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LAPB AWARD 2021. The Louisiana Association of Professional Biologists (LAPB) has awarded the “2021 Best Conservation Publication Award” to “The Ecological importance of crocodylians: Towards evidence-based justification for their conservation”, which appeared in *Biological Reviews* 95: 936-959. The paper was authored by Ruchira Somaweera, and co-authors James Nifong, Adam Rosenblatt, Matthew Brien, Xander Combrink, Ruth Elsey, Gordon Grigg, William Magnusson, Frank Mazzotti, Ashley Percy, Steven Platt, Matthew Shirley, Marisa Tellez, Jan van der Ploeg, Grahame Webb, Rom Whitaker and Bruce Webber.

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## **South Asia and Iran**

CONSERVATION STATUS OF THE MUGGER (*CROCODYLUS PALUSTRIS*): ESTABLISHING A TASK FORCE FOR A POSTER SPECIES OF CLIMATE CHANGE. The Mugger or Marsh crocodile (*Crocodylus palustris*) was described from the Gangetic Plains in India in 1831. It is a medium-sized crocodile, with adult females reaching 2-2.5 m and males 3-3.5 m on average, and rarely reaching 5 m TL. The species is distributed from southeastern

Iran to Pakistan and the Indian subcontinent, including Sri Lanka (Fig. 1). The species is considered extinct in Bhutan and Myanmar, with only transient individuals occasionally reported from Bangladesh. Fossilized remains suggest the species' existence in Pakistan for thousands of years (Sohrab Katrak 1963). Muggers inhabit freshwater habitats, including lakes, rivers, marshes, agro-wells and artificial ponds (“tanks” in Sri Lanka, and species is referred to there as ‘tank crocodile’), and occasionally hypersaline waters in Sri Lanka.

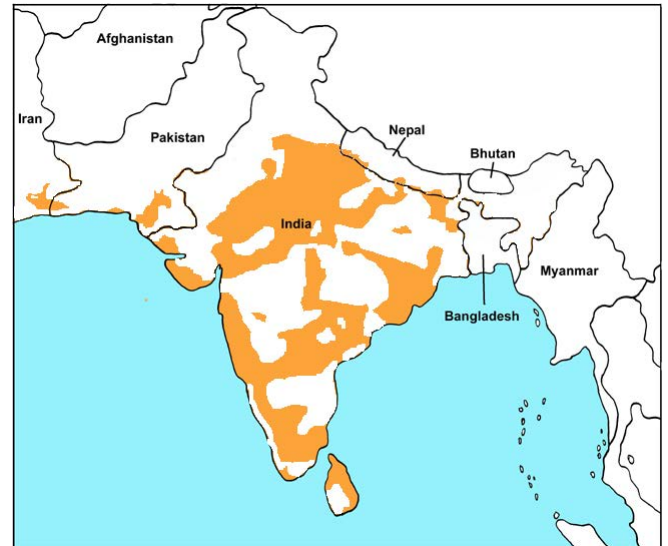


Figure 1. Distribution of the Mugger (*Crocodylus palustris*), from authors' data and data points for distribution in India from Tarun Nair. Source: Stevenson *et al.* (2021).

Muggers have the broadest snout among living members of the genus *Crocodylus*, and display adaptive behaviours, such as digging burrows to retreat from extreme temperatures and migrating over land at night to find suitable habitats during the hot, dry season (Whitaker and Whitaker 1989; Daniel 2016; Choudhury and de Silva 2013; Mobaraki 2015; De Silva 2013). In Sri Lanka, they have also been observed excavating a ‘guard burrow’ on the bank below their nest. One of the authors (AdS) has seen these in two contrasting areas in Sri Lanka; inside a forest, and amid a disturbed, anthropogenic habitat. These burrows serve several purposes: refuge for resting; thermoregulation; aestivation during prolonged drought; and, protection from natural predators and humans as well as nesting. Several Muggers, including hatchlings, can sometimes be found in one burrow.

Interestingly, H. Wermuth in Germany and P.E.P. Deraniyagala in Sri Lanka together lodged an appeal on the urgency of protecting crocodiles worldwide (Alice 1956). Sri Lanka and Germany, therefore, were taking a very early lead role in the conservation of crocodylians. The Mugger has been listed as “Vulnerable” on the IUCN Red List of Threatened Species since 1982, with the population trend being evaluated as stable (Choudhury and de Silva 2013). Considering the threats faced by the dwindling wild Mugger populations in range states, the species receives legal protection in the countries through national legislations. The species is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).



The Mugger is generally threatened by habitat destruction because of conversion of natural habitats for agricultural and industrial use, and as humans encroach into the crocodile's habitat, the incidence of conflicts increases. Climatic changes resulting in water shortage and droughts also compel Muggers to migrate from their shrinking natural niches to other suitable places, causing human-crocodile conflict (HCC). Muggers are entangled in fishing equipment and drown, and they are killed in areas where fishermen perceive them as competition.

Changes in environmental conditions also affect the species' ecology. The populations struggle to adapt to changes such as reduced water flow or water levels in habitats. Eventually, Mugger populations either migrate towards the optimum conditions or struggle to survive in their altered habitats in search for food and shelter. This increases the probability of encounters of Muggers with local communities. As Muggers migrate to more permanent water bodies, they are often victims of accidents with cars and trains (Mobaraki and Abtin 2007; Vyas 2012a; de Silva 2013), and come into villages, farms and community ponds. The opportunistic and accidental killing of Muggers is not frequent in most of wild habitats.

Periodic prolonged droughts and lack of precipitation as well as of water resulted in the habitats in Iran becoming more and more dry. This in turn, increases the temperatures. Thus the crocodiles have to tolerate hotter and drier conditions which may have effects on food availability and vegetation coverage too.

In Sri Lanka, crocodile eggs are destroyed by local people who generally fear crocodiles. In the natural habitats of the Mugger in the Gwadar District of Pakistan, the reduction in water flow due to low rainfall and droughts causes higher mortality, especially in Dasht Khor. Another threat is construction of small dams in the Saurashtra region of Gujarat State, India (Vyas and Vaghshiya 2020), which has caused mortality of crocodiles. Another example is the Mirani Dam, where the movement of Muggers has been observed from downstream of Dasht Khor/Dasht River towards Mirani Dam during increased temperatures, lack of timely rains and shortage of water in the Dasht River. During the drought period of 1999-2004, when the water level decreased in the Hingol River, many crocodiles died. Forest-clearing fires usually reduce the suitability of crocodile habitats. Habitat destruction and seasonal floods also destroy nesting areas and eggs of the Mugger in the wild (Javed *et al.* 2005; Khan 1988).

In Iran, there is no harvesting of the species, but in some countries Muggers are killed for their meat (which is sold illegally), and crocodiles are invariably killed after attacking humans. In 2006-2009, the extent of poaching in Pakistan had been reduced significantly, which perhaps contributed to an increase in the population of Muggers in Sindh Province. However, the actual extent of poaching and conflict with local communities cannot be estimated due to the lack of monitoring in the area. Unlike Muggers at Manghopir Shrine, the local communities of Gwadar District, Balochistan, do not have cultural beliefs and are unaware of the species'

ecological importance, resulting in the lack of conservation measures at the local community level in the area. There is a need to locate the crocodiles' breeding and nesting areas and construct fences around these sites. The promotion of ecotourism and awareness-raising was encouraged to protect the Muggers, their eggs, and their habitats in some villages.

The crocodile became the focus of the "Zoo Species of the Year Campaign 2021", which aims to raise awareness about the threats and conservation needs of lesser-known wildlife species kept in zoos, supporting their *in-situ* conservation, and raising funds for conservation projects working directly with these species (<https://www.zgap.de/index.php/en/about-us/zoo-animal-of-the-year>). During the year-long "Species of the Year" campaign, German-speaking zoos are engaged in lobbying activities for crocodiles and simultaneously collect funds to support *in-situ* conservation projects. Four partners active in species conservation are joining forces to achieve as much as possible for the species in focus in public relations work and concrete species conservation measures. With the leading Zoological Society for Conservation of Species and Populations (ZGAP), the institutions and members of the German Society for Animal Parks (Deutsche Tierpark-Gesellschaft e.V., DTG), the Association of Zoological Gardens (VdZ), and the Community of German Zoo Patronisers (Gemeinschaft der Zooförderer, GdZ) work closely together and ensure professional and effective conservation work.

In light of the announcement of the campaign, Asghar Mobaraki (Iran) contacted Thomas Ziegler (Cologne Zoo, Germany) in February 2021, and they subsequently created a WhatsApp discussion group to facilitate communication and discussion of Mugger conservation efforts in Iran. Initial group members were Asghar Mobaraki, Lonnie McCaskill (USA) and Thomas Ziegler. AM further added Elham Abtin (Iran) and TZ added Cologne Zoo's Terrarium Section Keeper, Anna Rauhaus.

Asghar Mobaraki and Elham Abtin have built up a crocodile breeding facility in southeastern Iran as the first multipurpose *ex-situ* conservation centre for the species in the country. Breeding stock consists of rescued crocodiles that were in unsuitable living situations and villages and considered to be a nuisance (Fig. 2). This small captive population of Muggers is now maintained for conservation breeding purposes and future population restocking actions (Fig. 3).



Figure 2. Muggers in conservation breeding center in Iran. Photographs: Asghar Mobaraki and Elham Abtin.



Figure 3. Mugger offspring in conservation breeding center in Iran. Photograph: Asghar Mobaraki.

To provide a better overview of the *ex-situ* conservation situation of the Mugger, populations kept in zoos and aquaria around the world were determined by AR and TZ using the Zoological Information Management Software (ZIMS: Species360, Bloomington, MN, USA; <https://zims.species360.org>). In total, 1986 Muggers are held globally in 14 institutions from three regions (1977 in Asia, 4 in Europe, 5 in North America), according to ZIMS (assessed in March 2021; see Table 1). However, the list may be incomplete, as some zoos do not use ZIMS. Actual numbers of Muggers in range state facilities thus might be much higher. For example, according to the official annual inventory (2019-2020) of the Central Zoo Authority of India, 2449 Muggers (175 males, 198 females, 2076 unsexed) were kept among 63 Indian zoos. The number of Muggers in the Department of National Zoological Gardens, Sri Lanka, according to the curator, was 9 (Dehiwala 4, Pinnawala 5). There is also a low number of

individuals in Sindh Province: 40 in Khar Centre, Kirthar NP; 39 in Karachi Zoological Garden (Karachi); 7 in Sufi Anwar Safari Park (Ghotki); 14 in Samzu Park (Karachi); and, over 100 in Manghopir Shrine (Karachi).

As Iranian Muggers are at the extreme western range of the species, and thus at the very fringe of its distribution, this westernmost population is somewhat unique. Thus, at the national level a very small population may meet the criteria for a species at high risk and be considered nationally Critically Endangered. An estimated 500 wild Muggers remain within the southeastern part of Iran, in Sistan and Baluchestan Provinces (the Gandou Protected Area). They occupy ponds along two large rivers, namely Bahu-Kalat and Kaju, two dam reservoirs [Pishin (Fig. 4) and Zirdan], small artificial water dams, and some manmade local ponds in villages; Mobaraki 2015; Mobaraki *et al.* 2019).

In the Pakistani Balochistan Province, Muggers inhabit Hub Dam Wildlife Sanctuary, Hingol NP, and Dasht NP and Wildlife Sanctuary. In Balochistan, the numbers of Muggers in the wild are more than 100 in the Basol River/Kalimat Khor and more than 50 each in Hingol NP and the Dasht River. In Sindh Province, Muggers inhabit the Mehrano Wildlife Sanctuary, Kirthar NP, Nara Desert Wetland complex, Deh Akro II Wildlife Sanctuary, and Chotiari Wetland Complex. Based on the habitat type, the roughly estimated number of Muggers in the potential wild habitats of Sindh Province include >100 each in Chotiari Wetland Complex and Nara Canal, >150 in Deh Akro II Wildlife Sanctuary and >100 in Haleji Lake.

The WhatsApp group aimed further to discuss the

Table 1. According to zoo database ZIMS (Species 360), assessed March 2021, 1986 Muggers are held globally in 14 institutions from three regions (Asia 1977; Europe 4; North America 5).

Region/Institution	Taxon/Origin	Total
<u>Asia: 11 institutions</u>		
Assam State Zoo and Botanical Garden	Mugger, <i>C. palustris</i>	1
Department of National Zoological Gardens, Colombo	Sri Lankan Mugger, <i>C. p. kimbula</i>	5
Madras Crocodile Bank Trust	Indian Mugger, <i>C. p. palustris</i>	1753
National Zoological Park, New Delhi	Mugger, <i>C. palustris</i>	3
Nehru Zoological Park, Hyderabad	Mugger, <i>C. palustris</i>	65
Sakkarbaugh Zoo, Junagadh	Mugger, <i>C. palustris</i>	3
Arignar Anna Zoological Park, Chennai, Madras	Mugger, <i>C. palustris</i>	115
Sri Chamarajendra Zoo (Mysore Zoo)	Mugger, <i>C. palustris</i>	3
Nandankanan Biological Park	Mugger, <i>C. palustris</i>	19
Singapore Zoological Gardens	Mugger, <i>C. palustris</i>	4
Veeramata Jijabai Bhosle Udyan & Zoo	Mugger, <i>C. palustris</i>	6
<u>Europe: 2 institutions</u>		
Krokodille Zoo	Mugger, <i>C. palustris</i>	2
Thrigby Hall Wildlife Gardens	Mugger, <i>C. palustris</i>	2
<u>North America: 1 institution</u>		
St. Augustine Alligator Farm	Mugger, <i>C. palustris</i>	1
St. Augustine Alligator Farm	Indian Mugger, <i>C. p. palustris</i>	4



development of Mugger conservation measures and continuing conservation-based research, which Asghar Mobaraki has long implemented with Elham Abtin in Iran (Abtin and Mobaraki 2016; Mobaraki 2015). As in other parts of the Mugger's range, HCC is an issue in Iran (Fig. 5). The conflict results from the proximity of villages and local people and crocodile habitat, especially during droughts and breeding seasons when crocodiles are more mobile. Most crocodile attacks are on livestock, and causes severe financial loss to local people. Also, direct attacks on people, particularly children, have been recorded (Mobaraki 2015).



Figure 4. Wild Mugger in Pishin Dam, Iran. Photograph: Asghar Mobaraki.



Figure 5. Poster highlighting the conservation status of the Marsh crocodile, prepared for public awareness and education in Iran. Photograph: Asghar Mobaraki.

The population in southeastern Iran remains severely vulnerable to extreme climatic events, such as periodic droughts and floods. Iranian Muggers are therefore directly impacted by climate change and in critical need of immediate study to evaluate this threat.

To predict the impacts of climate change on the habitat of the Mugger in Iran and Pakistan, and thus on the survival of the species itself, the necessity of species distribution modelling analyses emerged, and Dennis Rödder from the Zoologisches Forschungsmuseum Alexander Koenig (<https://bonn.leibniz->

[lib.de/en](https://lib.de/en)) in Bonn, Germany, was contacted as an expert in this field to perform research on this topic. MuggerOne initial topic of discussion was of course how temperature-dependent sex determination (TSD) would be affected by potential climate change parameters across the species' range. We want to monitor how muggers across the region adapt to any local environmental variations (timing and placement of nesting, distance from water, nearer to tree cover, etc.) where such behaviour is not driven by human-led disturbance.

Then another research project came to the fore, viz. extensive DNA analysis of the Mugger across the range to determine if the population in the most western extreme range of the species is unique and distinct to the larger South Asian population. Previous genetic studies have shown a low level of genetic distinction and diversity (Mobaraki *et al.* 2014; Campos *et al.* 2018). For the new, more comprehensive approach, a molecular biologist, Minh D. Le from the Vietnam National University in Hanoi, joined the group. For compiling the required samples from across the range, Colin Stevenson (United Kingdom) joined the group, as he has many contacts with experts in South Asia. Later, Ulrich Schepp, from the German Federal Agency for Nature Conservation, joined the group to support the project. Finally, we began to develop collaboration with CSG members from South Asia directly, including colleagues from Bangladesh (SMA Rashid), India (Brinky Desai, Soham Mukherjee, Dax Pandhi, Raju Vyas), Pakistan (Rafaqat Masroor, Tahir Rasheed, Shoaib Abdul Razzaque), Sri Lanka (Anslem de Silva) and Nepal (Bed Khadka).

Besides DNA analysis, we also aim to get better insights into regionally differing threats, such as habitat degradation and loss, illegal harvest of animals and eggs, climate change effects, mortality caused by fishing activities, and agriculture development.

The Mugger originally occupied an extensive range in South Asia, with different seasonal weather conditions and a temporally variable precipitation regime, mainly subject to the influence of the monsoon. It is, therefore, assumed that *C. palustris* encounters the respective limiting climatic extremes at the fringes of its natural range, to which the populations there have had to develop particular adaptations.

Thus, we also plan to investigate the differences in ecological adaptations over the distribution range, such as potentially varying realized niches, differing reproduction and egg-laying seasons, etc., due to diverging monsoon/dry seasons/aestivation (such as in Madhya Pradesh or at the northwestern border of the range in Gujarat (India; Figs. 6-8), Iran and Pakistan). Some examples are the mangrove inhabiting population in Kerala or the populations from particular xeric regions in Iran or Gujarat. Also, in parts of Yala NP (Fig. 9) and Wilpattu NP in Sri Lanka, Dasht Wildlife Sanctuary, Kalamat, and somewhat Hingol NP, had a substantial reduction in rainfall in the last couple of years. Hypersaline areas inhabited by the Mugger in Pakistan are the artificial Chotiari Wetland Complex, Hingol NP and Manghopir (due to limited pond size and irregular water supply).



Figure 6. Wild Muggers in the Kutch/Gujarat region in India.  
Photograph: Dax Pandhi.



Figure 7. Muggers basking socially on small islands of a village pond in the human-dominated landscape of Deva village, Gujarat, India. Photograph: Soham Mukherjee.



Figure 8. Wild Mugger in the Kutch/Gujarat region in India.  
Photograph: Dax Pandhi.



Figure 9. Basking Mugger in Yala National Park, Sri Lanka.  
Photograph: L. Nadarajha.

Mangrove populations are probably persisting in the only habitat available to them. Muggers have had to survive in small, fragmented populations since the 1960s. With some efforts with protection since the mid-late-1970s, these populations have increased but are restricted by lack of enforcement and habitat deterioration. These factors in the past from a few decades ago need to be considered within the context of these regional populations. Physiological and genomic data could help understand better local adaptations, as far as the present. Otherwise, only realized niche shifts could be quantified, but fundamental niche differences remain hidden.

The Mugger inhabits a wide range with very different climate zones and differing rainfall and water access. If there are substantial differences, is this due to regional stenoecy and do they already have taxonomic implications? In the older literature, two subspecies were recognized, the nominate form and *Crocodylus palustris kimbula* Deraniyagala 1935, which morphologically differ by the number of the lines of dorsal scutes (4 in *palustris* vs 6 in *kimbula*) and the size and the structure of the scales in the gular region (Wermuth and Fuchs 1978). This certainly would merit re-investigation, not only based on limited numbers of skin preparations as was done by Wermuth and Fuchs (1978), but rather in the persisting sub-populations. However, it has to be taken into account that in the past, individuals from different geographic populations were probably introduced into the now persisting populations, which might weaken morphological data on its own.

Furthermore, as a consequence, should populations with potential morphological/molecular and regional behavioural differences then be considered separate management units in the context of breeding/conservation breeding programs?

The reproductive cycle lasts from December to June/July in northern India and November to June in southern India. At the beginning of the dry season, in January or February, females start building nests. According to Daniel (2016), mating was observed from mid-January in south India to March in the country's northern parts. The breeding season in Iran starts in March with mating, followed by nesting in May and hatching in July (Mobaraki 2015; Mobaraki *et al.* 2013). In Sri Lanka, egg-laying occurs from July to September, with females typically laying up to 30 eggs. The Mugger is a hole-nesting species, with egg-laying taking place during the annual dry season - February-April in southern India, about one month later in northern India, February-March in Nepal, April-May in Iran, and June-July (and as late as August) in Sri Lanka (De Silva 2013; Mobaraki 2015; Whitaker and Whitaker 1984, 1989; Andrews and McEachern 1994).

Captive females are known to lay twice in a season ('double-clutching'), as observed in Madras Crocodile Bank Trust (Whitaker 1989; Whitaker and Whitaker 1984). It probably reflects a more secure environment and steady supply of nutritional resources in captivity, high temperatures and potentially the capacity for sperm storage.



With HCC becoming a critical factor in crocodile management programs worldwide in recent decades, we also consider the HCC situation of Muggers, as already briefly mentioned for Iran before. As crocodiles are more aggressive during the breeding season, most attacks are also recorded (De Silva 2013; De Silva *et al.* 2013; Vyas and Stevenson 2017). People and wild animals compete for resources, increasing the incidence of HCC, with direct attacks by crocodiles on humans and livestock. HCC with Muggers has increased exponentially in the past decade within India; 57 attacks (33 fatal, 24 non-fatal) reported between 2001 and 2010 and 338 attacks (134 fatal, 204 non-fatal) between 2011 and 2020 (CrocBite 2020). India's human population has increased from 1.23 billion in 2010 to 1.38 billion in 2020, and the Mugger populations in many areas across India are also growing (Stevenson *et al.* 2021). This is a situation that will result in increasing contact and conflicts between humans and crocodiles.

HCC remains one of the most important subjects regarding the management of the species in Iran, especially given that most human settlements are in proximity to natural ponds. Muggers also occupy artificial ponds inside the villages (called "Hootak"). Due to shortage and lack of water pipelines or unsuitable management of water supply, most of the local people are dependent on the outdoor water bodies for daily usage like washing, bathing, and drinking water. Moreover, when the livestock of poor villagers are attacked and eaten by crocodiles, it is an economic loss. The number of attacks on humans is relatively low, 2-3 non-fatal attacks annually in recent years. However, as the victims are mostly children, losses of body parts like arms and hands are commonly the consequence. As a result, it annoys local people and weakens their traditional beliefs and respect for crocodiles. Fortunately, people of Iranian Baluchestan, based on religious and cultural beliefs, respect crocodiles, and fortunately, there is no harvest on Muggers in Iran as already pointed out above.



Figure 10. Muggers feeding on fish in Sri Lanka (top) and the Kutch/Gujarat region in India (bottom). Photographs: R. de Silva (SL) and Dax Pandhi (I).

In Sri Lanka, Muggers have long been a known threat to local people, and as far back as the 1100s, one could not pass through the deep waters of some tanks due to the 'man-eating crocodiles' (Gieger 1929). De Silva (2010, 2013) and De Silva *et al.* (2013) covered HCC in Sri Lanka comprehensively after the first island-wide survey of crocodile attacks, finding that 80% of the 177 attacks investigated were on people whilst they washed or bathed in the community tanks. Crocodile Exclusion Enclosures, traditionally used by people in the southern wet zone of the island, were erected in the northern

dry zone tanks. Thirty wire mesh enclosures were installed at locations where Mugger attacks had occurred, a simple but effective way of protecting people and livestock, and reducing retaliatory killing of crocodiles (Somaweera and De Silva 2013).

In Pakistan, Mugger attacks are infrequent, yet these largely remain underreported, especially in areas in which the locals directly depend on the water resources for their daily use. In 2006, at Haleji Lake, a child was killed, and 8 other villagers sustained injuries, along with a number of attacks on livestock. In August 2020, two teenage girls, who were doing laundry at the village Allah Dino Mahar bank in Nara Canal near Salih Pat (Sukkur District), were attacked by a Mugger. Two girls, aged 8- and 4-years-old, were killed by crocodiles in 2020 and 2021 in the Nara canal, respectively. Around 16 Mugger attacks were recorded in the Sindh Province over the last 10 years. Some non-fatal attacks have been recorded from the Lodeeg Aap habitat in Gabdh village and Balochistan (CrocBITE 2021).

Our preliminary threat analyses revealed that socio-cultural differences are associated with the Mugger, and threats slightly differ regionally. Furthermore, in part, conservation measures are not sufficient and need a comprehensive overhaul.

It seems that in westernmost populations and ranges, in Iran-Pakistan, extreme weather conditions, prolonged drought, unseasonal flooding, and increasing temperatures impose considerably unfavorable conditions for the declining population of crocodiles, and cause the destruction of the species' habitats. Eventually, it needs to be addressed explicitly with science-based conservation plans and measures to mitigate the effects on the ecology and population of the crocodiles in the area.

To improve the conservation situation of this flagship species of the southwestern and southern Asian wetlands, we herein recommend:

- Modeling of effect of climate change on habitats and the species, to provide early warning for proper management measures.
- Conducting urgently needed biological and ecological studies to improve our knowledge of the species, including reproduction success and population status.
- Supporting *ex-situ* conservation programs and promoting sustainable use schemes. For example, such an approach has been known for a long time in India (since the 1970s) but has never been supported at the governmental level. This and related issues, also in several other countries, certainly require further efforts.
- Advancing close cooperation of the range states to develop conservation and research programs as well as educational plans.
- Implementing public education and awareness activities to increase the knowledge on the importance of crocodiles to reduce human-induced threats and HCC, as exemplarily executed in Gujarat (Voluntary Nature Conservancy 2021).

- Providing financial support, if possible, for *ex-situ* and *in-situ* conservation programs.
- Developing and implementing management strategies for the recovery of the Muggers in affected sites, including ranching and releasing surplus crocodiles into suitable environments and ongoing monitoring activities.
- Developing a long-term (10+ years) population monitoring program and recovery plan for the entire range of the species.
- Evaluating the success of strategies as mentioned above and conservation targets of Mugger populations regularly

Our course of action is another application of the 'One Plan Approach', which is supported by the IUCN and aims to develop integrative strategies to combine *in-situ* and *ex-situ* measures with groups of experts for improved species conservation. Moreover, even in times of the recent COVID-19 pandemic, with limited options and challenging travel logistics, the experts can build up a team to establish a global network for upscaling the conservation-based research at national and regional levels. The collaborative conservation efforts at the global level will help protect wildlife species and their natural habitats. These collective efforts will allow the threatened, endangered and protected (ETP) terrestrial wildlife species to live in harmony in their natural habitats while maintaining balanced and healthy ecosystems.



Figure 11. Mugger feeding on a pangolin in Sri Lanka. Photograph: J.M. Probst.

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## India

ATTACK ON RHESUS MACAQUE (*MACACA MULATTA*) BY FEMALE ESTUARINE CROCODILE (*CROCODYLUS POROSUS*) IN BHITARKANIKA NATIONAL PARK, ODISHA, INDIA. Bhitarkanika National Park (BNP) in Odisha, India, has the distinction of having the largest population of Estuarine crocodiles (*Crocodylus porosus*) in the country. The January 2021 census recorded 1768 crocodiles in various size classes in the river systems of BNP, including about 300 adults (Kar 2021). Through implementation of the FAO/UNDP, Government of India and State Forest Department Project, "Crocodile Breeding and Management" in early 1975, the mangrove habitat has been well protected, and the crocodile population, as well as other wildlife species, including prominent mammalian fauna, are increasing in abundance.

Occasional attacks by crocodiles on wild Sambar deer (*Rusa unicolor*), Spotted deer (*Axis axis*), boar (*Sus scrofa*), Otter (*Lutra perspicillata*) and Indian porcupine (*Hystrix indica*) have been recorded in BNP (Kar 1985, 1999). Here, I report on the first recorded attack on a Rhesus macaque (*Macaca mulatta*) in BNP.

Rhesus macaques are arboreal in nature, but they frequently go onto river/creek banks to eat tender shoots and tubers of grass species, especially Nalia grass (*Myriostachya wightiana*). At times, they come very close to the water in search of food, and have also been sighted crossing rivers/creeks in troupes, even during high tides.

During routine patrolling in the Bhitarkanika River in early February 2021, we observed a known female Estuarine crocodile of around 2.4 m total length suddenly emerge from a submerged position in the water with great force, and catch a full-grown Rhesus monkey by its neck (Fig. 1). The macaque had been about 0.6 m from the water's edge, feeding