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

NOTE FROM THE EDITOR

Dear Friends, Colleagues and Otter Enthusiasts!

It is with great sorrow that I have to inform you that we lost Vic Simpson a few weeks ago. I can only say that the whole OSG has lost a person that was always supportive in science, and positive and smiling in the personal realm.

As indicated earlier this year we are working on the backlog of manuscripts. So we have already closed the first issue of 2018 and open now issue 35/2 as the next issue of 2018. Right now we may have 4 issues this year and I can promise that interesting things will be soon online. Due to the continuous but diminishing backlog authors that need a statement that their manuscript has been accepted for internal reasons can contact me and I will provide the necessary documentation.

We have received a lovely set of photos to use for front covers, but anybody in possession of otter pictures and the copyright is invited to send them to Lesley or me – we try to choose a species much represented in the contents of a certain issue, so all thirteen species are welcome!

Most of you will have seen already that the location and the date of the next Otter Colloquium has been decided and more information will soon be available on the website.

“Merci villmols” to Lesley for her continuous efforts to improve the accessibility and layout of the Bulletin and to give it a professional look and an easy and intuitive navigation. Lesley puts a lot of energy into this voluntary work and without her the Bulletin would not exist anymore. We both also want to thank for the compliments that re receive from some of you when a new issue is closed.

OBITUARY

VICTOR ROBERT "VIC" SIMPSON
1941 – 2018

The otter community has lost a special member with the passing of Vic Simpson. Vic died on 31 July 2018 after a long struggle with cancer.

Victor Robert Simpson, BVSc, DTVM, FIBiol, HonFRCVS was a passionate wildlife pathologist and a tireless and meticulous scientist. He devoted most of his life to understanding health problems and causes of decline of wildlife species in UK, providing scientific bases for their conservation.

Vic has been special to many of us as individual and he has been truly special to the Otter Specialist Group as he has shown what a significant contribution veterinary science can make to the knowledge and conservation of otters.

Vic Simpson obtained his BVSc at Bristol University in 1964 and gained a Diploma in Tropical Veterinary Medicine at Edinburgh University a few years later. During the early and late seventies he worked in Africa, where he studied various arthropod-born viruses affecting both domestic livestock and game animals, in particular bluetongue. The years spent in Africa were an important tile in the mosaic of Vic's life.

On returning to the UK, Vic began his long career with the Veterinary Investigation Service of the Ministry of Agriculture, Fisheries and Food (MAFF), which spanned 30 years. The Service was organized as a network of "VIC"s (Veterinary Investigation Centres). Vic worked at the Polwhele VIC near Truro, in Cornwall. One of the major functions of the VICs is to conduct surveillance for livestock diseases in their locality. However, Vic didn't limit himself to investigating diseases of domestic species: he made a number of studies on conditions affecting wild vertebrates, in particular mute swans, otters, bats and marine mammals. Later he studied also red squirrels, finches, auks and several other wild species.

Vic recognized that Britain does not have a Department of Wildlife or any other government organization appointed to investigate the health and diseases in wild animal populations. He was lifelong committed to fill this lack and when he retired from MAFF in 2001, he celebrated his “retirement” by setting up a centre to study wildlife health problems: the Wildlife Veterinary Investigation Centre in Truro (Cornwall), the first VIC for wildlife ever established in UK.

The Wildlife VIC, which run on a no-profit basis, has been (and is) an exemplary centre at European level, not just in Britain. By setting up the Wildlife VIC and through his studies, Vic showed the important role of veterinary pathology as a part of the conservation disciplines. In practice, this meant that he made the best pathology research available for the conservation of threatened species. For example, his research on mortality of mute swans in the Trent River contributed to the banning of lead shot s weights in angling. Contaminant analysis of otters reinforced the case for banning organochloride insecticides, like dieldrin. His research on stranded cetaceans revealed that about 80% of the dolphins examined died in trawls. Recently Vic coauthored a paper supporting the hypothesis that naval exercises can cause dolphin mass stranding events.

The conservation organizations and specialist groups were main supporters of Vic and conservationists were Vic’s closest friends. The Wildlife Trust's Otter Group brought Vic road casualties for post-mortem since ‘80s and the Somerset Otter group has sent otters to Vic up until 2007. The Wildlife VIC operated as part of Cornwall Wildlife Trust and it became a collaborative partner in the Garden Bird Health Initiative in 2004.

Vic’s research was naturally collaborative and it couldn’t be otherwise. Vic was a friendly and kind person, always keen to exchange opinions and share knowledge. He had links with the Departments of Veterinary Pathology in UK universities, the Zoological Society of London and the Health Protection Agency. The Wildlife VIC had valuable support from colleagues of the Veterinary Laboratories Agency.

In one of Christmas Newsletters of the Wildlife VIC, Vic wrote “*There would be little point in doing this research if the results were not made publicly available*” and he put this into practice every single day by untiringly attending conferences, often as an invited speaker, writing reports or publishing cutting-edge papers.

Vic’s research was outstanding and internationally recognized. He received several awards during his life; of those, the most important and recent were: recognition from the British Veterinary Zoological Society and the Royal College of Veterinary Surgeons; the Dalrymple-Champneys cup and medal, the most prestigious scientific award for contribution to the knowledge of pathology of wildlife species from the British Veterinary Association in 2011; the Mammal Society Award for Outstanding Services to Mammalogy and the Emeritus Award from the Wildlife Disease Association received in 2016.

Vic has been an excellent teacher and a mentor for many. He trained a number of vet students aspiring wildlife pathologists during nearly 20 years at the Wildlife VIC.

Vic, Otters and the OSG

Vic examined nearly 900 dead otters from late ‘80s to 2011. About half of otter post-mortems was done at WVIC under a contract of the Environment Agency until 2007 and later on a completely voluntary and non-profit basis.

A meticulous gross pathology examination and histopathology of tissues enabled Vic to identify diseases of otters that have never been documented before in UK, to detect trends in mortality problems, and to evaluate possible mechanisms through which polychlorinated pollutants could have contributed to the otter decline.

He was the first to discover cholecystitis in UK otters caused by the digenean fluke *Pseudamphistomum truncatum*. He found that septic bite wounds from intraspecific aggression can be a direct cause of death in Eurasian otters and noticed that intraspecific aggressions increased over a fifteen years period possibly as a consequence of increased competition for resources in recovering otter populations. He described the first case of Tyzzer's disease in an otter cub. He suggested an index to evaluate abnormalities in adrenal glands that can be indicative of poor body conditions, stress or disease. His study on vitamin A level in otters suggested that vitamin A deficiency may have been widespread in Britain's otter population with a possible role in its earlier decline.

Vic compiled what is probably the most comprehensive database of otter pathology, mortality and values for anatomy, physiology, organ weights in Europe.

The otter post-mortem (PM) protocol developed by Vic is unique in that it deviates from a general veterinary necropsy protocol. Indeed it is not just aimed at determining the cause of death but it is "designed" to record measures and data about anatomy and organs, to appropriately collect tissue samples and organs for histology and other analyses, and to monitor evidence for disease. Each step of the protocol is functional to give optimal results and maximize information. Vic believed that data about anatomy and organs are precious to pathologists, but are scarce or don't exist yet for most wild species, included otters. His PM protocol for otters was intended to fill this gap.

OSG members met Vic in 2000 when he attended the First Otter Toxicology Conference organized by the IOSF (International Otter Survival Fund) at the Skye Isle. During the conference Vic presented his post-mortem protocol for otters with the aim to ensuring a better comparability of the results obtained from different laboratories across Europe.

Ten years later (in 2010) Vic was keynote speaker at the workshop "*Post-Mortem tools for otters: monitoring and research*" at the National Environmental Research Institute (NERI) in Denmark. The international workshop was organized by the European section of the OSG, in particular by Anna Roos and Morten Elmeros, and was aimed at developing standardized PM procedures for the Eurasian otter and at promoting the exchange and sharing of information on otter samples.

The co-organizers of the workshop Bjarne Søgaard, Aksel Bo Madsen and Morten Elmeros, remember about Vic: "*Vic's cheerful enthusiasm and generosity was very inspiring and he obviously enjoyed sharing his knowledge on wildlife diseases and health issues*". People from nine European countries had the pleasure and honor of meeting Vic, learning his procedure, and practicing his PM protocol under his supervision. In my opinion, the workshop was a particularly valuable initiative of the OSG in Europe. Vic's PM protocol for otters became a "common heritage" of European otter people after the workshop. As a standard, it has been applied from a number of research groups across Europe since. I believe Vic has been truly happy with this.

Vic was a guest speaker at the XI International Otter Colloquium in Pavia (Italy), where he recommended making full use of road-killed otters. This is an important message of Vic to the otter people. Although road-mortality is the most common known cause of mortality in otters, typically we are not able to fully evaluate if it is an effective threat to the viability of otter populations. Probably it's not so in most of cases, but when we find a road-casualty otter we have an invaluable source of data and information in hands that we do have the duty to use at the best for otters conservation and well-being.

A Personal Tribute

I met Vic and his fantastic wife, Jane, for the first time in 2010 at the “bloody workshop” in Denmark. A few years later, my partner Manlio and I had the true privilege of staying with them for some days during reciprocal visits in Italy and in Cornwall, at their lovely Jollys Bottom Farm and Wildlife VIC. I feel fortunate to have enjoyed their hospitality and friendship and hold many fond memories of time spent together: visiting a remote bloomed valley in Southern Italy; having a picnic along the Cornish coast or a drink on the bench in front of the pond at Jollys Bottom Farm; observing a crayfish in a river, honey buzzards in the sky or a salamander in the wood; cooking pizza together or tasting Jane’s excellent roast-beef “ritually” cut and served by Vic. Above all I greatly enjoyed talking with Vic about otters and everything.

Along with the vet pathologist prof. Leonardo Della Salda, I invited Vic to hold a one-day workshop on otter pathologies and PM protocol at the Faculty of Veterinary Medicine of the University of Teramo in 2012, as a part of a post-mortem study of otters in Southern Italy we had just started. Lectures and workshops on wildlife pathologies are not so frequent in Veterinary Faculties in Italy. I am grateful to Vic for having accepted our invitation and was delighted that so many veterinary students have attended the workshop. My only regret is that I could not provide a enough “good corpse” for the demonstration of the otter PM protocol. Even today I’m so sorry Vic!

One year later, Vic had gifted me with the unexpected opportunity of being trained in otter post-mortems refining my necropsy technique at the Wildlife VIC. During the year between our reciprocal visits in Italy and Cornwall, Vic has kept five otters for my training. I probably couldn’t thank him enough for his generosity. Although not a vet, I’m proud to be among “students” of Vic. I could appreciate his rigorous methodology and vast knowledge of otters. My otter post-mortems required something like two-fold time than Vic, nevertheless my hesitation or slowness didn’t prevent him to continue smiling and encouraging me during the procedure. At the end of the training, Vic told me “*now you are among a few people in the world that are able to remove thyroid glands from an otter*”.

I learned a lot from Vic not only about otters and post-mortem procedures. He taught me that a post-mortem is not concluded at the necropsy table but when you complete the necropsy report (i.e. only after having revised measures and data recorded at the table and compared them with your database)…and also that to being methodical can help you to accomplish even difficult tasks; that there is the time to work hard and time to relax and that it’s important to care and enjoy the second one…or that you can learn something in each moment or situation. When Vic and Jane were in Italy, we visited a church in a village where a nun was speaking to churchgoers. At the exit Vic suggested me to use the nun as an example of the right way to speak during a talk. He believed I speak too quickly and, I know, he was right.

Vic was a great naturalist and an acute observer of both nature and human experience. I loved his curiosity. He was admirer of engineering works and he cherished his native language. As a non-native English speaker I was indebted to Vic for his perfect pronunciation and calm slow speech.

All those who have known Vic, for years or for a few minutes during a conference, or even just through emails, describe him with the same words: warm hearted, a gentle man, truly fine person, lovely, friendly, kind when ask an advice, always ready to share his knowledge and to pass on information, awfully generous. And indeed Vic was truly like that. I think Vic was also a forthright person and he had an analytical and critical approach to any aspect of life not only to scientific issues.

He had a fine sense of humor and I will never forget his playful and ironic giggle.

I can’t close this tribute to Vic without paying homage to Jane. Jane is an extraordinary woman. Jane always supported Vic and his work. In Pavia Vic told me, jokingly, that Jane was his boss.

Vic will be missed by Jane, his grown up children, his family and friends, by us and…by otters and Britain’s wildlife.

Ciao Vic!

Romina Fusillo

A R T I C L E

ON THE REHABILITATION OF A HAND-REARED ADULT SMOOTH-COATED OTTER *Lutrogale perspicillata* IN BIHAR, INDIA

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Abstract: Otter species have been rehabilitated to their wild habitats as a conservation measure across the world. Otter rehabilitation success and post-release survival are influenced by age on arrival in captivity, time spent in human contact during captivity, age-at-release, human disturbance to habitat, and interactions between captive and wild otters. Attempts for rehabilitation are relatively fewer in developing countries owing to inadequate technical and financial support. This is an important gap for research and conservation efforts in countries like India, where only a few cases of otter rehabilitation are known. In this paper we report on the successful rehabilitation of an 8-yr old adult smooth-coated otter *Lutrogale perspicillata* in a human-dominated floodplain landscape along the Ganga River in Bihar, India. A male otter pup was rescued from poachers in the year 2000 and hand-reared until 2008. This otter was named 'Ganga' and rehabilitated as an adult in May 2008 after a soft-release program in the river, which took 42 days. Until 1.5 years later, Ganga was occasionally re-sighted with a wild otter pack, until he was found dead in March 2016. We report the technical details of and constraints faced in the rehabilitation, along with associated behavioral observations on Ganga in captivity, during release, and his interactions with wild otters. We demonstrate through this case that the success of rehabilitation through soft-release procedures was a key factor that ensured excellent post-release survival of Ganga in the wild. Rehabilitation success can be influenced strongly by social contexts, hence an understanding of the socio-ecological systems in which otters have to be conserved, is crucial.

Keywords - Smooth-coated otter, Ganga River, rehabilitation, survival, behavioral observations, wild otters

INTRODUCTION

Otter species are under threat from the degradation of riverine, coastal, and marine ecosystems on the one hand, and serious direct impacts from poaching, hunting, and persecution in fisheries on the other (Foster-Turley et al., 1990; Hussain, 2015). Given these threats, efforts to enable effective practices for otter rescue, captive maintenance, hand rearing, caregiving, and eventual rehabilitation or release back to the wild, holds great promise in helping otter populations recover locally in safe havens and refuges (Mason and MacDonald, 1986; Kruuk, 2006). Rehabilitation programs for otters have largely been conducted in the European Union and the Americas (e.g. Wayre, 1985; Sjøasen, 1997; Gómez et al., 1999; McTurk and Spelman, 2005; Nicholson et al., 2007), in conditions where excellent facilities exist along with technical expertise and financial resources towards ensuring rehabilitation success. Organizations such as the International Otter Survival Fund (IOSF; www.otter.org) have contributed substantially to otter release and rehabilitation efforts worldwide, including Africa and Southeast Asia (IOSF Otter News, Benza et al., 2009). These efforts are yet somewhat limited in South Asia, and rehabilitation of otters in this region is a key area for research and conservation interventions. We report on the rehabilitation of a smooth-coated otter *Lutrogale perspicillata* in Bihar (India) in this paper, after a global review of factors affecting rehabilitation success of otters.

The feeding and ranging habits of otters, their social interactions and behaviors, and their physiological adaptability to diverse conditions strongly influence prospects for their rehabilitation (Kruuk, 2006). Otters are wild semi-aquatic carnivores with peculiar social systems and habits (Mason and MacDonald, 1986; Foster-Turley et al., 1990; Kruuk, 2006). Aquatic carnivores like otters reach sexual maturity later than terrestrial Mustelid species and have prolonged periods of adult care of young (Bekoff et al., 1984). Otters could be solitary foragers, or form all-male groups, or family groups as seen in most species, to more complex societies as in giant otters and smooth-coated otters (Kruuk, 2006). River otters *Lontra canadensis* typically form all-male groups rather than mixed-groups (Blundell et al., 2002). Blundell et al. (2004) have shown conclusively for river otters that sociality might not be related to kinship or relatedness. In fact, benefits from location-based cooperative foraging strategies might increase success in capturing high-quality schooling fish prey (Blundell et al., 2002). Otters are generalist predators, with diets comprising several prey items (Carss, 1995; Hussain, 2015), ranging from fish, which are preferred and nutritionally profitable, to crustaceans, aquatic insects, birds, amphibians, reptiles, and rodents, which are less preferred but significantly supplement fish prey in resource-limited situations (Carss, 1995; Kruuk, 2006). Hunting otters might often minimize foraging costs by catching slower-moving species more frequently (Erlinge, 1968). They are also known to opportunistically change their diet as per seasonal availability and encounter frequency of diverse prey, including both native and non-native fish species (Prigioni et al., 2006). Den site selection in otters is also fairly typical, along sloping banks and firm substrates (e.g. Nawab and Hussain, 2012), and in sites protected from river or coastal inundation. Neotropical and European river otters selected den sites in upland areas protected from river flooding impacts for resting and raising young (Pardini and Trajano, 1999; Gorman et al., 2006).

In general, the overall reintroduction success for otters is attributable to availability of detailed knowledge of ecology and behavior, along with quality of captive care procedures (Wayre, 1985; Serfass et al., 1996; Yoxon, 2003; McTurk and Spelman, 2005) but also to their adaptability, social systems, and intelligence. River otters and Eurasian otters have been regularly reintroduced to the wild after initial time in captivity (Wayre, 1985; Serfass et al., 1996; Ben-David et al., 2002; Yoxon, 2003). Giant otters have also been rehabilitated quite successfully (Gomez et al., 1999; McTurk and Spelman, 2005). In this context, a review of factors that might have influenced rehabilitation success positively or negatively is required. Broadly, a few factors repeatedly emerge as impediments to successful rehabilitation: human disturbances at release sites, age-at-release, time spent in and extent of human interaction in captivity (causing semi-tame behavior), acclimatization, and social interactions with wild otters (Serfass et al., 1996; Sjoasen, 1997; Gomez et al., 1999; Ben-David et al., 2002; McTurk and Spelman, 2005). Hunting, killing, and otter trapping reduced overall survival of released otters in many cases (e.g. Ben-David et al., 2002; McTurk and Spelman, 2005). Ben-David et al. (2002) found that animals born and raised in captivity had lower survival rates than animals who had had some experience living in the wild, even if under stressful conditions. Behavioral interactions between captive male otters were found to be more positive than negative, and close interactions were linked to spatial proximity and familiarity, rather than relatedness (Hansen et al., 2009). However, reintroduced 1-year old *Lutra lutra* in Sweden showed strong evidence for competition between males for mating with females, and otters established their home ranges, avoiding pre-existing territories of other males (Sjøasen, 1997), as would be the case for wild otters dispersing naturally. Sjøasen recommended that release sites for captive otters should be away from sites where otters already were in existence. Such avoidance was also reported by Ben-David et al. (2005). In general, compared to wild otters, young animals released after an initial captive period had lower survival rates in the wild (Ben-David et al., 2002). Survival of adult male river otters was higher than that of adult females or sub-adults (Gorman et al., 2008).

Three species of otters are known to occur in the Indian subcontinent (Pocock, 1949), of which the smooth-coated otter *Lutrogale perspicillata* is the most widespread and common (Hussain, 2015). The other two species, the Eurasian Otter *Lutra lutra* and Clawless Otter *Aonyx cinereus* are rare, and have been recorded sporadically along high-altitude streams, typically away from human disturbance (Hussain, 2015, Joshi et al., 2016). The smooth-coated otter, in contrast, is distributed across the highly human-dominated river floodplains of South Asia. In India, the species continues to survive in several areas in spite of high human disturbance and instances of local extirpation due to poaching and hunting (Hussain, 2015). The species is classified as 'Vulnerable' by the IUCN Red List (de Silva et al., 2015).

Smooth-coated otters are also generalist feeders and use a range of habitats, but prefer flat riverbanks with shallow waters (Hussain and Choudhury, 1997; Anoop and Hussain, 2004; Shenoy et al., 2006; Nawab and Hussain, 2012). Group-living smooth-coated otters deposit spraints at specific, often well-defined latrine sites (Hussain and Choudhury, 1997). Group sizes range from 1 to 9, and are centered on an adult breeding pair and offspring of different ages (Hussain, 2015). In areas with heavy human disturbance, these otters often switch activity to nocturnal from diurnal (Shenoy et al., 2006). Linear home ranges were estimated at 5.5 km in females with pups and up to 17 km in adult males (Hussain and Choudhury, 1995).

The rehabilitation of an adult smooth-coated otter, named 'Ganga' was conducted in a highly human-dominated stretch of the Ganga River in Bihar, India. Ganga was under the care of the first author of this paper from 2000 to 2008, and after his rehabilitation, he survived in the wild for 8 years, and was found dead in 2016. In our report we first describe the strategies we chose for Ganga's rehabilitation program, our observations during the process, and the logistical constraints in which we worked. We include a detailed technical description of the rehabilitation program, with associated observations on behavioral changes in Ganga, and his interactions with wild otter packs near the rehabilitation site. We also compare our case with the only other reported rehabilitation attempt of a female smooth-coated otter from Bangalore, India, in 1999 (Nair, T. (rescue team member) pers. comm.; IOSF, 1999, 2000). Finally, we discuss the role of social systems in the smooth-coated otter, the importance of releasing Ganga as an adult otter, and the local socio-ecological conditions that ensured the success of rehabilitation.

ANIMALS, MATERIALS, METHODS, AND RESULTS

Study Area

The study area included a 5 km stretch of the Ganga River at Bhagalpur town, in the Bhagalpur district of Bihar, India. This site is within the Vikramshila Gangetic Dolphin Sanctuary area; a 67 km river stretch designated for the protection of endangered Ganges river dolphins (Fig. 1). High densities of smooth-coated otters have been reported from the area. Wild otter pack sizes range from 2 to 10 animals, although we have once seen a pack of 13 otters. The river stretch has a vast floodplain with agriculture and alluvial plains, with many compound meanders, braids, alluvial islands, side-channels, and confluence zones. River thalweg depths range from 1 to 40 m, and channel widths from 200 m to 2 km. Details of the study area and reports of initial otter sightings are provided in Choudhary et al. (2006). Fishing activity is also high in this region, with a few thousand fishers of the Mallah (Nishad) caste-group dependent on the river-floodplains for subsistence. Importantly, these fishers have positive cultural perceptions about otters despite suffering regular losses from otter-caused damage of nets. Some fisher groups in the study area also revere otters. Detailed information on this can be found in Choudhary et al. (2015). Gudger (1927) in his delightful review “Fishing with the Otter” cites C.J. O’Donnell’s 1877 report that fishers of Bhagalpur and Rajmahal regularly kept otters to help in fishing, but this practice is now extremely rare, if it exists at all. We have known only one fisherman to have kept an otter as a pet, and this practice is now likely nonexistent in India.

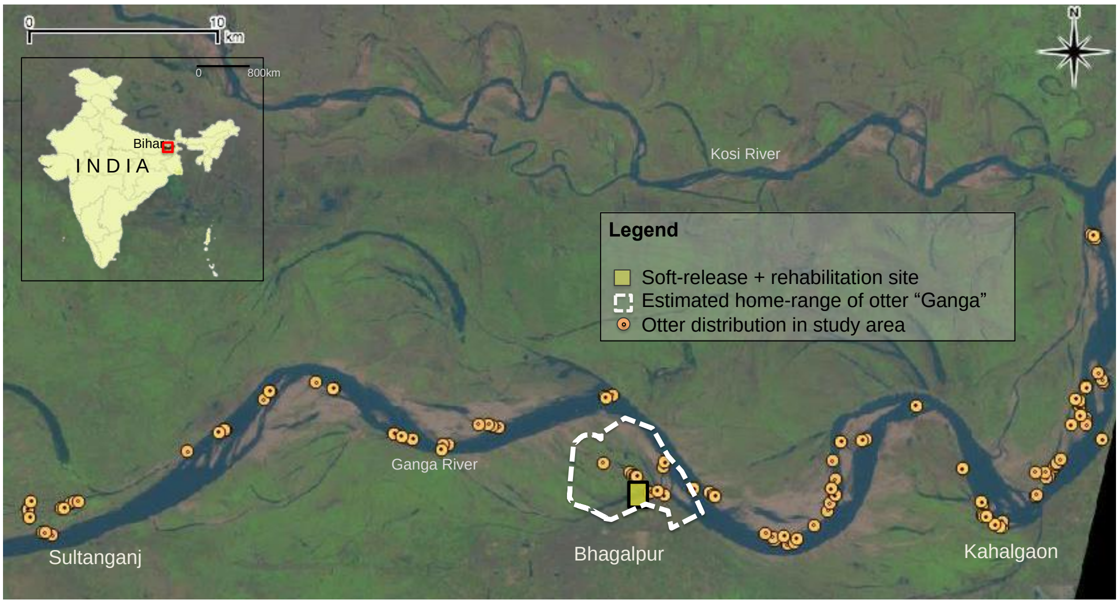

Figure 1. Map of the study area, with known locations of otter packs from field surveys (2000 to 2017) and the site selected for soft-release and rehabilitation of the otter ‘Ganga’.

Ethical Statement

As we have always worked as an informal research team studying river ecology and conservation, we did not have access to any institutional ethics guidelines for animal handling or captive caregiving. However, we ensured that the captive care program complied with the "Guidelines for the use of animals in research" (Animal Behavior, 1992). We also abided by the WAZA guidelines (WAZA, 2005) throughout the rehabilitation process. No invasive research was conducted on the focal male smooth-coated otter *Lutrogale perspicillata*. A female smooth-coated otter was also kept for 3 years (2005-2008) and no invasive study was conducted on her also (some details of her life in captivity are discussed later). The captive holding of both otters in the first two authors’ home premises was informed to and approved by the Sanjay

Gandhi Zoological Park, Patna, Bihar, which is the relevant authority in the Bihar state government's Department of Environment and Forests. The Divisional Forest Officer, Banka Division, Department of Environment and Forests, Bihar, granted the required permissions.

Hand rearing and caregiving in captivity

A month-old male otter pup was rescued from poachers in January 2000, and named 'Ganga'. The pup had a nick in the middle of its tail-tip (1.27 cm deep) and a slight bleed from an injury there. This wound was cured with antiseptic in 3-4 days. From 2000 to 2008, Ganga was kept in captivity, at the house of the first two authors in an enclosure room of 3.65m x 3.05m (12' x 10') dimensions. A water pool was constructed for the otter to play, eat, and rest. Ganga comfortably lived in his enclosure and showed no signs of ill health or stress. He had two occasions per day, each of 1-2 h, to play in a large terrace and verandah, which he would never miss. From 2000-2001, Ganga was fed about 1.2 kg of fish, over two feeds, per day. From 2001 onwards, the daily intake increased to approx. 1.5 kg fish per day. Small fishes were fed to Ganga in the first year, and bigger sizes were introduced later. The fishes mainly included pond-cultured carps *Hypopthalmichthys molitrix*, *Catla catla*, and *Cirrhinus mrigala* (80%) and the catfish *Clarias batrachus* (20%). Occasionally, river fishes or chicken were provided. Deworming was conducted and vitamin supplements were fed once a year. Our captivity schedule and management was roughly similar to the guidelines of the IUCN/SSC Otters in Captivity Task Force (2008), which became available after the rehabilitation program. In captivity, Ganga interacted with another young female (also kept for about 3 years by the first author, but which did not survive), but these interactions were not of sexual interest to either individual. The young female was highly secretive throughout her three years in captivity. She hardly ventured beyond her small territory and her association was generally restricted to when she would call out for food. Her sudden death was likely due to captive stress, but no clear symptoms or causative factors could be identified. In contrast, Ganga associated more closely with the first author. He demonstrated acute sharpness in following instructions and signals provided by the first two authors to him, during feeding and playtime. The otter would emit distress calls in the form of high-pitched squeals and sharp whistling or chirping noises when it would perceive stress, especially with the approach of unfamiliar persons or loud noises.

Table 1 provides a timeline from the year 2000 to 2016, including the rescue, life in captivity, soft-release and rehabilitation process, post-release monitoring, and death of the otter.

Site selection

After a thorough survey of the river stretch in March 2008 (summer), a sandy island north of the Hanuman Ghat in Bhagalpur (25.271N, 87.015E) was selected for the rehabilitation. The island was adjacent to a large floodplain area with extensive maize farming. Ganga the otter was taken to the site in a well-ventilated, 1.52m x 0.61m x 0.46m (5' x 2' x 1.5') grilled cage with a wooden sliding trapdoor with 2.5 cm thick plywood sheets, on 11 April 2008. As the otter was used to life in captivity, the trap cage did not affect its behavior or elicit any stress responses, as has been observed in translocated otters elsewhere (Serfass et al., 1996). The selected site had regular signs of otter presence, with fresh footprints, scat/spraints, latrines, and skeletal remains of big fish eaten by otters. The area also had regular catches of large fish, indicating good availability of prey. Local fishermen, operating in the area reported that two otter packs regularly used the island for fishing and movement across the river. The fishers particularly avoided the island to prevent net damage by otters, which often took fish from them. Regular informal monitoring and reporting by this network of fishers, and our long-term cordial relationships with them, were important factors in selecting this as the rehabilitation site.

Table 1. A chronological summary of phase-wise key events in the rescue and rehabilitation program, from rescuing the otter as a pup in 2000, to confirmed death in 2016.

Phase of monitoring	Time period	Key events	Remarks
Rescue	22 Jan 2000	Month-old male otter pup rescued from poachers, named 'Ganga', treated for injury on tail	Nick on tail-tip (1.27 cm deep), main identifying feature of the otter
Life in captivity	Jan 2000–Apr 2008	Housed in an enclosed room with a water pool	1.2-1.5 kg fish fed per day, observations of feeding and play recorded
Pre-release phase	Feb 2008	Condition of Ganga monitored	Slight delays in support and funding
Release: site selection	Mar 2008	Site selection, plan for soft-release	-
Release: construction and maintenance of enclosure + fish holding pen	Mar-Apr 2008	Enclosure built at site with artificial holt and fish-holding pen, catfish introduced in pen	Enclosure regularly maintained, otter use of sites and habitat exploration monitored
Release: skill development	Apr-May 2008	Need to develop skills of otter to catch fish in the river, after a long term of being used to provisioning	Rapid progress, able to catch fish from the river channel within 10 days during soft-release
Release: stamina-building	Apr-May 2008	Focus on weight reduction and improving swimming capacity of otter	Stamina building achieved considerably in 2-3 weeks
Interactions with wild otters	May 2008	Behavioral interactions monitored in detail	Antagonistic and neutral interactions, notable fighting bout with a large male of wild pack, subsequent injury and healing, assertion of territory and exploration by Ganga
Return to the wild	May 2008	Moved away with otter pack and likely mated with females from that pack	Occasional visits back to camp site, regular exploration of habitat continued
Post-release monitoring and confirmation	May 2008–Jul 2009	Confirmed to travel singly or with pack of wild otters for 1.5 years by fishers	Would respond to fishers calling out the otter by name through this period, but kept distance
Death	5 Mar 2016	Death at the same spot as the release site	Identified from the nick of the tail-tip

Enclosure construction for soft-release

An acclimatization enclosure of 10.67 m x 10.67 m (35’ x 35’) open from above, was erected with bamboo poles. The sides were enclosed with a 2.5 cm diameter chicken net (2.13 m (7’) high, with 0.9 m (3’) above water), supported by long bamboo strips embedded 30.5 cm deep, into the dry land and the soft bottom of the riverbed (Fig. 2). An artificial holt was made within the enclosure, with cement bags lining the hollow, plastered with sand. Within the enclosure, a 2.44m x 1.52m (8’ x 5’) plastic sheet was placed with dry sand piled on it, to maintain firm and dry substrate. The enclosure was built along a small inlet of water cutting around an edge of the island to have constant movement of water. Yet, there was a marked difference in temperature inside and outside the enclosure. As a result, an algal mat started growing on the net and caused the current to erode the bottom of the enclosure, causing some fish to occasionally escape. For this a bamboo barricade was constructed in front of the enclosure to divert the flow, and as a result the algal cover reduced, and the sand bottom stabilized. This enclosure was an important part of the soft release, as it helped acclimatize the otter with its natural habitat, but also provided supply of fish in a concentrated zone, making fish easy to be hunted by the otter in the first 4-5 days. The otter would dry himself by rolling and basking in the hot day hours, along the enclosure sides. After the first 5 days, the otter started coming out of the enclosure and exploring the outside habitat, visiting the enclosure only for feeding.

Construction of a fish-holding pen

A fish holding pen of 15 m x 15 m (50’ x 50’) was built next to the enclosure (Fig. 2), with the same materials used for the enclosure, and almost 20 kg of the hardy native catfish species *Clarias batrachus* was put in the enclosure (each fish was c.250 g, and 75-80 fishes were introduced). Later the otter also would catch fish directly from the pen. The fish were initially kept alive on chicken entrails, but they soon started consuming small *Aspidoparia* fishes in the river, and maintained themselves. *Clarias batrachus* are catfish with accessory air sacs and can move on land, and we found some fish wriggling away through the enclosure on land. To keep them restricted to the pen, we excavated the river island slope along the pen a little deeper, after which fish stayed put inside (Fig. 2). The otter regularly fished in this pen after the first 5 days of restricting itself to the enclosure. Wild smooth-coated otters, Indian foxes, jackals, jungle cat, and a greater adjutant were also regularly seen around the fish pen. Wild otters raided the pen at night when Ganga would be sleeping or away exploring the habitat.

Skill development

Ganga was reared in captivity and always fed with dead fish. The otter was also overweight when he was brought to the release site. It was thus essential to hone his natural hunting skills and catch fish irrespective of the chances of being accepted by a wild pack. The otter was experienced in capturing and eating live *Clarias batrachus* in captivity earlier, and in the enclosure, due to the greater search time for the fish, he had difficulty in catching fish underwater. The otter would tire out quickly in the first few days, as he had never swum this much in captivity. This reduced his enthusiasm to go on searching, and he started looking for food on land. Sometimes, live catfish had to be provided to him directly in the field. Gradually, with some help and cues provided to Ganga, he started catching fish in lesser time. These rewards were obviously precious, as the otter, having caught his meal, would not allow anyone to go close to it until he had devoured the entire fish. After a week, when Ganga would return from his forays he would not eat, indicating that he had probably eaten fish while away.

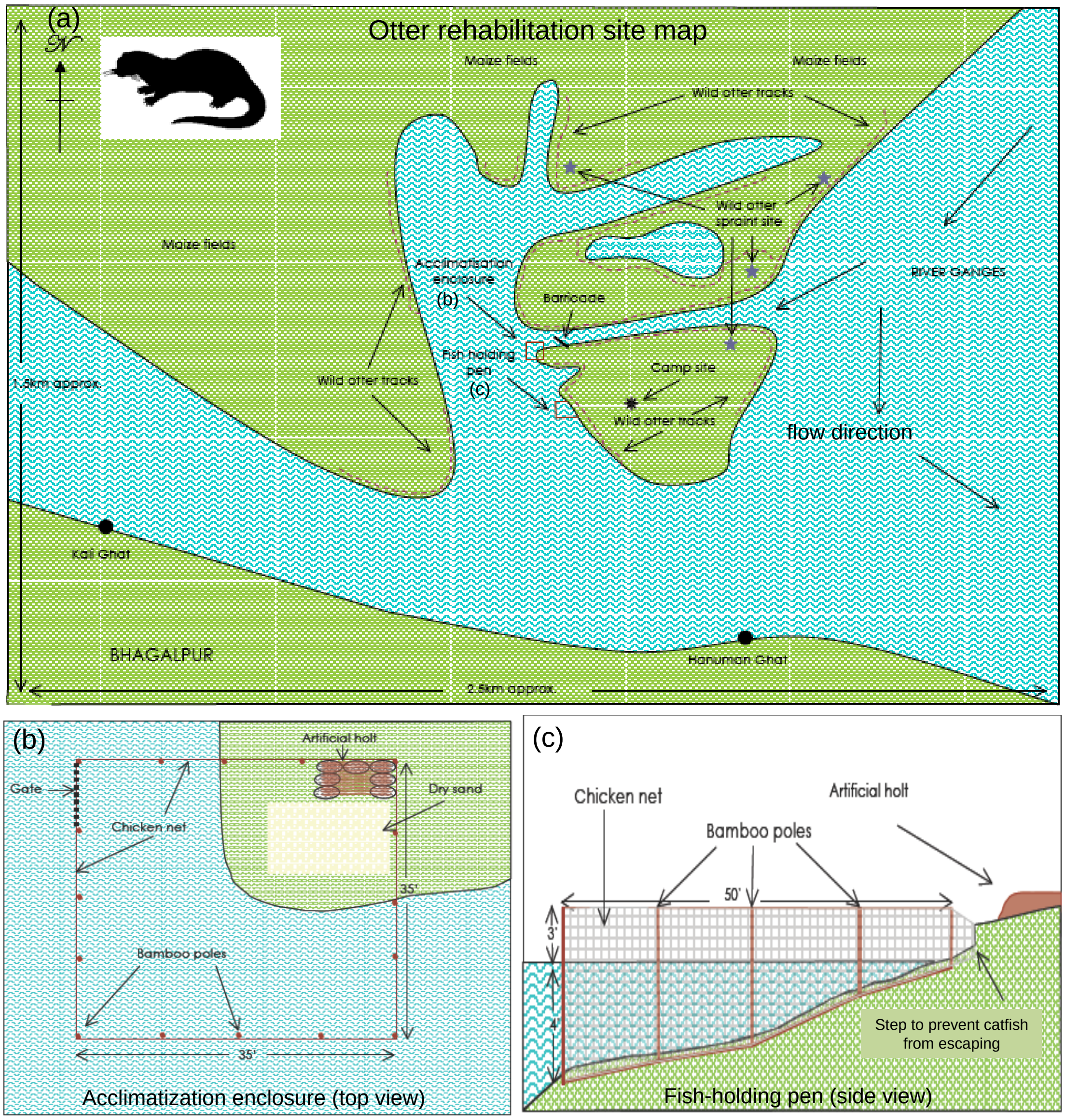

Figure 2. Detailed site map (a) with enclosures for the soft-release and stamina-building program of the otter Ganga in 2008, along with details of habitat, use of the area by wild otter packs, and site characteristics. b) Diagram of enclosure with artificial holt for the otter to stay at night. c) Diagram of fish-holding pen during the rehabilitation process.

Stamina-building

Ganga first exited his enclosure after 2 days, by tearing through the chicken net. He would swim and explore the site in the shallow areas of the river first. Initially, he would get tired within 30 minutes of swimming and return to the camping site. His daily routine included exploratory trips, feeding, and sleeping, both in the morning and evening, with each bout lasting for 2-3 hrs. Over time, the otter started to swim upstream with ease as it lost weight, and also started swimming long distances. While swimming he would occasionally emerge on the island to defecate, or to smell latrines deposited by wild otters at certain specific sites. Ganga would also rub himself dry at spots where we had observed wild otters do the same. Ganga would easily catch small fishes without much effort after he took to traversing long distances in these trips, lasting 5-6 hours after 10 days of initial stamina development and local exploration.

Behavioural Observations during Rehabilitation Program

Interactions with wild otters began within a few days of the rehabilitation soft-release process. First, a pack of wild otters (8-9 individuals) visited the enclosure at night on the 12th April 2008, and checked the area and scent-marked at the enclosure boundary. We saw fresh footprints and scrape-marks on the sand the next morning. Late at night on 18th April, when Ganga was sleeping near the enclosure, a pack of six wild otters (two large males and four slightly smaller animals, either females or sub-adults) visited the area. When they were about 12m away Ganga became highly vocal, and chirped excitedly. The otters were also making loud chirping calls and came running towards him. A lot of growling and snarling followed between Ganga and the large adult male leading the pack, after which Ganga followed the male and the otters to the neighboring floodplain. Severe fighting was observed between him and the large male here too, in which the otters tried to bite and claw at each other. After the fight the otter pack silently exited. Ganga was also not seen until the next day, when he returned to the enclosure, badly injured. The wounds took about 3 weeks to heal. A few days after this encounter, we heard of a dead adult male wild otter on the floodplain, which was probably killed during the fight. On 16th May Ganga was seen approaching a pack of 5 otters in daytime. This encounter consisted only of sniffing and lasted for a few minutes.

Return to the wild: completion of the rehabilitation process

We broke camp on 25th May 2008, leaving Ganga behind, as we were convinced that he could fend for himself from now on. At this time, Ganga would spend long hours of the day and night away from the release site, and would hunt by himself in the river. He would occasionally be seen with wild otters. However, his affinity to the artificial holt lasted for some time. For about 20 days after we left, fishers would see Ganga in the same area, sometimes even sleeping inside the holt.

Post-release monitoring

Floodwaters began rising from 11th June 2008, after which Ganga was not seen again for some time. Two months later, one group of fishers who knew Ganga from before the release, reported that they found him in the company of wild otters. We kept getting occasional reports of seeing Ganga from these fishermen for about 1.5 years after the rehabilitation, until late 2009. According to them, there was no attempt by the otter to approach them, despite noting their presence in the area. No confirmed reports were received about Ganga from 2010-11 to 2015-16. The approximate home range (i.e. linear river-bank distance covered), based on the few scattered observations, was estimated at about 3-4 km, which indicated continued fidelity to the rehabilitation site.

Death

Ganga the otter was found dead on 5th March 2016. His age was 16 years and the animal was identified from the peculiar nicked tail-tip that was his identifying feature. He seemed in otherwise good health, except for some signs of dental wear. He had died at the same location where he was released to the wild eight years ago. Fig. 3 shows a collage of pictures of the otter Ganga in captivity, during rehabilitation, and as a dead animal.

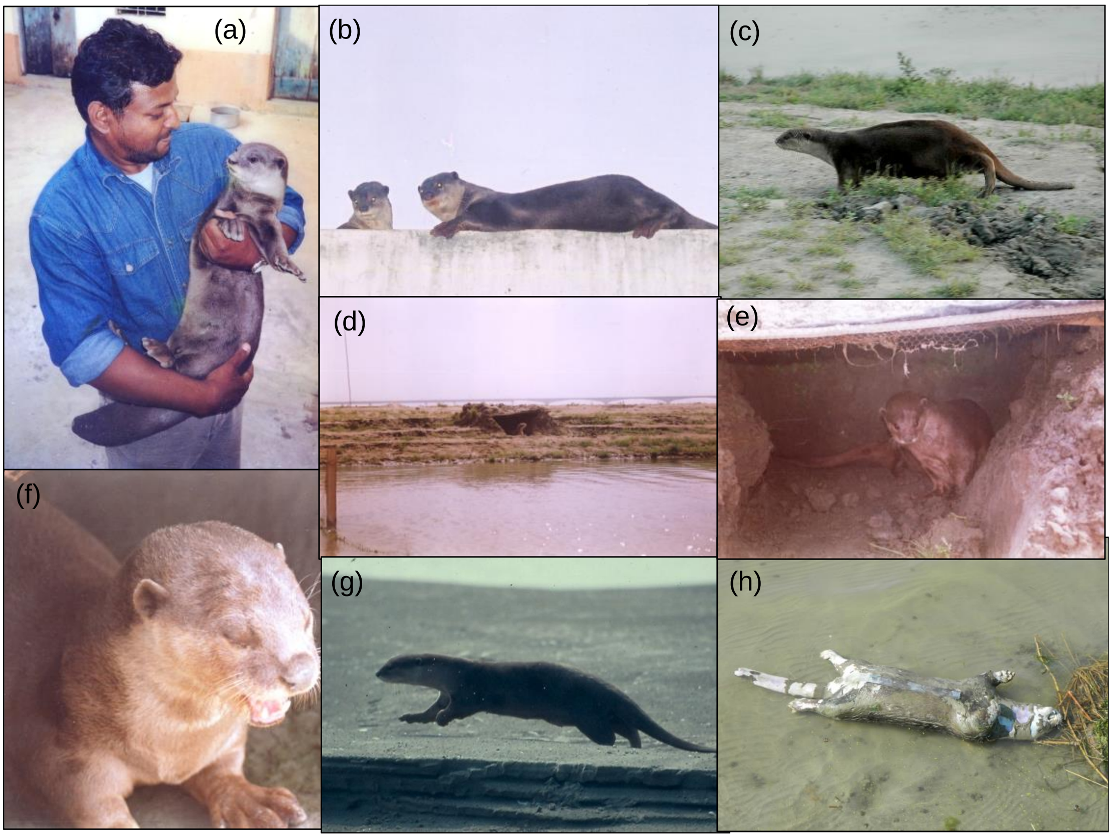

Figure 3. Pictures showing Ganga the otter a) as a pup, b) in captivity, with another female otter, c) as an adult at the rehabilitation site (2008), d,e,f) using enclosure during the soft-release. A wild otter in the Ganga River (g). Death of Ganga the otter (h), identified by the nicked tail, in 2016.

DISCUSSION AND CONCLUSIONS

Our report highlights the importance of rehabilitation of otters after the age at which they naturally leave their mothers, to ensure high post-release survival. Ganga was hand-reared by the first author using traditional care-giving methods, which might have been crucial in ensuring post-release adaptability. However, Nicholson et al. (2007) noted that success of rehabilitation was reported to be lower for sea otter pups thus reared, than those reared under the care of surrogate otter females. In this context, our case may be useful in identifying what factors might contribute to successful rehabilitation of hand-reared otters after a significant duration in captivity. We believe that Ganga’s release as an adult contributed substantially to his success in the wild. We posit that his ‘middle-age’ release might have helped confer certain competitive advantages (physical strength, health, vigor, etc.) to him. The importance of soft-release procedures, especially those involving stamina building and skill development exercises, was vindicated by our observations.

Ben-David et al. (2002) found a negative correlation between time spent by river otters in captivity and their post-release survival. Importantly, their experimental study, based on 55 captive-reared, experimentally manipulated, and radio-tagged otters found that even exposure to physiological stressors (crude oil in their case) did not affect post-rehabilitation success as much as captive detention time. However, our result contrasts their findings. We found that Ganga the otter had considerable head-starting advantage for adjusting to wild otters and river-floodplain habitat, having grown up securely in captivity. At a younger age, the vulnerabilities he might have faced would have likely been higher. Smooth-coated otters have a life span between 11 and 15 years (Hancox, 1992). Acharjyo and Mishra (1983) reported that a smooth-coated otter lived in the Nandankanan Zoo, Orissa, in captivity, for 20 years. Ganga’s age at death, at 16 years, is therefore indicative of a successful post-rehabilitation life in the wild.

Importantly, many rescue and release programs have tended to focus on the rehabilitation of younger animals and sometimes even pups, for head-starting recruitment and establishment into wild populations. In this regard, we support the suggestion by McTurk and Spelman (2005) that rehabilitation be conducted at ages nearing adulthood, than earlier. Our observations on negative interactions between adult male otters resemble their report on the rehabilitation and captive rearing on giant otters. In their case, wild giant otters killed five out of 28 giant otters, including one adult male. In our case, Ganga the otter not only survived a fierce fight with an adult wild male, but also probably killed the rival. The observed scent-marking by Ganga was likely to assess threat from other wild male otters in the area. Scent-marking is used to indicate social status by adult male otters (Rostain et al., 2004), or indicate feeding and resource use to other groups, apart from a variety of other purposes (Kruuk, 1992). The negative interactions that we recorded were likely related to Ganga intruding into the wild male's range, and Ganga's scent being distinguished as that of an unfamiliar intruder, by the wild male. The death of the young female in captivity makes us wonder if adaptability differs between sexes. We are unsure whether this female, if alive, would have had similar rehabilitation success. However, the rehabilitation of the female otter (Sushi), through similar caregiving methods by Compassion Unlimited Plus Action (CUPA) in Bangalore, India is a useful case, indicating typically high success (IOSF 2000). Sushi was c.1 yr old at the time of release and was in captivity since being a few weeks old (IOSF 1999, 2000).

Giant and smooth-coated otters are highly similar in their dietary niche, physical characteristics, and social structure (Kruuk, 2006). It is also likely that otters with complex social systems (multi-male, multi-female packs) as seen in these species might have higher survival post-rehabilitation than other otters, in which social bonds are likely less regular. Research on smooth-coated otter social systems is still limited (Hussain, 1999), but will be important in unraveling the potential survival implications of released individuals. As reported for river otters (Blundell et al., 2004), when kinship is not a criterion for social grouping, it is likely that younger otters will be assimilated into wild packs. Interestingly, Gomez et al. (1999) reported the adoption of two young otter pups by wild giant otter packs in Colombia. We believe that such positive interactions are also plausible in the case of smooth-coated otters. In fact, despite other reports to the contrary (e.g. Sjoasen, 1997), we decided that it was important to select rehabilitation sites close to wild otter home ranges, than away. This decision was based on our observations of social interactions within and between wild otter packs for many years.

That otters are revered and not deliberately disturbed or hurt in our study area (Choudhary et al., 2015) may have been the 'X-factor' in the successful rehabilitation of Ganga. This is in sharp contrast to most other cases, where anthropogenic threats strongly affected post-release survival. As a concluding point, we strongly emphasize deep and careful engagement with local people to understand the socio-ecological contexts and cultural settings in which interventions such as rehabilitation of otters may be planned. In addition to sound technical support and long-term ecological research, there is a need to track the social dynamics that may significantly enhance or depress the long-term survival and conservation of otters in the wild.

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RÉSUMÉ

A PROPOS DE LA RÉHABILITATION D'UN ADULTE DE LOUTRE À PELAGE LISSE, LUTROGALE PERSPICILLATA, ÉLEVÉ AU BIBERON, À BIHAR EN INDE

Différentes espèces de loutre ont été remises en liberté à travers le monde dans leur habitat sauvage au titre de mesure de conservation. Le succès de cette remise en liberté des loutres et leur survie après leur libération sont influencés par l'âge de la mise en captivité, la durée du contact avec l'homme durant la captivité, l'âge de la remise en liberté, la perturbation humaine de l'habitat et les interactions entre loutres captives et sauvages. Les tentatives de remise en liberté sont relativement peu nombreuses dans les pays en développement à cause d'une aide technique et financière insuffisante. C'est une importante lacune pour les efforts de recherche et de conservation dans des pays comme l'Inde où seul un faible nombre de réhabilitations de loutres est connu. Dans cette publication, nous relatons le succès de la remise en liberté d'un mâle adulte de loutre à pelage lisse, Lutrogale perspicillata, dans un paysage de plaine inondable dominé par l'homme, le long de la rivière Ganga, à Bihar en Inde. Un jeune mâle a été sauvé des braconniers durant l'année 2000 et élevé au biberon jusqu'en 2008. Cette loutre, nommée « Ganga », a été remise en liberté à l'état adulte en mai 2008, suite à la mise en place d'un programme de remise en liberté progressive qui a duré 42 jours. Un an et demi après, Ganga a été revue occasionnellement avec un groupe de loutres sauvages, jusqu'à ce qu'on la retrouve morte en mars 2016. Nous avons décrit les détails techniques et les contraintes de la libération, de même que des observations liées au comportement de Ganga en captivité, durant sa remise en liberté, ainsi que les interactions avec les loutres sauvages. Nous avons démontré, dans ce cas, que le succès d'une réhabilitation par des procédures de remise en liberté progressive fut un facteur prépondérant qui a assuré la réussite de la remise en liberté de Ganga dans la nature. Le succès de la réhabilitation peut être fortement influencé par les contextes sociaux, et, par conséquent, il est crucial d'avoir une compréhension des systèmes socio-écologiques dans lesquels les loutres doivent être protégées.

RESUMEN

SOBRE LA REHABILITACIÓN DE UNA NUTRIA LISA *Lutrogale perspicillata* ADULTA, CRIADA EN CAUTIVERIO, EN BIHAR, INDIA

Distintas especies de nutrias han sido rehabilitadas a sus hábitats naturales, como medida de conservación, en todo el mundo. El éxito de la rehabilitación y la supervivencia post-liberación están influenciadas por la edad de arribo al cautiverio, el tiempo transcurrido y el contacto humano durante el cautiverio, la edad al momento de liberación, el disturbio humano del hábitat, y las interacciones entre las nutrias cautivas y silvestres. Los intentos de rehabilitación son menos en los países en desarrollo, debido al inadecuado soporte técnico y financiero. Este es un importante hueco de esfuerzos de investigación y conservación en países como India, donde se conocen sólo unos pocos casos de rehabilitación de nutrias. En este trabajo informamos la rehabilitación exitosa de un adulto de 8 años de nutria lisa *Lutrogale perspicillata* en un paisaje de planicie aluvial dominado por humanos, a lo largo del Río Ganga en Bihar, India. Una cría macho de nutria fue rescatada de cazadores furtivos en el año 2000, y criada en cautiverio hasta 2008. Esta nutria fue llamada "Ganga", y fue rehabilitada como adulto en Mayo de 2008 después de un programa de liberación gradual en el río, que tomó 42 días. Hasta 1 año y medio después, Ganga fue re-avistada ocasionalmente junto con un grupo de nutrias silvestres, hasta que fue encontrada muerta en Marzo de 2016. Informamos los detalles técnicos y las limitaciones enfrentadas en la rehabilitación, junto con observaciones comportamentales asociadas, sobre Ganga en cautiverio, y sus interacciones con nutrias silvestres. Demostramos con este caso que el éxito de la rehabilitación mediante procedimiento de liberación gradual fue un factor clave que aseguró la excelente supervivencia post-liberación de Ganga en el ambiente silvestre. El éxito de rehabilitación puede estar influenciado fuertemente por los contextos sociales, por lo tanto un entendimiento de los sistemas socio-ecológicos en los cuales deben ser conservadas las nutrias, es crucial.

R E P O R T

STATUS OF THE HAIRY-NOSED OTTER (*Lutra sumatrana*) IN PENINSULAR MALAYSIA

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Abstract: An individual, of one of the most elusive and endangered of the otter species, the Hairy-nosed Otter (*Lutra sumatrana*) was seen on the Sungai Relau in Taman Negara, Malaysia, in September 2013 almost two decades since the last recorded observation of the species in 1994, in Perak, another part of the peninsular (Baker, 2013). The project reported here was initiated in and around Taman Negara based on the 2013 observation, to gain a better understanding of the population size, habitat type, threats and the conservation measures required to improve the status of the Hairy-nosed Otter.
Unfortunately, 7 months of continuous camera trapping, riverbank surveys and observations along the Sungai Relau and the Sungai Ceruai resulted in no Hairy-nosed Otter records. However, the project confirmed the presence of Asian Small-clawed Otter (*Aonyx cinereus*) and Smooth-coated Otter (*Lutrogale perspicillata*) in and around Taman Negara National Park while highlighting a number of threats to otter species in the area and providing an overview of the attitudes of local people to otters and otter conservation, especially of the indigenous Bateq community.

INTRODUCTION

Conservation Status of the Target Species, the Hairy-Nosed Otter

The Hairy-nosed Otter (*Lutra sumatrana)*, is the rarest and least known among the five species of otter occurring in Asia. Little-recorded in most of its historical range, the species has been recorded in recent years in Thailand, Vietnam, Cambodia, Borneo and Sumatra. In 2013, the species was sighted along the western part of Taman Negara (Baker, 2013; N. Baker pers. comm. 2014) almost two decades since it was last seen anywhere in Peninsular Malaysia according to the records in Sasaki et al (2009).

Lutra sumatrana is listed in Appendix II of CITES and is legally protected in all of its range countries. The IUCN Red List categorizes *L. sumatrana* as Endangered (Hussain *et al*. 2012), due to a decline in its population throughout its distribution range.

Conservation Status of Smooth-Coated Otter *and* Small-Clawed Otter, the other Species represented in the Study

The Smooth-coated Otter (*Lutra perspicillata)* and Small-clawed Otter (*Aonyx cinereus*) have a wide distribution in tropical Asia. Both species are listed in Appendix II of CITES and are legally protected in all of their range countries. The IUCN Red List of Threatened Species categorizes *L. perspicillata* as Vulnerable and the Oriental Small-clawed Otter is listed as Near Threatened (Shenoy *et al.* 2006; Hussain *et al*. 2008), due to declines in their global populations.

Despite these efforts, global otter populations of all three species continue to decline in parts of their distribution range. Habitat loss and fragmentation due to logging - both for commerce, as well as development projects and agriculture (such as palm oil plantations), are some of the significant threats to Hairy-nosed Otter in particular. There is also the issue of reclamation of wetlands for human settlement, commercial fishing and aquaculture, which is resulting in reduction of habitat and increasing human- otter conflict.

Identifying the essential resources and the particular threat of a species may be helpful to formulating conservation strategies to ensure survival of that species. Actions directed towards conservation of flagship species of land ecosystems, such as Tiger *Panthera tigris,* are believed to have contributed to the conservation of a range of associated ecosystems and species. Otters are among the top predators of the aquatic ecosystem. Otters therefore are potentially ideal flagship species for conserving the rapidly degrading aquatic ecosystems of Malaysia.

OBJECTIVE

1) To establish the presence of otter populations in Taman Negara, Peninsular Malaysia.
2) To gather information on the habitat, ecology and threats to otter populations.
3) To involve local communities, in the surveys and conservation process by getting them to participate in conservation and monitoring of otters.

METHODOLOGY

As a first step, we conducted verbal surveys in order to involve local communities from the beginning of the project with the idea of identifying species present and confirming their current status in Taman Negara. informal interviews were conducted through a translator allowing open answers by respondents. Respondents included individuals as well as groups.

The following questions were asked:

1) Have you seen otters?
2) Do you see otters often?
3) Have you seen different types of otters?
4) How many species/types of otters have you seen in this area? Describe the different types.
5) Are these species/different types of otters seen in the same area/river/stream?
6) Do you see more otters now compared to before?
7) Have otter populations increased or decreased in the area?
8) Do otters have a monetary value? ie live or dead trade?
9) Does anyone in your community hunt otters?
10) Do people like eating the meat of otters?
11) Are otters a source of conflict with villagers? What conflict?

The second step was to conduct biological surveys along riverbanks to seek to confirm otter presence. This involved walking surveys on both banks of the Sungai (= River) Relau and Sungai Ceruai (Fig. 1) A survey site was considered positive for otters if one or more signs (footprints, spraints [= faeces],slides, holts) were found or if any otter was sighted or camera-trapped. Otter signs, such as holts, slides, and food remnants were counted as a positive record only if supported by presence of either spraints or footprints. Remote camera traps with passive infrared heat-in-motion detectors were placed (Fig. 1) in areas where otter activities had been observed in order to capture images of otters. GPS coordinates were taken to record accurately and map the location of all field signs and the position of any photographs taken. Environmental parameters such as bank side geology (where signs were seen); water depth and distance of signs from water's edge were collected in order to understand habitat preferences. Outreach and conservation work included talking to and sharing information with local and indigenous communities and encouraging these communities to participate actively in the project. Other aspects of my outreach program included university lectures, other public talks, the Borneo Wildlife Festival, my talk at the Fishing Cat Symposium in Nepal, on my blog, twitter, facebook and instagram.

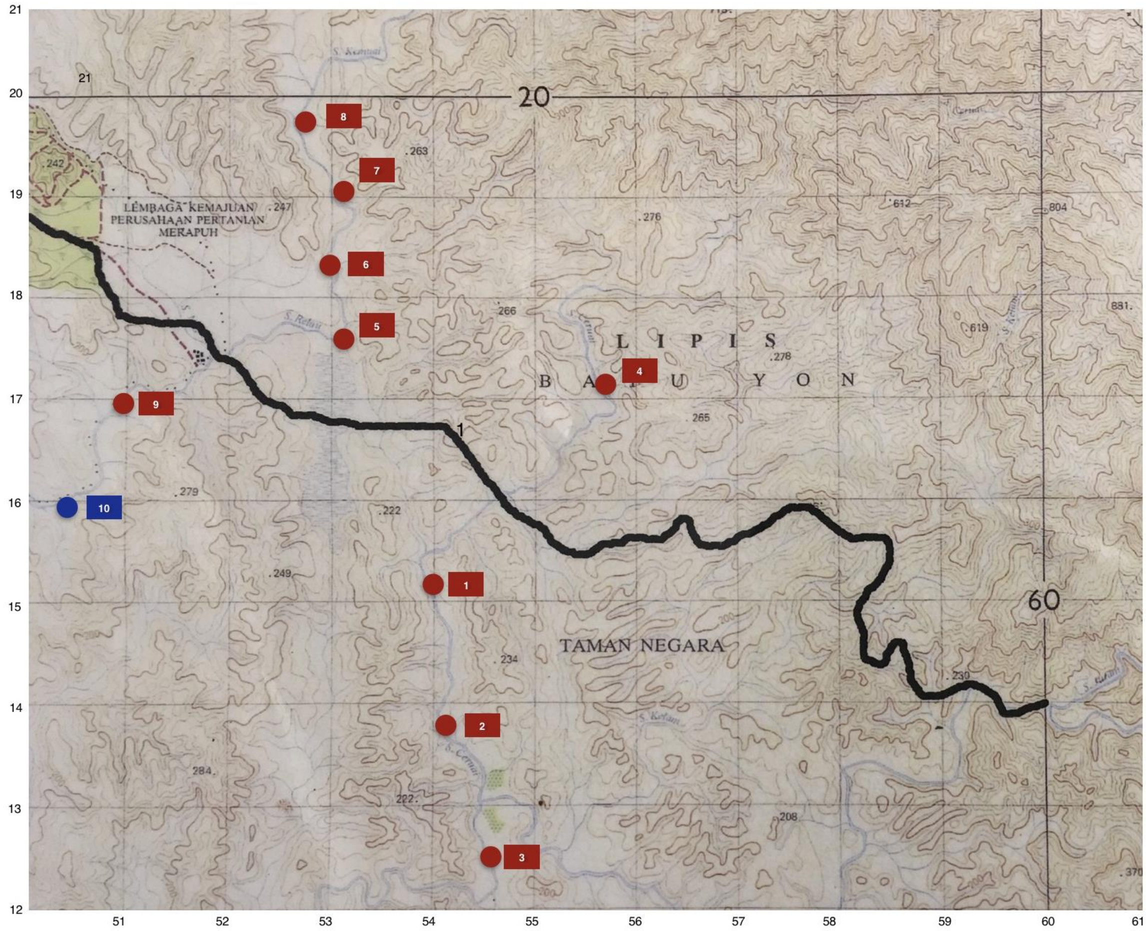

Figure 1. Study Area- Sungai Relau and Sungai Ceruai – Taman Negara National Park
= Camera Traps placed with corresponding camera trap number;
= Stolen camera number 10;
= Access road within Taman Negara National Park.
Source: Taman Negara National Park Office Merapoh

RESULTS AND DISCUSSION

Population Assessment and Habitat Use:

Interviews

The majority of the feedback from twenty nine verbal surveys conducted in Merapoh, a village on the outskirts of the park, suggested that there were otters present both within the park and on the outside, including sightings in palm oil plantations, in agricultural areas and at local fish farms. Nineteen of the respondents replied that there were larger otters outside seen raiding fish farms, while 23 respondents also stated that smaller otters were seen in palm oil plantations. Size of the animals was the only distinguishing factor that respondents could identify with regards to variation between types. Respondents also indicated that poaching did occur and that the poachers were typically Indonesian and Thai nationals. From a historical perspective gained from the interviewees (17 respondents) it was suggested that the otter population have declined significantly in the last three decades. This information was gathered from a total of 29 respondents that included 18 individual interviews and the remaining 11 respondents were from a group setting that included plantation workers and subsitance fisherman. Individual respondents included, small farm holders, fish farmers, national park tourist guides and palm oil plantation workers.

Five members of the indigenous Bateq community were interviewed as well but the respondents answered with caution and were not very forthcoming. I assessed the situation as them being wary of strangers and naturally suspicious. They did agree that there were two types of otter species (one larger than the other) and that these animals used to be seen more easily in the past. But the Bateq also said that that this was likely to be because they, as a community, do not now much venture into the national park and depend less on its resources, than they did in the past and so the chances of encountering the animals now are slimmer. They also said that the community used to hunt and eat otters in previous generations but suggested that chicken was now a cheaper and more viable option as sustenance. However, neither the indigenous community members nor the other local inhabitants were able to recognize (in photo surveys of the four different species in tropical Asia or describe any individual characteristics of a type of otter other than size. So the verbal surveys proved inconclusive in terms of my search for the Hairy-nosed Otter in particular.

Habitat characteristics within Taman Negara

Of the 48 positive otter sites recorded in this study, within the boundaries of Taman Negara, i.e. where an otter sign was present, 36 were spraint sites, of which 22 were combined with clear prints. Another five of the positive otter sites were holts, of which two were combined with prints and one with spraint and the remaining seven positive otter sites consisted of footprints and grooming sites. All 48 otter sites were positively identified as Small-clawed Otter based on spraint type (size, shape and smell) and footprint (size and shape).

Spraints were deposited on rocks (71%) and on sandy slopes (29%). These sand slopes were also used as grooming sites and slides. Rock spraints were at an average of 1.8 meters away from the water's edge and sand sprints were on average 2.8 meters away from the waters edge. Preference for grooming and resting sites included areas with sandy beaches, with 70% to 80% canopy cover and thick surrounding undergrowth vegetation. 80% of grooming sites had small inlets/streams that led into the main river. These inlets/streams were on average 1.4 meters wide and had slow-flowing water.

Habitat characteristics on outer boundary of Taman Negara

The area that forms a boundary with the park consists of agricultural land. This includes palm oil plantations as well as smaller agricultural farms belonging to the people living in the village of Merapoh. Several old abandoned tin mines in the area have naturally converted into lakes. These old tin mine lakes have become natural reservoirs and suitable habitats for Smooth-coated Otters. A few of these lakes have subsequently further been developed into small-scale aquacultures. Four of these lakes were monitored during the course of the study. Two of the four were natural with no current, active human presence/disturbance and the remaining two were small aquaculture ponds.

The natural tin mine lakes were surrounded by vegetation that comprised primarily tall grasses and reeds (70%) and some smaller secondary forest tree species (30%) that provided 20% canopy cover. Here there were no direct sightings of otters but there were positive Smooth-coated Otter signs (17) during 3 separate survey visits.

The remaining two tin mine lakes with the small aquaculture operations had Smooth-coated Otter visits on a daily basis. These lakes were also surrounded by grasses and reeds (90%) with a few small shrubs and trees surrounding the lakes (10%). There was no canopy cover in this area and the lakes were adjacent to human habitation. These otters were habituated to human presence and all efforts by the owners to scare them away proved unsuccessful and resulted in them having to shut down their aquaculture farms towards the end of 2015. Tactics used to scare them away included using scarecrows, making noises and being physically present so that the otters did not approach the holding tanks. Camera traps were not placed at these sites, as this was not the target species of this study.

Camera traps

A total of 4,707 camera trap images were recorded from a total of 1557 camera trap nights from 9 cameras (Map:1). Four cameras were placed in positively identified otter sites along the Sungai Ceruai and six cameras were placed similarly on the Sungai Relau. One of the cameras on the Sungai Relau (camera #10) was illegally removed from the site by unknown person/persons. All that remained at the site were the visible marks (on the tree trunk) of the knife used to break through the python lock that had secured the camera to the tree.

Of the 4,707 images recorded, 341 images were blanks. Of the 341 blank images, 142 (12.79%) were notionally independent (defined as photos recorded more than half-an-hour from the proceding or succeeding image). The remaining images included 927 notionally independent encounters of mammals (864 = 77.83%), birds (33 = 32.97 %) and reptiles (30 = 32.70%). There were 41 (43.69%) notionally independent observations of human beings in the park. Some of these can be positively identified as poachers (Fig. 2).

A total of 54 (5% of total records and 6% of mammal records) notionally independent photographs of Small-clawed Otter were recorded across all stations on the Sungai Ceruai and in two out of the 5 stations on the Sungai Relau. The most observations were made on the Sungai Ceruai. (Table 1). Although, all camera trap photos were by day with most images recorded in the morning between 7am and 11 am, this is not a conclusion to activity patterns of the Small-clawed Otter.

Table 1. Camera Trap records of Small-clawed Otter on the Sungai Relau and the Sungai Ceruai; (Y= Present)

Camera Trap #	# of photos	Notionally independent records	Sg. Relau	Sg. Ceruai	Total photos
1	32	19		Y	167
2	39	26		Y	454
3	4	2		Y	181
4	2	1		Y	59
6	4	1	Y		403
7	14	5	Y		108

Wild Pig (*Sus scrofa*) accounts for 69% of the 4707 images recorded and 41% of notionally independent images and was the most frequently recorded animal. Areas with the highest wild pig activity had few or no otter records. More study needs to be conducted in order to check whether there is a correlation between wild pig activity and otter presence.

Figure 2. Habitat types of otters in and around Taman Negara
A: Sungai Relau - Small-clawed Otter habitat, B and C: Tin Mine Lakes converted to Fish farms - Smooth-coated Otter habitat, D: Small streams leading into Sungai Ceruai – Small-clawed Otter habitat

Threats:

Within the park camera trap photos provide evidence of poachers walking along the banks of the Sungai Ceruai in areas where otters were present (Fig. 3). The trade in live otters as well as in their fur and other body parts is still significant in South East Asia (Gomez et al., 2016) and although the photos provide no direct evidence that otters are the target species of these poachers, it is significant that there are poachers in the park area and that they are active in areas where otters are present. Another significant finding was that in areas on the Sungai Relau where there was tourist activity, Small-clawed Otter activity was less compared to the Sungai Ceruai, which has no tourist activity at all (Table 1). Whether this difference results from effects of tourist visitation or simply reflects inherent differernces between the streams cannot be determined. Given that the Sungai Relau had more tourism and less otters and the Ceruai had no tourism, more otters but also evidence of poachers, it could be possible that tourism reduces poaching activity so thre is the possibility that while it might also reduce otter activity, its overall effect on otters in a situation of poaching cannot be predicted.

Figure 3. Evidence of poacher in same area as otter presence

Illegal gold mining (Fig. 4) is presently a looming threat to otter habitat in the area. Evidence of small operators was seen along parts of the river (Fig. 4), and aside from the disturbance of this activity there is opportunity for poaching alongside. A significant portion of the boundary of Taman Negara has been converted to Oil Palm plantation. This results in agricultural pollutant runoff entering local streams that then drain into the larger rivers. This is a potential threat to the prey species, resulting in reduction of prey biomass, but also a direct threat to the Small-clawed Otter especially if using organochlorides. More studies need to be conducted in this area to be more conclusive.

Figure 4. Illegal gold mining operations

Figure 5. Otters at fish farms

Conservation and Outreach

All of my outreach work was conducted outside the national park as per the requirements of my research permits. All of the community outreach was done in the villages of Merapoh of the Bateq village.

Bateq – Through my interaction with the Bateq people and by showing them numerous images of different species of otters I had gathered that their identification skills for the different species was inconclusive. Over time, working with me, my guides learned to identify two different species (*A. cinereus and L. perspicillata*) based on their physical appearance as well as the subtle differences in their faeces (smell, texture and contents) and foot prints. I have seen these skills being passed on to the next generation. My field assistant, Angela Smith, and I spent 2 afternoons a week interacting with the Bateq children (of all ages), teaching them English and incorporated otters into their English language learning activities. We also gave them drawing and colouring exercises that included otters (Fig. 6). We had photo and video sessions. We also took them to jungle school, which was a day out in the jungle, walking along the riverbanks trying to identify different footprints, significant vegetation in the area and other signs of wildlife. Quantifying the outcomes of working with the Bateq has not been possible. The number of children we interacted varied from visit to visit and even during a particular visit. Children would join the group and leave and then return. What we can quantify was the ability of the children (in most scenarios as a collective) to start recognising different characteristics amongst otter species through photographs and videos.

The non-indigenous local communities – I spent a lot of time with the local farmers, some of whom were trained guides employed by the National Park to take tourists into the park. I used photos and videos of otters to capture their interest in the animals and eventually showed them what to look for in the field and why they are important and need to be protected. Similar strategies were used in local schools as well. This resulted in my getting notified when an otter was spotted any where in a 50 Kilometre radius of Merapoh village. This was very useful for me to keep track of otter presence and confirm this presence by surveying that area.

Outreach outside local communities

I was able to give public lectures (via Monash University), increased my network via TRAFFIC South East Asia, spoke to people who walked the Tiger Trails through MYCat, presented at the Borneo Wildlife Festival, engaged with ECOTEER volunteers and their teams, engaged with foreign tourists that were visiting the National Park. I also use social networking as a tool to keep people interested and updated. I also took groups of people out of Kuala Lumpur on weekends to explore the Tin Mine lakes and to learn otter identification skills and give them a first hand experience of otter habitats and conservation efforts.

Figure 6. Outreach with Bateq children

CONCLUSIONS

Camera trapping and extensive surveying yielded no evidence of the Hairy-nosed Otter along the Sg Relau and Sg Ceruai in Taman Negara. The rivers within Taman Negara as well as the Sungai Yu, which is in the corridor outside the park, is a thriving habitat, supporting a good population of Small-clawed Otter.

This study has been instrumental in contributing to the knowledge on the habitat preferences, ecology and threats of the Smooth-coated Otter and the Small-clawed Otter in and around Taman Negara. All of these topics are important information for conservation. These are also significant when considering engaging local communities because a large number of local guides from Merapoh village support tourism within the park. There are also park rangers, oil palm plantation workers and owners (otters have been seen in the streams on their properties) and fishing communities. As iconic and flagship species, otters can be used to draw attention to larger issues such as water quality, habitat degradation, and chemical pollution from pesticide runoff, mining and tourism exploitation and other anthropogenic activities that will have an impact on the river ecosystem. Otter conservation will increase awareness, regulating the fishing and tourism activities, reducing habitat fragmentation and will provide protection and result in a healthy wetland habitat since otter presence indicates good water quality. I continue to advocate for these species in Malaysia and else where in Asia.

Figure 7. My guides - On left is a ranger provided by Taman Negara Parks and on right is my Bateq guide

The search for the Hairy-nosed Otter needs to be extended to other areas in the peninsular. A lack of knowledge about the different otter species that are present in the region, and their importance in their ecosystem, and how these animals are exploited in the pelt and pet trade amongst many other threats are some of the factors that need to be addressed. From my experience, this past one year, involving the community is a necessary and significant approach to otter conservation in the region. Talking to people, showing them images of otters and detailing the threats they face seems to have made a difference in attitudes towards the species, at least in the short-term.

Figure 8. Otter Signs - On left is otter spraint, center is foot prints near waters edge, right is close up of foot print

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RÉSUMÉ

STATUT DE LA LOUTRE DE SUMATRA (*Lutra sumatrana*) DANS LA PÉNINSULE DE MALAISIE

Un individu, de l’une des espèces de loutre les plus insaisissables et menacées, la loutre de Sumatra (*Lutra sumatrana*), a été aperçu sur le Relau Sungai dans le Taman Negara, en Malaisie, en septembre 2013, presque 20 ans après la dernière observation de l’espèce en 1994, à Perak, une autre région de la péninsule (Baker, 2013). Le projet mentionné ici a été initié dans et autour de Taman Negara et est basé sur une observation datée de 2013, pour avoir une meilleure compréhension de la taille de la population, du type d’habitat, des menaces et des mesures de conservations nécessaires à l’amélioration du statut de la loutre de Sumatra.

Malheureusement, 7 mois d’utilisation continue de pièges photos, d’étude des berges et d’observations le long du Sangai Relau et du Sungai Ceruai n’ont pas permis d’obtenir de données sur la loutre de Sumatra. Cependant, le projet a confirmé la présence de la loutre cendrée (*Aonix cinereus*) et à pelage lisse (*Lutrogale perspicillata*) dans et autour du parc national de Negara, mettant également en évidence un certain nombre de menaces pour les espèces de loutre présentes dans la zone et fournissant un aperçu des attitudes de la population locale, spécialement la communauté indigène Bateq, vis-à-vis des loutres et de leur protection.

RESUMEN

STATUS DE LA NUTRIA DE SUMATRA (*Lutra sumatrana*) EN MALASIA PENINSULAR

En Septiembre de 2013, fue avistado un individuo de una de las especies de nutria más elusivas y amenazadas, la Nutria de Sumatra (*Lutra sumatrana*), en Sungai Relau, en Taman Negara, Malasia; casi dos décadas después de la última observación registrada de la especie en 1994 en Perak, otra parte de Malasia peninsular (Baker, 2013). El proyecto informado aquí fue iniciado en y en alrededores de Taman Negara, en base a la observación de 2013, para obtener un mejor entendimiento del tamaño poblacional, tipo de hábitat, amenazas y medidas de conservación requeridas para

mejorar el status de la Nutria de Sumatra. Desgraciadamente, 7 meses de monitoreo continuo con cámaras-trampa, relevamientos de riberas de ríos y observaciones a lo largo de Sungai Relau y el Sungai Ceruai, no resultaron en ningún registro de la Nutria de Sumatra. Sin embargo, el proyecto confirmó la presencia de nutria de uñas pequeñas asiática (*Aonyx cinereus*) y nutria lisa (*Lutrogale perspicillata*) en y alrededor del Parque Nacional Taman Negara, al mismo tiempo que permitió detectar un número de amenazas a las nutrias en el área y proveer un panorama de las actitudes de los habitantes locales hacia las nutrias y su conservación, especialmente la comunidad indígena Bateq.

A R T I C L E

A REVIEW OF OTTER DISTRIBUTION MODELING: APPROACH, SCALE, AND METRICS

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ABSTRACT: All otter species are of conservation concern and are used both as flagship species for conservation and as indicators of watershed health; consequently, identifying and understanding their distribution is a basic necessity. We reviewed the published literature to identify otter distribution modeling efforts worldwide and then compiled information on the different metrics/variables used, what information is commonly available and what may be required, what different results can be obtained with different models, and model limitations. We identified 29 studies of 8 species that used 4 main methods of modeling otter distribution across a given area or the relationship between otter species and certain environmental factors. The studies modeled distribution across a variety of scales, including local, regional, country, continental, and at the geographic extent of the species. We cataloged 301 different environmental metrics used in otter models, which we then sorted into six main categories: anthropogenic disturbance, climate, terrestrial, aquatic, and biological interaction. Food, water availability and quality, and anthropogenic influences are all regularly identified as important variables correlating with otter distribution, but they are often measured in a variety of ways, or identified in models by proxy or surrogate variables because relevant data availability is low or absent. Scale, approach, and metric selection all need to be carefully considered for each study, but understanding measurement issues and model shortcomings identified by others should help improve otter modeling in the future. Review of information in this review paper can inform future efforts in modeling processes, data types used, data gathering methods, and variables/metrics to include. This information should still be carefully evaluated for use to specific study areas, species of interest, and as a basis for developing innovative, and more effective methods.

KEYWORDS - climate, habitat, landscapes, *Lontra*, *Lutra*, water

INTRODUCTION

All of 13 otter species in the world are on the International Union for Conservation of Nature Red List (IUCN Otters Specialist Group, 2013). They often are used as flagship species for conservation and are considered indicators of healthy watershed habitats (Kruuk, 2011; Stevens et al., 2011). Other than the two marine species (*Enhydra lutris* and *Lontra felina*), otters live in a variety of freshwater habitats, though some species may also be found along marshes, rocky coasts, and mangroves (Kruuk, 2006). In general, aquatic habitat requirements for otters include rivers that contain deep pools that retain water during the winter and dry seasons, dense vegetation surrounding the river for protection, rivers with sandy banks, and a substantial prey density (Pardini, 1998; Ruiz-Olmo et al., 2001; Kruuk, 2006; Sánchez, 2007). As apex predators, otters have an important role within their local food chain, feeding on fish, crustaceans, amphibians, and even birds, reptiles, and mammals (Pardini, 1998; Kruuk, 2006). Unfortunately, as semi-aquatic top predators, they also are highly vulnerable to habitat degradation, as well as to direct removal for the protection of other species and human livelihoods (e.g., fisheries and domestic fowl) and because of the value of their furs (Kruuk 2006, 2011; Scorpio et al., 2016).

Studying otters can be challenging because they are scarce, elusive, can be nocturnal, sometimes live in difficult-to-access habitats, and have fairly large territories and home ranges (Kruuk, 2011). Because of these factors, data collection can be expensive and labor-intensive (Kruuk, 2011). Consequently, the presence of some otter species is largely unknown over large geographic areas, population declines are nearly impossible to detect (Kruuk, 2011), and many questions about their biology, population sizes, and distribution remain unanswered (Foster-Turley et al., 1990; Kruuk, 2006). Thus, it is very challenging to try to ameliorate threats that affect otter persistence, since factors such as population and range size can affect their vulnerability (Brodie et al., 2013).

In the face of a biodiversity crisis, efforts are increasing to improve our understanding of species declines and conservation efforts (Marcelli and Fusillo, 2009). Understanding the factors that drive the distribution of species is important for their conservation and determining their ecological requirements (Lopes Rheingantz et al., 2014). Scientific studies can answer several questions about potential species distributions and species conservation, but can be prohibitive for mammals with large ranges due to cost and amounts of effort required (Lopes Rheingantz et al., 2014). Species distribution modeling is becoming an essential tool for the management of ecosystems and species conservation, as it gives a geographical perspective that can be used as context for future studies (Barbosa et al., 2003). By studying over time, these models can allow tracking of occurrence patterns and changes in population in order to focus conservation efforts in areas that require it the most.

Many modeling approaches exist that accommodate a varied number of data types to estimate species distributions. Therefore, we classified the modeling approaches found, based on the type of data that was used for the model's development and the statistical process used. When there is lack of information of otter presence or when studying over a large range, common environmental factors related to the species, in general, can be used. Deductive habitat suitability models do not require otter presence data as they use conceptual knowledge about the species-habitat relationships based on expert opinion, literature, and research (Ali et al., 2010). Presence-only models use incomplete information (presence-only data) to represent the ecological niche of a species from the analysis of several variables to define their distribution across an area (Santiago-Plata, 2013; Gomez et al., 2014; Bieber, 2016). In an occupancy model analysis, presence/absence data is used with different variable combinations to choose the model that best accounts for the probability of an individual occupying a site and being detected in a survey (Bennett, 2014). Finally, phenomenological models used presence/absence data to find relationships or correlation between species presence and a variety of factors, sometimes defining whether these relationships are negative or positive. Due to information gaps and the diverse habitat and resource use among the different otter species, much effort has been invested in modeling otter distribution and discovering more about the correlations between their presence and their surrounding habitats and conditions (Barbosa et al., 2001; Park et al., 2002; Nel and Somers, 2007; Sepúlveda et al., 2009; Ali et al., 2010; Jeffress et al., 2011; Lopes Rheingantz et al., 2014; de Oliveira et al., 2015).

In this paper, we assess models constructed for otter species in order to inform future efforts. We compile information on the different variables used to model the distribution of otters, what information is commonly available and what may be required, what different results can be obtained with different models, and model limitations. This should make future modeling of otter distribution easier and more efficient by providing insights as to what is necessary to make successful and useful models, thus improving our conservation efforts. This will also help disseminate knowledge to non-scientists about important factors that can affect the distribution of otter species.

RESULTS

We found 29 publications containing different modeling methods for assessing otter distributions and correlating distribution with environmental factors. Most of the articles found were related to *Lutra lutra,* and were from studies across its range in the Tyne catchment (England), Abruzzo region (Italy), southern Italy, Molise region (Italy), Soraksan Nacional Park (Korea), Spanish provinces, the Iberian Peninsula (Spain and Portugal), Hungary, Switzerland, Italy and across Europe. For *Lontra canadensis,* we identified studies in Maine, the Midwest, New Jersey and Nebraska in the U.S. For *Lontra longicaudis,* we located studies in Ibera Lake (Argentina), central México, Rio San Juan (Costa Rica), Parana River Delta (Argentina), Pueblo Nuevo (México) and across its geographical range, and for *Lontra provocax* in Nahuel Huapi National Park (Argentina) and Chile. Studies of *Aonyx capensis* were from South Africa, *Pteronura brasiliensis* from the northern Brazilian Amazon, *Lutrogale perspiccillatea* from the Indus plains of Pakistan, and *Enhydra lutris* from Glacier Bay, Alaska (see Appendix A1 for Tables A1-A8 that summarize the variables used for each species). Species such as *Lontra provocax*, *Aonyx capensis*, *Pteronura brasiliensis*, and *Lutroale perspicillata* are relatively underrepresented. These results also highlight unrepresented species, such as *Aonyx cinereus*, *Aonyx congicus*, *Lontra feline*, *Hydrictis maculicollis*, and *Lutra sumatrana.*

Among these studies there were four main modeling approaches for defining otter distribution across a given area or the relationship between otter species and certain environmental factors (Table 1). These included deductive habitat suitability models, presence-only models, occupancy model analysis, and presence-absence phenomenological models/variable correlation. The use of these different methods could have been influenced by the availability of modeling techniques at the time, the availability of information, the objectives of the study or analysis, and the extent and/or type of area being used or described (see Appendix A2 for information on advantages and disadvantages for each modeling approach, according to articles reviewed).

There were also differences in the scales of the modeling efforts (Table 2), including local, regional, country, continental, and at the geographic extent of the species. The use of different scales was likely due to the information need/gaps for the different species and the objectives of the study or analysis, such as species status in an area or reintroduction efforts (see Appendix A3 for Tables A9-A13 that summarize the metrics used at each scale).

When we cataloged all of the different environmental metrics used in the otter modeling literature, we identified a total of 301 metrics which we then sorted into six main categories: anthropogenic disturbance, climate, terrestrial, aquatic, and biological interaction (Table 3). These metrics were used by authors in different combinations and with different methods in an attempt to better understand the relationship between otters and their habitat, and here we describe them in more detail and, in particular, identify those that were deemed to significantly correlate with otter distributions.

Table 1. Model types used to assess otter distribution

Model type	No. of References	References
Presence-only models	8	Sepúlveda et al., 2009 Cianfrani et al., 2010; 2011 Santiago-Plata, 2013 Cirelli and Sánchez-Cordero, 2009 Gomez et al., 2014 Lopes Rheingantz et al., 2014 Bieber, 2016
Occupancy model analysis	4	Santiago-Plata, 2013 Jeffress et al., 2011 Bennett, 2014 Bieber, 2016
Deductive Habitat Suitability	5	Ottino et al., 1995 Loy et al., 2009 Ottaviani et al., 2009 Ali et al., 2010 Gomez et al., 2014
Presence-Absence phenomenological models/variable correlation	19	Dubuc et al., 1990 Kemenes and Demeter, 1995 Thom et al., 1998 Barbosa et al. 2001; 2003 Park et al., 2002 Aued et al., 2003 Gori et al., 2003 Nel and Somers, 2007 Sepúlveda et al., 2009 Marcelli and Fusillo, 2009 Cianfrani et al., 2010; 2011; 2013 Gomez et al., 2014 Carone et al., 2014, de Oliveira et al., 2015 Cruz et al., 2017 Williams et al., 2017

Anthropogenic Disturbance variables

Anthropogenic disturbance variables are significant contributing factors to negative effects on otter presence and habitat quality, and are the result of human population growth and human behaviors (de Oliveira et al., 2015). Freshwater habitats are highly impacted by anthropogenic activity, such as pollution and water diversion and use, which affect water quality and quantity, and riparian vegetation (Kemenes and Demeter, 1995; Barbosa et al., 2003; Nel and Somers, 2007; Sepúlveda et al., 2009; Cianfrani et al., 2010). Roads have an effect on otters via habitat fragmentation, high sedimentation of watercourses, and increased human disturbance due to greater access to otter habitat (Barbosa et al., 2003).

Table 2. Scales used to model otter distributions

Scale	No. of References	References
Local	9	Dubuc et al., 1990 Thom et al., 1998 Park et al., 2002 Aued et al., 2003 Gori et al., 2003 Santiago-Plata, 2013 Gomez et al., 2014, Cruz et al., 2017 Williams et al., 2017
Regional	10	Ottino et al., 1995 Cirelli and Sánchez-Cordero, 2009 Loy et al., 2009 Cianfrani et al., 2010 Ali et al., 2010, de Oliveira et al., 2015

		Jeffress et al., 2011 Bennett, 2014 Carone et al., 2014 Bieber, 2016
Country	8	Kemenes and Demeter, 1995 Barbosa et al., 2001; 2003 Nel and Somers, 2007 Sepúlveda et al., 2009 Marcelli and Fusillo 2009 Ottaviani et al., 2009 Cianfrani et al., 2013
Continent	1	Cianfrani et al., 2011
Geographic range	1	Lopes Rheingantz et al., 2014

Table 3. Factors considered relevant to otter distribution and their classification into different types of variables. There are two metrics under the name of "other" that are not included in this table because they represent metrics of different categories under one single name.

Categories and subcategories of variables	**No. of Metrics**	**References**
Anthropogenic Disturbance Roads Population Tourism Contaminants Land use Others	**80** 15 13 6 4 30 12	Dubuc et al., 1990 Kemenes and Demeter, 1995 Ottino et al., 1995 Barbosa et al., 2001 Park et al., 2002 Aued et al., 2003 Barbosa et al., 2003 Nel and Somers, 2007 Loy et al., 2009 Marcelli and Fusillo, 2009 Ottaviani et al., 2009 Sepúlveda et al., 2009 Ali et al., 2010 Cianfrani et al., 2010; 2011 Jeffress et al., 2011 Cianfrani et al., 2013 Santiago-Plata, 2013 Bennett, 2014 Gomez et al., 2014 Lopes Rheingantz et al., 2014 de Oliveira et al., 2015 Bieber, 2016
Climate factors Air humidity Evapotranspiration Temperature Precipitation Other	**46** 3 4 16 18 5	Barbosa et al., 2001 Aued et al., 2003 Barbosa et al., 2003 Cirelli and Sánchez-Cordero, 2009 Sepúlveda et al., 2009 Cianfrani et al., 2011; 2013 Santiago-Plata, 2013 Lopes Rheingantz et al., 2014
Terrestrial characteristics Vegetation variables Elevation Others	**70** 55 9 6	Dubuc et al., 1990 Kemenes and Demeter, 1995 Ottino et al., 1995 Thom et al., 1998, Barbosa et al., 2001, 2003 Park et al., 2002 Aued et al., 2003 Gori et al., 2003 Nel and Somers, 2007 Cirelli and Sánchez-Cordero, 2009 Loy et al., 2009 Marcelli and Fusillo 2009 Ottaviani et al., 2009 Sepúlveda et al., 2009 Ali et al., 2010 Cianfrani et al. 2010; 2011; 2013 Jeffress et al., 2011 Santiago-Plata 2013 Bennett 2014

		Carone et al., 2014 Gomez et al., 2014 Lopes Rheingantz et al., 2014 Bieber, 2016 Cruz et al., 2017
Aquatic features Water body characteristics River Hierarchy Others	**92** 54 36 2	Dubuc et al., 1990 Kemenes and Demeter 1995 Ottino et al., 1995 Park et al., 2002 Aued et al., 2003 Gori et al., 2003 Nel and Somers, 2007 Loy et al., 2009, Marcelli and Fusillo, 2009 Ottaviani et al., 2009 Sepúlveda et al., 2009, Ali et al., 2010 Cianfrani et al., 2010; 2011 Jeffress et al., 2011 Santiago-Plata, 2013 Bennett, 2014 Gomez et al., 2014 Lopes Rheingantz et al., 2014 de Oliveira et al., 2015 Bieber, 2016 Cruz et al., 2017 Williams et al., 2017
Interspecies interactions Competition Resource availability Food	**11** 1 5 5	Dubuc et al., 1990 Thom et al., 1998 Aued et al., 2003 Gori et al., 2003 Nel and Somers, 2007 Sepúlveda et al., 2009 Cianfrani et al., 2010 Bennett, 2014

The variables most commonly used were roads, population density/distribution, and land use. Metrics significantly affecting otter presence were distance to roads (Park et al., 2002), number of visitors to a park (Park et al., 2002), human settlements (Aued et al., 2003), water use and pollution (Nel and Somers, 2007), roads (Sepúlveda et al., 2009), agriculture/livestock adjacent areas (Marcelli and Fusillo, 2009), proportion of urban areas (Marcelli and Fusillo, 2009), distance from industrial areas (Marcelli and Fusillo, 2009), human population density (Lopes Rheingantz et al., 2014; Marcelli and Fusillo, 2009), distance from surface excavations (Cianfrani et al., 2010), distance from productive areas (Cianfrani et al., 2010), proportion of area comprised of cropland (Jeffress et al., 2011), location of fishing nets (de Oliveira et al., 2015), location of homes (de Oliveira et al., 2015), and distance to the nearest otter release site (km)(Bieber, 2016).

Sometimes, using anthropogenic disturbance variables can be complex since their effect on otter presence is variable. Otters have been found to have high resistance to disturbance factors and can be found in areas that we normally consider too disturbed to be ideal for their use (e.g. Kemenes and Demeter, 1995; Bennett, 2014). Human density or development may have a negative effect on otter distribution, but this may vary at a regional scale or with habitat quality (Bennett, 2014). The effect of disturbance factors may be direct, causing otters to avoid certain areas, or indirect through changes inhabitant conditions (Bennett, 2014).

Terrestrial variables

For otters, vegetation could be important as a source of refuge (Gori et al., 2003), as resting and breeding sites, for providing water quality, and for increasing fish productivity (Cianfriani et al., 2010, 2011, 2013; Carone et al., 2014). Riparian vegetation is commonly correlated with high water quality, high primary productivity, high fish biomass, and high availability of alternative prey species (Ottaviani et al., 2009). Altitude/elevation is limiting when considering that there is more food availability at lower and medium river sections than in headwaters (Barbosa et al., 2003). Acclivity (upward slope) may be considered important because very steep river banks have been considered good indicators of areas inaccessible to humans, and as optimal sites for otter holts/dens and couches/resting sites (Ottaviani et al., 2009). Mean altitude has been used as a surrogate of otter habitat quality and its variation (Marcelli and Fusillo, 2009). Slope and topographic convexity are variables that may influence the hunting opportunities (Kruuk, 2006; Cianfrani et al., 2013). Soil permeability is a factor that may affect otter presence in a negative way due to its effect on superficial freshwater availability (Barbosa et al., 2003).

Vegetation and elevation were the variables most commonly used. Metrics found significant for otter presence were percent of forested land composed of birch-aspen (Dubuc et al., 1990), percent of forested land composed of mixed hardwood-softwood (Dubuc et al., 1990), sum of the areas of all water bodies characterized by emergent herbaceous vegetation (Dubuc et al., 1990), density of bank vegetation (Kemenes and Demeter, 1995), soil permeability (Barbosa et al., 2001), mean longitude (Barbosa et al., 2001), coarse scale extra-riparian CORINE (Coordination of Information on the Environment, Land Cover database developed by project of Commission European of the European Union) land cover (Park et al., 2002), vegetation type of stream bank zone (Gori et al., 2003), vegetation complexity (Aued et al., 2003), elevation (Aued et al., 2003), semi-dense riparian vegetation (Sepúlveda et al., 2009), proportion of survey area buffer comprised of woodland (Jeffress et al., 2011), and proportion of survey area comprised of grassland (Jeffress et al., 2011).

Sometimes using terrestrial variables can be complex, since their effect on otter presence is variable. For example, Lopes Rheingantz et al. (2014) describe how elevation was not found to influence their model as it did in other studies, and that vegetation cover had little influence on the model. Variables such as elevation, slope, and density of bank were identified as significant in some studies, but not in others.

Aquatic variables

Water availability is crucial for otters (Cianfrani et al., 2011), a semi-aquatic species that spends a large part of its time in aquatic environments. Water bodies are also a source of fish, which is the most common otter food. Water availability and water quality should have an influence on otter distribution and presence (Kemenes and Demeter, 1995; Cianfrani et al., 2013). Otters appear sensitive to reduction of water depth (Kemenes and Demeter, 1995), as well as stream order and its variation (Marcelli and Fusillo, 2009). Hierarchy of tributaries is used as a proxy of water flow (Ottaviani et al., 2009). If otters are forced to find food sources out of the water or too close to the shore, they may become more vulnerable to terrestrial predators, in turn affecting their survival rates (Ruiz-Olmo and Jimenez, 2009).

In modeling efforts, water body characteristics and river hierarchy were the variables most commonly used. Metrics found significant for otter presence included mean shoreline diversity index (shape; Dubuc et al., 1990), total stream length, over all stream orders (Dubuc et al., 1990), water depth (Kemenes and Demeter, 1995; Nel and Somers, 2007), river/stream width (Park et al., 2002), bottom structure of stream (Park et al., 2002), bank (shore) type (Gori et al., 2003), current type (Nel and Somers, 2007), anastomosed (two or more interconnected channels that enclose flood basins) river length (Sepúlveda et al., 2009), sum of the waterbody perimeters/sum of waterbody areas for entire watershed (Jeffress et al. 2011), sum of stream (3rd order) km within the watershed/watershed area (Jeffress et al., 2011), number of waterbodies within the watershed/watershed area (Jeffress et al., 2011), river water level (de Oliveira et al., 2015), long-term median flow rate of the river (ft^3/s) (Bieber, 2016), flow zone (Cruz et al., 2017), total dissolved solids (Cruz et al., 2017) and pH (Cruz et al., 2017).

Sometimes using aquatic variables can be a challenge, since the characteristics that need to be measured for their effect on otter presence are not easily defined. Water fluctuations can have a negative effect on fish abundance and size; therefore, floods and droughts can cause otters to abandon areas (Ruiz-Olmo et al., 2001), though this reaction seems to vary from species to species, and from area to area. In some areas, species such as *Lutra lutra* are able to live in dry rivers during the summer, as long as there are pools that provide enough fish to eat throughout the season (Ruiz-Olmo et al., 2001; Prenda et al., 2001). For other species, like *Aonyx capensis* in South Africa, freshwater availability is more important than prey availability (Van Niekerk et al., 1998). Also, variability in the metrics presented shows how difficult it is to define which characteristics of a water body can affect otters. Sometimes the scale of the study could be what affects the effect of the metrics; river/stream width was considered a significant variable by Park et al. (2002; local scale), but in Nel and Somers (2007) it was not (country scale) (Appendix A3, Tables A9-A13).

Climate variables

Climate mostly influences distributions of species at macroscales (Cianfrani et al., 2011). Climate factors at large scales have high potential as surrogates for local freshwater availability, and water warming could affect fish species diversity and abundance (Cianfrani et al., 2011). Floods can increase the deposit of suspended solids, which tend to bury potential denning areas, as well as decreasing food availability for fish and otters (Ruiz-Olmo et al., 2001). Droughts may also increase mortality, because with a drought comes diminishing food availability which may trigger an increase in territoriality among individuals (Prenda et al., 2001).

In the models we looked at, temperature and precipitation where the climate variables most commonly used. Significant metrics affecting otter presence included relative humidity in January (Barbosa et al., 2001) and annual temperature (Lopes Rheingantz et al., 2014). Lopes Rheingantz et al. (2014) also found that annual precipitation was the most relevant climatic metric for neotropical otter (*Lontra longicaudis*) distribution within its geographic range.

Using climatic variables can have its difficulties, such as finding the information at an appropriate scale for the study. The common use of macroscale global climatic data, even in local studies, is a clear example of this. The effect of climatic variables on otters has not been directly measured, so many studies use variables that are assumed to be most significant to the species and/or were used in previous mammal studies (e.g., Lopes Rheingantz et al., 2014).

Biological interaction variables

Food availability has been found to be the factor of most importance for otter presence (Kruuk, 2006; Nel and Somers, 2007; Cianfrani et al., 2013). Mink (*Mustela vison*) are considered a potential competitor for resources (Aued et al., 2003), and beaver (*Castor canadensis*) presence has been found to be a predictor of otter presence (Dubuc et al., 1990; Bennett, 2014). The metrics found significant for otter presence were: percent of all wetlands with active or inactive beaver sign (Dubuc et al., 1990), food availability (Nel and Somers, 2007), and freshwater crab and crayfish abundance (Sepúlveda et al., 2009).

Disadvantages of using biological interaction variables include how costly and time consuming it is to define food availability, which is considered as the most important factor affecting otter distribution. In many cases, it is easier to use surrogate variables for food availability rather than measure actual food presence and abundance, but this could cause overprediction, may not be as accurate, and makes it riskier to interpret the data (Sepulveda et al., 2009).

DISCUSSION

The reliability of modeling efforts may be influenced by the modeling scale (i.e., ecological scale or the extent of the landscape under consideration) used, measuring issues, and several other shortcomings that we are forced to face as we work with such complex ecosystems (cf. Elith and Graham 2009). Some of the complications found or mentioned in the reviewed articles are as follows:

Influence of modeling scale

The importance of scale is very often underestimated or not accounted for in many ecological studies (Thom et al., 1998). Using course resolution in an analysis can make it complicated to assess land use and connectivity during the analysis (Cianfrani et al., 2011). In addition, scale mismatch between data and ecological process is a major problem in ecological modeling. Fine-scale data is important for modeling some species, including otters, because characteristics such as riparian vegetation cover may not be well represented in coarser data layer such as land cover (Loy et al., 2009). Habitat variables that might be effective to predict species response at one scale might not be as effective other scales (Ali et al., 2010); unfortunately, the resolution of variables usually depends on data available. HIS models are used under the assumption that habitat-wildlife relationships are consistent at all scales (Ali et al., 2010). Environmental data for freshwater bodies (water temp, depth, water velocity, etc.) is usually not spatially accurate to be used in models (Cianfrani et al., 2013).

Otter habitat is complex, consisting of a narrow strip of an aquatic and riparian ecosystem, and though individuals may move several hundred meters from this area, their activity mostly occurs close to this strip (Ruiz-Olmo et al., 1998; Ottaviani et al., 2009). Therefore, fine-scale modeling is appropriate to measure decreasing habitat suitability as one considers habitats away from a waterway, as well as the effects of land use as it moves towards riparian habitat (Ottaviani et al., 2009). It is not easy to obtain useful large-scale information of habitat suitability based on fine scales habitat linearity (Ottaviani et al., 2009). Relevant information such as fish abundances, water flow, hunting pressure, and water pollution are rarely available or reliable at large spatial scales, particularly since they fluctuate a lot within time and space. Also, survey techniques are difficult to standardize at large scales for some species in some systems; therefore, proxies are commonly used (Ottaviani et al., 2009; Cianfrani et al., 2013). Large-scale efforts need to be refined with local data such as pollution, food availability, and human disturbance when you want to apply them in local conservation plans, or else only be used for large scale conservation strategies (Ottaviani et al., 2009).

Fine-scale models are limited in their application and evaluation of potential habitat at a larger scale (Park et al., 2002). Sometimes one has to use a larger, less accurate scale to identify the fine scale of microhabitat (Lopes Rheingantz et al., 2014); this is because the fine-scale data are usually not available over large areas.

Measurement issues

Sparse otter occurrence may lead to overestimated range sizes when including areas of sporadic occurrences (Marcelli and Fusillo, 2009). Some areas where otters are observed are used only to move from one site to a better one, and they do not necessarily represent an area that the otter regularly inhabits. Using the characteristics of these rarely used areas as basis for defining habitat suitability can cause for overestimating the areas that are used by the species. Also, insufficient numbers of data points may not provide enough information to use independently for validation and calibration, therefore performance could be overestimated (Sepúlveda et al., 2009). In general, overprediction and underprediction can affect results for distribution ranges and for conservation efforts; therefore, making different types of models and then overlaying them may be a good way of reducing this effect, but there are definitely pitfalls to avoid (Cade, 2015). Optimization methods in modeling fitting and testing for such deviations in predictive ability should be useful way forward in model selection (e.g., Elith and Leathwick, 2009; Merow et al., 2014)

Sometimes it is difficult to measure the time in which a track was made or when spraints were deposited, usually due to their location; therefore, there may be discrepancies with the actual environmental conditions in which they were made (Kemenes and Demeter, 1995). Weather (snow and rain) and water level variations may affect the ability to detect indirect signs of otter presence, and therefore affect the results of our models, so monitoring should be done consistently during drier seasons (de Oliveira et al., 2014; Bieber, 2016).

The use of more detailed variables will allow a better understanding of actual relationships between otter and their surrounding habitat (species or types of vegetation for example). Fish population estimates at each site might not be representative of the population of the full stretch of habitat/river (Thom et al., 1998), though obtaining a more representative estimate might be impractical due to financial and time constraints.

In most of the work related to absence/presence data there is a possibility of being biased due to “false absences”. It is difficult to know *a priori* which absences are reliable and which ones are not since species distribution is usually a snapshot in time of a system that is dynamic (Cianfrani et al., 2010). Sometimes the species may be considered as absent in an area, but in reality, it was just not detected (Jeffress et al., 2011; Ruiz-Olmo et al., 2001). There is also always a possibility of errors when using multiple/inexperienced observers.

Sometimes when using data collected over time, methods might not be comparable between the surveys (e.g. difference in grid system or lack there off, surveying one or both bank sides; Marcelli and Fusillo, 2009). Information (scat census or density and vegetation cover) used may not always be from the same time periods, and may have changed since the time the information was produced (outdated), affecting the relationships found within the model and therefore the accuracy the results. Usually when using data from different time frames and projects, the geographic extent of the surveys is not the same (Marcelli and Fusillo, 2009).

The information available for modeling efforts can come from different sources such as scientific collections, museums, herbariums and online databases (Table 4). This information might have several issues: there may only be presence data, the species might not have been classified, the data might not be correctly georeferenced, and data are usually collected for different reasons, without a standardized methodology, therefore representing a biased distribution of the species (Santiago-Plata, 2014).

Table 4. Types of data collected in reviewed articles

Data collection	Frequency	Article/Thesis Authors
track /foot prints	12	Dubuc et al., 1990, Ottino et al., 1995 Kemenes and Demeter, 1995 Gori et al., 2003, Nel and Somers, 2007 Sepúlveda et al., 2009 Santiago-Plata, 2013, Gomez et al., 2014 Jeffres et al., 2011 Bennett, 2014 de Oliveira et al., 2015 Bieber, 2016
camera-traps	2	Gomez et al. 2014 Bieber 2016
observations	9	Dubuc et al., 1990 Nel and Somers, 2007 Sepúlveda et al., 2009 Ali et al., 2010 Santiago-Plata, 2013 Bennett, 2014 de Oliveira et al., 2015 Bieber, 2016, Williams et al., 2017,
latrine/spraints/scats	16	Dubuc et al., 1990 Ottino et al., 1995 Kemenes and Demeter, 1995 Thom et al., 1998 Gori et al., 2003 Nel and Somers, 2007 Sepúlveda et al., 2009, Marcelli and Fusillo, 2009 Cianfrani et al., 2010, Jeffres et al., 2011, Santiago-Plata, 2013, Gomez et al., 2014 Bennett, 2014, de Oliveira et al., 2015, Bieber, 2016 Cruz et al., 2017
burrows	1	Gomez et al., 2014
skins	1	Gomez et al., 2014
interviews/questionnaires	3	Nel and Somers, 2007 Santiago-Plata, 2013 Gomez et al., 2014,
anal secretions	3	Ottino et al., 1995 Thom et al., 1998 Gori et al., 2003
published maps /information of previous otter surveys	9	Barbosa et al., 2001 Barbosa et al., 2003, Aued et al., 2003, Loy et al., 2009, Marcelli and Fusillo, 2009 Ottaviani et al., 2009 Ali et al., 2010, Cianfrani et al., 2011 Carone et al., 2014

literature	2	Nel and Somers, 2007 Rheingantz et al., 2014
researcher's records	3	Nel and Somers, 2007 Cianfrani et al., 2013, Lopes Rheingantz et al., 2014
ecological indicators of species presence	2	Cirelli and Cordero-Sanchez, 2009 Cianfrani et al., 2013
scrapes/scratches	2	Gori et al., 2003 de Oliveira et al., 2015
dens	3	Gori et al., 2003 Santiago-Plata, 2013 de Oliveira et al., 2015
slides	3	Dubuc et al., 1990 Gori et al., 2003 Bennett, 2014
rolling places	2	Gori et al., 2003 Santiago-Plata, 2013
Otter trace/signs	1	Park et al., 2002
camp sites	1	de Oliveira et al., 2015
food remains	1	Gori et al., 2003
historical records	1	Bieber, 2016

Shortcomings

It is common to lack enough data points for the range being modeled, or for there to be areas that are unrepresented by available data. When working with data from different time frames, usually one of the observation times has a limited dataset (Carone et al., 2014). Fish density (when available) is usually not measured evenly within the otter's range.

The level of productivity of rivers varies, being usually low in the headwater, increasing in the middle reaches and peaking in the lower reaches (Nel and Somers, 2007). Therefore, considering all of a river as suitable or with the same suitability is not adequate or realistic. Temporal, spatial, or quantitative variation in negative or positive effects of factors on the species may be case specific (Marcelli and Fusillo, 2009). Lack of observed influence of some variables could be due to their low variability through study area (Jeffress et al., 2011, Cruz et al., 2017). Using different climate scenario for future predictions can cause discrepancies in the models (Cianfrani et al., 2011).

Spraint numbers are not sensitive to changes in otter distribution in relation to changes in prey distributions (Thom et al., 1998). Location of spraint and spraint sites might sometimes interfere with their relationship to the periods of feeding activity, and in some sites, they might last longer (Thom et al., 1998).

Sometimes the lack of information on local water fluctuations will force one to downgrade the suitability of certain areas such as smaller streams and areas located at certain altitudes (Ottaviani et al., 2009). It is common to ignore water regimes of different watercourses in the modeling process, even though it affects their carrying capacity at several levels (Ottaviani et al., 2009).

It is not a simple task to determine if you have been able to choose all relevant factors that affect otter presence and distribution (Barbosa et al., 2003), particularly because of surrogate variables and the extent to which they may correlate to other variables used. Using regional bioclimatic variables (representing annual tendencies, stationarity, and extreme factors) without taking into account that some of them might not have a relationship with the species being modeled may generate instability in the models generated (Santiago-Plata, 2014). Selection of variables may lead to randomness in the predictions (Cianfrani et al., 2010). Reliability of models also depends on the species ability to adaptation and the environment’s temporal and spatial variability (Cianfrani et al., 2010). Pseudo-absence data will affect distribution modeling efforts, no matter how minimized their effect is (Carone et al., 2014).

Additional considerations

Sometimes, as in the case of Aued et al. (2003), the lack of otter presence in an area within the study cannot be defined quantitatively, therefore you can infer what factors can qualitatively be causing this absence. These inferences cannot be statistically demonstrated, but perhaps further research will provide the information needed.

There are also cases in which there are too many variables to consider or factors that cannot be accounted for directly, and in order to make the analysis less complex or to include other possibilities, a single variable of “other” is used. This is a complicated decision to make, since the effect of these compound variables is not being clearly defined, and since any of the many options included could be responsible for it. Also, the extent to which each variable is responsible for affecting the otter species is difficult, if not impossible, to measure. This highlights the need for more careful attention to model choice and model fitting, for which there is a vast literature (e.g., Burnham and Anderson, 2003; Johnson and Omland, 2004; Guisan et al., 2017).

Many of the variables that are important in determining otter abundance are affected by climate change. Temperature and precipitation ranges and distribution are the main factors affected directly by climate change. Though their direct effect on species is usually unknown, their effect through freezing, drought and flooding could have negative consequences on otter populations. These two variables have a huge impact on other variables such as vegetation, food availability, and waterbody-related variables. Vegetation community assemblages are expected to vary due to climate change (Brodie et al., 2013), and vegetation is considered an important variable because it is commonly used as a proxy for refuge and food resources.

Though climate change studies are more common for terrestrial species, we found one paper related to climate change and otters (Cianfrani et al., 2011). The main focus of this research was identifying the effects of temperature and precipitation on otter distribution. Precipitation is expected to have an important role in water availability and distribution. Temperature on the other hand, is expected to affect fish assemblages as water warms up. Results indicated that climate change may cause a profound reshuffling in the potential otter distribution across Europe, though there was some variation in outcomes across the range. Even when vulnerability to climate change and conservation status seem to be correlated, their relationship is not perfect, as other factors may affect their degree of correlation (Brodie et al., 2013).

CONCLUSIONS AND RECOMENDATIONS

As apex predators, otters have an important role in ecosystems, but their dependence on aquatic habitats makes them vulnerable. This dependency on water sources and the food and shelter they provide makes freshwater species more vulnerable, with higher extinction rates, than terrestrial species (Scorpio et al., 2016). Otters are considered among the most threatened mammals in the world (Kruuk, 2006; Scorpio et al., 2016) and prey and water availability seem to be the two most important factors that limit otters (Prenda and Granado-Lorencio, 1996; Prenda et al., 2001; Ruiz-Olmo et al., 2001).

Otters are difficult to study, and thus large information gaps exist for many of the species (see Kruuk, 2011 for species-specific research recommendations based on information gaps). Defining otter distribution, even with the advances in software and technology today, is a complicated process given the gaps in important information. There are several factors that have been deemed important for otter distribution, based on the studies reviewed, such as anthropogenic disturbance, climatic, terrestrial, aquatic and biological interaction variables. Unfortunately, we are still uncertain on how many of the factors are directly or indirectly affecting otters or whether they have the adaptability to deal with changes within them. The relationship between otters and some of these factors are simple to interpret, but other relationships are still unclear. Sometimes a variable deemed as important in one study is considered unimportant in another. Even when a variable is known to be important, it may be hard to measure. Most research had focused on *Lutra lutra*, though based on the differences between their life histories and geographic ranges with other otters, the results can often not be extrapolated to predict impacts on other species. Even if the results of species-specific studies cannot often be extrapolated, the processes and data types used, the data gathering methods, and the variables/metrics considered can still provide guidance for future research. Researchers should still be careful in considering what really applies to their study areas and species of interest.

We still need to have a better understanding of the relationships among many factors and otter distribution, as well as their varying effects on different otter species, and articles cited in this review provide many useful suggestions for improved modeling. Modeling should be considered a dynamic process in order to progressively improve the quality of the predictions, and adequate evaluation indexes should be used when evaluating model quality (Cianfrani et al., 2010). Robust spatially explicit models for identifying and hierarchically assessing areas for otter conservation and restoration can be achieved with sequential implementation of methods combining species modeling and place prioritization (Cirelli and Sánchez-Cordero, 2009). The use of multiple survey methods, data sets and analysis methods to allow a better representation of the areas of interest and the direct comparison between the methods being used (Bieber 2016).

With respect to the type of model being used, accuracy of presence data is important for calibrating habitat suitability models (Cianfrani et al., 2013), as is definition of the cut-off point above which the presence of a species is more likely than expected at random, since it can be used to correct the established thresholds that are used to separate unsuitable from suitable areas (Ali et al., 2010). When the species-environment equilibrium assumption (this assumption presumes that a species occupies all suitable habitat that is available) is not met (e.g. recolonization and expansion), habitat suitability models' predictions should be assessed carefully (Cianfrani et al., 2010). Prior to employing environmental niche models, an important step is to test for environmental similarity (Cianfrani et al., 2013). When dealing with species with unstable spatial equilibrium, presence-only models may be a better option than presence–absence methods for making reliable predictions of suitable areas for expansion (Cianfrani et al., 2010).

Using the same variables at different scales may have different effects on populations, and therefore should be analyzed the most appropriate scale (Thom et al., 1998). Unfortunately, there are many variables whose information is not usually available at different scales. Studies of regional-scales processes are an important complement for local-scale studies, providing a broader geographic perspective that can be seen as context in local studies, and allowing us to take into account factors that have an effect on a larger scale (Barbosa et al. 2003).

Better research on direct factors affecting otter distribution is needed, since proxy variables, and even seemingly direct habitat characteristics, sometimes indicate the opposite of expectations (Kemenes and Demeter, 1995). In considering the shifting dynamics over time and how factors effect on species distributions may vary (Sépulveda et al., 2009), radio-telemetry may provide the best data for the analysis of habitat choice and use by otters (Nel and Somers, 2007). Despite being difficult to quantify, additional emphasis should be placed on water quality and prey availability, given their importance. Finding better ways of integrating these factors into analyses will allow results to be more reliable. Distribution studies could be directed towards areas where there is previous information available regarding other important factors, such as water quality assessment (Bennett, 2014) and food availability, in order to help include this critical but hard to obtain information within the studies. PCB contamination and fish density are necessary in a spatially explicit way, and therefore should be a priority for future research (Cianfrani et al., 2013). When trying to build models on the effect of environmental variables, the results from field surveys should always be compared with water quality data (Kemenes and Demeter, 1995).

Also, it is important to collect long-term site occupancy data and to use modeling procedures that account for imperfection in detectability (Marcelli and Fusillo, 2009). Avoiding the concentration of data points in a particular area over another (i.e., having an equal distribution of data along the area of study) is needed to prevent bias in the probability of distribution of the models (Santiago-Plata, 2014). It also is important to obtain data on trends over time from periodic survey of factors such as water quality, land use, anthropogenic disturbance changes, and vegetation.

We need to have a better understanding of the relationship between otters and the variables that are commonly used to describe their habitats, especially water quality and prey availability, as these seem to be the most important but the hardest to quantify. Ultimately, to gain a more accurate and meaningful understanding of otter survival, we need to focus on finding better ways of integrating measurable variables into our analyses.

After considering the modeling approaches used in the papers reviewed, a few suggestions come to mind. Williams et al. (2017) applied a Bayesian approach for the first time in these modeling efforts while calculating sea otter occupancy and abundance; it would be interesting to try these methods on other otter species, as well as other methods such as simulations and mission learning tools. Advances in technology and science open the door for the use of new tools for our conservation efforts; thus, we need to keep an eye on these advances and an open mind to distribution studies made for other species.

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RÉSUMÉ

SYNTHÈSE BIBLIOGRAPHIQUE DES MODÈLES DE LA DISTRIBUTION DE LA LOUTRE: DÉMARCHE, ÉCHELLE ET MÉTRIQUES

Toutes les espèces de loutre sont concernées par la conservation et sont utilisées comme espèce parapluie pour la conservation et comme indicateur de la santé des bassins versants; En conséquence, l'identification et la compréhension de leur distribution est une nécessité élémentaire. Nous avons passé en revue la littérature publiée afin d'identifier un modèle de distribution de la loutre dans le monde et la compilation de données sur différentes métriques/variables utilisées: quelle information est communément disponible et peut être requise? Quels résultats distincts peuvent être obtenus avec différents modèles et limitations de modèle? Nous avons identifié 29 études sur 8 espèces qui utilisaient principalement 4 méthodes de modélisation de distribution de la loutre à travers une région déterminée ou la relation entre les espèces de loutre et certains facteurs environnementaux. Les études ont été modélisées sur base d'une distribution à différentes échelles, incluant l'extension géographique locale, régionale, nationale et continentale. Nous avons catalogué 301 métriques environnementales différentes utilisées dans les modélisations que nous avons ensuite classées en 6 catégories principales : perturbation anthropogénique, climat, interactions terrestre, aquatique et biologique. L'alimentation, la disponibilité en eau et sa qualité, ainsi que les influences anthropogéniques sont régulièrement identifiées comme variables importantes corrélées avec la distribution de la loutre, mais sont souvent mesurées de différentes façons, ou identifiées dans des modèles par des variables indirectes ou de substitution parce que la disponibilité des données pertinentes est insuffisante ou absente.

L'échelle, la démarche, et la sélection des métriques, tout cela demande à être envisagé avec précaution pour chaque étude. Cependant, la compréhension des problèmes de dimensionnement et des lacunes de modélisation identifiées par d'autres devraient permettre d'améliorer ce type de modélisation dans le futur. L'examen du contenu de cet article de synthèse bibliographique peut fournir des indications sur les efforts ultérieurs dans les processus de modélisation, les types de données utilisées, les méthodes de collecte des informations, et des variables/métriques à inclure. Cette information doit encore être évaluée avec précaution pour une utilisation sur des zones d'études spécifiques, des espèces dignes d'intérêt, et comme base de développement de méthodes innovantes et plus efficaces.

RESUMEN

REVIEW DEL MODELADO DE DISTRIBUCIÓN EN NUTRIAS: ENFOQUE, ESCALA Y MÉTRICA

Todas las especies de nutrias son de preocupación de conservación, y son utilizadas tanto como especies-bandera para la conservación, así como indicadores de salud de cuencas; consecuentemente, identificar y entender su distribución es una necesidad básica. Revisamos la literatura publicada para identificar esfuerzos de modelado de distribución, en todo el mundo, y luego compilamos información sobre distintas métricas/variables usadas, qué información está comúnmente disponible y qué se puede requerir, qué distintos resultados se pueden obtener con diferentes modelos, y limitaciones de los modelos. Identificamos 29 estudios sobre 8 especies que utilizaron 4 métodos principales para modelar distribución de nutrias en una determinada área, o la relación entre las especies de nutria y ciertos factores ambientales. Los estudios modelaron distribución a través de una variedad de escalas, incluyendo la local, regional, nacional, continental, y de toda la distribución de la especie. Catalogamos 301 diferentes métricas ambientales usadas en los modelos, que luego clasificamos en seis categorías principales: disturbios antropogénicos, clima, interacciones terrestres,

acuáticas y biológicas. El alimento, disponibilidad y calidad del agua, y las influencias antropogénicas todas fueron regularmente identificadas como variables importantes que se correlacionan con la distribución de nutrias, pero son a menudo medidas en una variedad de maneras, o identificadas en los modelos mediante variables proxy ó sucedáneas, porque la disponibilidad de los datos relevantes fue escasa o ausente. La escala, el enfoque, y la selección de métricas, todas necesitan ser cuidadosamente consideradas para cada estudio, pero entender los temas de medición y las limitaciones identificadas en los modelos, deberían ayudar a mejorar el modelado de nutrias en el futuro. La revisión de información de este paper de review puede ayudar a futuros esfuerzos respecto de procesos de modelado, tipos de datos usados, métodos de recolección de datos, y variables/métricas a incluir. Esta información debería de todos modos ser cuidadosamente evaluada antes de usarse en áreas de estudio o especies específicas, y como una base para desarrollar métodos innovadores y más efectivos.

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Appendix A1 – Variables used for different otter species

Table A1 - Factors use for modeling *Lutrogale perspicillata.* Many studies do not consider variable significance in their analysis.

Article/thesis name	Factors	Scale
Ali et al., 2010	roads, population, vegetation, water body characteristics	regional

Table A2 - Factors use for modeling *Aonyx capensis.* Factors in **bold** where found to be significant for this species.

Article/thesis name	Factors	Scale
Nel and Somers 2007	land use**, water body characteristics, water use, pollution, food resources,** vegetation	country

Table A3 - Factors use for modeling *Lontra provocax.* Factors in **bold** where found to be significant for this species.

Article/thesis name	Factors	Scale
Aued et al., 2003	competition (mink), water body characteristics, **elevation, vegetation, population**, precipitation, roads	local
Sepúlveda et al., 2009	**Food resources, water body characteristics, vegetation,** temperature, **roads**	country

Table A4 - Factors use for modeling *Pteronora brasiliensis.* Factors in **bold** where found to be significant for this species.

Article/thesis name	Factors	Scale
de Oliveira et al. 2015	**population, fishing nets, water body characteristics**	regional

Table A5 - Factors use for modeling *Lontra canadensis.* Factors in **bold** where found to be significant for this species. Many studies do not consider variable significance in their analysis.

Article/thesis name	Factors	Scale
Dubuc et al., 1990	roads, population, **vegetation, water body characteristics, river hierarchy, resource availability (beavers)**	local
Bieber, 2016	**distance to the nearest otter release site (km)**, vegetation, **water body characteristics**, resource availability	local
Jeffress et al., 2011	Local: **vegetation,** river hierarchy, water body characteristics, land use Landscape**:** land use, vegetation, ***river hierarchy***, roads	regional
Bennett, 2014	land use, vegetation, water body characteristics, competition (mink), resource available (beaver), other (ecosystem types and land uses)	regional

Table A6 - Factors use for modeling *Enhydra lutris.* Many studies do not consider variable significance in their analysis.

Article/thesis name	Factors	Scale
Williams et al., 2017	water body characteristics	regional

Table A7 - Factors use for modeling *Lutra lutra.* Factors in **bold** where found to be significant for this species. Many studies do not consider variable significance in their analysis.

Article/thesis name	Factors	Scale
Thom et al., 1998	vegetation and food resources **(no relationship found)**	local
Park et al., 2002	**water body characteristics, vegetation, road, tourism**	local
Ottino et al., 1995	vegetation, water body characteristics, disturbance	regional
Loy et al., 2009	population, elevation, vegetation	regional
Cianfrani et al., 2010	vegetation, **land use**, population, elevation, water body characteristics, food resources	regional
Carone et al., 2014	vegetation, elevation	regional
Kemenes and Demeter 1995	**land use, other possible factors (variable, e.g. pollution, dry section in water body), water body characteristics, vegetation**	country
Barbosa et al., 2001	**longitude, soil permeability, air humidity, roads,** latitude, precipitation, insolation, solar radiation, evapotranspiration, run-off, bioclimatic belts, temperature, phytogeographic sectors, population, tourism, land use, vegetation	country
Barbosa et al., 2003	run-off, soil permeability, latitude and longitude, elevation, precipitation, insolation, solar radiation, frost days, evaporation, temperature, air humidity, population, roads	country
Marcelli and Fusillo, 2009	population, land use, roads, river hierarchy, elevation	country
Ottaviani et al., 2009	roads, vegetation, elevation, water body characteristics	country
Cianfrani et al., 2013	bioclimatic model: temperature, precipitation regional environmental model: land use, elevation, population, vegetation	country
Cianfrani et al., 2011	Roads, population, precipitation, river hierarchy, land use, vegetation, water body characteristics, elevation	continental

Table A8 - Factors use for modeling *Lontra longicaudis.* Factors in **bold** where found to be significant for this species. Many studies do not consider variable significance in their analysis.

Article/thesis name	Factors	Scale
Gori et al., 2003	**vegetation, water body characteristics, resource availability**	local
Santiago-Plata, 2013	**species distribution model:** **land use**, **roads**, population, river hierarchy, **elevation**, **precipitation** and temperature. Occupancy model: Local variables: vegetation, water body characteristics, elevation, human (impacts) landscape variables: vegetation, **land use**, roads, **river hierarchy**	local
Gomez et al., 2014	elevation, water body characteristics, population, polder cover (%), boat traffic, vegetation, land use, contaminants	local
Cruz et al., 2017	**water body characteristics**, vegetation	local
Cirelli and Sánchez-Cordero, 2009	vegetation, elevation, precipitation, temperature	regional
Lopes Rheingantz et al., 2014	precipitation, temperature, elevation, population, vegetation, water body characteristics	geographic extent

Appendix A2 – Advantages and disadvantages of modeling approaches

Presence-Absence phenomenological models/variable correlation *methods*

Advantages

The variety of tools available for this method (e.g. artificial neural networks, generalized linear models, generalized boosting models, generalized additive models, classification tree analysis, multi-adaptive regression splines, univariate and multivariate logistic regressions, stepwise discriminant analysis, flexible discriminant analysis, analyses for correlation, linear tend surface equation, partial regression analyses, piecewise linear functions, random forests, nearest-neighbor analyses, bootstrapping, variable transformations, correlation tests), allow us to take into consideration the information that is available and the selection of the most appropriate tools for the type of analysis that is being considered.

Can assess the relative importance of spatial, environmental and human factors that influence otter distribution (Barbosa et al., 2001).

Can be used to specify how much of the variance of the distribution of otters is due to different types of factors (variance partitioning), due to interactions between factors, and due to the combinations of factors (Barbosa et al., 2001).

These methods allow the establishment of negative or positive correlations, statistical significance of the relations found, and the level of confidence in the results obtained (Marcelli and Fusillo, 2009; Nel and Sommers, 2007).

Can be used to stablish ranges (thresholds) upon which the presence of certain factors exerts a greater influence (negative or positive) on the probabilities of observing a species (Marcelli and Fusillo, 2009; Nel and Sommers, 2007).

Distribution models based on presence probabilities, allow a more detailed knowledge of a species potential distribution when they are extrapolated to scales of finer resolution (Barbosa et al., 2003).

The sighting data used can take many forms, including presence-absence, sighting rate (de Oliveira et al. 2015), number of signs (Gori et al., 2013), proportion of positive sights (Barbosa et al., 2001), and frequency distribution (Thom et al., 1998).

These methods can be used to create habitat suitability maps, distribution of probability of occurrence maps, and presence-absence prediction maps which can be used to define action plans for conservation efforts (Gomez et al., 2014).

Disadvantages

Causal relationships among variables that are shown through the use of statistical regressions are not necessarily direct. A variable used could be an indicator or surrogate for a different unmeasured variable that does have an influence on the dependent variable (Barbosa et al.,2001; Barbosa et al., 2003).

It is important to understand that some of the factors we would like to consider can be correlated, and therefore the understanding of their individual effect may not be easy to interpret or define.

The variables chosen can provide randomness in the predictions made (Cianfrani et al., 2010; Santiago-Plata, 2013).

The quality of presence-absence HSM models should be carefully revised when the species-environment equilibrium assumption is not met (i.e. as in the case of species recolonization or expansion) (Cianfrani et al., 2010).

Since these methods use species presence/absence data for the analysis, false-positive, and false negative observations can affect the results obtained (Marcelli and Fusillo, 2009; Cianfrani et al., 2010).

Since the habitat suitability for otter species can be restricted to a 150m buffer around rivers or water bodies, it is important for the presence data to have high locational accuracy, particularly when calibrating the model (Cianfrani et al., 2013).

It is important to have enough otter presence/absence data to use some of the information in the calibration of the model and the other part in the validation of the model. If the same information is used for both processes, the model performance can be overestimated (Sepúlveda et al., 2009.)

Deductive Habitat Suitability methods

Advantages

In habitat suitability models, the classification of suitable and unsuitable areas can be made deductively based on the information known of the species of interest. A GIS overlay is a commonly used method (Ottaviani et al., 2009; Loy et al., 2009).

By providing information on overall habitat quality, HSMs provide an important base for determining potential habitats for species of interest (Ali et al., 2010).
Habitat suitability maps don't require otter sighting data, but it can be used to validate the models (Loy et al., 2009).

Disadvantages

When choosing areas for conservation prioritization based solely on ecological niche and habitat models, there is a high probability of including areas of low presence likelihood for the species of interest; i.e., overprediction (Cirelli and Cordero-Sanchez, 2009).
Wildlife habitat selection is affected by many factors and therefore no single theory is suitable for every animal since other factors that are not being considered or that have not been measure or determined could be limiting their distribution (Ali et al., 2010).
Because HSM are usually build based on the information that is available, they are commonly used under the assumption that wildlife-habitat relationships are consistent throughout different scales (Ali et al., 2010).
The variables chosen can provide randomness in the predictions made (Cianfrani et al., 2010; Santiago-Plata, 2013).

Occupancy methods

Advantages

Occupancy models use presence/absence data and the attributes of each site to define species-habitat relationship that are described as the probability of occupancy by a species (Santiago-Plata, 2014; Bieber, 2016).
To improve their assessment of species distribution and species-habitat relationships, occupancy models are now developed to account for mistakes in species detection by including estimates of detection probability. Detection probability reduces bias issues and allows for stronger inferences about species-habitat relationships (Jeffress et al., 2011; Bieber, 2016).
There are tools that are already developed for occupancy modeling, such as PRESENCE software and single season models.
One can assess the results obtained from the PRESENCE software with other statistical analyses to choose best model and define direction and relative effect size of variables used (Jeffress et al., 2011).
This approach can create ranges of occupancy estimates (Bieber, 2016).

Disadvantages

Requires more visits within the same site (like river stretch), which are necessary to allow for spatial replication, in order to determine the detection probability (Jeffress et al., 2011)
Substrate type can affect the detection probability (Jeffress et al., 2011).
In occupancy models, when the surveys for calculating detection probability are not the same day, it is recommended to survey the sites 3 or more times if the probability is > 0.5 (Bieber, 2016).

Presence-only methods

Advantages

These methods use incomplete information (presence-only data) to represent the ecological -niche of a species from the analysis of several variables and as a result produces a map of a species distribution probability (potential distribution) or habitat suitability within an area of interest (Santiago-Plata, 2013; Bieber, 2016).
There are tools that are already developed to create habitat suitability models, such as ENFA (Ecological Niche Factor Analyses), GARP, and MAXENT (Maximum entropy algorithm). These programs require presence data and thematic maps of the variables being considered.
Maxent includes the possibility using analyses that examine relative impact of each environmental variable (Jackknife test) and measures the fitness of the model (test of the area under the curve (AUC) in the receiver operating characteristic (ROC) plot) (Santiago-Plata, 2013; Bieber, 2016). It also has a generative approach, rather than a discriminative one, which prevents the over adjustment of the model when there is a reduced number of values (Santiago-Plata, 2013)
ENFA models compares the environmental characteristics of the sites occupied by the species to the characteristics of the whole area of interest (Cianfrani et al., 2010).

Absences may prevent models identifying areas that are suitable for a species to spread into. Therefore, when working with species that have an unstable distribution (recolonization a or expansion) presence-only models are more reliable (Cianfrani et al., 2010).
Distribution models based on presence probabilities, allow a more detailed knowledge of a species potential distribution when they are extrapolated to scales of finer resolution (Barbosa et al., 2003).

Disadvantages
Maxent does not have a rule of minimum of maximum number of data values require for it to provide an adequate analysis, therefore there is still some discrepancy regarding these values (Santiago-Plata 2013). It is also sensible to the location of the presence data values; therefore, it may underestimate in areas where there are no observations registered, even when the region has suitable characteristics (Santiago-Plata, 2013).
Maxent produces three possible types of outputs: raw, log, and cumulative. This should be considered when choosing an output and interpreting the results (Santiago-Plata, 2013; Bieber, 2016).
When using Maxent for occupancy estimation, it may produce more liberal results than when using other occupancy estimation methods (Bieber 2016). The estimates obtained through Maxent can vary a lot based on the occupancy threshold that is established (Bieber, 2016).
There is no limit to the variables used in these models, therefore one must be very careful with variables that are selected, since the quality of the model will depend on the quality of the predictors considered (Cianfrani et al., 2010; Santiago-Plata, 2013).
These methods function based on incomplete information, therefore underestimation and overestimation are still possible, depending on the quality of the data available. The results will be better when the presence data represents a wider variety of environmental condition under which the species can be found (Cianfrani et al., 2010).

Appendix A3 – Metrics used at each scale

Table A9 - Metrics used at the local scale. Metrics in **bold** where found to be significant at this scale. Many studies do not consider variable significance in their analysis.

Classification	Variables	Metrics
Disturbance variables	Roads	distance to roads, number of major roads, park roads and paved roads crossing the watershed, number of dirt roads crossing the watershed, roads, total highway and roads density, **range distance to road**
	Population	distance to towns, total number of human residences within 500 m of the watershed occupied year-round, total number of homes within 500 m of the watershed occupied on a seasonal basis, settlement density, **human settlements**
	Tourism	**number of visitors**
	Contaminates	suspended solids, nitrates, phosphates, coliforms, dissolved oxygen
	Land use	grazing area, crops, land use, floodplain area (%), protected area (%), urban use
	Others	total number of times a footpath(s) crossed the stream, total length of footpath(s) within 25 m of the watershed, boat traffic (2), impact(human), polder cover (%)
Climate variables	Temperature	temperature
	Precipitation	precipitation
Terrestrial variables	Vegetation variables	**vegetation type of stream bank zone**, **vegetation type**, **vegetation complexity**, plant cover(%), riverbank vegetation (types), forest, tree cover(%), forestry(%), % of forested land area within 100 m of all streams and water bodies, % of forested land composed of mixed softwood, **% of forested land composed of birch-aspen**, **% of forested land composed of mixed hardwood-softwood**, % of forested land composed of "wetland softwood", % of forested land composed of northern-hardwoods, sum of the areas of all water bodies characterized by alder-willow, sum of the areas of all water bodies characterized by emergent herbaceous vegetation/ sum of the area (ha) of all water bodies, sum of the areas of all water bodies characterized by floating-leaf vegetation, **sum of the areas of all water bodies characterized by emergent herbaceous vegetation**, sum of the areas of all water bodies characterized by ericaceous vegetation, herbaceous cover, shrub cover, canopy cover, tree density sclerophylous, visual obstruction between 0 - 0.50 m, visual obstruction between 0.50 - 1.0 m, visual obstruction between 1.0 - 1.50 m
	Elevation	elevation, **slope**

Aquatic Variables	Water body characteristics	**water depth**, river length, stream velocity, **river/stream width**, average width of river, **bottom structure of stream**, **mean shoreline diversity index(shape)**, **bank types (shore type)**, average width of bank, number of pools, number of tree logs, area lake, tributary presence, sum of the perimeters of all water bodies, sum of the area (ha) of all water bodies, sum of all open water areas of all water bodies, average stream gradient over the entire watershed, **total dissolved solids**, **pH**, **flow zones**, water temperature, distance to shore, bottom slope, shoreline complexity
	River Hierarchy	distance to rivers of high hierarchy(3,4, 5), distance to rivers of low hierarchy(1,2), rivers(hierarchy), sum of the perimeters of all water bodies, sum of the area (ha) of all water bodies, sum of all open water areas of all water bodies, total length of all first-order stream, total length of all second-order stream segments, total length of all third-order stream segments, **total stream length over all stream orders**, total point-to-point length of all first-order streams, total point-to-point length of all second-order streams, total point-to-point length of all third-order streams, total point-to-point stream lengths over all orders, ratio1 (total length of all first-order stream / total point-to-point length of all first-order streams), ratio2 (total length of all second-order stream segments / total point-to-point length of all second-order streams), ratio3 (total length of all third-order stream segments/ total point-to-point length of all third-order streams), ratiot (total stream length over all stream orders/ total point-to-point stream lengths over all orders) average stream gradient over all first-order streams, average stream gradient over all second-order streams, average stream gradient over all third-order streams
Predator - Prey/Competition variables	Competition	mink presence
	Resource availability	**refuge availability**, % of all wetlands with active beaver sign, **% of all wetlands with active or inactive beaver sign**

Table A10 - Metrics used at the regional scale. Metrics in **bold** where found to be significant at this scale. Many studies do not consider variable significance in their analysis.

Classification	Variables	Metrics
Disturbance variables	Roads	distance to roads, sum of road km within the watershed/watershed area
	Population	distance from cities, distance to towns, human population density, **location of homes**
	Land use	**proportion of survey area comprised of cropland**, proportion of watershed comprised of cropland, frequency of dry herbaceous cropland in a 5-km radius, frequency of arboreal cropland in a 5-km radius, frequency of heterogeneous agricultural areas in a 5-km radius, high intensity development, low intensity development, proportion of watershed comprised of urban, (commercial, industrial, transportation, and recreation), **distance from surface excavation**, **distance from productive areas**
	Others	the site was a reservoir, **location of fishing nets (5.1 km sections),** disturbance, stream distance of site to nearest of border line for either Missouri or Oklahoma, **distance to the nearest otter release site (km)**
Climate variables	Temperature	mean annual temperature, minimum daily temperature, maximum daily temperature
	Precipitation	mean annual precipitation, mean daily precipitation, maximum daily precipitation
Terrestrial variables	Vegetation variables	riparian vegetation cover, land cover, bankside fine scale land cover, coarse scale extra-riparian CORINE land cover, vegetation type, distance from riparian vegetation, **proportion of survey area buffer comprised of woodland**, proportion of watershed comprised of woodland, frequency of deciduous forest in a 5 km radius, frequency of sclerophylous vegetation in a 5 km radius, **proportion of survey area comprised of grassland,** proportion of watershed comprised of grassland, upland natural, non-coastal wetlands, dominant vegetative land cover, amount of non-river channel wetland area
	Elevation	elevation, slope, aspect, convexity (hunting efficiency)
Aquatic Variables	Water body characteristics	water depth, bank height, bankfull height, bank slope, river/stream width, survey segment sinuosity, flow accumulation, **river water level**, water quality, AMNET/FIBI water quality, AMNET/FIBI habitat quality, the waterbody is 303(d) impaired, distance from water (rivers), distance to the closest lake/pond, freshwater, long-term median flow rate of the river (ft^3/s), last five year-dry history
	River Hierarchy	the site was a 3rd order stream, the site was a 4th order stream, the site was a 5th order stream, the site was a 6th–7th order stream, sum of all open water

		areas of all water bodies, **sum of the waterbody perimeters/sum of waterbody areas for entire watershed**, **sum of stream (3rd order) km within the watershed/watershed area**, **number of waterbodies within the watershed/ watershed area**
Predator - Prey/Competition variables	Competition	mink presence
	Resource availability	beaver presence, probability of beaver occupancy
	Food resources	fish biodiversity
Other		Cemetery, managed wetlands, schools, flats, tidal areas, bays, among others

Table A11 - Metrics used at the country scales. Metrics in **bold** where found to be significant at this scale. Many studies do not consider variable significance in their analysis.

Classification	Variables	Metrics
Disturbance variables	Roads	distance to the nearest highway, number of major roads, park roads and paved roads crossing the watershed, national road density, secondary road density, roads, total highway and roads density, presence of valley roads within 1 km, **main roads**, secondary roads, **highway density**, density of habitat cells (%of cell in the neighborhood occupied by roads)
	Population	distance to the nearest town with more than 100,000 inhabitants, distance to the nearest town with more than 500, 000 inhabitants, distance to small urban settlement, distance to large urban settlement, human population density, **mean density of human population**
	Tourism	hotels per km, vehicles per km, vacancies in tourist apartments per km, total tourist vacancies per km, vacancies in camping sites per km
	Land use	**agriculture**, percentage of agricultural area, relative pasture area, relative cropland area, agricultural/livestock as adjacent area, **proportion of agriculture area**, land use, percentage of urban area, **proportion of urban area**, no vegetation as adjacent area, **distance from industrial areas**, distance from mines, nearest distance from dam reservoirs
	Others	**water use**, **pollution**
Climate variables	Air humidity	**mean relative air humidity in January**, mean relative air humidity in July, annual relative air humidity range
	Evapotranspiration	annual potential evapotranspiration, annual actual evapotranspiration, mean annual potential evapotranspiration, mean annual actual

	Temperature	mean temperature in January, mean temperature in July, mean annual temperature, annual temperature range, average monthly mean temperature, average monthly minimum temperature, average monthly maximum temperature, daily temperature range, maximum temperature of the warmest month, minimum temperature of the coldest month
	Precipitation	mean annual number of days with precipitation, average monthly precipitation, mean annual precipitation, maximum precipitation in 24h, relative maximum precipitation, precipitation seasonality, annual days of precipitation, precipitation of the driest month, precipitation of the wettest month, pluviometric irregularity
	Others	mean annual insolation, mean annual solar radiation, mean annual number of frost days, mean daily solar radiation, number of bioclimatic belts
Terrestrial variables	Vegetation variables	**density of bank vegetation**, land cover, diversity of density of riparian vegetation (Simpson index), riparian vegetation width < 20 m, open riparian vegetation, dense riparian vegetation, riparian vegetation width>20 m, **semi-dense riparian vegetation**, forestry (%), relative woodland area, temu pitra swamp forest, exotic forest plantations as adjacent area, native vegetation as adjacent area, absence of riparian vegetation, upland natural, non-coastal wetlands, number of phytogeographic sectors
	Elevation	elevation/altitude, slope, aspect, mean altitude, minimum altitude, maximum altitude, altitude range, convexity (hunting efficiency), acclivity
	Others	mean annual run-off, **soil permeability**, west coordinate, south coordinate, mean latitude, **mean longitude**
Aquatic Variables	Water body characteristics	**water depth**, river slope, **anastomosed river length**, **current type**, narrow river, medium river, wide river, river/stream width, straight river, meandric river, shore type, streams, habitat type, average river elevation, total watercourses, hydrographic network
	River Hierarchy	stream order, first order rivers, second order rivers, third order rivers, fourth and fifth order rivers
Predator - Prey/Competition variables	Food resources	**freshwater crab**, **freshwater crayfish**, **food availability**
Others		other possible factors e.g. pollution, dry section of water body

Table A12 - Metrics used at the continental scale. Many studies do not consider variable significance in their analysis.

Classification	Variables	Metrics
Disturbance variables	Roads	roads, distance to roads
	Population	distance to the nearest town with more than 100,000 inhabitants, human population density
	Land use	industrial areas
Climate variables	Precipitation	annual precipitation, mean precipitation driest quarter, mean precipitation wettest quarter
Terrestrial variables	Vegetation variables	forest
	Elevation	elevation/altitude
Aquatic Variables	Water body characteristics	% lake
	River hierarchy	% rivers 1-2 Strahler order, % rivers 3–5 Strahler order, % rivers 6–9 Strahler order

Table A13 - Metrics used at the geographic extent scale. Metrics in **bold** where found to be significant at this scale. Many studies do not consider variable significance in their analysis.

Classification	Variables	Metrics
Disturbance variables	Population	**human population density**
Climate variables	Temperature	**annual temperature**, temperature standard, isothermality
	Precipitation	annual precipitation, precipitation of the driest months, precipitation seasonality, precipitation of the warmest quarter
Terrestrial variables	Vegetation variables	vegetation cover
	Elevation	elevation/altitude
Aquatic Variables	Water body characteristics	percentage of water bodies

S H O R T   N O T E

SMOOTH-COATED OTTER *Lutrogale perspicillata* RECEIVES FORMAL PROTECTION IN INDONESIA, BUT SMALL - CLAWED OTTER *Aonyx cinereus* DOES NOT

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Abstract: The illegal wildlife trade in Indonesia is a major threat to a long and growing list of species. Otters are no exception and recent research has shown the trade in otters as pets in Indonesia is on the rise. While it is illegal to capture and trade otters from the wild in Indonesia, until recently only two of the four native otter species received formal legal protection, and the remaining two species were protected by an insubstantial zero-harvest quota. Recently, the government of Indonesia has provided full legal protection to the Smooth-coated Otter, however, and unfortunately, the Small-clawed Otter remains absent from the list of protected species in Indonesia, and therefore more vulnerable to exploitation.

Keywords: Indonesia, otters, wildlife trade

There are four species of otters in Indonesia, all found west of the Wallace Line in the Greater Sundas. These are the Eurasian Otter *Lutra lutra,* Hairy-nosed Otter *L. sumatrana,* Small-clawed Otter *Aonyx cinereus* and the Smooth-coated Otter *Lutrogale perspicillata*. There is little information on the status of wild otter populations in the country, but it is generally believed that all four species are in decline due to increasing loss and degradation of suitable habitat, impacts from environmental pollution, human-otter conflicts and poaching for trade.

For these very reasons, all four otter species have been assessed and considered at risk from extinction with the Hairy-nosed Otter listed as Endangered, the Small-clawed and Smooth-coated Otters as Vulnerable, and the Eurasian Otter as Near-threatened on the IUCN Red List of Threatened Species (Aadrean et al., 2015; de Silva et al., 2015; Wright et al., 2015). Furthermore, the Eurasian Otter is prohibited from being traded internationally for commercial purposes as it is listed on Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I, while the other three species are listed on Appendix II, allowing for trade with a valid permit.

Recent studies have shown a sharp increase in the illegal trade in otters for pets, with many of these being traded online (Aadrean, 2013; Gomez et al., 2016; Gomez and Bouhuys, 2018). Indonesia has emerged as a key source and demand country for pet otters. In Gomez and Bouhuys (2018), Indonesia is revealed as a major consumer of otters with over 700 otters found for sale online. It was also implicated in the international trade of otters to Japan. Indonesia dominated, by a high margin, in the number of online advertisements for otters in comparison to the other countries assessed in Southeast Asia. It also appears that much of this trade is being supplied by wild-caught otters. In Java, few otters were observed for sale in pet markets but there were traders willing to acquire otters for the right price. There were some traders who claimed these were sourced entirely from the wild, and some who claimed a mix of wild-sourced and well as captive-bred otters, although the latter could not be verified.

It is cheaper to trap wild otters than breed them. In addition, there did not appear to be a steady supply of otters into the pet markets in Java, suggesting that breeding was not actively and consistently supplying the market. This is a concern, especially for the Small-clawed Otter, the species currently most impacted by the pet trade.

In July 2018, the Indonesian government launched a revised list of protected species in Indonesia under the *Government Regulation No.7, 1999, Concerning the preservation of flora and fauna*, a list which until now, hadn't been updated since it was gazetted. In the past, only the Hairy-nosed Otter and Eurasian Otter were protected by this law in Indonesia. The new list however now includes the Smooth-coated Otter. This essentially means that the trade and harvest of wild-caught Smooth-coated Otters is now prohibited unless it involves second generation captive-bred individuals, which may only be bred by traders under special permit. Violation of the law stipulates a five-year prison sentence and a fine of IDR100 million (USD7 200) under the *Act of the Republic of Indonesia No.5 of 1990 concerning conservation of living resources and their ecosystem.*

While this is certainly good news for the Smooth-coated Otter, that still leaves the Small-clawed Otter vulnerable, the species currently most exploited for trade in Indonesia (Gomez et al., 2018). Hunting and trade in animals that are not protected is regulated under *Regulation of the Minister of Forestry No. 447/Kpts-II/2003* concerning administration directive of harvest or capture and distribution of wild specimens. The regulation states that a yearly provincial quota is set for all animals that can be captured in the wild. Catching animals for which no quota has been set, in excess of quota that have been set, or outside provinces for which quotas have been set, is deemed illegal, even when the species concerned is not considered protected. No harvest quotas have yet been established for the Small-clawed Otter. While this inadvertently protects the Small-clawed Otter from trade, no punishments for transgressions are stated however under this law, and therefore this regulation is difficult to enforce.

We applaud the government of Indonesia for the inclusion of the Smooth-coated Otter in the list of protected species in Indonesia and encourage the authorities to take swift and strong actions to end the illegal trade in this species. However, this protection needs to extend to the Small-clawed Otter as well. This species is not only in high demand as a pet locally, but it is also coveted internationally in countries like Japan where there is no protection for non-native species especially if they are listed in CITES Appendix II, permitting their sale even if they're obtained illegally.

As such we strongly urge the government of Indonesia to take steps to protect its Small-clawed Otter. We also urge the government of Indonesian to enact provisions to regulate online wildlife trade. The seriousness of the illegal trade should be reflected in both wildlife and online trade laws, particularly through high penalties for any transgressions of the law. Strong penalties could favour law enforcement agencies by serving as a strong deterrent, especially as online trade also encourages opportunistic trade, which should be weeded out.

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RÉSUMÉ
LA LOUTRE À PELAGE LISSE, *Lutrogale perspicillata*, A OBTENU UNE PROTECTION OFFICIELLE EN INDONÉSIE, MAIS PAS LA LOUTRE CENDRÉE, *Aonyx cinereus*

Le commerce illégal d'animaux sauvages en Indonésie est une menace majeure pour un nombre élevé et croissant d'espèces. Les loutres ne sont pas une exception et une étude récente a montré que le commerce de loutres, en tant qu'animal de compagnie, est en augmentation en Indonésie. Bien qu'il soit illégal de capturer et de faire le commerce de loutres issues du milieu naturel en Indonésie, jusqu'à il y a peu, deux des quatre espèces de loutres natives avaient obtenu une protection légale officielle, et les deux espèces restantes étaient protégées par un quota de capture zéro inefficace. Récemment, le gouvernement d'Indonésie a fourni une protection légale totale à la loutre à pelage lisse, cependant et malheureusement, la loutre cendrée reste absente de la liste des espèces protégées en Indonésie, et est, de ce fait, plus vulnérable à une exploitation.

RESUMEN
LA NUTRIA LISA *Lutrogale Perspicillata* RECIBE PROTECCIÓN FORMAL EN INDONESIA, PERO LA NUTRIA DE UÑAS PEQUEÑAS ASIÁTICA *Aonyx Cinereus*, NO

El comercio ilegal de fauna silvestre en Indonesia es una de las grandes amenazas que pesan sobre una larga y creciente lista de especies. Las nutrias no son la excepción, e investigaciones recientes mostraron que el comercio de nutrias como mascotas en Indonesia, está en aumento. Aunque es ilegal capturar y comerciar nutrias silvestres en Indonesia, hasta hace poco solamente dos de las cuatro especies nativas de nutrias recibían protección legal formal, y las otras dos especies estaban protegidas por una cuota-cero de cosecha, insustancial. Recientemente, el gobierno de Indonesia ha provisto de protección legal completa a la nutria lisa; sin embargo, y desafortunadamente, la nutria de uñas pequeñas asiática continúa ausente de la lista de especies protegidas en Indonesia, y por lo tanto más vulnerable a la explotación.

NEW BOOK

THE BIOLOGY AND MANAGEMENT OF ANIMAL WELFARE
Frauke Ohl, Rory PUTMAN and members of DWM, Utrecht

This new book starts from a statement of the Brambell Committee (1965) that,

> „Welfare is a wide term that embraces both the physical and the mental well-being of the animal. Any attempt to evaluate welfare, therefore, must take into account the scientific evidence available concerning the feelings of animals that can be deried from the structure and function and also from their behaviour.“

While this is not a book about otters much can easily applied to otter species. Otters are kept in captivity but are also topic of field research and as such we need to think about ethical aspects in our daily work. This book is definitely very valuable food for thought. Chapters include the changing attitute towards animals and their welfare, biology of welfare or assessment of welfare. Interstingly the last chapters is subdivided into welfare of the individual and welfare of the group and there are many aspects of group welfare that I personally feel may need more attention when animals are kept in captivity. Another short subchapter relates to „intervene or not to intervene“ which reminded me of long discussion I had with Claus Reuther about this sensitive topic already 20 years ago. Overall I am sure, that many of us may have use of this excellent written book.

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OSG MEMBER NEWS

Since the last issue, we have welcomed 5 new members to the OSG: you can read more about them on the Members-Only pages.

Mike Bottini, USA: Mike has a MSc. from the University of British Columbia where he studied the effectiveness of several designs of wildlife underpasses to allow for elk movement across fenced portions of the Trans-Canada Highway in Banff National Park. He has worked as an environmental planner and wildlife biologist on eastern Long Island for thirty years. He initiated the Long Island River Otter Project in 2008, and has continued monitoring the population. Mike also teach field naturalist courses, leads nature paddles, and has a Track & Sign level III certification through the Cybertracker evaluation program.

Mirela Cuculescu-Santana, United Kingdom: Since 2012 I have studied the behaviour and enclosure use of Asian small clawed otters in captivity at three different establishments in the NE of England, using different methods of quantitative data collection. I am interested in how their behaviour and enclosure use are influenced by seasonal temperatures in indoor and outdoor enclosures, and by various forms of enrichment, to provide quantitative information to support husbandry practices that ensure high welfare in captivity.

David Fleck, Peru: I work for the Peruvian NGO Acate Amazon Conservación. I am principally work with the Matses people, on their traditional knowledge of animals including otters. As well as conducting long term censuses for Giant Otters in Matses territory, I am devising conservation plans to reduce human impact on otter populations, running otter conservation awareness workshops, and creating teaching materials for use in Matses schools.

Hyeonjin Kim, Japan: I have worked on otter distribution in Korea and Japan for many years. I am interested in otter ecology and island biogeography. I also want to engage in conservation measures based on otter ecology and sociopolitical protection measures when the otter population has recovered.

Inge Teilen, Peru: Cikananga Wildlife Center, West-Java, has the only rehabilitation facilities for otters in Indonesia and is therefore part of the SERO program for receiving surrendered or confiscated pet otters, rewilding and returnning them to the wild. With ongoing arrival of otters we aim to professionalize the rescue, rehabilitation, release and post monitoring activities. We are also working with schools and the public to educate them about otters as part of the ecosystem.