SANCTUARY IN THIRUVARUR DISTRICT, TAMIL NADU, INDIA

K. CHITRAPRIYA[1*], K. VISWANATHAN[2*], R. GOWTHAM[1], A. SANKARI[1], M. MOORTHI[1]

[1]PG & Research Department of Zoology and Wildlife Biology, A.V.C. College (Autonomous), Mayiladuthurai – 609305, Affiliated to Annamalai University, Chidambaram, Tamil Nadu, India
[2]Department of Chemistry, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai-600 077, India
Corresponding Authors' Emails : cpearthworm@gmail.com (K. Chitra Priya), viswanathanphd@yahoo.com (K. Viswanathan).





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Abstract: Smooth-coated otters play a vital role in freshwater ecosystems. The freshwater Otters such as *Lutrogale perspicillata* are common across Asia. In this communication, we conducted the first study of the smooth-coated otter's feeding patterns in response to variations in fish supply at the Vaduvoor Bird Sanctuary in Tamil Nadu, India. The bird sanctuary contained eleven fish species, while the otters ate eight different types of prey. The relative proportions of prey categories remained constant. The reserve is home to the *Oreochromis mossambicus* which formed a maximum 12±0.5% of the otter's diet. Other species included *Catla catla* (11±0.4%), *Anabas testudineus* (7±0.3%), *Cyprinus clupeoides* (6±0.2%), *Rastrelliger Kanaguria* (11±0.4), *Labeo rohita* (6±0.3), and *Clarias batrachus* (1%). Finally, this study discusses the fish species that otter species primarily eat, as well as their preferences, types, and proposed diet compositions.

Citation: Chitrapriya, K., Viswanathan, K., Gowtham, R., Sankari, A., and Moorthi, M. (2024). Investigating the Dietary Composition of Smooth-Coated Otters (*Lutrogale perspicillata*) at Vaduvoor Bird Sanctuary in Thiruvarur District, Tamil Nadu, India. *IUCN Otter Spec. Group Bull.* **41** (4): 241 - 248
Keywords: Smooth-coated otter; diet

INTRODUCTION

India is home to three otter species: Smooth-coated otter (*Lutrogala perspicillata*), Eurasian otter (*Lutra lutra*), and Oriental small-clawed otter (*Aonyx cinerea*) (Foster-Turley and Santiapillai, 1990; Khoo et al, 2021). The present populations of the three otter species and their habitats in India have not been thoroughly examined, therefore little information on their status is known. All three otter species have been documented from the Southern Indian section of the Western Ghats, however there are no records from Tamil Nadu's coastal regions. Shrestha et al. (2021) reported the first evidence of a European otter in Nepal, and the Smooth-coated otter (*Lutrogala perspicillata*) is classified as vulnerable on the IUCN Red List (Khoo et al, 2021). Otters live in bodies of water such as streams, rivers, lakes, and dams (Kruuk and Conroy, 1987); degradation of pristine aquatic ecosystems is the most significant hazard to the survival of otter populations (Foster-Turley, 1992). Smooth-coated otters are believed to be extinct in nations such as Laos, and its population in India is steadily diminishing, according to IUCN status reports (Shenoy, 2006). Other significant risks to otters in India include illegal trade (Meena, 2002), reduced prey availability, persecution by fishermen, and water pollution (Mason and MacDonald, 1986). Otters are at a high trophic level, and suffer from pollutant accumulation in food chains (Foster-Turley, 1992). As a result, conservation efforts for this species must begin immediately.

Fish are a preferred component in their diet, but they also eat a wide variety of other foods, including insects, and smaller vertebrates like frogs and birds. (Anoop and Hussain, 2005). Foraging takes place among fallen tree trunks, rapids, fishing nets, and other obstacles (Shariff, 1984). Small fish are consumed whole (Helvoort et al., 1996), while larger fish are brought to shore (Ansell, 1947). The majority of foraging takes place in water; however, the animals do return toland to eat large fish, rest, and defecate. According to score bulk estimation, fish accounted for up 92% of *L. perspicillata's* entire diet along the Johor Straits in Singapore. These results support the observation that *L. perspicillata* is primarily a piscivore (Kruuk et al., 1994; Haque and Vijayan, 1995; Hussain and Choudhury, 1998; Anoop and Hussain, 2005; Sivasothi, 1995; Nawab and Hussain, 2012), which is unique among Asia's four otter species but similar to *Pteronura brasiliensis* in South America and *Hydrictis maculicollis* in Africa (Kruuk, 2006). A study in India reached a similar finding, with fish species consumed and preferred by otters varying per river based on availability during different seasons (Nawab and Hussain, 2012). This seeming opportunistic hunting behaviour is shared by otter species such as *Lutra lutra*, *Pteronura brasiliensis*, and *Lontra canadensis* (Duplaix, 1980; Kruuk etal., 1989; Bowyer et al., 1995; Carter et al., 1999). This study found that *L. perspicillata* prefers to consume small- and medium-sized fish (less than 18 cm) in SR, which is comparable to the conditions in a reservoir in Periyar, India (Anoop and Hussain, 2005). *L. perspicillata's* diet is primarily, but not entirely, piscivorous, and is determined by the prey community in its surroundings.

MATERIALS AND METHODS

Spraint Analysis and Sample Collection

Spraints were employed not only to indicate otter presence, but also to determine the food content at the research site. Spraints were only found in cluster deposits, making it difficult to identify individual spraints. Spraints on the ground were assessed visually and collected using gloved hands. Each spraint was collected in a separate zip lock bag and labeled with identification information. In the majority of instances, sprains were fresh or only a day old.

Spraint Sample Analysis

Each spraint was washed separately with biological washing powder (Suffolk Otter Group, 2017) and filtered through a screen to remove debris such as grass. Following filtration, the spraint was spread on newspaper and dried in the sun for a day. The spraint pieces were weighted individually. Throughout the process, the spraints were carefully numbered to maintain their individuality. The dried spraint was displayed on a white sheet in the light. Scales, bones, and other materials were classified and separated based on their size and structural characteristics. The anatomy of the spraint materials was employed to determine the taxonomy of feed composition. Using a magnifying lens, each particle was viewed and photographed at various angles on a clean, crisp background. The process is shown in Figure 1.

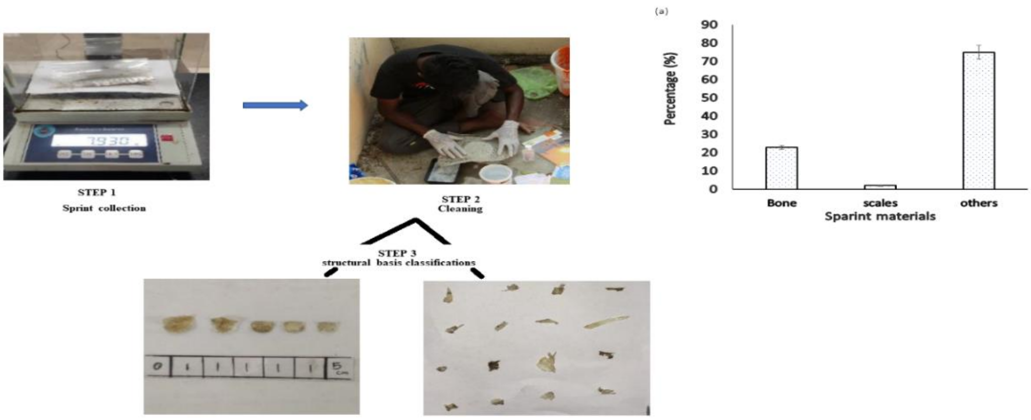

Figure 1. Spraint sample analysis steps for Smooth-coated Otter in Vaduvoor Bird Sanctuary (n= 22).

RESULTS

The composition of prey species was determined in spraints using bones and scales. Because it is impossible to identify all of the components included in the spraint, only recognized prey species were noted, and assessed based on their frequency of presence in the samples, as shown in Figure 1; Table 1 shows the fish present in the bird sanctuary and differs slightly from the previously published data (Gokula and Ananth Raj., 2021).

Table 1: Major Fishes available in Vaduvoor lake

S. No	Common Name	Scientific Name	Family
1	Bloch	*Cyprinus clupeoides*	*Cyprinidae*
2	Catfish	*Clarias batrachus*	*Clariidae*
3	Catla	*Catlacatla*	*Cyprinidae*
4	Climbing perch	*Anabas testudineus*	*Anabantidae*
5	Eel Fih	*Anguilla bengalensis*	*Anguillidae*
6	Indian mackerel	*Rastrelliger kanagurta*	*Scombridae*
7	Murrel	*Channa striata*	*Channidae*
8	Rohu	*Labeo rohita*	*Cyprinidae*
9	Spined Loach	*Cobitis taenia*	*Cobitidae*
10	Tank Cleaner Fish	*Pterygoplichthys pardalis*	*Loricariidae*
11	Tilapia	*Oreochromis mossambicus*	*Cichlidae*

Spraint components were examined individually using the identifications. According to the results (Table 2), 71 samples were found, with the majority of the samples showing *Oreochromis mossambicus* (14 samples equal to 20%), *Catla catla* (9 samples equal to 13%), *Anabas testudineus* (8 samples equal to 11%), *Cyprinus clupeoides* (6 samples equal to 8%), *Rastrelliger kanagurta* (5 samples equal to 7%), *Labeo rohita* (5 samples equal to 7%), and *Clarias batrachus* (2 samples equal to 3%). The remaining 22 samples (31%) revealed no definite identification and were referred to as the unidentified group. In addition to spraint analysis, the first reports of otters eating turtles, tank cleaning fish, and birds were made.

Table 2. Diet composition from spraint analysis

S. No	Species Name	Count	Percentage %
1	*Unidentified*	22	31
2	*Oreochromis mossambicus*	14	20
3	*Catla catla*	9	13
4	*Anabas testudineus*	8	11
5	*Cyprinus clupeoides*	6	8
6	*Rastrelliger kanagurta*	5	7
7	*Labeo rohita*	5	7
8	*Clarias batrachus*	2	3
Total		71	100

According to the analysis, fish bones are predominantly composed of vertebral regions, skulls, and spines, which are commonly observed. Weighing spraint components demonstrates that bones account for more than half of the proportion to scale, as well as other components discovered in the spraint samples. This could be because otter feeds primarily on large bony fish (Fig. 2). Remaining samples are classified as Unidentified group because no clear identification was found in bones to identify the fish type, and this category accounts for approximately 31%, however, in the identified category, *Oreochromis mossambicus* was dominant with 20 % of total

number samples, followed by *Catla catla* (13%) and *Rastrelliger kanagurta* with 11% of total samples and *Anabas testudineusi* with 8%.

Figure 2. Otters fishing

Table 3. The Smooth-coated otter diet composition in Vaduvoor bird sanctuary, Thiruvarur District, Tamil Nadu (n=22).

Sl. No.	Species Name	Number Found	Occurrence (%)	Total weight (g)	Weight percentage (%)	Dry weight (g) (Mean ± SE)
1	*Anabas testudineus*	8	11	5.772	7	0.3 ± 0.1 2
2	*Catla catla*	9	13	9.282	11	0.4 ± 0.1 3
3	*Clarias batrachus*	2	3	1.018	1	0.0 ± 0.0
4	*Cyprinus clupeoides*	6	8	5.460	6	0.2 ± 0.1 5
5	*Labeo rohita*	5	7	5.522	6	0.3 ± 0.2
6	*Oreochromis mossambicus*	14	20	10.239	12	0.5 ± 0.1
7	*Rastrelliger kanagurta*	5	7	9.542	11	0.4 ± 0.3
8	Unidentified	22	31	40.122	46	1.8 ± 0.3
Total		71	100	87	100	

DISCUSSION

In this study, the highest otter cluster size is four individuals, including two juveniles. Previously, in March 2020, there were a maximum of six identical clusters at Vaduvoor Bird Sanctuary. However, in 2021, Arivoli and Narasimmarajan reported that no juveniles were found in the research area. The current investigation shows the presence of a juvenile (Fig. 2). As a result, it is clear that the population has begun to breed in this Bird Sanctuary. Otters have only been present here for a few years. By comparison, a pair of smooth-coated otters returned to the Sungei Buloh Wetland Reserve in 1998 and raised pups (Theng and Sivasothi, 2016), and there is now a healthy population of at least 170 individuals in Singapore (Shivram et al, 2023).

The current study found that otters mostly eat fish, with birds and amphibians accounting for only a small portion of their diet. Previous research has found a similar pattern (Gaethlich, 1998). Earlier research, however, suggested a link between fish availability and the makeup or preference for fish species in otters' diets (Erlinge 1968). Sallai (2002) discovered that some otters graze on non-native fish species. As with most spraints, the analysis was difficult because the bones were damaged. Furthermore, most of the spraint components werein the undetermined group because the remains were highly fragmented, necessitating further specific observations at a particular time. The reliability of spraint analysis as a measure of the relative frequency with which different prey are caught has been thoroughly explored. In general, the weight or volume of prey in spraints provides the most reliable assessment, though frequency of occurrence results in an accurate rank order of prey categories (Wise et al., 1981; Carss and Parkinson, 1996; Jacobsen and Hansen, 1996) Though a thorough diet calculation is impossible, *Oreochromis mossambicusis* is both more common in occurrence and has a higher mass in recognized spraint components. This suggests that this species is frequently consumed in the study area, which aids in the classification of prey species. The diversity of the prey community influences the otter's diversity of consumption of dietary resources. Understanding otter diet therefore contributes to biodiversity information on the otter prey community, which should then be addressed and protected. There is also evidence of otter feeding on other taxa, including as birds and turtles, although this was not found in thise spraint study.

Because otter species rely significantly on fish stocks, changes in stock quality and quantity may have a significant impact on their numbers.

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RÉSUMÉ: ENQUÊTE SUR LA COMPOSITION DU RÉGIME ALIMENTAIRE DES LOUTRES À PELAGE LISSE (*LUTROGALE PERSPICILLATA*) AU SANCTUAIRE DES OISEAUX DE VADUVOOR DANS LE DISTRICT DE THIRUVARUR, AU TAMIL NADU, EN INDE

Les loutres à pelage lisse jouent un rôle essentiel dans les écosystèmes d'eau douce. Les loutres d'eau douce telles que *Lutrogale perspicillata* sont communes en Asie. Dans cette communication, nous avons mené la première étude sur les habitudes alimentaires de la loutre à pelage lisse en réponse aux variations d'approvisionnement en poissons au sanctuaire des oiseaux de Vaduvoor au Tamil Nadu, en Inde. Le sanctuaire des oiseaux a révélé onze espèces de poissons, tandis que les loutres mangeaient huit espèces de proies différentes. La fraction des catégories de proies des sites est restée constante. La réserve abrite l'*Oreochromis mossambicus* et la loutre en a consommé au maximum 12±0,5%. Les autres espèces comprenaient *Catla catla* (11±0,4%), *Anabas testudineus* (7±0,3%), *Cyprinus clupeoides* (6±0,2%), *Rastrelliger kanaguria* (11±0,4), *Labeo rohita* (6±0,3) et *Clarias batrachus* (1%). Enfin, cette étude a abordé les espèces de poissons que les espèces de loutres consomment prioritairement, ainsi que leurs préférences, types et compositions des régimes alimentaires proposés.

RESUMEN: INVESTIGANDO LA COMPOSICIÓN DE LA DIETA DE LA NUTRIA LISA (*Lutrogale perspicillata*) EN EL SANTUARIO DE AVES VADUVOOR, DISTRITO DE THIRUVARUR, TAMIL NADU, INDIA

Las nutrias lisas desempeñan un rol vital en los ecosistemas de agua dulce. Las nutrias de agua dulce, como Lutrogale perspicillata, son comunes en Asia. En ésta comunicación, condujimos el primer estudio de los patrones alimentarios de la nutria lisa, en respuesta a variaciones en la disponibilidad de peces en el Santuario de Aves Vaduvoor en Tamil Nadu, India. El santuario de aves reveló tener once especies de peces, y las nutrias comieron ocho diferentes tipos de presa. The fraction of prey category sites remained constant. La reserva alberga Oreochromis mossambicus y la nutria consumió un máximo de 12±0.5%. Otras especies incluyeron Catla catla (11±0.4%), Anabas testudineus (7±0.3%), Cyprinus clupeoides (6±0.2%), Rastrelliger Kanaguria (11±0.4), Labeo rohita (6±0.3), y Clarias batrachus (1%). Finalmente, este estudio discute las especies de peces que comieron primariamente las nutrias, así como sus preferencias, tipos, y proposed diet compositions.

R E P O R T

LOCAL PEOPLES' KNOWLEDGE AND PERCEPTIONS OF, AND CONSERVATION THREATS TO, EURASIAN OTTERS IN THE KALI GANDAKI WATERSHED IN MYAGDI DISTRICT, NEPAL

Pravin GIRI[1,2], Purna Man SHRESTHA[2]

[1]*Agriculture and Forestry University, Faculty of Forestry, Hetauda, Nepal*
[2]*Wildlife Research and Education Network, Tokha-3, Kathmandu, Nepal*

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Abstract: While there are an increasing number of field surveys reporting on distribution and habitat factors of Eurasian otters (*Lutra lutra*) in Nepal, there is still a significant lack of research on human interactions with the species. This study documents the socioeconomic status of local people, their perceptions and knowledge about Eurasian otters, and the pervasive threats to otters around the Kali Gandaki watershed area in the Myagdi District. A semi-structured questionnaire survey, using a purposive sampling technique, was conducted in the study area to explore these factors. Seventy residents living in the watershed participated in the survey. Simple descriptive statistics were used to analyze the quantitative data and Fisher's exact test was employed to evaluate the relationship between categorical variables. Our study findings show that local respondents have a positive attitude toward otters, likely attributed to the absence of commercial fishing activities. Around 62% of respondents reported that they believed otter populations have declined over the past 10 years. The majority of the respondents had little or no knowledge about the ecological value of otters in aquatic ecosystems. Nevertheless, a significant number of participants exhibited heightened enthusiasm and a keen interest in the conservation of otters in their locality. Hydropower dams and flash floods were ranked as the most prominent threats to the species' survival. Stringent enforcement of environmental laws related to riverine ecosystems coupled with community outreach programs are essential for the conservation of otters and their habitats.

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Keywords: Eurasian otter, Nepal, conservation, threats, local people perceptions

INTRODUCTION

Human-wildlife interactions are common phenomena when the resources which contribute to their sustenance overlap. As such, direct competition for fish is prevalent between fishing folk and otters since fish play an important part in people's livelihoods and income generation (Barbieri et al., 2012; El Alami et al., 2020). Destruction of fishing gear and depredation on fish in gillnets by otters have been reported in many parts of the world, leading local people to perceive otters as a pest (Ergete et al., 2018; Dias, 2021; Trivedi and Variya, 2023). However, perceptions may vary across individuals ranging from positive or neutral to harshly negative depending on the level of knowledge, economic status, age, occupation, and level of interactions with otters (Biru et al., 2017).

The Eurasian otter (Lutra lutra) is a flagship semi-aquatic mammal having the widest distribution range among 13 extant otter species in the world. It inhabits primarily freshwater ecosystems such as rivers, lakes, ponds, and wetlands and forages mainly on fish and occasionally crabs, frogs, and other aquatic animals (Kruuk, 2006). This species is listed in the IUNC Red List as Near-Threatened with a declining population trend (Loy et al., 2022) and in Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Eurasian otters throughout Asia and the Himalayan Range are threatened by human activities such as pollution, irrigation canal and hydropower dam construction, declines in fish biomass, bankside vegetation removal, and illegal trade (Duplaix and Savage, 2018; Loy et al., 2022). These threats are more profound in South Asia, including Nepal, due to the rapid rise in population in this region, ongoing large developmental projects, and the inevitable pressure on rivers and wetlands.

There are no specific policies or laws dedicated to the protection of otters in Nepal (Acharya et., 2022). The Aquatic Life Protection Act 1961, amended in 2002, provided some degree of legal protection to two otter species: Eurasian otter and Smooth-coated otter. However, this law has not been effectively enforced for a long time, as there is no reported case of a person being persecuted under the act (Acharya et al., 2022). Similarly, the National Park and Wildlife Conservation Act, 1973 has not yet listed any otter species, including Eurasian otter, as protected mammals.

The population status of the Eurasian otter in Nepal is poorly understood, but it appears to survive in low numbers in rivers and wetlands of the mid-hill region, mostly outside protected areas (Basnet et al., 2020; Shrestha et al., 2021; Shrestha et al., 2022). For the first time, verifiable evidence of the Eurasian otter in Nepal was recorded at Begans Lake in 1993 (Acharya and Gurung, 1994) and recently in Roshi, Tubang, Pelma, and Barekot Rivers (Shrestha et al., 2021; Shrestha et al., 2022). An unusual carcass of an Eurasian otter has been found in a Kathmandu valley (Shrestha et al., 2023). Although recent surveys have enriched the general overview of the distribution of Eurasian otters in Nepal, little is known about local people's knowledge, attitudes, and perception towards them (Basnet et al., 2020; Shrestha et al., 2023).

Some studies have shown that local human populations possess valuable knowledge of their natural resources and environment, in which they live and utilize (Drew, 2005; Ulicsni et al., 2019). Systematically documented local knowledge can potentially offer valuable information for the design of effective conservation and management plans (Suwal et al., 2022; Basnet et al., 2020; Shrestha et al., 2023). As the success of conservation initiatives depends on public support, consideration of public attitudes and perceptions towards conservation and wildlife management is essential (Špur et al., 2018; Basnet et al., 2020; Shrestha et al., 2023). In this study, we assessed 1) local people's knowledge 2) their perceptions and attitudes towards Eurasian otters, and 3) their perceptions of threats towards Eurasian otters and their habitat.

METHODOLOGY
Study Area

The Myagdi District (28°42′24″N, 83°38′43″E) is located in Gandaki Province in the Mid-western part of Nepal, covering an area of 2297 km2. The district is elevated from 792 m above sea level (asl) to as high as 8167 m, comprising four different types of climates: sub-tropical, sub-temperate, temperate, and alpine (Poudel, 2022). The survey was conducted mainly in the villages of Tatopni, Simalchaur, Babiyachaur, Darbang, Tiplyang, Baisani, Galeshwor, and other small human settlements near three major rivers: the Kali Gandaki, Myagdi, and Rahuganga Rivers (Fig. 1).

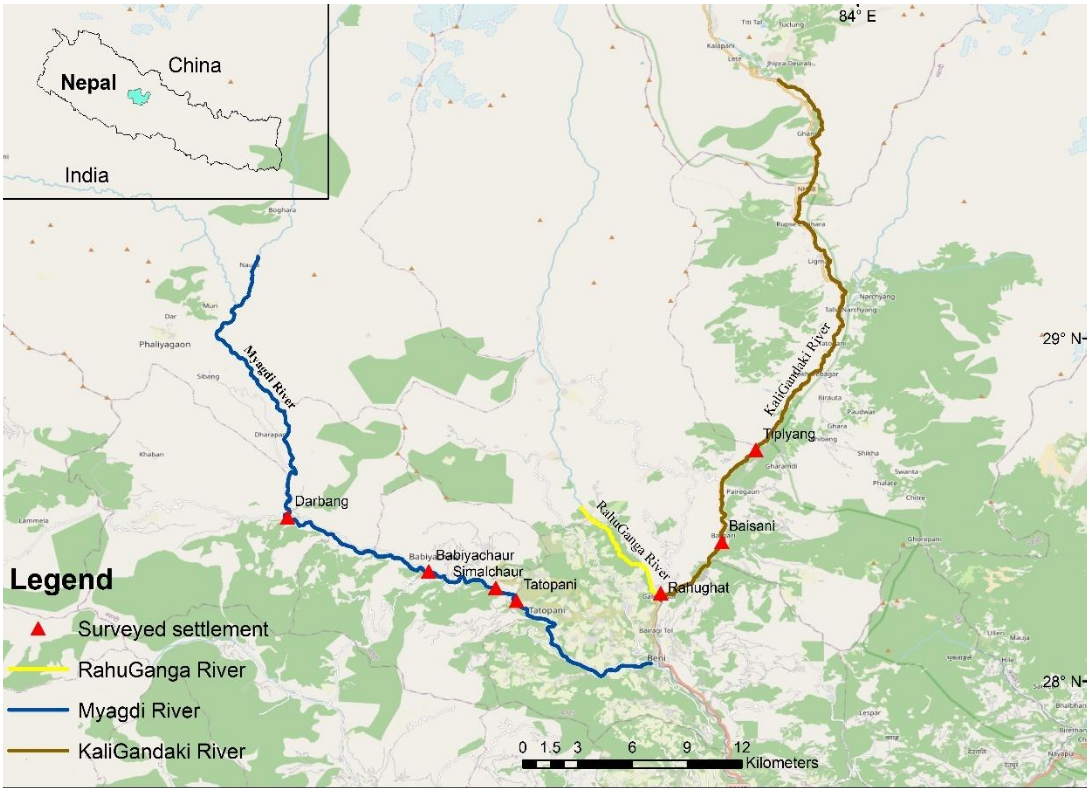

Figure 1. Map of the study area (World Street Map is used as the base map) showing major surveyed settlements and three major Rivers: Kali Gandaki, Myagdi, and Rahuganga Rivers.

The total population of Myagdi District in 2021 was 107,033, of which 48.7% were male and 51.3% female, with a population density of 47 persons per km2 (National Population and Housing Census, 2021). Skilled agriculture, forestry, and fishery (67.3%) is the dominant economic activity of the people, followed by elementary workers (12%), managers (4%), professionals (3.5%), crafts and related trade workers (3.4%), service and sale (3.4%) and other activities. The district’s literacy rate stands at 79.7%, with a slightly higher proportion of males (87.7%) compared to females (72.2%) (National Population and Housing Census, 2021). Major ethnic groups are: Magar, Kshetri, Bishwokarma, Brahman, Pariyar, Mijar, Pun, Chhantyal, Thakuri, and Newar. The majority of people follow the Hindu religion (87.6%) followed by Buddhist (8.2%), Christian (1.5%), Prakirti (2.1%), Islam (0.2%), and Kirat (0.02%) (National Population and Housing Census, 2021).

Questionnaire Survey Methodology

In November and December 2022, we conducted a semi-structured questionnaire survey with local people living in proximity to the three rivers. In Nepal, the post-monsoon season in these two months offers suitable climatic conditions for field work. A purposive sampling method was followed since our main purpose was to elicit as much information as possible from informants (Tongco, 2007). Seventy respondents participated in our survey. Age was taken into consideration while selecting respondents, since older people were assumed to have more knowledge and experience of natural resources and their utilization. If there were young people who frequently visit the rivers for fishing, they were prioritized over the other, older, family members. Only one member of each family was interviewed. Some fishermen were interviewed while they were fishing in the river. A picture of the Eurasian otter was shown, and details of its characteristics were explained to participants to avoid confusion with crab-eating mongooses and other similar small mammals. The purpose of the survey was described to each of the participants, and they were assured that their identities would remain confidential. Verbal consent was obtained from each participant prior to the survey. The survey was conducted by the authors in the Nepali language and later translated to English for data analysis.

The questionnaire survey was categorized into five sections with a mix of closed and open-ended questions. In the first section, data on socio-economic and demographic information about the participating individuals were collected. In the second section, we documented the use of rivers, and fishing practices employed. In the third section, people were asked about sightings, and ethno-biological information associated with Eurasian otters. In the fourth section, data on the perceptions and attitudes of people towards otters were gathered. In the final section, people were asked to list possible threats to otters based on their observations.

Field observations by researchers and perceptions by respondents were used to estimate threats to Eurasian otters. During the field survey, the survey team recorded visible threats to otters and their habitat. Perceived threats to otters in the Myagdi District were collected through the questionnaire survey. The combined list of threats obtained from questionnaire survey and field observation were refined to six most plausible direct threats for whole site threat ranking method.

Data Analysis

Simple descriptive statistics such as mean, frequency, and percentage were used for the analysis of quantitative data. Fisher's Exact Test was employed to evaluate the relationship between otter sightings (seen/heard of otter or not seen/heard of otter) and demographic factors including respondents' age, gender, education level, and preferred fishing season. The small sample size and low number of expected observations are the reasons behind opting for Fisher's Exact Test for understanding the relationship between categorical variables.

The relative whole-site threat ranking method developed by World Wildlife Fund (WWF, 2007) was applied to rank the most prominent threats to Eurasian otters (WWF, 2007; Kafle et al., 2020; Neupane et al., 2020). Six threats reduced from the combined list were then ranked by ten key stakeholders most familiar with the otter and their habitat, based on scope, severity, and urgency, ranging from value 6 to 1 (i.e., value 6 implies very high with serious effects and 1 implies very low impacts) (Table 1). For example, for ranking for scope, the largest value (6) was assigned to the threat affecting the largest habitat or population, continuing down to a rank of 1 for the threat that affects the smallest habitat or population of Eurasian otters. Similarly, each threat was ranked for severity and urgency. The mean response was calculated and these values classified into a four-point scale: (very high (13.6-≤18), high (9.1-≤13.5), medium (4.6-≤9), and low (≤4.5).

Table 1. Relative whole-site threat ranking method under scope, severity and urgency criteria (WWF, 2007)

Threat Classification Category	Definition
Scope	The proportion of the targeted population that can be affected by the threat within ten years, assuming that current circumstances and trends continue.
Severity	Within the scope, the damage level to the target population from the threat can reasonably be expected within the ten years, assuming that the current circumstances and trends continues.
Urgency	Importance of taking immediate actions to address threats in order to sustain a long-term healthy population of the target species.

RESULTS

Demographic Structure of the Respondents

Of the 70 respondents who participated in the interview, 89% were male and 11% were female. The age of the respondents ranged from 16 to 81 years of age, out of which 37% of the respondents were younger than 40 and 63% were older than 40. The majority of respondents were farmers (80%), followed by teachers (7.14%), students (5.71%), businessmen (4.29%), and labourers (2.86%). More than half of the respondents (57.14%) were literate, while 21.43% had primary education, 12.86 % were above secondary education, and 8.57% were illiterate.

Fishing Practices

More than half of the respondents (55.7%) said that they preferred fishing in early summer whereas 25.7% fish all year round, and 18.6% fish in both summer and winter. Around 84% of the people responded that electric and poison fishing is not prevalent in their area, whereas 15.7% believe that people still fish using electric currents and poison. All the respondents (100%) agreed that fish populations in the river have decreased in the past 10 years. The gillnet (Tehari jal) was the preferred fishing gear used by local people.

Local Knowledge of Respondents

Old-aged (42%) and middle-aged (40%) people reported having seen Eurasian otters more frequently than the younger people (18%). Fisher's Exact Test showed a statistically significant association between seen/heard of otters with age group

(P=0.001), and gender (P=0.005). We did not find a significant association between education level (P=0.078) or preferred fishing season (P=0.145) with seen/heard of otters.

Based on the interviews, 62.9% of people believed that the otter population has decreased in the last ten years, while 38.6% did not provide any response to the question (Table 2). Respondents mostly observed Eurasian otters in the early summer (40%), followed by winter (24.3%) and monsoon season (1.4%), while (24.3%) people gave no response. Of the total respondents, only 17.1% of people could identify the scat of otters, while the majority (82.9%) of respondents answered negatively. Almost all of the respondents (95.7%) said that there are no cultural or traditional myths associated with the otter. All respondents (100%) said that they do not use the body parts of otters for medicinal purposes, nor have they observed it in their community.

Table 2. General information on Eurasian otter ecology, cultural association with humans, and usage based on respondents' knowledge (N=70).

Characteristics	Responses	Number	Percentage (%)
Do you know where otters live?	Yes	43	61.4
	No	27	38.5
Status of otter population in the last 10 years?	Decreased	44	62.8
	No response	26	37.1
In which season are otter mostly seen?	Monsoon	1	1.4
	Early summer	28	40.0
	Winter	24	34.3
	No response	17	24.3
Can you identify otter scats?	No	58	82.9
	Yes	12	17.1
Cultural or traditional myths associated with otters?	No	67	95.7
	No response	3	4.3
Medicinal value of any body parts?	Yes	0	0
	No	70	100

Perception and Attitudes of Local People about Otter Conservation

Respondents who expressed appreciation for otters account for 48.6% (N=51). 4% were neutral (Table 3). While 31.43% of respondents felt that otters are good for aquatic ecosystems, 68.6% gave no response. A large number of people (64.3%) believe that the presence of otter decreases the availability of fish, whereas 35.7% of people did not agree. Interestingly, 71.4% of respondents stated that the otter is not a harmful animal, while 27.1% were neutral. A significant number (81.4%) of respondents felt that otter should be conserved and only 18.6% did not provide a clear response.

One respondent said: "Why I would hate these animals? They pose no threats to me so, I would love to see their population growing in our rivers".

Table 3. General perception of respondents (n=70) on the Eurasian otter, its role in maintaining ecosystem services, and its conservation.

Characteristics	Opinion	Number	Percentage (%)
Do you like otters?	Yes	34	48.6
	Neutral	36	51.4
Is the presence of otters good for the ecosystem?	Yes	22	31.4
	No response	48	68.6
Influence of otter presence on fish populations?	Decrease	45	64.3
	Remains same	0	0
	Don't know	25	35.7
Is the otter a harmful animal?	Yes	1	1.4
	Neutral	19	27.1
	No	50	71.4
Should we conserve otters?	Yes	57	81.5
	No	0	0
	Don't know	13	18.6

Ranking of Perceived Threats to Otters

All the respondents (100%) stated that no awareness program related to otters had previously been conducted in their locality. Only 2.9% of participants stated that they had killed an otter in retaliation, while 55.7% of participants had no knowledge of such incidents happening in their area. Based on the interviews, 14.3% of respondents had seen otters caught or killed by someone, while 85.7%, had not have observed such occurences. Among all participants, 8.6% reported that an otter had been entangled in fishing gear, while 91.43% stated that they had not witnessed such incidents.

"Some respondents recalled that, about 20 to 30 years ago, people from the Terai region used to come to these rivers, and set up tents along the river banks for months to hunt otters."

These results suggest that, of the six major threats listed, the hydropower dam construction and flash floods were believed to be the most urgent threats to otters in the study area (Table 4). Unsustainable fishing, and expansion of roads and development projects were also highly ranked. Habitat destruction and hunting/illegal killing were ranked as medium and low respectively.

Table 4: The relative whole-site threat ranking results of six prominent threats to otters in the study area.

SN	Conservation Threats	Scope	Severity	Urgency	Total	Classification
1.	Hydropower dam construction	5.6	5.3	5.2	16.1	VH
2.	Expansion of roads and development projects	4.2	3.9	3.9	12	H
3.	Unsustainable fishing	3.6	4.3	3.4	11.9	H
4.	Flash floods	4.6	4.5	4.5	13.6	VH
5.	Habitat destruction (sand and boulder extraction, grazing and deforestation)	1.9	1.8	2.6	6.3	M
6.	Hunting/illegal killing	1.1	1.2	1.4	3.7	L
	Total	21	21	21		

Note: Very High (VH), High (H), Medium (M), Low (L)

DISCUSSION

The number of male participants is quite high in these surveys because of their greater knowledge and information about the species in contrast to female participants. Usually, men go to the river for fishing, collection of wood, and other purposes while women are restricted to household chores and are therefore less familiar with the species, their habitat, and ecological information.

The questionnaire survey revealed that, with few exceptions, commercial fishing was not practiced by the people living along these rivers. Rather, local people occasionally went fishing for household consumption and recreation. This might be explained by increased opportunities for jobs in recent times and decreasing fish stocks in the river. Local people apparently prefer to fish in early summer or before the onset of monsoon, perhaps because of the good weather condition, low river current, optimal water temperature, and greater fish movement during this season (Singh, 2021). In our survey, the percentage of people using explosives, electric current, or poison for fishing is relatively low (17.6%); in contrast, Khatri et al. (2023) have reported the rampant practice of illegal fishing in Kathe River, Baglung Nepal. In our study, the majority stated that they use gill nets and cast nets for fishing, practices considered less harmful to otters. It may be that people were reluctant to disclose information about electric current, explosive or poison fishing since they are unlawful in Nepal. Respondents reported that the fish populations have drastically decreased in the last ten years as a consequence of habitat destruction, flash floods, unsustainable fishing, and dams.

The number of respondents who had observed otters was relatively low. Otters were observed more often in winter and early summer, perhaps due to the preferred fishing season. Respondents who were aware of otters believed that their population had decreased considerably in the last decade and were observed less frequently now than before. This assertion is further reinforced by the year-wise analysis of the data from the questionnaires survey, revealing that mostly middle and old-aged people (age=36+) have observed otters in rivers, while young people have fewer sightings rate. This inference aligns with the results of Shrestha et al. (2023), suggesting either a decline in otter population, or a reduction in fishing activities by the young respondents, or both. However, we do not have quantitative historical and current data to support or oppose the questionnaire survey findings, highlighting a need for immediate population survey of the Eurasian otter. The decreasing otter population could be attributed to the reduction in prey biomass, habitat destruction, damming, and illegal poaching/killing (Basnet et al., 2020). Very few respondents (12%) were able to identify the indirect signs such as scat, tracks, and dens, suggesting less familiarization of local people with the otter. Our study found no cultural myths and beliefs associated with otters and no body parts were used for medicinal purposes, similar to the findings of (Basnet et al., 2020).

In many parts of the world, conflicts between humans and otters have been linked to economic losses due to fish depredation and net damage (El Alamit et al., 2020; Dias, 2021; Jain and Karanth, 2023). Commercial or extensive subsistence fishing practices are, however, not prevalent in the study area, which is one reason why respondents may not perceive otters as harmful or nuisance animals. Most respondents were unaware of the ecological role of the otter in freshwater ecosystems, potentially undermining the effectiveness of otter conservation efforts. This is consistent with the result of El Alami et al., (2020), where only 3% of the interviewees were aware of the ecological role of the Eurasian otter. A large number of respondents agreed that Eurasian otters should be conserved and protected, which is a promising sign for otter conservation. However, we suggest conducting Eurasian otter-centric awareness and community outreach programs in these local communities as a foundation for sustainable conservation of the species.

Hydropower dam construction and flash floods are perceived as the major threats to Eurasian otters in the study area. Hydropower dams are under construction on the Myagdi and Rahuganga Rivers, potentially resulting in disruption of the regular flow of water, habitat fragmentation, and reduced food availability impacting the otter population (Acharya et al., 2022). Some respondents reported that construction of Kali Gandaki A (144MW) hydropower dam in the Syangja District has impeded the upward migration of large fish, again potentially affecting the otter population - a finding consistent with the case study report prepared by the Asian Development Bank (2018). The regional mean temperature of the Himalayas over the past 100 years has increased by 0.74º C (Lamsal et al., 2017), leading to a rapid rise in snow melts, catastrophic avalanches, flash floods, erosion, and landslides (Arora et al., 2016), likely to have severe consequences on otters, which live in a narrow linear riverine habitat (Kruuk, 2006). Flash floods, with their excessive mud content may block the holes and rock cervices along the riverbank that otters rely on for shelter. Pandey et al. (2022) similarly identified natural calamities as the major threats to otter species in India. The ever-increasing expansion of road construction is also detrimental to river dwelling species. Ineffective enforcement and implementation of existing national policies to curb the impacts of developmental projects is a challenge for conservation (Acharya et al., 2022). Evidence suggests that large developmental works including hydropower projects in Nepal do not fully comply with environmental regulations (Acharya et al., 2022). The scant evidence of hunting/killing of otters in the area in recent times may reflect depletion of otter populations. In contrast, Shrestha et al. (2023) documented intense poaching of otters in the past in the Mugu District, perhaps prompted by closer international border and an easy trade route to China (Li et al., 2000). Unsustainable fishing practices such as electric current, explosives, or poison fishing are widespread in rivers and wetlands in the mid-hills region of a country (Khatri et al., 2023) and cause severe damage to the entire aquatic ecosystem. Such practices pose detrimental threats to fishes, the primary prey of otter that will ultimately impose adverse consequences on the Eurasian otter's survival.

CONCLUSION AND CONSERVATION IMPLICATIONS

Eurasian otter populations may have experienced a decline in the Kali Gandaki watershed in recent decades, as suggested by reduced sightings by locals. A systematic survey is needed to accurately assess the population status of the otter. The lack of significant human-otter conflict in the study area may reflect a positive attitude of local people towards otters. We strongly advise that environmental laws and regulations that would more effectively protect the Eurasian otter be implemented and that regular follow-up monitoring be conducted. For example, regular monitoring of the provision of Environmental Impact Assessment before and after the dam construction will be critical in mitigating the negative impacts of dams on a river system. Awareness and community outreach programs would be invaluable in enhancing the conservation knowledge of local people and promoting their participation in otter conservation at the local level. In addition, partnership and collaboration among the relevant conservation stakeholders could positively reward the otter conservation efforts. For sustainable management of Eurasian otter populations and their habitat in the Kali Gandaki watershed, conservation measures specific to otters should be implemented and their significance recognized in the broader management strategies of rivers basins.

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RÉSUMÉ: CONNAISSANCES, PERCEPTIONS ET MENACES POUR LA CONSERVATION DES LOUTRES EURASIENNES (LUTRA LUTRA) DANS LE BASSIN VERSANT DE KALI GANDAKI, DISTRICT DE MYAGDI, AU NÉPAL

Bien qu'un nombre croissant d'enquêtes de terrain rendent compte de la répartition et des facteurs d'habitat des loutres eurasiennes (*Lutra lutra*) au Népal, il existe encore un manque important de recherches sur les interactions humaines avec l'espèce. Cette étude documente le statut socioéconomique des populations locales, leurs perceptions et leurs connaissances sur les loutres eurasiennes, ainsi que les menaces omniprésentes qui pèsent sur les loutres autour du bassin versant de Kali Gandaki dans le district de Myagdi. Une enquête à l'aide d'un questionnaire semi-structuré, utilisant une technique d'échantillonnage ciblé, a été menée dans la zone d’étude pour explorer ces facteurs. Septante résidents vivant dans le bassin versant ont participé à l’enquête. De simples statistiques descriptives ont été utilisées pour analyser les données quantitatives et le « test exact de Fisher » a été appliqué afin d’évaluer la relation entre les variables catégorielles. Les résultats de notre étude montrent que les personnes interrogées ont une attitude très positive envers les loutres, probablement liée à l’absence d’activités de pêche commerciale. Environ 62 % des personnes consultées ont déclaré qu’elles pensaient que les populations de loutres avaient diminué au cours des 10 dernières années. La majorité des personnes sondées n'avaient que peu ou pas de connaissances sur la valeur écologique des loutres dans les écosystèmes aquatiques. Néanmoins, un nombre significatif de participants ont fait preuve d’un enthousiasme accru et d’un vif intérêt pour la conservation des loutres dans leur localité. Les barrages hydroélectriques et les crues soudaines ont été classés comme les menaces les plus importantes pour la survie de l’espèce. Une application stricte des lois environnementales liées aux écosystèmes fluviaux, associée à des programmes de sensibilisation communautaire, est essentielle pour la conservation des loutres et de leurs habitats.

RESUMEN: CONOCIMIENTOS Y PERCEPCIONES DE LA POBLACIÓN LOCAL, Y AMENAZAS A LA CONSERVACIÓN DE LAS NUTRIAS EURASIÁTICAS EN LA CUENCA DE KALI GANDAKY, DISTRITO MYAGDI, NEPAL

Aunque hay un número creciente de reportes de campo que informan sobre la distribución y factores del hábitat de las Nutrias Eurasiáticas (Lutra lutra) en Nepal, aún hay una significativa falta de investigación sobre las interacciones de la especie con el ser humano. Este estudio documenta el status socioeconómico de la población local, sus percepciones, y su conocimiento sobre la nutria Eurasiática, y las extendidas amenazas sobre las nutrias en los alrededores de la cuenca de Kali Gandaky, en el Distrito Myagdi. Condujimos un relevamiento con cuestionario semi-estructurado, utilizando una técnica de muestreo deliberado, para explorar estos factores. Participaron en el relevamiento, setenta residentes que viven en la cuenca. Utilizamos estadísticos descriptivos simples para evaluar la relación entre las variables categóricas. Nuestros hallazgos muestran que los pobladores locales que respondieron tienen una actitud positiva hacia las nutrias, probablemente atribuible a la ausencia de actividades de pesca comercial. Alrededor del 62% de los que respondieron expresaron que creían que las poblaciones de nutria han declinado en los últimos 10 años. La mayoría de los que respondieron tenían poco o ningún conocimiento sobre el valor ecológico de las nutrias en los ecosistemas acuáticos. Sin embargo, un número signnificativo de participantes exhibió un acentuado entusiasmo y un alto interés en la conservación de las nutrias en su localidad. Como las amenazas más prominentes para la superviviencia de la especie, fueron rankeadas las represas hhidroeléctricas y las inundaciones repentinas. El control riguroso de las leyes ambientales relacionadas con los ecosistemas fluviales acoplado con programas de vinculación con la comunidad, son esenciales para la conservación de las nutrias y su hábitat.

A R T I C L E

DIET OF THE EURASIAN OTTER (*Lutra lutra*) IN BOUJAGH NATIONAL PARK, GUILAN, IRAN

Niloofar Sojdeh[1], Saeid Naderi[1]*, Alireza Mirzajani[2], and Shabnam Shadloo[3]

[1]*Department of Environmental Sciences, Natural Resources Faculty, University of Guilan, Iran*
[2]*Inland Water Aquaculture Research Center, Iranian Fisheries Science Research Institute, Agricultural Research Education and Extension Organization (AREEO), Bandar Anzali, Iran*
[3]*Institute of Oceans and Fisheries, University of British Columbia, Canada*
** Email address: naderi@guilan.ac.ir*

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Abstract: In this study, the diet of the Eurasian otter (*Lutra lutra*) was investigated in Boujagh National Park for one year. During this investigation, 615 spraints were collected, and the contents of each were identified in the laboratory. To estimate the amount of food items consumption, several statistics, such as percentage of relative frequency of occurrence (RFO%), percentage of frequency of occurrence (PFO%), percentage of relative importance (RI%), and percentage of biomass (Bio%), were calculated. The results showed that fish were the most frequent food item in the species' diet, and among the fishes, Gobiiformes, Mugiliformes, and Cypriniformes were the most abundant. RFO% were 14%, 12%, and 22% in the warm periods, and 26.94%, 20.23%, and 17.3% in the cold periods, respectively. Such fish species seem valuable because of their size, abundance, and behavioral characteristics. Other taxa, including insects, crustaceans, birds, reptiles, and amphibians were also observed in the otters' diet. Among them, insects in both warm (RFO=13%) and cold (RFO=6.15%) periods, and reptiles in the warm (RFO=14%) seasons of the year, have had more nutritional importance in Boujagh National Park. The width of the ecological food niche and the diversity of the consumed prey have higher values in the warm seasons. Also, the otter's food items overlap index indicates a medium value in both warm and cold periods of the year.

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Keywords: Ecology, Food Items, Warm and Cold Periods, Spraint Analysis

INTRODUCTION

Carnivores' foraging habits are important in social structure, habitat use, and reproductive rates, especially if access to food resources is seasonal. In general, if the food resources are abundant, the predator has more options, so it chooses the prey that is easier to hunt and provides more energy. In situations where food resources are plentiful and available, the predator's diet has less diversity. Conversely, if food resources are limited, the predator often hunts any available prey, which makes the species' diet more diverse (Stephens and Krebs, 1986; Tinker et al., 2008; Young et al., 2008; Thompson et al., 2014; Garcia-Silva et al., 2020).

The Eurasian Otter (*Lutra lutra*) is a top predator in aquatic ecosystems. Most research on otters' diets has been done in freshwater habitats. Only a few studies have investigated the diet and behavior of otters in marine environments. Therefore, more extensive research is needed to determine the importance of marine habitats for this species (Parry et al., 2011).

The food items of Eurasian otters include fish, insects, birds, crustaceans, reptiles, and amphibians, amongst which fish is the main prey. Otters mainly prefer small-sized and slow-moving fish species that are easily caught. The amount of feeding from non-fish alternative prey varies depending on the season and habitats. Most studies show that the degree of flexibility of the Eurasian otter's diet is directly related to the availability of its prey and habitat. The abundance and variety of prey can affect the width of a predator's ecological niche. Generally, the predator species that has a significant ecological niche width, has access to more food items (Parry et al., 2011; Kanchanasaka and Duplaix et al., 2011; Gorgadze, 2013; Krawczyk et al., 2016; Bouros et al., 2017; Mirzajani et al., 2021).

Among different otter species, the Eurasian otter is the most widely distributed in the world, but the actual status of this species is unclear. Most of the species' population was lost due to pollution in the past years, but later, they have recovered, partly through habitat restoration. Currently, this species is classified as Near Threatened in the IUCN Red List and Appendix II of the CITES Organization. As a top predator, otters play an important role in the functioning of aquatic ecosystems (Karami et al., 2006; Novais et al., 2010; Hadipour et al., 2011; Naderi et al., 2017). Their population density, successful reproduction, feeding behavior, and local mortality rate are related to prey availability, which in turn indicates the state of an ecosystem (Reid et al., 2013; Yoxon and Yoxon, 2019) (Fig. 1).

Figure 1. Eurasian Otter (*Lutra lutra*) feeding on amphibians (Photographer: Amin Sharif)

Boujagh National Park is an important habitat for this species in Iran. This park is of great ecological importance due to diverse marine, river, wetland, and estuary ecosystems (the junction of the Sefidroud River with the Caspian Sea). Despite the importance of this species in this region, no study has been done on it so far. In the present study, the diet of the Eurasian otter was studied for one year to analyze the effects of seasonal changes on the animals' diet.

MATERIALS AND METHODS

Area of Study

Boujagh National Park is located in the south of the Caspian Sea, Guilan Province, geographical coordinates 49° 51' 40'' to 49° 59' 50'' E, 37° 25' 00'' to 37°

28' 50" N. The national park has a total area of 3278.140 hectares and a circumference of 31.409 km. This area is 23 meters below sea level and is a plain with slopes between 0 and 0.5%. The park's northern boundary extends to a depth of 6 meters into the Caspian Sea. This park is primarily humid and has two rivers (Sefidroud and Oshmak) and two wetlands (Kiashahr Lagoon and Boujagh wetland). The Kiashahr lagoon, one of the oldest lagoons in Guilan Province, is critical for fish reproduction and bird breeding and wintering areas (Naqinezhad, 2012; Asadi Kapourchal et al., 2014; Saeidi Mehrvarz, 2016) (Fig. 2).

This area also consists of forests, meadows, streams, wetlands, riverbeds, agricultural lands, and roads. It has been designated as a National Park under the management of the Department of Environment for the protection of plant and animal species since 2002 (Naqinezhad, 2012; Asadi Kapourchal et al., 2014; Reihanian et al., 2015a, b; Saeidi Mehrvarz, 2016).

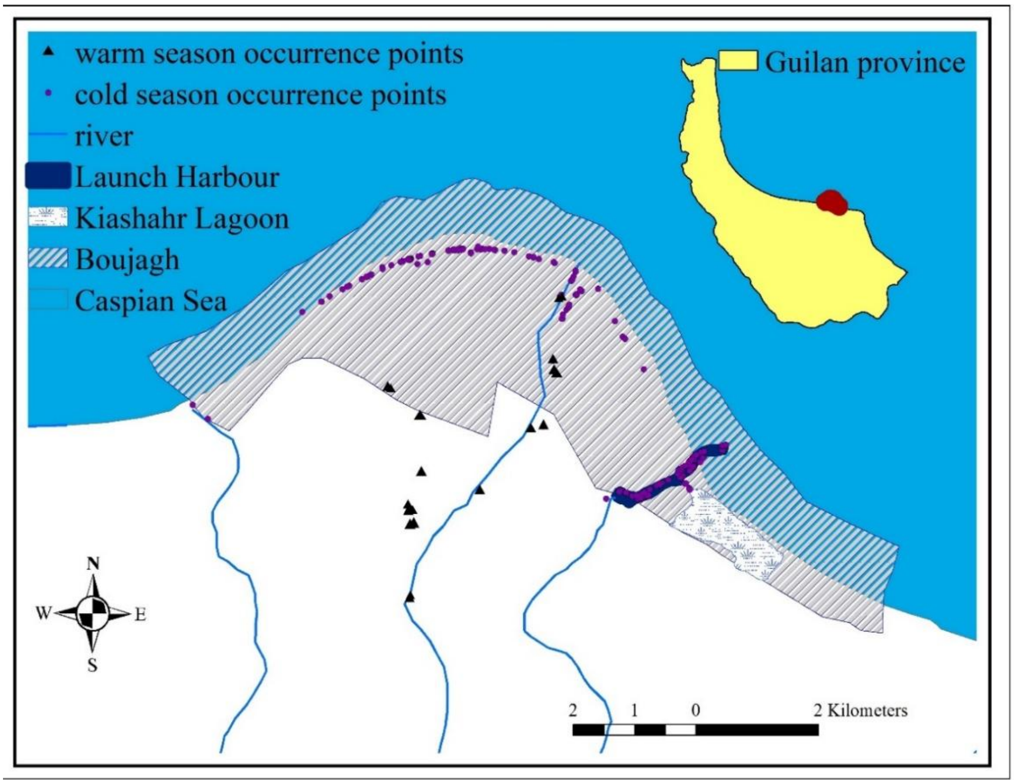

Figure 2. The study area (Boujagh National Park) and the species occurence points in two warm and cold periods of the year

Sampling

The entire area of Boujagh National Park, especially around the wetlands, was investigated, and all observed spraints (615 faeces in total) were collected from July 2018 to June 2019. Collected samples were stored separately in zip-locked plastic envelopes, and the related data of each sample, including date, and geographical coordinates and other descriptive information of the area's environmental conditions were recorded (Fig. 3).

Figure 3. Otter spraint marks in different places across Boujagh National Park

The spraints were analyzed in a laboratory. First, they were washed through a sieve with a mesh size of 0.5 mm. Then their dry weight was measured by a digital scale (with a sensitivity of 0.01 g). Finally, the samples were entirely washed with water, and their contents were identified in Petri dishes under a stereo microscope and a microscope (Sales-Luís et al., 2007; Hey, 2008; Remonti et al., 2008; Gorgadze, 2013; Mirzaie et al., 2014; Bouros et al., 2017) (Fig. 4).

The prey items were classified into several categories: fish, birds, reptiles, amphibians, insects, and crustaceans. Fish, as the most important prey of the Eurasian otter, were identified to the lowest possible level and split into three categories based on their habitat type (river, marine, and river/marine fishes).

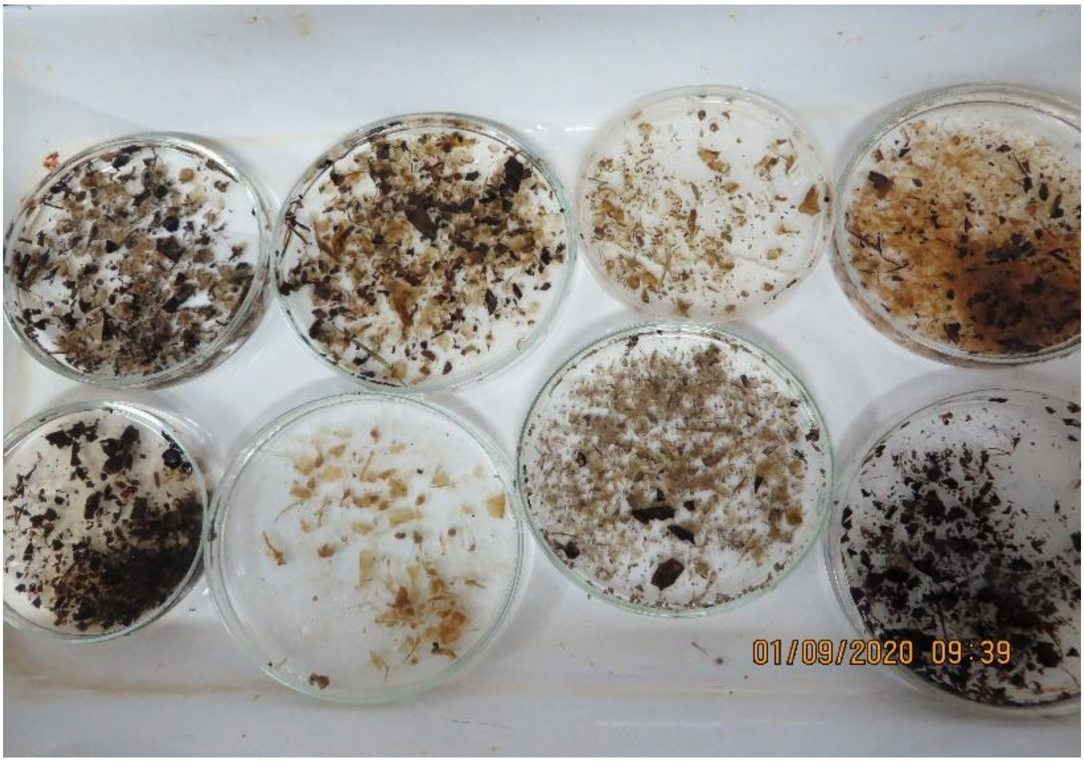

Figure 4. Washed samples in petri dishes for examination under microscope

Data Analysis

Diet data were expressed in terms of both frequency and biomass. The relative frequency of occurrence (RFO%) was calculated by dividing the number of each prey item occurrence by the total number of all prey items occurrence. The percentage of frequency of occurrence (PFO%) was calculated by dividing the number of spraints that contained the specific prey by the total number of spraints. Following Wise et al (1981), we also calculated the percentage of Relative Importance (Eq. 1), where W_i is the dry weight of each spraint and S_i is the score of each food item, ranging between 1 and 10 (Chuang and Lee, 1996; Bouros et al., 2017).

Equation 1: $RI = [\sum(W_i \times S_i) \div \sum(W_i \times 10)] \times 100$

The percentage of consumed biomass (Bio%), was assessed based on the dry weight of prey remains and the following digestibility coefficients (the ratio of the live prey weight to the remains of that prey in the spraint): 25 for fish, 18 for reptiles and amphibians, 12 for birds, 5 for insects, and 7 for crustaceans (Lockie, 1961; Jedrzejewska et al., 2001; Krawczyk et al., 2016).

The percentage of occurrence of different types of prey was then calculated for each spraint. The data collected from the region were divided into two categories related to warm (July - October 2019, and May - June 2020) and cold periods (November - December 2019, and January - April 2020). Since the data did not follow a normal distribution, the non-parametric Mann-Whitney U Test was used to examine the difference in the percentage of occurrence of each prey item in spraint in two warm and cold periods (Bouros et al. 2017). In addition, in order to compare the difference in percentage of frequency of occurrence and biomass in each group of fish (marine, freshwater, marine-freshwater) and also other prey between warm and cold periods, the non-parametric Mann-Whitney U was used.

The Levins index was used to investigate the width of the food niche of Eurasian otter in two warm and cold periods in Boujagh National Park (Levins, 1968). Using the ratio of food items consumed by the species and Equation 2, the width of the food niche of the species was calculated.

Equation 2: $B = \frac{1}{\sum {P_i}^2}$

Here, B is the width of Levins' niche, and P_i is the ratio of each consumed food group. Also, based on Equation 3, the amount of B_A, which is the width of the standardized niche, was calculated on a scale of 0 to 1. In this equation, n is the number of food items consumed by the species (Gorgadze, 2013; Bouros et al. 2017).

Equation 3: $B_A = \frac{B-1}{n-1}$

The Schoener index was calculated to determine the amount of dietary overlap between the year's warm and cold periods (Schoener, 1974). This index is measured using Equation 4. Here, Cxy is the estimation of overlap value, and P is the ratio of the occurrence of prey I in two warm (x) and cold (y) periods. If the value of this index is zero, it indicates no overlap in the consumed prey species in two periods. If the value of the index is 1, it means complete overlap, while values close to 1 indicate a significant overlap (Garcia-Silva et al. 2020).

Equation 4: $Cxy = 1 - 0.5(\sum|Px_i - Py_i|)$

The Shannon diversity index determines the aspects of diversity in a community. Using Equation 5, the species diversity of the consumed prey species in the two warm and cold periods was calculated.

Equation 5: $H = - \sum P_i \times \mathrm{Ln}\, P_i$

Here, P_i is the frequency of occurrence of item i. The higher the value of this index represents the higher species diversity of consumed food items (Clavero et al., 2003).

RESULTS

In general, the diet of Eurasian otter consists of nine orders of fish (Gobiiformes, Mugiliformes, Cypriniformes, Perciformes, Esociformes, Syngnathiformes, Atheriniformes, Clupeiformes, and Salmoniformes), one species of insect from the Coleoptera family, three species of crustaceans (shrimp, Amphipoda, and crab), two bird families (Rallidae and Scolopacidae), a snake and a lizard from reptiles, and frogs from amphibians. We were unable to distinguish species within the fish orders of Gobiiformes and Clupeiformes due to certain limitations, such as sample deterioration and similarities in identification keys for closely related species within these families. Nevertheless, all fish were identified at least to the level of their order (Table 1, Table 2).

Table 1. Fish prey identified in the Eurasian otter diet in Boujagh National Park

Order	Family	Species	Habitat
Gobiiformes	-	-	river/marine
Mugiliformes	Mugilidae	Golden grey mullet (*Chelon aurata*)	marine
		Golden grey mullet (*Chelon aurata*)	marine
Cypriniformes	Cyprinidae	Common carp (*Cyprinus carpio*)	river
		Prussian carp (*Carassius gibelio*)	river
	Leuciscidae	Common bleak (*Alburnus alburnus*)	river
		Kutum (*Rutilus frisii*)	marine
		Common bream (*Abramis brama*)	marine
	Gobionidae	Stone moroko (*Pseudorasbora parva*)	river
	Acheilognathidae	European bitterling (*Rhodeus amarus*)	river
Perciformes	Gasterosteidae	Stickleback (*Gasterosteus aculeatus*)	river/marine
	Percidae	European perch (*Perca fluviatilis*)	river
Esociformes	Esocidae	Northern pike (*Esox lucius*)	river
Syngnathiformes	Syngnathidae	Short-snouted pipefish (*Syngnathus caspius*)	marine
Atheriniformes	Atherinidae	Caspian sand smelt (*Atherina caspia*)	marine
Clupeiformes	-	-	marine
Salmoniformes	Salmonidae	Rainbow trout (*Oncorhynchus mykiss*)	river

Fish formed the bulk of otter diet in both warm and cold periods of the year. In warm seasons, reptiles and insects ranked second and third. In the cold period, the second rank of importance was related to insects; the rest of the food items were consumed in small quantities. Among the six main food items identified in Eurasian otter spraints, there was no significant difference in the consumption of crustaceans (P=0.488) and birds (P=0.532) between two warm and cold periods of the year. On the other hand, a significant difference was observed in the consumption of fish, insects, reptiles, and amphibians (Table 2).

In both warm and cold periods of the year, the families of Gobiidae, Mugilidae and Cyprinidae were the favorite prey of the otters. Iin the warm period of the year, the Cyprinidae (22%) family had the highest amount of consumption, and two families, Gobiidae (14%), and Mugilidae (12%), were ranked second and third. While among the three families Gobiidae, Mugilidae and Cyprinidae in the cold period of the year, Gobiidae (26.94%), with the highest frequency of occurrence, was the otters' priority, followed by Mugilidae (20.23%) and Cyprinidae (17.3%) (Table 2).

Table 2. Statistical analysis of the identified preys in the Eurasian otter spraints in the year's two warm and cold periods in Boujagh National Park. RFO%: relative frequency of occurrence. PFO%: percent frequency of occurrence. RI%: relative importance. Bio%: percentage of biomass; U: Mann-Whitney statistical test. *P*: statistical significance value.

Prey	Warm Period								Cold Period								Mann-Whitney Analysis	
	RFO%		PFO%		RI%		Bio%		RFO%		PFO%		RI%		Bio%			
	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	U	*P*
Fishes	**67.00**		**88.88**		**71.31**		**80.39**		**87.54**		**98.44**		**93.77**		**97.92**		**6778.5**	**0.000**
Gobiidae	14.00	2	38.88	2	6.11	5	6.74	4	26.94	1	60.44	1	32.36	1	33.33	1	6934.5	0.000
Mugilidae	12.00	5	33.33	5	22.11	2	24.86	2	20.23	2	45.42	2	26.21	2	27.80	2	9066.5	0.150
Cyprinidae	22.00	1	61.11	1	26.23	1	29.66	1	17.3	3	38.86	3	19.46	3	20.54	3	8086.5	0.011
Gasterosteidae	0		0		0		0		8.08	4	18.13	4	5.85	4	5.86	4	8532.0	0.005
Percidae	6.00	6	16.66	6	5.55	8	6.26	6	3.39	8	7.59	8	2.21	8	2.27	7	9428.5	0.043
Esocidae	3.00	8	8.33	8	5.58	7	6.28	5	4.3	7	9.67	7	2.81	7	2.97	6	10316.5	0.842
Syngnathidae	4.00	7	11.11	7	0.76	12	0.99	12	0.84	12	1.89	12	0.47	11	0.50	9	9467.0	0.001
Atherinidae	3.00	8	8.33	8	1.17	10	1.33	10	6.3	5	14.16	5	4.39	5	4.63	5	9801.5	0.317
Clupeidae	2.00	11	5.55	11	1.12	11	1.25	11	0		0		0		0		9843.0	0.000
Salmonidae	1.00	12	2.77	12	2.68	9	3.02	8	0		0		0		0		10132.5	0.000
Unidentified fisł	0		0		0		0		0.16	15	0.34	15	0.01	16	0.02	16	10386.5	0.724
Insects	**13.00**		**36.11**		**6.02**		**1.35**		**6.15**		**13.81**		**3.48**		**0.73**		**8276.0**	**0.001**
Coleoptera	13.00	3	36.11	3	6.02	6	1.35	9	6.15	6	13.81	6	3.48	6	0.73	8	8276.0	0.001
Crustaceans	**2.00**		**5.55**		**0.20**		**0.06**		**3.92**		**8.8**		**1.4**		**0.38**		**10076.0**	**0.488**
Shrimp	1.00	12	2.77	12	0.05	16	0.01	16	3.00	9	6.73	9	1.18	9	0.32	10	10017.0	0.354
Amphipoda	0		0		0		0		0.92	11	2.07	11	0.22	15	0.06	15	10206.0	0.383
Crab	1.00	12	2.77	12	0.15	15	0.05	15	0		0		0		0		10132.5	0.000
Birds	**1.00**		**2.77**		**0.31**		**0.17**		**2.24**		**5**		**1.42**		**0.69**		**10180.5**	**0.532**
Rallidae	0		0		0		0		1.00	10	2.24	10	0.5	10	0.25	12	10188.0	0.364
Scolopacidae	0		0		0		0		0.77	13	1.72	13	0.47	11	0.24	13	10260.0	0.451
Jnidentified bird	1.00	12	2.77	12	0.31	14	0.17	14	0.47	14	1.03	14	0.44	13	0.20	14	10262.0	0.431
Reptiles	**14.00**		**38.88**		**15.15**		**12.34**		**0**		**0**		**0**		**0**		**6369.0**	**0.000**
Snake	13.00	3	36.11	3	14.71	3	11.98	3	0		0		0		0		6658.5	0.000
Lizard	1.00	12	2.77	12	0.44	13	0.36	13	0		0		0		0		10132.5	0.000
Amphibians	**3.00**		**8.33**		**7.01**		**5.69**		**0.15**		**0.34**		**0.36**		**0.28**		**9591.5**	**0.000**
Frog	3.00	8	8.33	8	7.01	4	5.69	7	0.15	16	0.34	15	0.36	14	0.28	11	9591.5	0.000

Prey	Warm Period								Cold Period								Mann-Whitney Analysis	
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	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	U	*P*
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Coleoptera	13.00	3	36.11	3	6.02	6	1.35	9	6.15	6	13.81	6	3.48	6	0.73	8	8276.0	0.001
Crustaceans	**2.00**		**5.55**		**0.20**		**0.06**		**3.92**		**8.8**		**1.4**		**0.38**		**10076.0**	**0.488**
Shrimp	1.00	12	2.77	12	0.05	16	0.01	16	3.00	9	6.73	9	1.18	9	0.32	10	10017.0	0.354
Amphipoda	0		0		0		0		0.92	11	2.07	11	0.22	15	0.06	15	10206.0	0.383
Crab	1.00	12	2.77	12	0.15	15	0.05	15	0		0		0		0		10132.5	0.000
Birds	**1.00**		**2.77**		**0.31**		**0.17**		**2.24**		**5**		**1.42**		**0.69**		**10180.5**	**0.532**
Rallidae	0		0		0		0		1.00	10	2.24	10	0.5	10	0.25	12	10188.0	0.364
Scolopacidae	0		0		0		0		0.77	13	1.72	13	0.47	11	0.24	13	10260.0	0.451
Jnidentified bird	1.00	12	2.77	12	0.31	14	0.17	14	0.47	14	1.03	14	0.44	13	0.20	14	10262.0	0.431
Reptiles	**14.00**		**38.88**		**15.15**		**12.34**		**0**		**0**		**0**		**0**		**6369.0**	**0.000**
Snake	13.00	3	36.11	3	14.71	3	11.98	3	0		0		0		0		6658.5	0.000
Lizard	1.00	12	2.77	12	0.44	13	0.36	13	0		0		0		0		10132.5	0.000
Amphibians	**3.00**		**8.33**		**7.01**		**5.69**		**0.15**		**0.34**		**0.36**		**0.28**		**9591.5**	**0.000**
Frog	3.00	8	8.33	8	7.01	4	5.69	7	0.15	16	0.34	15	0.36	14	0.28	11	9591.5	0.000

According to statistical analyses, a significant difference was observed in the most frequently eaten fish species (Gobiiformes, Cypriniformes) between two warm and cold periods (*P*<0.05). The Mugiliformes and Perciformes orders were also important in the diet of Eurasian otters, but there was no significant difference in their consumption between the two periods (*P*=0.150; 0.334). Likewise, there was no significant difference in the amount of taking of Esociformes and Atheriniformes (less hunted fish species) between two periods of the year. Syngnathiformes, Clupeiformes, and Salmoniformes were also observed in tiny amounts in Eurasian otter spraints. However, the results show a significant difference in their consumption between the two periods of the year (Table 2).

Among the non-fish prey species, insects (water cockroaches) are a crucial part of the Eurasian otter diet throughout the year. Reptiles (mainly snakes) were only found frequently during the warm period. On the other hand, the amount of bird hunting in the warm period was markedly low, whereas the families of Rallidae and Scolopacidae were identified in small amounts in the cold period. Similarly, shrimps were detected more in the cold period. The rest of the crustaceans, such as Amphipoda and crabs, were caught in small quantities. Frogs were hunted more frequently during the warm period by Eurasian otter (Table 2) (Fig. 5).

According to the results, Eurasian otters hunt differently in marine and riverine ecosystems. In the warm period, the highest abundance of prey remains are freshwater fish (28.95%). After that, marine fish (26.31%) and non-fish prey (26.31%) were the most abundant. Fish species that are common in both rivers and the Caspian Sea included 18.42% of the otters' diet. However, the results are slightly different in terms of the percentage of biomass consumed; marine fishes (44.22%) have the first rank, and freshwater fishes (29.43%), non-fish prey (19.61%), and fish inhabiting both the rivers and the Caspian Sea (6.74%). Also, in the cold period, the highest frequency of prey occurrence in Eurasian otter diet was for the fish order Gobiiformes, and Gasterosteidae family (Perciformes), which are common species in the Caspian Sea and rivers (35.03%). Marine and freshwater fish species (28.26%, and 24.12% respectively), and non-fish species (12.58%) followed in consumption rank (Table 3).

According to the statistical analysis based on the frequency of occurrence of each prey in the spraints, there was a significant difference between the warm and cold period in the consumption of common marine-freshwater fish species and non-fish species (*P*-value=0). There was no significant difference between the warm and cold period in the frequency of consumption of marine and freshwater prey. The results obtained from the analysis of biomass are also similar to the frequency of occurrence. There is only a difference in relation to freshwater fish, where a significant difference was seen between the warm and cold periods of the year (*P*=0.007) (Table 3).

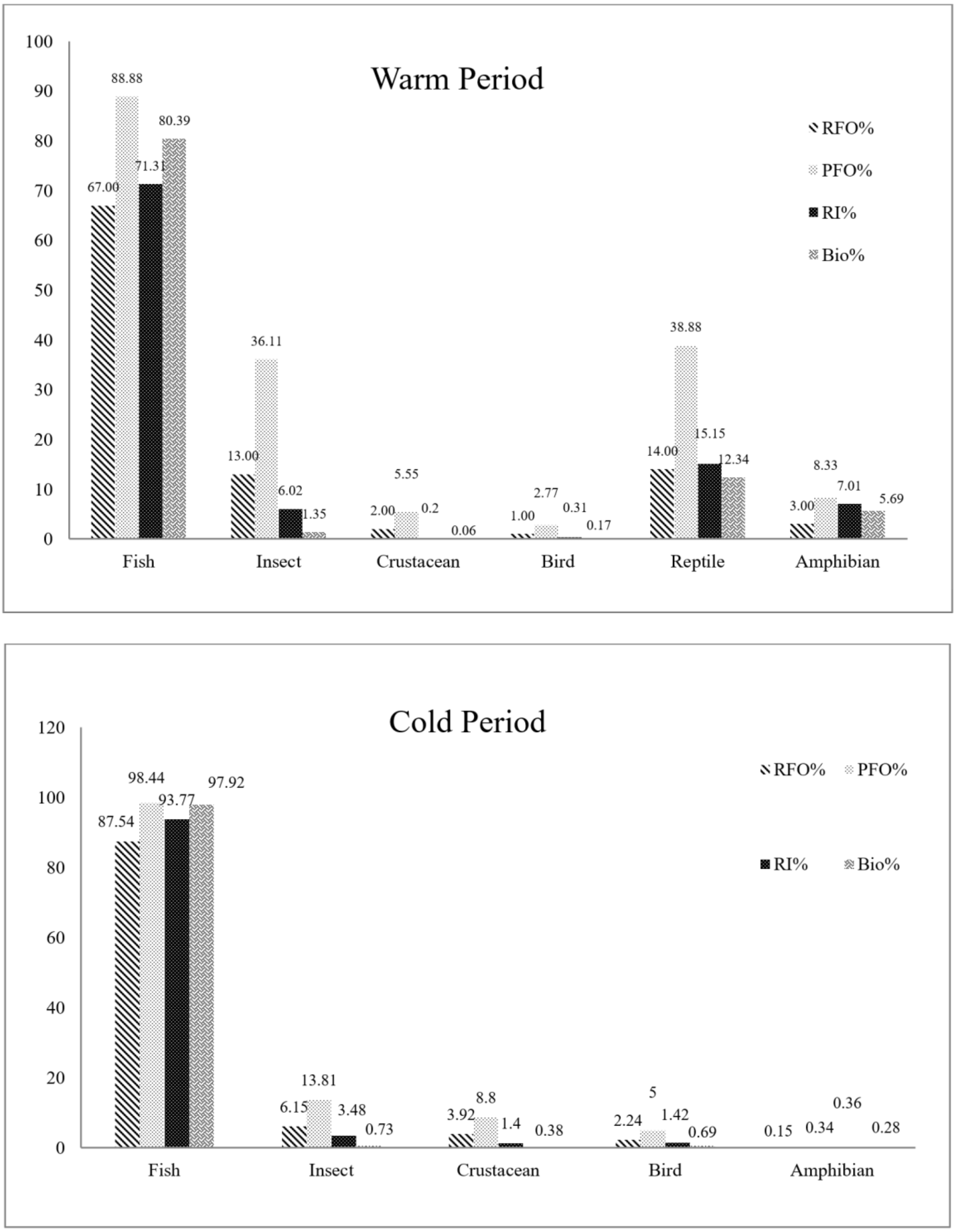

Figure 5. The recognized main food categories of the Eurasian otter diet in Boujagh National Park, in two warm and cold periods of the year, based on four methods of spraint analysis

Table 3. Statistical analysis of fish species prey (river, sea, and common in river-sea) and non-fish prey based on the consumed biomass and frequency of occurrence prey items in warm and cold periods of the year in Boujagh National Park

Prey Type	Period		Mann-Whitney Analysis	
	Warm (N=36)	Cold (N=579)	U	*P*
	RFO%			
Marine	26.31	28.26	10373.0	0.960
Freshwater	28.95	24.12	8756.5	0.082
Marine-Freshwater	18.42	35.03	5837.5	0.000
Non-fish prey	26.31	12.58	6763.5	0.000
	Bio%			
Marine	44.22	33.27	9998.5	0.668
Freshwater	29.43	26.03	7835.5	0.007
Marine-Freshwater	6.74	38.64	6805.5	0.000
Non-fish preys	19.61	2.06	6187.5	0.000

The width of the food niche (B) of Eurasian otter in Boujagh National Park is larger in the warm period of the year. The standard food niche (B_A) and the overall Shannon diversity index are also higher in the warm period. The estimated value of the Schoener index (0.63) indicates the medium overlap between the Eurasian otter's diet in warm and cold periods in Boujagh National Park (Table 4).

Table 4. Estimation of the food niche width, diversity index, and the amount of diet overlap in two warm and cold periods
(B: food niche width. B_A: standard food niche width. N: number of analyzed spraints)

	Warm Period	Cold Period
N	36	579
B	7.996	5.978
B_A	0.349	0.248
Shannon diversity index	2.31	2.02
Schoener index	0.63	

DISCUSSION

Using indirect methods to estimate the diet of a predator species requires caution. Most of the information obtained from these studies can create a general and approximate picture of the nutritional behavior of the target species. However, the accuracy of this analysis is affected by the method used to estimate the diet and many related complicated factors (Clavero et al., 2004; Remonti et al., 2008; Lanszki et al., 2015; Bouros et al., 2017).

During the year, fish always form the most significant amount of the species' diet, and are always their preferred food, but there is still a difference in the amount of their consumption in the two periods. Our study shows that the amount of fish consumption decreases in the warm season. This reduction is because chasing and hunting fish in warmer water needs more energy, because with the increase of water temperature, fish species' metabolism rates and swimming speed increases. On the other hand, during the warm season, more alternative prey are available to the otters (Clavero et al., 2003; Brzeziński et al., 2006; Bauer-Haáz et al., 2014).

According to a study by Mason and Macdonald (1986), feeding on fish depends on their size and availability. Smaller fish (less than 200 mm) are more dominant in the otters' diet. During the two periods, the consumption of Gobiiformes was more than that of other fish orders. The small size of Gobiiformes species (often between 50 and 100 mm), their abundance in the aquatic ecosystems of Boujagh National Park, and their relatively slower swimming speed can influence their hunting rate by Eurasian otters.

Two orders of Cypriniformes and Mugiliformes were most preferred by Eurasian otters. Among the Cypriniformes fishes, Prussian carp (*Carassius gibelio*) was the most abundant in spraint. This species is relatively small in size. Because young and immature otters cannot hunt larger prey, they mainly target smaller fish. Despite the higher consumption of small-sized fish by otter, they do sometimes feed on the larger fish (greater than 1000 grams) (McMahon and McCafferty, 2006; Gorgadze, 2013; Lanszki et al., 2015).

Seasonal variation in reptile consumption was consistent with their availability, as during the cold period reptiles are less active, and often hibernating. However, it is different for amphibians. Amphibians were hunted in small amounts in cold seasons despite hibernation. This can happen for several reasons. Firstly, during cold seasons, some temporary warm periods can make frogs come out of their hibernation places to small ponds in a dozy state, making them easy prey for otters. Moreover, otters can take advantage of the opportunity when amphibians hibernate under stones and sticks, as they can turn them over with their snouts and feed on the sleeping amphibians. Furthermore, the end of the cold period (March and April) coincides with the beginning of the frogs' mating season, during which they make elaborate noises to attract mates, which can also attract otters as predators. Finally, in warm seasons, amphibians inhabit spawning waters, ponds, and other bodies of water for breeding, making them accessible prey for otters (Weber, 1990; Sulkava, 1996; Britton et al., 2006; Brzeziński et al., 2006; Cousins et al., 2011; Krawczyk et al., 2016; Sittenthaler et al., 2019; Andeska et al., 2021).

Birds formed only a tiny fraction of their diet. Among the bird species, coots (*Fulica atra*) were found in the highest proportion. It may be due to their nesting behavior as they build their nests on the ground and often near the shore and reeds. They also usually loaf on the water's edge and the emergent plants (Chanin, 1981; Irwin et al., 1997; Hey, 2008).

In contrast to previous research findings where mammals were noted as part of Eurasian otter diet (Remonti et al., 2008; Mirzaie et al., 2014; Lanszki et al., 2015), in the present investigation within Boujagh National Park, there was no evidence or traces of mammal consumption.

Conroy and Jenkins (1986) and Beja (1991) stated that preying on fish in marine environments requires more energy than freshwater, so otters prefer to feed in freshwater. However, in the present study, marine and marine-riverine fish species were the most significant part of the diet, indicating the dependence of otters on both freshwater and marine environments. It seems that changes in the abundance of fish populations in different seasons, secure access to food resources, and probably habitat alterations affect on the trends of this process (Clavero et al., 2004; Parry et al., 2011).

Based on the findings, the food niche breadth and Shannon diversity index are significantly greater in the warm period than to the cold period. This is attributed to a relative decrease in fish abundance during the warm season, which forces otters to expand their food niche in order to provide sufficient energy and consume a wider range of items. Conversely, the warm period sees an increase in the availability of alternative prey such as reptiles and other species, further contributing to the expanded dietary options for otters. These dietary changes lead to an increase in Shannon's diversity index during the warm period. On the contrary, during the cold period, due to the high levels of primary food sources, Eurasian otters often hunt for fish, which reduces dietary diversity and nutritional items. Because fish provide more energy than other food items and are highly available in cold seasons, they comprise much of the species' diet. This makes the food niche width and Shannon index less in this period. Similar results have been obtained in previous studies (Brzeziński et al., 1993; Baltrūnaitė, 2006; Georgiev, 2006; Gorgadze, 2013).

As previously explained, the diversity of species eaten by otters in warm seasons is greater than in cold seasons. This difference in the variety of the eaten prey species has therefore led to the medium overlap of dietary items in two periods (Schoener = 0.6). This result is consistent with the data of some other studies (Brzeziński et al., 1993; Baltrūnaitė, 2006).

Despite Eurasian otters being specialized for feeding on fish, the opportunistic behavior of this species has been proved in many dietary studies: when fish density in an area decreases, otters turn to feeding on other prey species (Sulkava, 1996; Jedrzejewska et al., 2001; Brzeziński et al., 2006). Its feeding habits therefore vary depending on the time and environmental conditions. Providing an environment with the least stress and the highest food resources can effectively conserve this valuable species' population.

CONCLUSION

In conclusion, since this species prefers to feed on fish, it is essential to investigate the abundance and behavior of fish in the waters of Boujagh National Park, considering the species' foraging behavior, especially during the breeding season. This can be pivotal for planning of applied conservation program for this critical species.

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RESUMEN : RÉGIME ALIMENTAIRE DE LA LOUTRE EURASIENNE (*Lutra lutra*) DANS LE PARC NATIONAL DE BOUJAGH, GUILAN, IRAN

Dans cette étude, le régime alimentaire de la loutre eurasienne (*Lutra lutra*) a été étudié dans le Parc National de Boujagh pendant un an. Au cours de cette investigation, 615 excréments ont été collectées et le contenu de chacune d'entre elles a été identifié en laboratoire. Pour estimer la quantité de produits alimentaires consommés, plusieurs statistiques telles que le pourcentage de fréquence relative d'occurrence (FRO), le pourcentage de fréquence d'occurrence (PFO), le pourcentage d'importance relative (IR%) et le pourcentage de biomasse (Bio%) ont été calculés. Les résultats ont montré que les poissons étaient l'aliment le plus fréquent dans le régime alimentaire de l'espèce et que parmi les poissons, les Gobiiformes, les Mugiliformes et les Cypriniformes étaient les plus abondants et que le pourcentage de RFO était de 14 %, 12 % et 22 % pendant les périodes chaudes, et de 26,94 %, 20,23 % et 17,3 % pendant les périodes froides, respectivement. Ces espèces de poissons semblent précieuses en raison de leur taille, de leur abondance et de leurs caractéristiques comportementales. D'autres taxons, notamment des insectes, des crustacés, des oiseaux, des reptiles et des amphibiens, ont également été observés dans le régime alimentaire des loutres. Parmi eux, les insectes pendant les périodes chaudes (RFO=13%) et froides (RFO=6.15%), ainsi que les reptiles pendant les saisons chaudes (RFO=14%) de l'année, ont eu une plus grande importance nutritionnelle dans le parc national de Boujagh. La largeur de la niche alimentaire écologique et la diversité des proies consommées ont des valeurs plus élevées pendant les saisons chaudes. De plus, l'indice de chevauchement des aliments de la loutre indique une valeur moyenne aussi bien dans les périodes chaudes que froides de l'année.

RESUMEN: DIETA DE LA NUTRIA EURASIÁTICA (*LUTRA LUTRA*) EN EL PARQUE NACIONAL BOUJAGH, GUILAN, IRÁN

En éste estudio, se investigó la dieta de la Nutria Eurasiática (*Lutra lutra*) en el Parque Nacional Boujagh, durante un año. Durante ésta investigación fueron colectadas 615 fecas, y se identificó el contenido de cada una en el laboratorio. Para estimar el monto del consumo de los items alimentarios, se calcularon diversos estadísticos, como el porcentaje de frecuencia relativa de ocurrencia (RFO%), porcentaje de frecuencia de ocurrencia (PFO%), porcentaje de importancia relativa (RI%), y porcentaje de biomasa (Bio%). Los resultados mostraron que los peces son el item alimentario más frecuente en la dieta de la especie, y entre los peces, los más abundantes fueron los Gobiiformes, Mugiliformes, y Cypriniformes, con RFO% de 14%, 12%, y 22% en los períodos cálidos, y 26.94%, 20.23%, y 17.3% en los períodos fríos, respectivamente. Estas especies de peces parecen ser valiosas en la dieta a causa de su tamaño, abundancia, y características de comportamiento. Otros taxones, incluyendo insectos, crustáceos, aves, reptiles, y anfibios también fueron observados en la dieta de las nutrias. Entre ellos, los insectos tanto en períodos cálidos (RFO=13%) como fríos (RFO=6.15%), y los reptiles en las estaciones cálidas del año (RFO=14%), tuvieron mayor importancia nutricional en el Parque Nacional Boujagh. La amplitud del nicho ecológico alimentario y la diversidad de las presas consumidas mostraron valor más altos en las estaciones cálidas. También, el índice de superposición de items alimentarios indica un valor medio tanto en períodos cálidos como fríos.

چکیده

در مطالعه حاضر، رژیم غذایی گونه شنگ اوراسیایی (*Lutra lutra*)، در پارک ملی بوجاق برای یک سال، بررسی شد. در طی این بررسی، 615 مدفوع جمع آوری شدند و محتویات هر یک از آن ها، در آزمایشگاه، شناسایی شدند. برای تخمین مقدار مصرف آیتم های غذایی، چندین آماره مختلف مانند درصد فراوانی نسبی وقوع (RFO%)، درصد فراوانی وقوع (PFO%)، درصد ارجحیت نسبی (RI%)، و درصد بیوماس (Bio%)، محاسبه شدند. نتایج، حاکی از آن بود که ماهی فراوان ترین آیتم رژیم غذایی گونه بوده، و در میان راسته های ماهی، گاوماهیان، کفال ماهیان و کپورماهیان، فراوان ترین بودند و مقدار RFO در دوره های گرم به ترتیب 14%، 12% و 22% و در دوره های سرد 26.94%، 20.23% و 17.3% درصد بود. چنین ماهیانی، به نظر می رسد بخاطر اندازه، فراوانی و خصوصیات رفتاری، برای شنگ ها ارزشمند هستند. سایر موجودات، شامل حشرات، سخت پوستان، پرندگان، خزندگان، و دوزیستان نیز در رژیم غذایی شنگ مشاهده شدند. در میان آن ها، حشرات در هر دو دوره گرم (RFO=13%) و سرد(RFO=6.15%)، و خزندگان، در فصول گرم (RFO=14%) سال، بیشترین ارزش تغذیه ای را در پارک ملی بوجاق، برای شنگ داشتند. پهنای آشیان اکولوژیک غذایی و تنوع طعمه های مصرف شده در فصول گرم سال، دارای مقادیر بالاتری بودند. همچنین، شاخص همپوشانی آیتم های غذایی شنگ، مقدار متوسطی را در هر دو دوره گرم و سرد سال نشان داد.

A R T I C L E

MAINTENANCE OF THE EURASIAN OTTER *Lutra lutra* IN A SECTION OF THE BEHT RIVER (KHÉMISSET PROVINCE, MOROCCO) IN THE FACE OF HUMAN ACTIVITY

Abdallah MAHAMOUD[1]*, Mohammed HILMI[1], Melvin ONDIBA[2], Mohammed Aziz EL AGBANI[1], Abdeljebbar QNINBA[1]

[1]*Laboratory of Geo-Biodiversity and Natural Heritage (GEOBIO), Scientific Institute, Mohammed V University in Rabat, Morocco*
[2]*Laboratory of Biodiversity, Ecology and Genome, Faculty of Sciences, Mohammed V University in Rabat, Morocco*
**Corresponding author: E-mail: amc1997mbeni@gmail.com*

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Abstract: The Eurasian Otter *Lutra lutra* is one of the threatened carnivorous mammals in Morocco. It is listed as Near Threatened and Largely Depleted by the IUCN. From 2020 to 2024, we carried out seasonal monitoring of an otter population living in a section of the lower valley of the Beht River, which is heavily exploited for agriculture, livestock farming and the extraction of building materials (quarries), with the aim of assessing the species' tolerance to the pressures and changes affecting its habitat. Monitoring has been carried out in almost all seasons during these four years, during which we have noted the pervasive presence of the species in the section, despite the challenges and sometimes extreme conditions it faces. Our observations show that in the short term, the Eurasian Otter can resist substantial changes in the environment caused by anthropogenic activity.

Keywords: Eurasian otter, Human activities, Beht River, Morocco

INTRODUCTION

The Eurasian Otter *Lutra lutra* has a Palearctic distribution and occurs in Europe, Asia and North Africa. It is a semi-aquatic mustelid (family Mustelidae) that feeds mainly on fish, amphibians and insects (Cusin, 2003). It is closely associated with aquatic environments, and particularly rivers. It is therefore an excellent indicator of the quality of these environments (Lemarchand, 2007).

The Eurasian Otter is classified as near-threatened (NT A2c) on the IUCN red list on a global scale (Loy et al., 2022) and “Vulnerable” in Morocco (Cuzin, 1996). Delibes et al. (2012) reported in their studies that the species was observed to be absent from intensely populated and cultivated flat areas and experienced a decline in the Atlantic plains in Morocco.

In Morocco, there have been significant alterations to the hydrographic systems, particularly in the lowlands and plains. The water quality and the hydrological conditions in Moroccan rivers have been significantly changed due to prolonged drought, excessive pumping, increased use of pesticides and fertilizers, and increased damming with lack of environmental flow. These transformations have led to long periods of hydrological drought, leaving the river beds completely dry for considerable distances (Libois et al., 2012). Conversely, water pollution negatively affects the presence and the quality of the Eurasian Otter’s prey, namely fish.

From February 2020 to February 2024, we conducted seasonal monitoring of a population of otters in a section of the lower valley of the Beht river, heavily exploited by humans for agriculture, livestock and farming, and extraction of construction materials (quarries), in order to assess the tolerance of the species to anthropogenic pressure.

MATERIALS AND METHODS

Study Area

The study was carried out in the Beht River, one of the principal rivers of the Atlantic plains of Morocco. The Beht river flows through a diverse range of landscapes, encompassing plains and mountainous areas. The Beht begins its course in the western edge of the Middle Atlas Causse, and drains the northern edge of Central Morocco (Laabidi et al., 2016).

The study area is located in the north-east of the province of Khémisset in Morocco. It extends between the geographical coordinates 33°51'14.1"N - 5°55'26.3"W downstream to 33°44'00.4"N - 5°56'28"W upstream, and stretches for a distance of 25 kilometres. The altitude in the study area varies between 145 m and 152 m (Fig. 1).

The monitored stretch of the river hosts different species of fish that are consumed by the otter, like *Carasobarbus fritschii*, *Lusciobarbus maghrebensis*, *Lepomis microlophus*, *Oreochromis niloticus*, and some unidentified carps (Hilmi et al., 2023). The study area also hosts a population of the freshwater crab *Potamon algeriense* (Hilmi et al., 2023), which has been found to be consumed by the Eurasian Otter in the study area (Mahamoud et al., 2024).

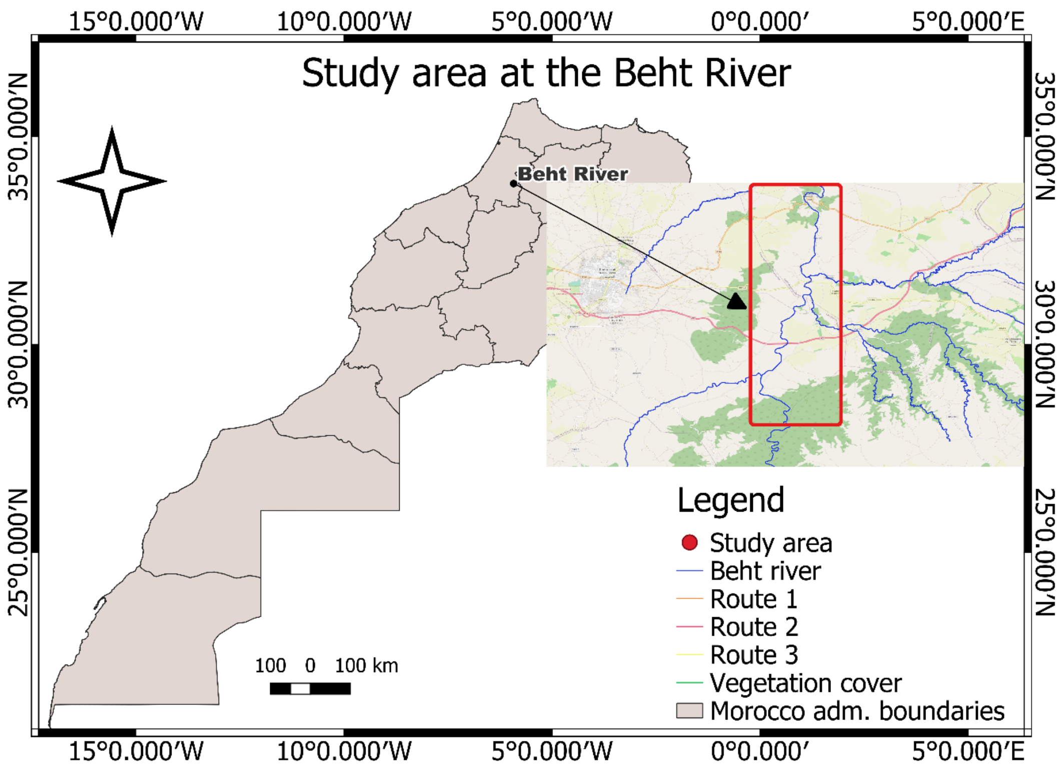

Figure 1. Geographical location of the study area (source: QGIS 3.30.3)

Methods

Development of the Land Use Map

A land use map was developed for the study area using ArcGIS software version 10.8 and visual observations carried out in the field.

Search for Signs of the Presence of the Otter

Due to the otter's extreme discretion and distrust, the detection of its presence and the assessment of its distribution can only be achieved effectively by looking for presence clues in its environment (faeces and footprints). Indeed, the species is very difficult to observe directly, yet it leaves clear and distinctive marks that are relatively easy to spot.

The initial selection of monitoring stations was made on the basis of their location along the section, with a spacing of 2.5 to 5 kilometers between them. The selection was based on the identification of locations that provide optimal habitat for the otter. This included areas with sufficient water depth, the presence of suitable shelter along the banks, and other factors conducive to presence of otters (Reuther et al., 2000; Richard-Mazet, 2005) (Fig. 2).

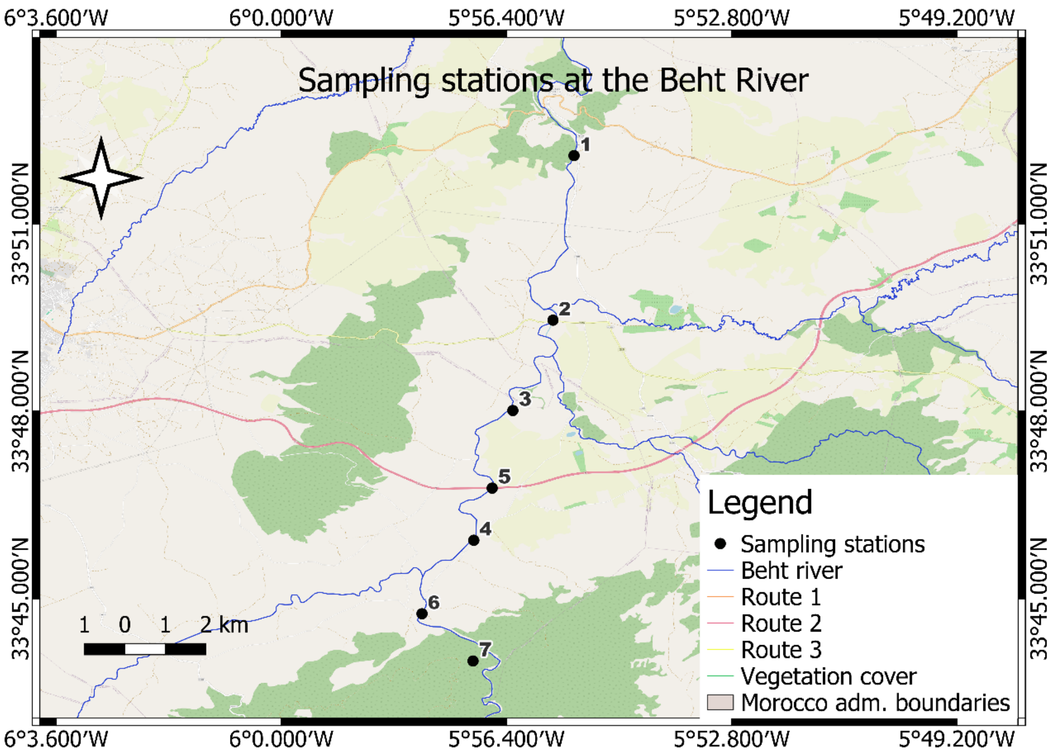

Figure 2. Sampling stations in the study area (source: QGIS 3.30.3)

Research missions and presence index surveys were carried out from February 2020 to February 2024 with a frequency of one to nine missions per season, except for spring season in 2020 (due to the COVID19 pandemic). Mission durations varied from one to three days.

The surveys were carried out in the seven chosen stations in accordance with the IUCN survey protocol (Reuther et al., 2000), adapted to the context of the chosen study area. The protocol suggests searching by foot, on each of the study stations previously defined and distributed within the study area, for the most reliable indices of the Eurasian Otter's presence, namely spraints (faeces) and imprints (paw marks) (Bouchardy et al., 2008) on 300 meters on either side of the reference point, on both banks when possible (Varanguin and Sirugue, 2008). A minimum of one visit was conducted at each station during each season, with the exception of spring 2020, during which surveys were not carried out at stations 1, 2, 3, 4, 5, 6, and 7. Additionally, surveys were not conducted at station 7 during the years 2023 and 2024. Some stations were surveyed on more than one occasion, given their potential for the species to become established (see Table 1). The signs of presence found were photographed as well as the surrounding environment; then, the spraints (faeces) were collected in freezer bags and transported to the laboratory for further analysis.

Use of Camera Trap

Camera traps (Browning Trial Cameras model BTC-8A) were set throughout the night during certain missions at the stations where we had detected the most signs of presence to try to observe the animal in activity and visually confirm the presence of the species. The parameters of the camera traps were set based on the study of Wright, 2023; the camera settings were set to image (12 MP), where 3 images were taken after the camera detected movement. An interval of one second was set between each image.

Station Characterisation

A detailed description of the environment was recorded at stations. The following environmental variables were considered:

- The riparian zone, with a description of the presence or absence of refuges and shelters.
- The presence or absence of water permeability.
- Average depth
- Dam releases
- The presence of gueltas (natural pools of water in the watercourse)
- The presence of large boulders in the bed of the river or on the bank.
- The presence/absence of human activities in the vicinity of the river (agriculture, quarrying, etc.) or artificial structures (bridges and culverts).

Analysis of Similarity between Stations.

A hierarchical ascending classification was employed to compare the presence of species indicators between stations within the study area. This statistical analysis was conducted using the PRIMER software package (Plymouth Routines in Multivariate Ecological Research).

DISTLM Analysis

A DISTLM (Distance-Based Linear Modelling) analysis was employed to evaluate the impact of the diverse environmental parameters observed in the field on the variability observed in the presence and absence of indices at the stations (Anderson and Mcardle, 2001).Sequential tests were utilised to ascertain which combinations of environmental variables most effectively explained the variability in presence (Legendre and Anderson, 1999).

RESULTS

Land Use Mapping of the Study Area.

Using ArcGIS 10.8 software, we mapped land use based on field observations we made in the field (Fig. 3). The map shows that almost the entire section is devoted to agriculture, on both sides of the Harmful agricultural practices in the study area that affect the river's hydrology and riparian habitats include excessive pumping from the river to irrigate crops, and bulldozing riverbanks (and associated plant cover) to acquire more agricultural land (Hilmi et al., 2024). In addition to agriculture, local people practice extensive livestock farming on both banks of the river in the totality of the study area.

The map also shows human settlements in and around the study area. We also note the presence of quarries for the extraction of construction materials. Aggregate mining companies extract their materials directly from the bed of the river (Libois et al., 2012).

At both ends of the study area, there are also remnants of natural vegetation.

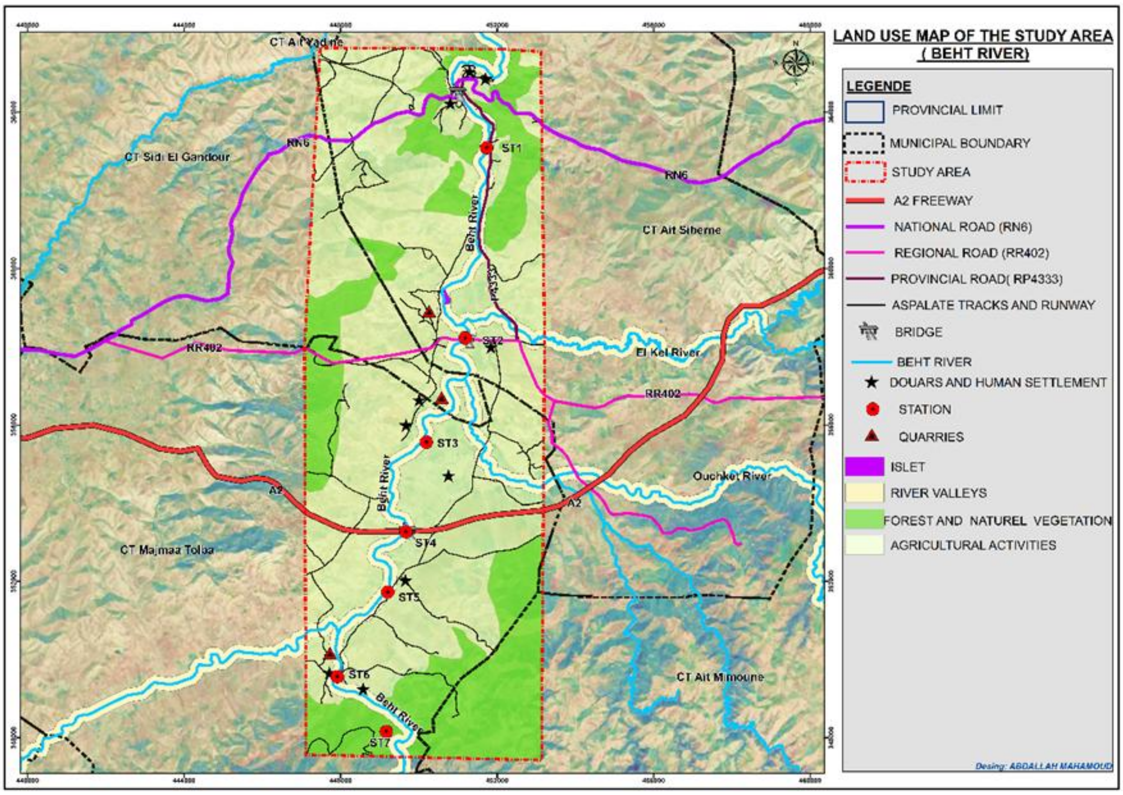

Figure 3. Land use map within the study area (Source: ARCGIS 10.8)

Distribution of the Otter in the Study Area

The table below provides a detailed account of the number of visits made to each station per season and per year.

Table 1. Number of visits made to each station per year and per season (W: winter; SU: summer; SP: spring; AU: autumn).

STATION	NUMBER OF VISITS																TOTAL
	2020-2021				2021-2022				2022-2023				2023-2024				2020-2024
	W	Sp	Su	A	W	Sp	Su	A	W	Sp	Su	A	W	Sp	Su	A	Seasons
01	2	0	2	2	2	1	2	7	4	3	2	3	2	5	2	4	43
02	2	0	2	3	2	2	3	9	6	5	3	4	5	7	3	5	61
03	2	0	1	1	1	1	1	4	2	2	1	2	1	3	1	1	24
04	2	0	1	1	2	2	2	8	3	2	1	3	3	4	1	3	38
05	2	0	1	1	1	1	1	4	2	2	1	2	2	3	1	1	25
06	2	0	2	3	2	2	3	9	6	5	4	4	5	7	3	6	63
07	1	0	1	1	1	1	1	2	0	0	0	0	0	0	0	0	8

Several signs of otter presence were observed in the study area in all of our visits over the four years. Fresh and/or dry tracks were the most frequently observed, even during the summer, which is characterised by prolonged drought of certain parts of the river (Fig. 4). On the other hand, Eurasian Otter tracks were mainly observed on the exposed muddy riverbed during the rainy seasons, especially in autumn and winter, and during periods when the riverbed was well filled (Figure 5).

Figure 3. Spraint (Faeces) of Eurasian Otters in different stations in the study area (Photo credit A. Mahamoud)

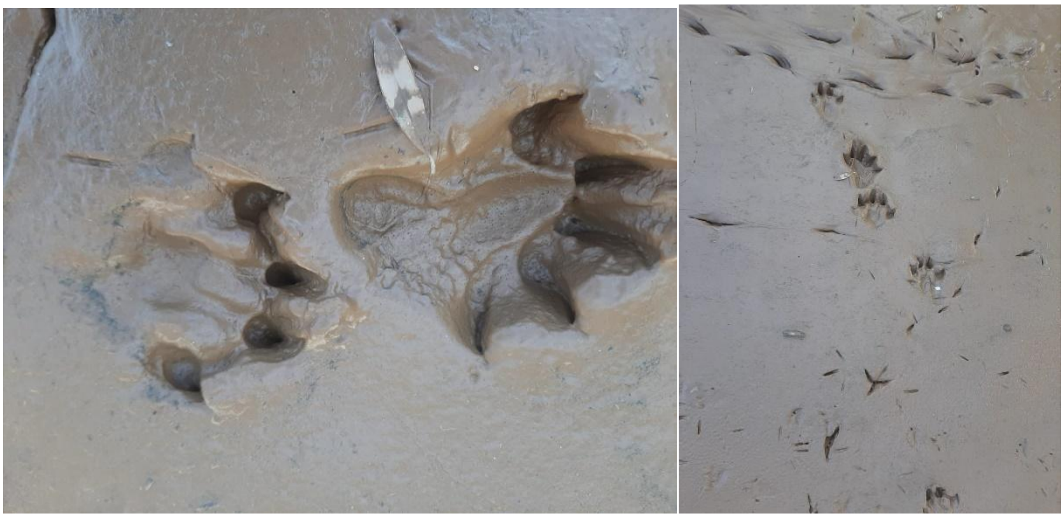

Figure 4. Eurasian Otter footprints taken in the study area (Station 1 and 6) (Photo credit A. Mahamoud)

The examination of Station 7 yielded positive results during the spring, winter, and autumn seasons of the first two years. However, it was not explored in the final two years due to access difficulties. It is at stations 1, 2, and 6 that we noted the most otter sign during all four seasons of each year. Station 4 was only positive when water was present: during periods of drought, the water flow at this station ceased, especially during the summer seasons (Table 2, Fig. 6).

Table 2. Results of the search for signs of otter presence over the 4 years
(+ = presence of clues, - = absence of clues, and 0 = no search).

Station	Results of presence index searches during each season															
	2020-2021				2021-2022				2022-2023				2023-2024			
	W	Sp	Su	A	W	Sp	Su	A	W	Sp	Su	A	W	Sp	Su	A
01	+	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+
02	+	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+
03	-	0	-	-	-	+	-	-	-	-	-	-	-	-	-	-
04	+	0	-	+	+	+	-	+	-	+	-	+	-	-	+	+
05	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
06	+	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+
07	+	0	-	+	+	+	-	+	0	0	0	0	0	0	0	0

Figure 5. Station 4 is completely dry during the summer of 2023

Only a single footprint was ever seen at station 3. Station 5, in contrast, never exhibited the slightest indication of the presence of the otter (Table 2). Based on these results, a distribution map of the species in the study area was constructed (Fig. 7).

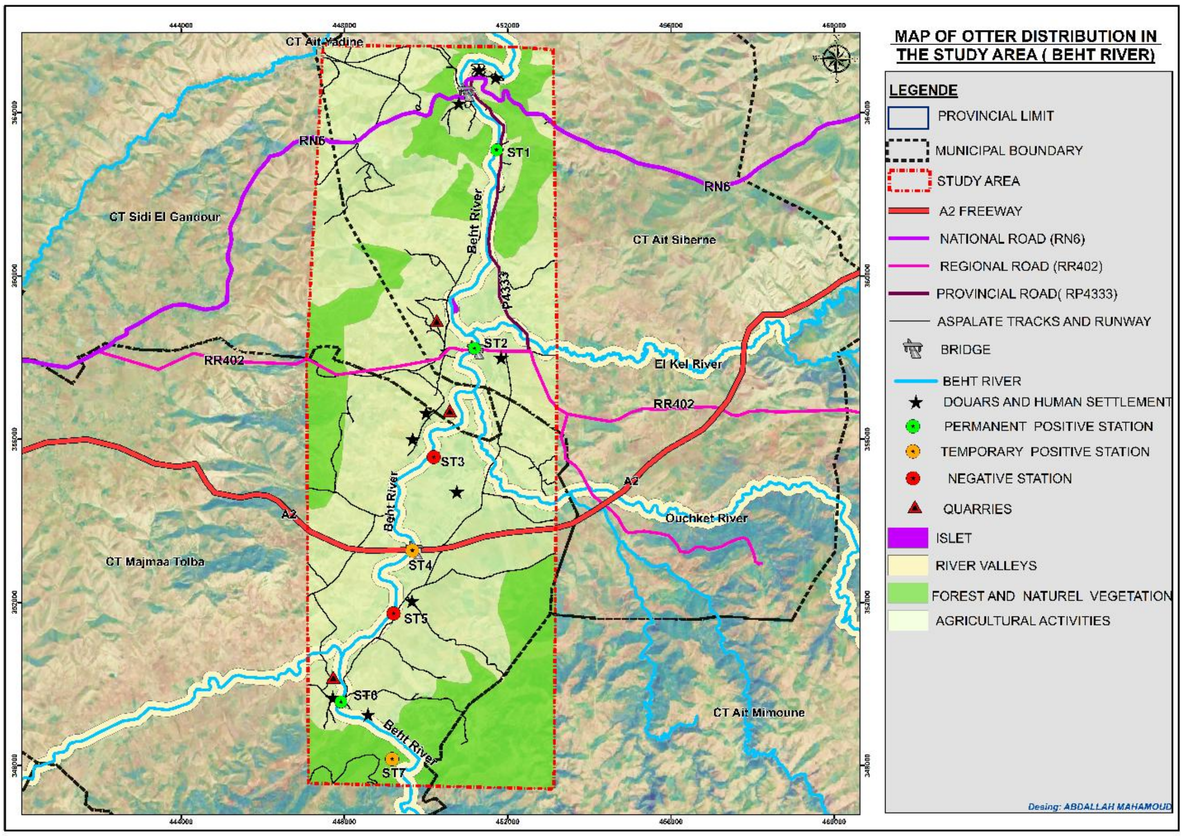

Figure 6. Map of otter distribution in the study area (Source: ARCGIS 10.8)

The dendrogram (Fig. 8) obtained by hierarchical ascending classification (HAC) analysis, combined with a SIMPROF test, applied to otter presence/absence data at seven stations, revealed a main group (C) comprising stations S1, S2, S4, S6 and S7, while isolating two stations (S3 and S5) from the four years of index research carried out. Within group C, stations S1, S2, S4 and S6 are 100% similar, while station S7 is 66.67% similar. On the other hand, the two isolated stations (S3 and S5) share no similarity either with each other or with the other stations.

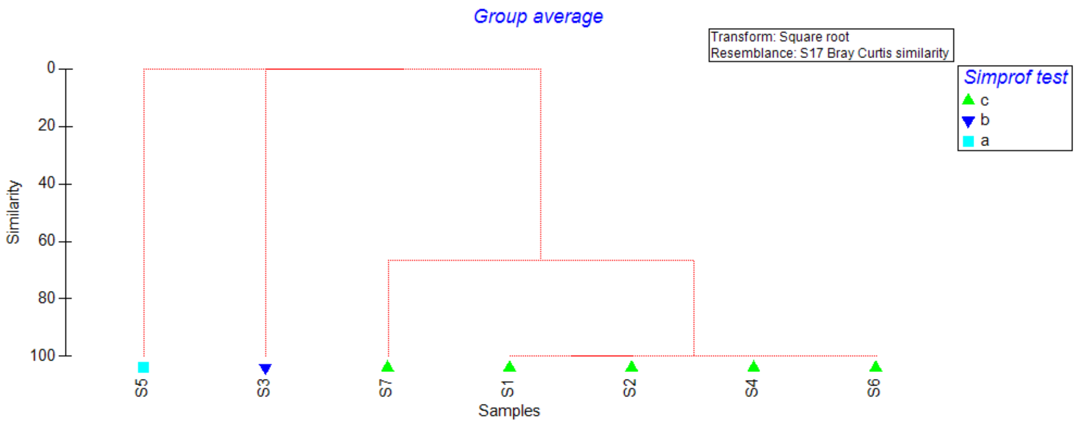

Figure 7. Dendrogram resulting from hierarchical ascending classification based on data on the presence/absence of otter indexes at the 7 stations.

The non-parametric distance-based linear regression (DISTLM) analysis of the influence of environmental variables on otter presence (Fig. 9) indicates that, considering all 7 stations over the four years, there is a significant correlation between the presence of otter signs and 4 environmental parameters. The data analysis identified several environmental variables influencing the presence of the Eurasian otter. Dense riparian vegetation had an influence of 84.5% (Pseudo-F=27.281; *P*=0.035), Average depth (Mpr) 76.7% (Pseudo-F = 7.6246; p = 0.051), water permanence (Water Mpr) 60.4% (Pseudo-F=16. 495; *P*=0.007) and the presence of large boulders in the bed or on the banks (GBR) 54.9% (Pseudo-F=6.1032; *P*=0.049). These results show that otters are highly dependent on the presence of dense riparian vegetation and permanent water, as well as on the presence of large boulders in the river.

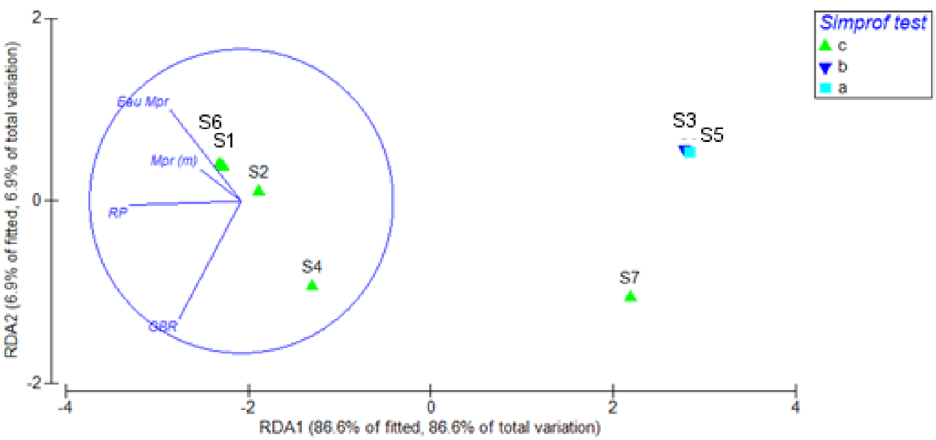

Figure 8. RDA obtained using DISTLIM analysis for all 7 stations

The graph shows that stations 1, 2 and 6 contain the most environmental variables influencing otter presence. Stations 3 and 5, on the other hand, do not appear to have any significant presence of these variables. Stations 4 and 7 show a less marked degree of significance with regard to the presence of these variables. The proximity of most of the stations in group (c) reflects their similarity, strongly influenced by the environmental variables mentioned above.

In 2020 and 2024, camera traps set overnight captured specimens. One individual was probably female, given its small size (Fig. 10), and was observed walking up the river on the bank downstream of station 2. Another individual was probably male given its large size, and was observed swimming upstream of the station 6 culvert pipe (Fig. 11).

Figure 10. Photo of an otter taken with a trap camera downstream of station 2

Figure 11. Photo of Eurasian Otter taken with camera trap at station 6

DISCUSSION

Our results show that the Eurasian Otter permanently resides in the studied section of Beht river, even though some stretches completely dry up during the summer. Footprints were often only observed on mud during winter seasons and periods when the water level was high. Photos were taken by camera traps the first year and the last year, which reinforced the certainty of the permanent presence of the species in the study area.

The study was carried out over a 25 km stretch of river. The distribution patterns observed during the surveys reveal the presence of at least three individuals in the area, including one male (identified by a photo showing a large individual) and two females (photos of smaller individuals, taken downstream). The home ranges of these individuals appear to overlap, as an intermediate area between downstream and upstream shows little evidence. This could indicate that one female occupies the area downstream of station 4, while another is upstream.

The detection of indices of the species' presence at the various selected stations revealed notable variations. In all instances, and throughout the whole course of our surveys, stations 1, 2 and 6 consistently yielded positive results, whether in the form of footprints, imprints or prey remains. The consistent occurrence of otters at these stations can be attributed to the sustained presence of conditions that are conducive to their survival. Indeed, at these three stations, water was consistently present, although at variable flow rates throughout the year, providing a habitat supporting the presence of fish, which constituted the primary food source for the otter. Furthermore, the discontinuous riparian plant cover along the watercourse provides the otter with shelter and refuge, enabling it to maintain its discretion and stealth qualities. The presence of artificial structures, which create refuge areas for fish populations (Simonnet and Gremillet, 2009) also contributed to the availability of food for the otter.

The presence of large boulders enabled individuals to mark their territory in a conspicuous manner. These observations are consistent with the findings of Lafontaine and de Alencastro (2002), who demonstrated that the presence or absence of the otter is influenced by a multitude of factors, including the availability of fish, the nature of the banks, and the quality of water. Furthermore, Reuther et al. (2000) point out that otters use their spraints on obstacles to demarcate their territory. The present study is distinguished from previous research in that it considers the impact of human activities on the persistence of the species in question, despite the presence of serious disturbances such as excessive water pumping, quarrying, and damming without implementing environmental flow.

Conversely, at stations 3 and 5, water was not a constant feature; for instance, the stream flow ceased entirely during the summer months. Furthermore, the banks were largely devoid of vegetation, providing minimal refuge for the species. The absence of permanent water, coupled with the lack of water pools in the vicinity of these stations, does not foster favourable conditions for the presence of the otter, as indicated by the findings of Simonnet and Gremillet (2009). Additionally, intensive human activities such as agriculture (Libois et al., 2012) exert a detrimental impact on the species' presence.

Station 7 was not surveyed in any of the four years due to access difficulties but, as with Station 4, conditions are favourable for the presence of otters subject to the presence of water. Water is temporarily present at these stations, especially during the wetter seasons or during large releases from the Ouljet Essoltane dam upstream of the study area. This suggests that the otter is strongly tied to its environment; when it encounters unfavourable conditions it may migrate to survive but always returns to its original habitat when conditions improve.

In Morocco, according to Broyer et al. (1988), a large rural population is located wherever water is easy to access, especially along the edges of most rivers. Traditional pastoral practices, particularly strong in the mountains, contrasts with the intensive agriculture which affects all the northern plains (Broyer et al., 1988). This is true and clearly visible in our study area, as it is almost entirely exploited for agriculture, which in turn affects the river by excessive and direct pumping for irrigation.

The works of Aulagnier et al. (2015); Delibes et al. (2012); Étienne (2005) and Kruuk (2013) show that this species tends to desert heavily deforested, populated and intensively cultivated rural areas where river banks had little or no vegetation. It is also threatened by excessive use of water and possibly by pollution.

A study on the evolution of the distribution of the species in Morocco (Libois et al., 2012) has demonstrated that the drying up of wadi beds may potentially constitute a significant ecological barrier for the otter. This could result in the partitioning and isolation of mountain and lowland populations over time, with detrimental consequences for genetic variability. We observed that the otter exhibits considerable behavioural plasticity in response to the various pressures it encounters, including water scarcity and habitat disruption due to drought, and the non-compliance with the environmental requirements of dams, as evidenced by the Ouljet Essoltane dam, situated upstream of the study area. Additionally, human activities such as intensive agriculture, extensive livestock farming, and the extraction of building materials, with all the associated disturbances, also exert a considerable impact. This demonstrates that the species in question is capable of tolerating extreme conditions to a certain extent, provided that its fundamental needs are not entirely negated.

From upstream to downstream of the study area, there are human settlements on either side of the banks, including douars (villages), hamlets, and farmhouses; an important human presence which does not seem to cause the ottersto avoid an area.

Our observations confirm those of Cuzín (2003) who showed that the species is very frequently observed near irrigated crops and proves that its cohabitation with humans, in highly anthropized environments, is possible. These results also match those of Étienne (2005), Kuhn and Jacques (2011), Simonnet and Gremillet (2009), Sordello (2012) which showed that the otter demonstrates a capacity to occupy habitats co-inhabited by humans, particularly during its phases of colonization of new territories. This phenomenon is manifested in this species by its ability to cross human-occupied at night without being detected, or even to establish its presence in the immediate vicinity of intense human activities, subject to finding adequate food resources as well as places suitable for shelter.

We focused on the presence/absence of indices, which did not allow us to evaluate the density of the otter population in the study area. Otters have fairly large home ranges that can overlap (Étienne, 2005, Kuhn and Jacques, 2011), despite being territorial animals that mark their territories by depositing spraints in specific areas of the home range (Étienne, 2005).

These results demonstrate a permanent presence of otters in the river section despite the challenges it faces, namely the temporary drying out of certain parts of the river and anthropogenic activities. This study highlights the fidelity of the Eurasian Otter to its natural habitat and its remarkable capacity to adapt to various environmental challenges. Our research demonstrates that this species can tolerate extreme conditions, and that human presence does not necessarily seem to lead to its disappearance. It is possible for the otter to coexist with humans while retaining its natural discretion.

CONCLUSION

Our work shows that, despite the challenges it faces, especially the absence of water over long periods, the otter demonstrates consistent fidelity to its territory, and adapts to extreme conditions. Our observations show the ability of the Eurasian Otter to adapt but also underline the importance of taking into account the ecological needs of the otter in the management and conservation of its habitat, in order to ensure cohabitation between this species and humanity.

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RÉSUMÉ : MAINTIEN DE LA LOUTRE D'EUROPE *LUTRA LUTRA* DANS UN SECTEUR DE L'OUED BEHT (PROVINCE DE KHÉMISSET MAROC) FACE A DES ACTIVITES ANTHROPIQUES

La Loutre d'Europe *Lutra lutra* fait partie des mammifères carnivores de la faune sauvage dulçaquicole du Maroc et elle est inscrite dans la liste rouge de l'IUCN. De 2020 à 2024, nous avons effectué un suivi saisonnier d'une population de Loutre présente dans un tronçon de la basse vallée du cours principal de l'Oued Beht fortement exploité par l'homme pour l'agriculture, l'élevage et l'extraction des matériaux de construction (carrières) dans le but d'évaluer la tolérance de l'espèce face aux pressions et aux changements que subit son habitat. Des missions de suivi ont été réalisées dans la quasi-totalité des quatre saisons pendant ces quatre années au cours desquelles nous avons noté une présence permanente de l'espèce dans l'aire d'étude malgré les défis et parfois les conditions extrêmes auxquelles elle est confrontée. De plus la présence humaine ne semble pas nécessairement entraîner la disparition de l'espèce qui continue de cohabiter avec l'homme tout en conservant sa discrétion naturelle.

RESUMEN : MANTENIMIENTO DE LA NUTRIA EUROPEA LUTRA LUTRA EN UNA SECCIÓN DEL RÍO BEHT (PROVINCIA DE KHÉMISSET, MARRUECOS) DE CARA A LA ACTIVIDAD HUMANA

La nutria Europea (*Lutra lutra*) es uno de los mamíferos carnívoros que forman parte de la fauna silvestre de agua dulce de Marruecos, y está incluida en la Lista Roja de UICN. Entre 2020 y 2024 llevamos a cabo el monitoreo estacional de una población de nutrias que vive en una sección del valle inferior del cauce principal del Río Beht, que está intensamente explotado por el ser humano para agricultura, ganadería y extracción de materiales para construcción (canteras), con el objetivo de evaluar la tolerancia de la especie a las presiones y cambios que afectan su hábitat. El monitoreo se llevó a cabo durante las cuatro (4) estaciones del año durante éstos 4 años -cubriendo casi todas las estaciones. Hemos notado una extendida presencia de la

especie en ésta sección de río, a pesar de las condiciones desafiantes y a veces extremas. Es más, la presencia del ser humano no necesariamente parece causar que la especie desaparezca o se desplace, en lugar de ello parece mantener una co-habitación con el hombre, aunque mantenniendo su natural discreción.

الملخص

استمرار تواجد القضاعة الأوراسية في جزء من وادي بهت (إقليم الخميسات المغرب) أمام الضغط الكبير للأنشطة البشرية

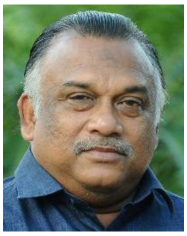
القضاعة الأوراسية هي أحد الثدييات آكلة اللحوم المهددة بالانقراض في المغرب. وقد أدرجها الاتحاد الدولي لحفظ الطبيعة والموارد الطبيعية على قائمة الحيوانات القريبة من خطر الانقراض. في الفترة من 2020 إلى 2024، أجرينا مراقبة موسمية لمجموعة من القضاعات الأوراسية التي تعيش في الجزء السفلي لوادي بهت، الذي يعرف استغلالا بشريا كبيرا يتمثل خاصة في الفلاحة واستخراج مواد البناء (المقالع)، بهدف تقييم مدى تحمل القضاعة للضغوط والتغيرات التي تؤثر على موائلها. تم إجراء الرصد تقريبا في جميع فصول هذه السنوات الأربع، حيث لاحظنا خلالها انتشارا واسعا لهذا النوع في هذا الجزء من الوادي، على الرغم من التحديات والظروف القاسية التي يواجهها في بعض الأحيان. تظهر ملاحظاتنا أن القضاعة الأوراسية تستطيع على المدى القصير مقاومة تغيرات مهمة ناجمة عن النشاط البشري في بيئته.

ARTICLE

LESSER-KNOWN SENTINELS: ROLE OF ENVIRONMENTAL VARIABLES INFLUENCING THE SEASONAL RESOURCE USE PATTERNS OF ASIAN SMALL-CLAWED OTTERS (*Aonyx cinereus nirnai*) IN THE WESTERN GHATS MOYAR RIVER BIODIVERSITY HOTSPOTS

Kannadasan NARASIMMARAJAN[1,2]*, Manu Thomas MATHAI[1],
Matthew W. HAYWARD[3], Sonaimuthu PALANIVEL[4]

[1]Dept. of Zoology, Madras Christian College, Tambaram, Chennai – 600059, India
[2]Bombay Natural History Society, Hornbill House, Opp. Lion Gate, Shaheed Bhagat Singh Marg, Fort, Mumbai – 400001, India
[3]Conservation Science Research Group, University of Newcastle, Callaghan, NSW 2308, Australia
[4] PG and Research Department of Biotechnology, Sri Sankara Arts and Science College (Affiliated to University of Madras), Kanchipuram - 631561, Tamil Nadu, India
**Corresponding Author: e-mail: wildlife9protect@gmail.com*

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Abstract: We examined the role of environmental variables influencing the resource use patterns of Asian small-clawed otters (*Aonyx cinereus nirnai*) by sampling the entire River Moyar of the Western Ghats between March 2015 and September 2017, using otter signs as an indicator. An occurrence-based framework was used to determine the influence of environmental covariates on otter detectability. Information on environmental parameters was recorded every time otter signs were detected and non-detected at sites spaced every 400 meters along the riverbanks in the post monsoon, winter, and summer seasons. Detectability of otter sign was influenced by river substrate, habitat characteristics, riverbank traits and forest types. Otters prefer high altitude/elevation, narrow rivers, and rocky areas with shallow water, but avoided sandy, wider and deep river areas. Resource use patterns were determined by river and habitat characteristics in all three seasons. Various forms of disturbance adversely affected otter occurrence. Asian small-clawed otters required habitat specific specialized environmental traits for their long-term endurance in human-dominated landscape. Restoration of degraded habitats and sites invaded by non-indigenous wattle trees is necessary to improve the long-term conservation prospects of the Asian small-clawed otter. Otter conservation plans need to be species-specific to help maintain the ecological balance of the Moyar River ecosystem.

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Keywords: Asian small-clawed otters; Conservation; Environmental variables; Resource use patterns; habitat traits; Western Ghats

INTRODUCTION

The *Aonyx cinereus nirnai* Illiger, 1815 is a recognized subspecies of the Asian small-clawed otter - the smallest otter of the world occurring in the Western Ghats region, Southern India (Narasimmarajan, 2020; Hussain, 1999) where it is restricted to a few hill streams in the region (Perinchery et al., 2011). Being an amphibious 'apex predator' of the aquatic ecosystem otters play an important role for land-water continuum (Narasimmarajan et al., 2023) and the otter presence is largely dependent on the continuous availability of adequate prey base and uncontaminated aquatic environments (Melquist and Hornocker, 1983; Macdonald and Mason, 1983). Most wetlands and waterways in Asia, however, lack an adequate prey base for sustaining otter populations as a result of pollution by eutrophication and the accumulation of pesticide runoff into the water, poaching for the pelt and pet trade, hydroelectric dams, illegal hunting, ichthyotoxic plants, indiscriminate fishing, and habitat degradation (Wright et al., 2015; Narasimmarajan et al., 2021). Thus, the disappearance of otters from apparently suitable sites is often associated with the habitat degradation and natural deaths in river pits of their wetland habitats (Narasimmarajan et al., 2024) and human causes such as hunting (Kruuk, 1995).

The Asian small-clawed otter is widespread from India through southern Asia, and it is the smallest otter species in the world (Hussain, 1999). The Asian small-clawed otter is considered ‘Vulnerable’ to extinction by the IUCN Red list A2cde+3cde ver 3.1 (Wright et al., 2021). Increased influx of pesticides into the streams from the plantations reduces the quality of their habitats. The threat posed by poaching is still very significant in many parts of India, and South-east Asia and will certainly count as a major threat that needs to be constantly monitored. Poaching for pelts has been reported from across the Western Ghats in southern India (Meena, 2002; Prakash et al., 2012). The Asian small-clawed otter is currently under-represented in the literature, which may partly be due to difficulty in documenting them in their natural habitat (Narasimmarajan, 2020; Prakash et al., 2012; Perinchery et al., 2011).

Only a few detailed Asian small-clawed otter survey reports exist in India (Perinchery et al., 2011; Prakash et al., 2012; Mohapatra et al., 2014; Raha and Hussain, 2016; Narasimmarajan, 2020; Palei et al., 2023), which point to a preference for high hill streams (Perinchery et al., 2011). These records contribute to our understanding of the coarse habitat selection by *Aonyx cinereus*; however, fine-scale patterns of habitat selection in this preferred hilly terrain remain poorly understood. Species assessments predict a decreasing population trend due to habitat loss and conversion; with a diet composed chiefly of crabs, crustaceans, and other molluscs (Sivasothi and Nor, 1994). Asian small-clawed otters prefer moderate to low vegetation structure (possibly for escape cover) in riparian systems, although they also have been recorded from areas with sparse vegetation (Hussain and de Silva., 2008). Other records of Asian small-clawed otters are from peat swamps, rice fields, and other brackish and marine habitats in Malaysia (Sivasothi and Nor, 1994). We aimed to identify the environmental factors that influence the resource use patterns of Asian small-clawed otters in the Moyar River, southern Western Ghats of southern India. We attempted to develop detailed data on factors that influenced the species’ persistence in protected habitats, however future studies should focus on anthropogenic changes in otter habitats and the consequences of this to survival of otter populations over different seasons.

MATERIALS AND METHODS

Study Area

The Moyar River is 102 km long and is located within the UNESCO recognized world heritage site of the Nilgiri Biosphere Reserve. The river originates in Upper Bhavani at 2054 masl in the Nilgiri district of Tamil Nadu, India, and then flows through several protected areas (Mudumalai and Sathyamangalam Tiger Reserves, Nilgiri North and South Forests Divisions), and ends in Bavanisagar Dam at 254 masl in Erode District (Fig. 1) (Narasimmarajan et al., 2018). About 47 km of the Moyar River borders the Bandipur Tiger Reserve, Karnataka. The upper reaches of the river area receive >5,000 mm of rainfall, whereas the downstream area receives ~824 mm of rainfall annually (Puyravaud and Davidar, 2013). The minimum and maximum annual average temperatures in this region vary from 14 °C - 30 °C in higher elevations, and 25 °C - 38 °C in the lower elevations (Narasimmarajan et al., 2018). The Mudumalai, Sathyamangalam, Bandipur landscape supports a large population of Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Asian elephant (*Elephas maximus*), Otters (*Lutrogale perspicillata; Aonyx cinereus*), Dhole (*Cuon alpinus*), and Endangered Vultures (*Gyps benghalensis; Gyps indicus*) (Narasimmarajan et al., 2021).

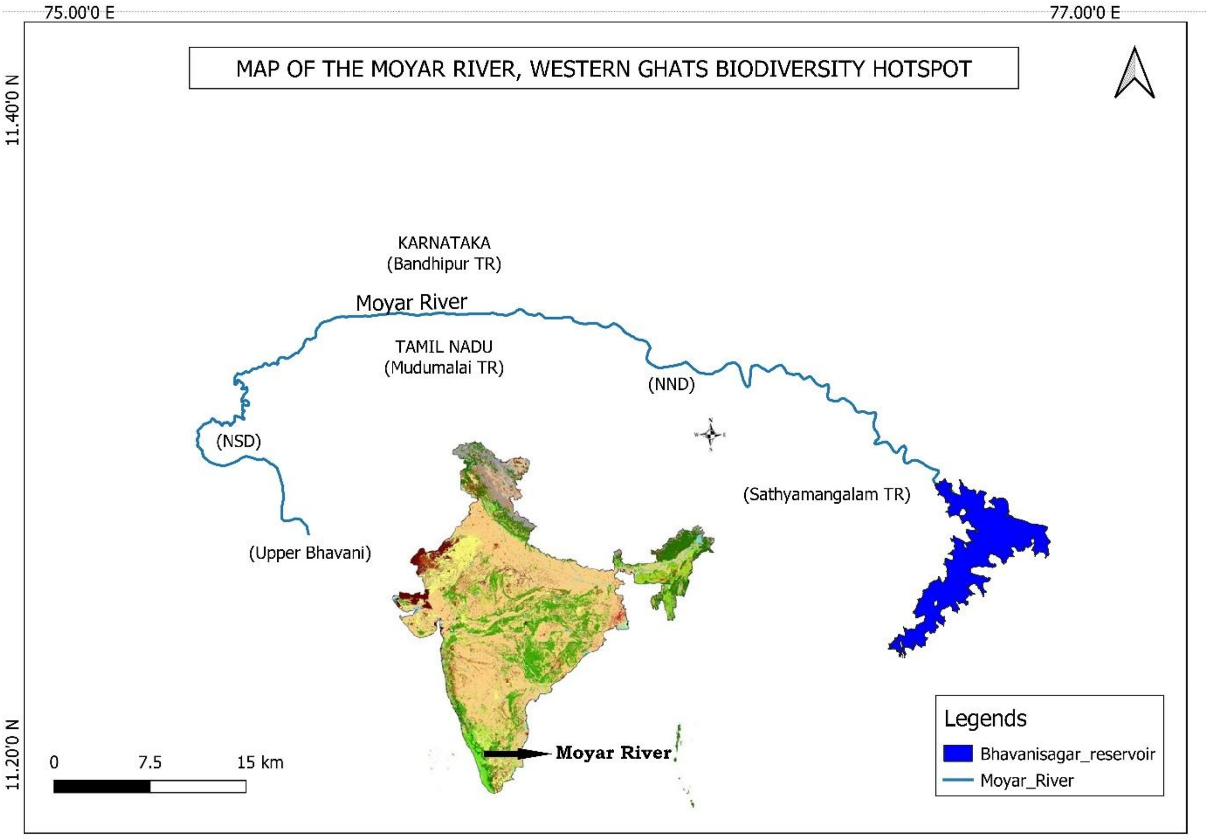

Figure 1. Showing the Moyar River and its important landmarks in the Western Ghats biodiversity hotspot.

The riverbanks of the Moyar support different forest types such as evergreen forests, riparian forests, deciduous forests, scrub forests, bamboo dominated riparian forests and non-indigenous invasive plants including black wattle (*Acacia melanoxylon*), mesquite (*Prosopis juliflora*) (introduced by British colonial era for firewood) and *Lantana camara* that is catastrophically invading the river gorges (Champion and Seth, 1962; Narasimmarajan et al., 2021).

The Moyar River is an important source of irrigation for thousands of hectares of agricultural land and supports the livelihoods of more than a million people (Puyravaud and Davidar, 2013). However, like other freshwater river ecosystems in India, the River Moyar faces many threats, such as agricultural pesticide runoff, hydroelectric projects, unrestricted illegal fishing activities, invasive species, and the spilling of motor oil (Narasimmarajan 2020).

Data Collection

The data were collected between March 2015 and September 2017. We aimed to investigate the seasonal resource use patterns of Asian small-clawed otters in the Moyar River study region using the survey methods described by Hussain and Choudhury (1995); Nawab and Hussain (2012); and Narasimmarajan et al. (2021). The entire River Moyar and its tributaries were divided into 6 km segments based on Narasimmarajan et al. (2023) using geographical information systems. During the survey, whenever otter signs were seen, data on environmental parameters, and spraints, tracks, dens, and grooming sites were recorded in 15 m width x 100 m length strip width plots. In addition, at each significant crossing/access point where otter sign was not detected, a random stratified plot (15 x 100 m stripe width) of the Moyar River was surveyed to compare the resource use pattern of otters in latrine and non-latrine sites (Narasimmarajan et al., 2021). A team of four researchers conducted the survey by walking along both riverbanks, searching for otter signs. In each survey season (post-monsoon (September - November), winter (December - February) and summer (March - June), the plots where spraints, tracks, grooming plots, dens and other signs of otter presence were found were defined as a 'used/positive site'. Signs are correlated positively with otter habitat use and preference (Guter et al., 2008). A new plot was considered as such only when spraints were separated by >15 m away from previous used/positive site (Melquist and Hornocker, 1983; Newman and Griffin, 1994; Medina, 1996), whereas spraints within 15 m were considered as the same latrine site. For the estimation of habitat availability, each plot was categorized as a rocky stretch, sandy stretch, muddy stretch, clayey stretch and alluvial stretch. In each survey season, data on environmental parameters (i.e., river character variables, habitat character variables and substrate variables) and disturbance that were considered potentially important to otters were collected from each plot (Macdonald and Mason, 1983; Brzeziński and Jedrzejewska, 1993; Anoop and Hussain, 2004) (Table 1).

Opportunistic observations of otters during the course of the surveys were also recorded and their group size, structure and activity were noted.

Table 1. List of environmental variables were collected and used for discriminant function analysis.

Variables	Description	Range
Type of river substrate (%)	Approximate percentage of total (100 m x 15 m) strip width plot covered by sand, rock, boulders, stone, mud, clay or alluvial deposits. Values attributed by eye.	0.00 -100
Depth of the river (m)	The depth of the river was measured at four-point cross section at each plot site using a Metered Pole and the mean depth was calculated.	0.20 – 8.0
River width (m)	The width of the river was measured at one point on each plot site using Laser Range Finder and the mean width was calculated.	3.0 - 310
Water current (score)	The most frequent flow velocity per site was visually assigned as 1-stagnant, 2-slow, 3-moderate and 4-fast.	1 - 4
Water quality (score)	The quality of water was assessed through visually as 1-turbid and 2-clear.	1 - 2
River bank-slope types (degree score)	1-gentle (0-20°), 2-moderate (20-50°) and 3-steep (50-90°). Measured using clinometers.	1 - 3
Shoreline vegetation (score)	Emergent riparian vegetation on shoreline that was sufficient to provide cover for otters while travelling or resting. Estimated by eye. 1-dense, 2-fair and 3-no/nil.	1 - 3
Distance of escape cover from shoreline (m)	Nearest distance from the water's edge to shoreline vegetation, which provides cover for otters. Measured using a measuring tape.	0.0 - 20

Canopy cover %	Percentage of canopy cover of each plot was estimated using two-wheeler rear mirror	0.0 - 100
Dry leaf litter cover %	Percentage of Dry leaf litter cover was visually estimated.	0.0 - 100
Avg. grass/ herb height (ft)	The extent of grass and herbs cover in the plot estimated by visual estimate.	0.0 – 5.0
Elevation (m)	Elevation of each plot was measured using global positioning system (Garmin).	248 - 2054
Disturbance (present/absent)	Evidence of destructive fishing practices such as various fishing nets, dynamiting, hydro-electric projects, removal of sand and boulders, domestic use of water using oil motor, oil mixing in the river, pesticide runoff mixing in the river and visible pollution. 0-absent and 1-present.	0.0 – 1.0

Data Analysis

A detection history was created based on whether otter signs were detected (1) or non-detected (0) at each 400 m (15 x 100 m strip width plot) along the riverbank for each season. The covariate data collected for available and used plots was organized in sample-habitat parameter matrix for post monsoon, winter and summer seasons respectively. The raw data matrix was arranged into proportionate and continuous data, which had to be transformed via arcsine and log transformation and standardized following Zar (1984). Factor analysis was used to reduce the dimensionality of the environmental variables. The first three factors (predictors) were used for interpretation as these explained maximum variations in the dataset, and Pearson product moment coefficient as the input and a *varimax* rotation of these factors (Van Emden, 2008). Simple cross-tabulations and χ^2 statistics were used to calculate the detection of possible relationships between resource variables (i.e., the presence/absence of different environmental traits, and presence/absence of sprainting activity) and auto-correlated null variables were dropped due to their nonaligned influence on the sprainting activity (Van Emden, 2008). Pearson's correlation was used to subset the null deviations, and the constant-only model was used to identify the significant covariates for further analysis (MacKenzie, 2006; Kruuk, 1995). Significant associations between habitat traits, and the presence or absence of spraints were enumerated**.**

Spraints are likely to be detected more often than expected where rocks and boulders occur in the immediate vicinity of a survey plot (White et al., 2003) and may be overlooked in dense vegetation. Spraints are likely to be found less often than expected at plots with grass either in the surrounding land or the immediate vicinity respectively. Pearson's correlation was used to subset the null deviations and constant-only model used to test the significance of the covariates of further analysis (MacKenzie, 2006). We attempted to account for this differential detectability using land cover variables representing river order, river gradient and habitat characters in the logistic regression analysis (White et al., 2003). Global logistic regression model including variables relating to habitat, the physical characteristics of the river and surrounding vegetation cover was able to predict the presence or absence of otter sprainting at different survey plots with an accuracy of 92% (Z-value) using software R (R Core Team, 2018).

RESULTS

Distribution Patterns of Asian Small-Clawed Otter Signs in the River Moyar, Western Ghats

Total of 693 strip width plots (15 m width x 100 m length) were surveyed, in which 87 Asian small-clawed otter positive/used sites were recorded. Otter signs were found at 24.7% (n=18) of sites during the post-monsoon, 34.0% (n=27) during winter and 41.4% (n=42) during summer (**Table 2**) consisting of 73 spraints, 11 tracks, 3 grooming site and 3 active dens. Dens were usually made under wild mango (*Mangifera indica*) trees in the River Moyar.

Observations clearly show that the Asian small-clawed otter occurs in the Moyar river in all three seasons i.e., Post monsoon, Winter and Summer. Latrine sites were mostly found between 796 m asl to 2050 m asl in the river Moyar where the dense forests cover and narrow river with steep bank slope habitat dominated.

Table 2. Sprainting activity and other Asian small-clawed otter signs in river Moyar at Western Ghats.

Otter Signs	No of Signs	Percentage of Signs
Spraints	73	81.93
Tracks	11	11.64
Grooming Sites	3	03.44
Den	3	03.44

The logistic regression analysis showed an efficiency of 91.61% of available and utilized plots. This model also suggested that the Asian small-clawed otter sprainting activities were found in rocky areas with steep bank slopes, alongside the presence of many tall trees, and tall grass cover with less disturbance respectively.

Otter sprainting sites were found in narrow river stretches, and they avoided sprainting far from riverbanks. Otters also avoided low altitudes and high amounts of dry leaf litter cover at sites for grooming, while favouring river pits/pools in the high-altitude areas.

Otter sprainting activities were positively linked with the river pools/pits and stagnant water currents in the high-altitude areas, and the sprainting sites were not recorded in wattle invaded areas near the riverbanks. Spraints were mostly recorded at sites with more shoreline vegetation cover. Spraint sites were influenced by prey availability and otter spraints were as likely to occur near mugger crocodile sites as not (< 650 m asl). Higher otter spraints were recorded from sites that had rocky, high altitude and no disturbance areas.

Resource Availability

Fourteen categories of environmental covariates were surveyed in the study area. Overall landscape level environmental variables, such as mean hard sand (46.26%), followed by rocky stretches composed of boulders (28.19%), loose sand stretches (15.43%) and while stones constituted the least (7.01%) in the otter used sites. Other habitat variables were measured, including the mean canopy cover (51.24%), dry leaf litter cover (40.59%), riverbank grass height (2.83%). River characters represented by water current attitude (1.87) (2-slow), bank slope (steep/moderate), mean river depth (16.72 m) and river width (12.88 m) (Table 3).

Table 3. Percentage and mean value of environmental variable availability from River Moyar, Western Ghats between March 2015 and September 2017.

Variables	Loose sand (%)	Hard sand (%)	Rocky (%)	Stone (%)	Gravel (%)	River depth (m)	River width (m)	Water current (S)
mean	15.43	46.26	28.19	7.01	1.11	16.72	12.89	1.87
<u>+ SE</u>	2.47	7.40	4.51	1.12	0.18	2.68	2.06	0.50
Variables	**Water quality (S)**	**Bank Slope (DS)**	**Bank vegetation (S)**	**Escape distance (M)**	**Canopy cover (%)**	**Dry leaf cover (%)**	**Grass height (ft)**	**Elevation (m)**
mean	1.19	2.26	2.63	15.80	51.24	40.59	2.83	596.14
<u>+ SE</u>	0.15	0.32	0.42	2.53	18.20	6.49	0.97	29.01

%- percentage; S- score; M- metre; ft- feet; DS- degree score

Sprainting activity varied significantly with season, river characteristics, elevation and disturbance. The logistic regression model included variables relating to habitat highlighting that the physical characteristics of the river and surrounding vegetation cover were critical to the presence or absence of otter sprainting at different survey seasons.

Spraints occurred more often than expected where rocky and hard sand was found in the immediate vicinity (15 x 100 m strip width plot) of the survey site, and where other covariates were found in the surrounding land (100 x 15 m strip-width cell neighborhood). Spraints were found less often than expected at sites where dry leaf litter cover was found either in the surrounding land or the immediate vicinity, and low canopy cover (Table 4).

Table 4. Summary of the significant results of analysis using cross-tabulation and Pearson's correlation tests.

Significant Environmental Factors	15 x 100 m Strip Width Plot	$\chi 2$	Type of Association	Significance (*P*)
Rocky	%	0.37	+	0.925
Dry leaf litter cover	%	-0.35	-	0.045
Elevation	Meters	0.31	+	0.056
Canopy cover	%	0.51	+	0.048
Bank vegetation	%	-0.43	-	0.871

A significant χ^2 value indicates that there was a significant association between the presence or absence of spraints and that habitat type. A positive association of sprainting with particular habitat types are indicated by a plus sign and a negative association by a minus sign in the table.

Factors influencing Asian Small-Clawed Otter Occurrence in Post-Monsoon Winter and Summer Seasons in the Moyar River

The logistic regression model explained 80.23% of the variance in otter habitat use. Post-monsoon factors were positively related with altitude/elevation (z=2.347, p<.01), rocky stretches (z=1.043, *P*<.05), hard sand (z=0.492, *P*<0.05), disturbance (z=2.025, *P*<0.05) but negative related with water current, (z=-2.363, *P*<0.01), river width (z=-1.973, *P*<0.01), and canopy cover (z=-2.363, *P*<0.01). During winter, otter occurrence was positively related with altitude/elevation (z=4.129, *P*<00.01), disturbance (z=1.708, *P*<0.01), and negative related with river width (z=-3.155, *P*<0.001), water current (z=1.946, *P*<0.01) and hard sand (z=-2.441, *P*<0.01). In summer, otter occurrence was positively related with altitude/elevation (z=2.347, *P*<0.01), and negatively correlated with water current (z= -2.362, *P*<0.01), river width (z=-2.181 *P*<0.01), canopy cover (z=-2.362, *P*<0.01) and hard sand (z=-2.441, *P*<0.01; Table 5).

Table. 5. Forward stepwise logistic regression analysis testing the effect of 11 environmental variables on latrine sites (n=18) and non-latrine sites (n=675) during post monsoon, latrine sites (n=27) and non-latrine sites (n=666) during winter and latrine sites (n=42) and non-latrine sites (n=651) during summer at river Moyar locations. Only those explanatory variables were shown and added to the model until R approached 1.0 (*P*>0.05).

Seasons	**Post Monsoon**				**Winter**				**Summer**			
Variables	**Estimate**	**SE**	**z- value**	**Pr(>|z|)**	**Estimate**	**SE**	**z- value**	**Pr(>|z|)**	**Estimate**	**SE**	**z- value**	**Pr(>|z|)**
Intercept	-0.0727	1.72811	-0.063	0.8632	0.27004	1.39682	0.193	0.8467	-0.0796	1.72811	-0.046	0.9632
l.snd	1.9554	2.25442	0.666	0.3857	-7.3755	5.63842	-1.308	0.19085	-1.9553	2.25442	-0.867	0.3857
rck	1.50658	1.44504	1.043	0.2971	-0.0567	0.9287	-0.061	0.9513	1.50658	1.44504	1.043	0.2971
h.snd	0.6456	1.31238	0.492	0.6228	-2.8741	1.17737	-2.441	0.01464**	0.6456	1.31238	0.492	0.6228
bnk.veg	-1.5638	1.40152	-1.116	0.2645	-1.4563	1.21248	-1.201	0.22972	-1.5637	1.40152	-1.116	0.2645
dr.lf	0.15856	1.20429	0.132	0.8953	0.72834	1.50877	0.483	0.62928	0.15856	1.20429	0.132	0.8953
rv.wd	-14.813	7.50601	-1.973	0.0184**	-17.914	5.67843	-3.155	0.00161***	-14.812	7.50601	-1.973	0.048*
wt.cur	-2.3282	0.98522	-2.363	0.0181**	-1.9301	0.99157	-1.946	0.0516*	-2.3282	0.98522	-2.363	0.018**
slp	-1.8663	0.85575	-2.181	0.0292*	-2.434	0.83453	-2.917	0.00354**	-1.8663	0.85575	-2.181	0.029*
can.cov	3.8666	1.63721	2.362	0.0182**	-0.687	1.47105	-0.467	0.64047	-3.8666	1.63721	-2.362	0.018**
elev	8.17687	2.62354	2.347	0.008**	7.13018	1.72673	4.129	0.0036**	6.17687	2.63154	2.347	0.018**
Dstb	1.53846	0.75973	2.025	0.046*	1.21385	0.71059	1.708	0.08759	-1.5384	0.75973	-2.025	0.042*

Residual deviance of the constant-only model was shown in 103.4. Significance of the difference between constant-only model and the models listed is indicated by asterisks (*, P <0.05; **, P <0.01; ***, P <0.001). Codes; l.snd- Loose sand, rck- Rocky, h.snd- Hard sand, bnk.veg- Bank vegetation, dr.lf- Dry leaf litter cover, rv.wd- River width, wt.cur- Water current, slp-Bank slope, can.cov- Canopy cover, elev- Elevation/altitude and Dstb- Disturbance

After the monsoon, Asian small-clawed otters preferred rocky areas with high altitude/elevation, rocky stretches, stagnant water current, and avoid wider river, medium water flow, and dense canopy cover (Fig. 2). In winter, otters maintained their preferences for rocky areas with high altitude/elevation, but avoided wider, deeper river sites in lower altitude and stagnant water flow (Fig. 3). In summer, Asian small-clawed otters preferred higher altitude/elevation, shallow water, rocky areas with boulders, and a moderate canopy, while avoiding anthropogenic disturbance, loose and hard sandy areas, stagnant water flow, and lower elevations similar to previous seasons (Fig. 4). Otter sign occurrence varied with water current (i.e., fast, slow and stagnant), shallow water plots yielded more spraints. No spraints were recorded at plots (129 plots) where wattle had invaded > 89% shore vegetation cover. Spraints were most frequently recorded at plots with moderate shoreline vegetation.

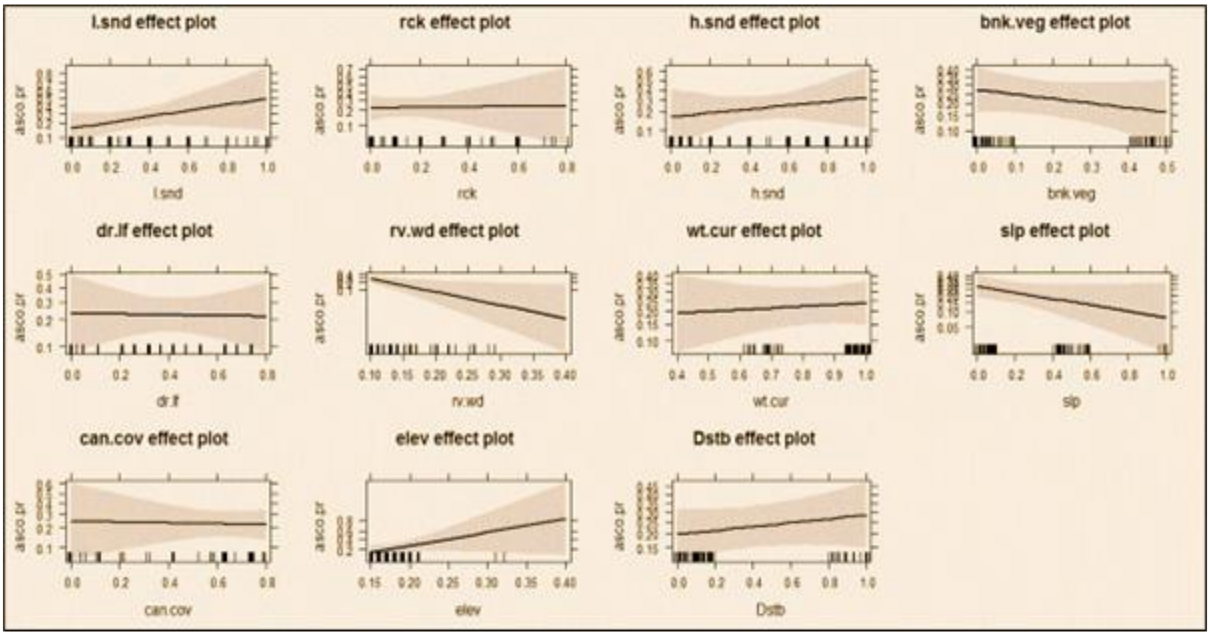

Figure 2. Effect plots of generalized liner model for predicting habitat suitability for Asian small-clawed otters
in **post monsoon season** in the Moyar River, Western Ghats.

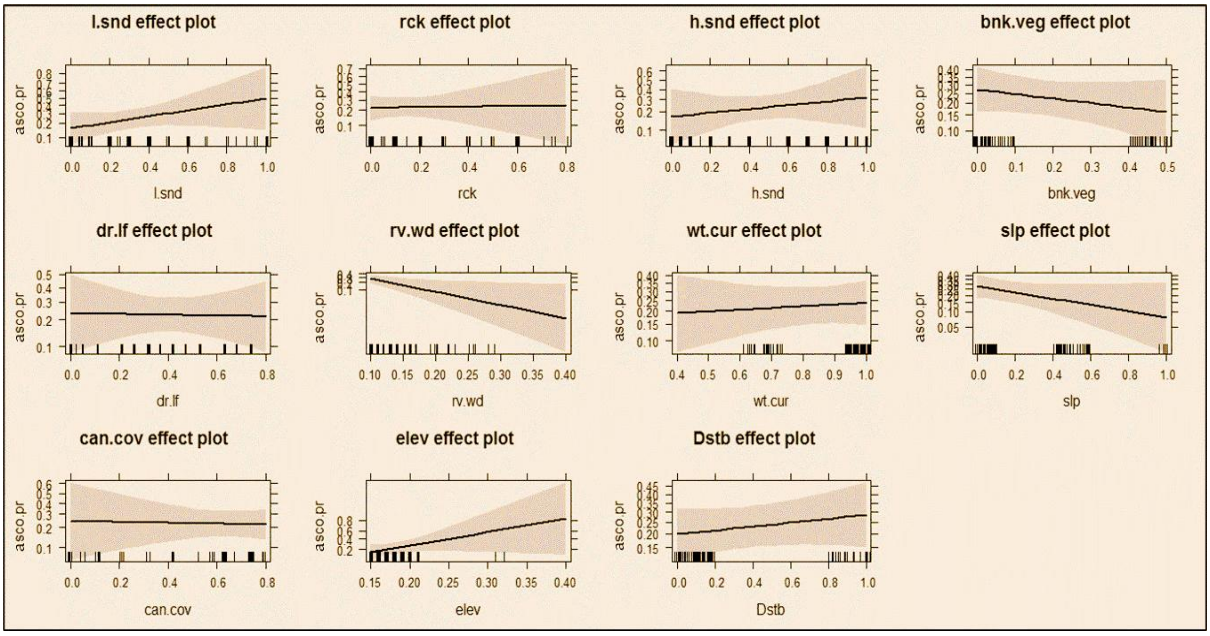

Figure 3. Effect plots of generalized liner model for predicting habitat suitability for Asian small-clawed otters in **winter season** in the Moyar River, Western Ghats.

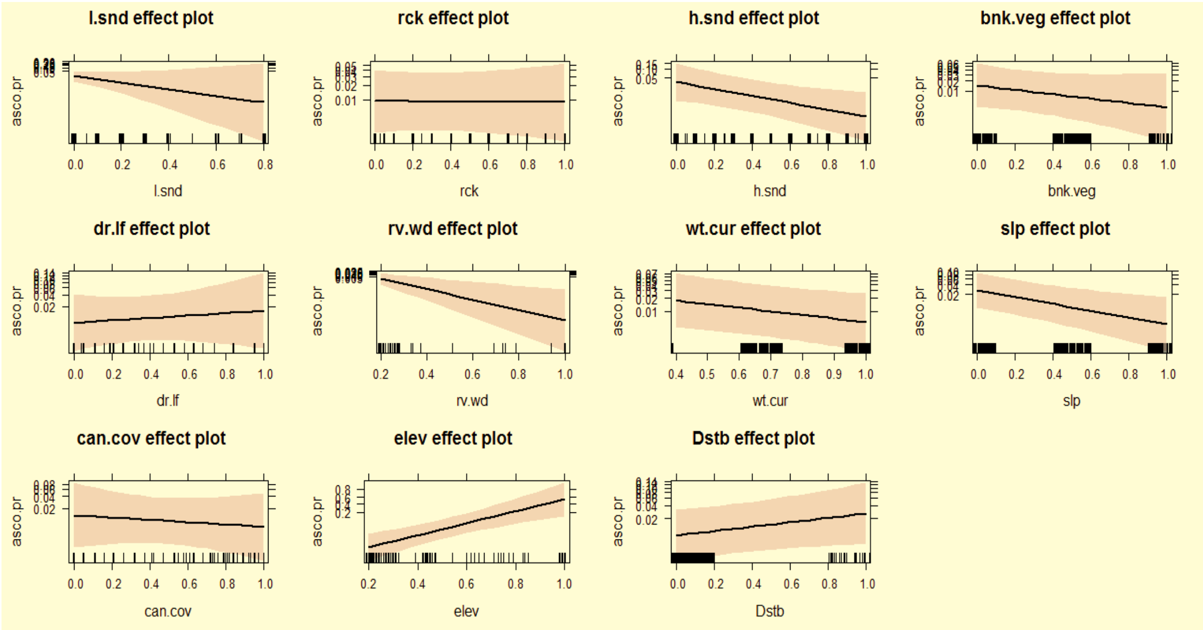

Figure 4. Effect plots of generalized liner model for predicting habitat suitability for Asian small-clawed otters
in **summer season** in the Moyar River, Western Ghats

DISCUSSION

Occurrence-based surveys are particularly useful for conservation assessments of poorly studied and elusive species, such as the Asian small-clawed otter. This approach can be used even in single-time surveys to generate rigorous baseline data when detectability is adequately accounted (Beja, 1992). At the same time, it also allows ecological questions on the determinants of finer scale habitat selection to be addressed (Perinchery et al., 2011). Policy-based action, research on factors affecting survival, habitat-based actions on creation and, where required, expansion of protected areas and communication and awareness building among local communities are suggested by Hussain (1999) as fundamental to the conservation of the Asian small-clawed otter. This is first ever attempted to address the factors affecting the resource use of Asian small-clawed otter from this region. Ultimately, altitude/elevation and river characteristics played an important role in determining the presence of Asian small-clawed otter. This is consistent with natural history accounts of the species in southern India (Pocock, 1941; Perinchery et al., 2011) and highlights the importance of high-altitude habitats for the conservation of this species (> 660 m asl) . In Southeast Asia, however, the species also occurs in low-elevation habitats, such as wetland systems with pools and stagnant water (Hussain , 1998; Sivasothi and Nor, 1994). Further detailed surveys would be necessary across a greater altitudinal gradient across southern Western Ghats to determine if the distribution of the species also includes lower-elevation regions (e.g., below the ≤650 m asl of this study).

Having selected home ranges based on altitude for a given number of seasons, otters seem to concentrate habitat use at higher altitudes within their occupied streams. The preference for high altitude river stretches over cascades and riffles is unsurprising given that the species is a specialized feeder on crustaceans and molluscs, locating prey mainly by touch (Ewer 1973). Elevation gradient, river substrate, grass cover, and ground cover along the banks also was a better predictor of otter habitat use than compared to stream order (Arden-Clarke, 1986; Perinchery et al., 2011). Our study demonstrates the utility of modeling occurrence-based detectability simultaneously (Mackenzie et al., 2002). Several recent studies have successfully applied the approach to estimate sign detectability, and the role of habitat-related and other covariates in determining these, for a range of species (e.g., Baldwin and Bender, 2008; Bonesi and Macdonald, 2004; Buckley and Beebee, 2004; Carter et al., 2006; Martin et al., 2006; Mazerolle et al., 2005; Moritz et al., 2008; O'Connell et al., 2006; Welsh et al., 2008).

The identification of the species' preference for higher altitudes and pits/pools in a protected area will help identify sites for conservation efforts targeting Asian short-clawed otters; high-altitude streams and small pools should be seen as important conservation zones in unprotected areas as well, because they can be prospective habitats for this species, if it does not currently occupy the area. This study also can help direct future surveys by predicting the presence of Asian small-clawed otter in similar areas. Given that this study was conducted in the partially disturbed Moyar River, the findings indicate patterns of habitat use in the presence of human disturbance or habitat modification. Therefore, Asian small-clawed otter required fine-scale environmental factors in each season to satisfy their habitat requirements, and adaptive management to conserve those factors is needed for their long-term survival in a human-dominated landscape, such as the Moyar. However, the majority of freshwater habitats in southern India are not protected and are located within or near human-dominated areas (Perinchery et al., 2011), and anthropogenic impacts on riparian landscapes can entirely alter species composition (Jelil et al., 2021). Otters tend to avoid human presence either spatially or temporally by restricting activity to certain seasons (Rosas et al., 2007; Shenoy et al., 2006; Tuzun and Albayrak, 2005). But, in Moyar they tend to tolerate human presence up to certain level during post monsoon and winter seasons (Figure 2, 3).

CONCLUSION

Although our study has developed detailed data on factors that are influence the species' persistence in protected habitats, future studies also should focus on anthropogenic changes in otter habitats and the consequences for survival of Asian small-clawed otter populations. We recommend a comprehensive survey covering the entire distribution of the species in the Western Ghats of southern India, spanning wide elevational, latitudinal, altitudinal, habitat and disturbance-related gradients to obtain an understanding of regional status and threats faced by *Aonyx cinereus nirnai.*

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RÉSUMÉ: DES MUSTELIDÉS MÉCONNUS : RÔLE DES VARIABLES ENVIRONNEMENTALES DANS L'INFLUENCE DES MODÈLES SAISONNIERS D'UTILISATION DES RESSOURCES DES LOUTRES CENDRÉES (AONYX CINEREUS NIRNAI ILLIGER, 1815) DANS LA RIVIÈRE MOYAR DU POINT CHAUD DE LA BIODIVERSITÉ DES GHATS OCCIDENTAUX, EN INDE

Nous avons examiné le rôle des variables environnementales influençant les schémas d'utilisation des ressources des loutres cendrées (*Aonyx cinereus nirnai*) en échantillonnant l'ensemble de la rivière Moyar des Ghâts occidentaux entre mars 2015 et septembre 2017, en utilisant les indices de présence de loutre comme indicateur. Un cadre basé sur l'occurrence a été utilisé pour déterminer l'influence des covariables environnementales sur la détectabilité des loutres. Les informations sur les paramètres environnementaux ont été enregistrées chaque fois que des indices de présence de loutre ont été détectés ou non détectés sur des sites espacés de 400 mètres le long des berges de la rivière pendant les saisons post-mousson, hivernale et estivale. La détectabilité des indices de présence de loutre était influencée par le substrat de la rivière, les caractéristiques de l'habitat, les caractéristiques des berges et les types de forêts. Les loutres préfèrent la haute altitude/élévation, les rivières étroites et les zones rocheuses aux eaux peu profondes, mais évitent les zones de rivières sablonneuses, plus larges et profondes. Les schémas d'utilisation des ressources ont été déterminés par les

caractéristiques de la rivière et de l'habitat au cours des trois saisons. Diverses formes de perturbation ont eu un effet négatif sur la présence des loutres. Les loutres cendrées ont besoin de caractéristiques environnementales spécialisées et spécifiques à leur habitat pour survivre à long terme dans un paysage dominé par l'homme. La restauration des habitats dégradés et des sites envahis par des acacias non indigènes est essentiel pour améliorer les perspectives de conservation à long terme de la loutre cendrée. Les plans de conservation des loutres doivent être spécifiques à chaque espèce pour aider à maintenir l'équilibre écologique de l'écosystème de la rivière Moyar.

RESUMEN: CENTINELAS MENOS CONOCIDOS: INFLUENCIA DE LAS VARIABLES AMBIENTALES EN LOS PATRONES ESTACIONALES DE USO DE RECURSOS POR LAS NUTRIAS DE UÑAS PEQUEÑAS ASIÁTICAS (AONYX CINEREUS NIRNAI ILLIGER, 1815) EN EL RÍO MOYAR, HOTSPOT DE BIODIVERSIDAD DE LOS GHATS OCCIDENTALES, INDIA

Examinamos el rol de variables ambientales que influencian los patrones de uso de recursos por las nutrias de uñas pequeñas Asiáticas (*Aonys cinereus nirnai*), muestreando la totalidad del Río Moyar, Ghats Occidentales, entre marzo de 2015 y Septiembre de 2017, utilizando los signos de nutria como indicador. Utilizamos un marco basado en la ocurrencia para determinar la influencia de las covariables ambientales en la detectabilidad de las nutrias. Registramos información sobrre parámetros ambientales cada vez que se detectaban o no se detectaban signos de nutria en sitios espaciados cada 400 metros a lo largo de las barrancas del río, durante las estaciones post monzones, invierno, y verano. La detectabilidad de los signos de nutria estuvo influenciada por el sustrato del río, las características del hábitat, los rasgos de la barranca del río, y los tipos forestales. Las nutrias prefieren ríos en alta altitud/elevación, angostos, y áreas rocosas con aguas poco profundas, pero evitaron áreas del río arenosas, más anchas y más profundas. Los patrones de uso de recursos estuvieron determinados por las características del río y del hábitat, en las tres estaciones. Varias formas de disturbio afectaron en forma adversa la ocurrencia de las nutrias. Las nutrias de uñas pequeñas Asiáticas requirieron rasgos ambientales especializados, específicos de hábitat, para prosperar a largo plazo en éste paisaje dominado por el ser humano. Es necesaria la restauración de los hábitats degradados y de los sitios invadidos por el zarzo dorado (no nativo), para mejorar las perspectivas de conservación a largo plazo de la nutria de uñas pequeñas Asiática. Los planes de conservación de nutrias deben ser especie-específicos para mantener el balance ecológico en el ecosistema del Río Moyar.