

Chairs were working on forming the network since August 2021. There have been regular meetings and discussion sessions to share knowledge and experience, as well as build collaborations and friendships. There are currently 40 members from 5 Asian countries, and we look forward to welcoming members from more countries moving forward.

For our inaugural expert speaker event in February 2022, we were delighted to be joined online by Romulus Whitaker (Fig. 1), who talked us through his remarkable journey of 50 years working with crocodilian conservation across various countries. Anslem de Silva kindly wrote a note on the inception of the network, supporting its activities and creation. Soham Mukherjee gave a talk in March 2022 on crocodilian behaviour as a part of his captive work with crocodilian enrichment and projects involving conservation and conflict mitigation. In April 2022, Gowri Mallapur shared insights into her professional journey as a veterinarian and herpetologist working with crocodilians and other reptiles across India. Most recently, Nikhil Whitaker gave a talk sharing his academic journey as well as his journey as a researcher and head curator at the Madras Crocodile Bank Trust. We look forward to welcoming Rob Stuebing as our forthcoming speaker in August.



Figure 1. Participants at first ECCN expert speaker event, featuring Rom Whitaker.

Our plans for ECCN members in the near future are:

1. To have sessions where members break into smaller groups to discuss their projects and share ideas. The aim is to develop positive collaborations and have a chance to get to know one another.
2. To provide a forum for members to present their work to others, to get constructive input, and also as a way of practicing presentation and discussion with peers in advance of presenting to other audiences.
3. To have online workshops on project planning, grant writing, to help members develop projects and gain funding. We also plan to eventually raise funds to support members' work on early career projects, helping them to develop and run their projects.

The ECCN network is open to anyone in the early career stage in Asia, currently working on crocodilians for research, conservation, or education (including veterinary and conflict mitigation). If that sounds like you, please find us through our

website ([www.earlycareercroc.net](http://www.earlycareercroc.net)) and apply to join.

We define the “early career stage” as that applying to people early in their career academically and non-academically, who are trying to run their projects under the niche of research, education, and conservation. Early career is not age-dependent but experience-dependent. People who are less experienced (less than 8 years in the field) in comparison to well-established individuals (8+ years in the field). We try to get well-established individuals to give talks to the ECCN members, and try to make a bridge between established individuals to share their knowledge and guidance to the newcomers in the field that encourages them to work on crocodilians.

If you are not-so-early career but would be happy to give an expert talk or panel session in the future, we would be delighted to host you, so please get in touch by e-mail ([earlycareercrocnetwork@gmail.com](mailto:earlycareercrocnetwork@gmail.com)). We are especially keen to reach out to students and individuals in Asia to participate in this network. We would be grateful if you are a CSG member from Asia and could be able to highlight this opportunity to students and early-career professionals working with crocodilians, who you may know.

Phoebe Griffith ([phoebe.griffith@zsl.org](mailto:phoebe.griffith@zsl.org)) and Brinky Desai ([brinky.d@ahduni.edu.in](mailto:brinky.d@ahduni.edu.in)), *Early Career Crocodile Network for Asia* ([earlycareercrocnetwork@gmail.com](mailto:earlycareercrocnetwork@gmail.com)).

## India

**STATUS OF *CROCODYLUIS PALUSTRIS* IN KUTCH DISTRICT, GUJARAT, INDIA.** The Mugger (*Crocodylus palustris*) population in the state of Gujarat was previously estimated to comprise around 1500 individuals (Vyas 2013), and increasing (De Silva and Lenin 2010). Based on a 1997 survey at a limited number of sites, the Kutch district of Gujarat (Fig. 1) was reported to have an estimated total population of 176 Muggers (Vyas and Stevenson 2017). The Kutch district is the largest in India, with an area of 45,674 km<sup>2</sup>, and with an arid environment with very little regular rainfall and frequent droughts (Pai *et al.* 2014).

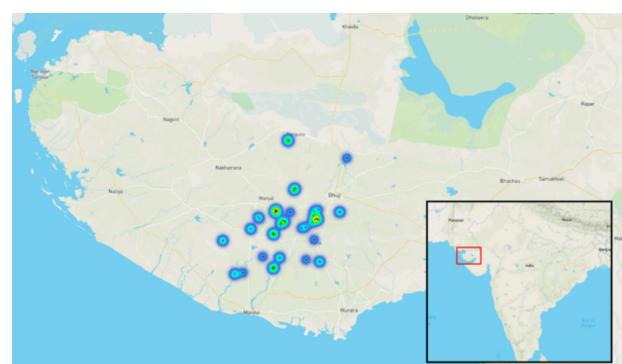


Figure 1. Kutch district, with hotspots denoting the largest crocodile populations.

There had been no systematic investigation or research on

Muggers in Kutch since 1999. Between 2012 and 2020 we conducted regular observations of various crocodile populations in central Kutch. We conducted surveys at various “known” crocodile sites to gather new data, and also investigated previously unexplored crocodile habitats.

In 2018, we started augmenting our ground surveys with a “DJI Phantom 4 Pro v2”, a widely used drone. We hoped that frequent medium-low altitude flights would help us get a better estimate of the populations than ground surveys alone, as the geography would not always allow for clear observations without disturbing the animals (Figs. 2 and 3). Drone flights also revealed several previously unrecorded water bodies supporting crocodile populations that were virtually inaccessible by foot. An additional advantage of aerial surveys is the higher subsurface visibility from the incident light angle, which allows for better detection of partially, and sometimes completely, submerged crocodiles, depending on the turbidity of the water. We surveyed connected water bodies with multiple flights at different times of the day and within a maximum period of 4 days to prevent data inaccuracies from minor migrations.



Figure 2. Muggers detected in a portion of observation map created from a drone flight.



Figure 3. Larger sites, such as Nara Dam, required drones for effective surveys.

One of our secondary goals was to create methods of drone observation that allow getting relatively close to crocodiles

without disturbing them. These methods have allowed us to not only get higher accuracy while counting, but also to approach crocodiles in remote places to examine them visually and assess their physical condition (Fig. 4). These methods have also been useful in providing preliminary data for dorsal scute pattern-based identification (Mukherjee *et al.* 2020). Some of our observation and process videos were annotated and included in the CSG Virtual UAS Workshop 2020 (<http://www.iucncsg.org/pages/Virtual-UAS-Workshop.html>) and additional footage is available on YouTube (<http://youtube.com/pandhiorg>).



Figure 4. Low-altitude sighting of a Mugger from a drone, and which was not visible from the ground.

Based on the findings from these flights and exploration on the ground, we decided on a list of potential sites for a large-scale survey covering the majority of Kutch’s habitable areas. We presented the plan to the Forest Department, which was keen to expand its data on this protected species, as well as use this opportunity for spreading awareness about Muggers.

In cooperation with the Kutch (West) Forest Division, we organized a citizen science initiative to carry out the first wide-scale crocodile survey of the region. We invited anyone interested in the initiative to volunteer, and more than 200 citizens volunteered from across the state. From these, 120 volunteers were chosen based on local COVID-19 regulations and logistic limitations. A high proportion of the volunteers comprised seasoned naturalists, zoology students from Kutch University, and experienced wildlife enthusiasts. We were pleasantly surprised to find several dozen volunteers were ordinary citizens from various walks of life with very little or no prior experience with crocodiles, including engineers, dentists, programmers, air force personnel and businessmen. Over 20 Forest Department personnel also participated in the survey. Volunteers were trained in observation and documentation techniques and taught how to approach crocodile habitats with both their and the animals’ safety in mind.

Although our projects suggested that there were over 250 crocodile sites in Kutch, we restricted surveys to 186 sites; 120 sites based on our active map of crocodile habitats and recent documented activity, and an additional 66 sites based on Forest Department recommendations (Fig. 5). Manpower limitations, logistics and safety concerns were also taken into account in deriving this initial list of sites. Water bodies in this region usually dry out within a month or two of rainfall, as winter temperatures during the day are quite high ( $>30^{\circ}\text{C}$ ). Most smaller water bodies tend to dry out by October.

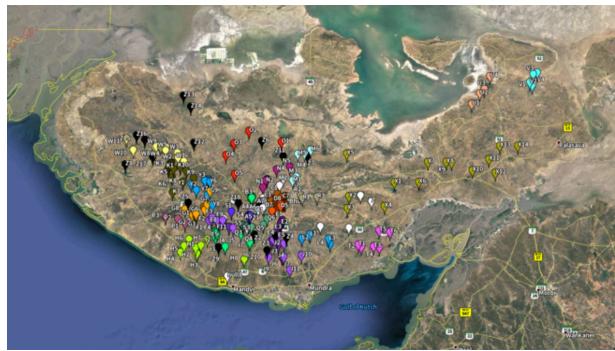


Figure 5. Sites designated for the Crocodile Status Survey.

The survey was carried out in late-February 2021, primarily during the day to conform to COVID-19 regulations. The volunteers were divided into teams and assigned individual site clusters. Most sites were surveyed once, but 13 key sites were surveyed multiple times within that week to correct any irregularities in sightings or to clarify ambiguous data, and 20 key sites were also surveyed by drone for additional accuracy or if they were too difficult to reach on foot.

Volunteers submitted extensive photographic and video evidence of observations, habitat details, and elements related to potential or active conflict. Over 1TB of data was collected from the survey, which was sifted and verified by our team and Forest Department personnel. Our team at the Mahim Pandhi Wildlife Foundation created custom software applications to analyze the collected data as well as drone observations. This data will also be used to seed further aerial automation methods for observations and surveys.

Table 1. Results of surveys. Totals (N= 113) refers to those sites recorded as containing Muggers.

Division	No. of Sightings	No. of Sites	Area (km <sup>2</sup> )	Rel. Density (ind./km <sup>2</sup> )	Mean Ind./site
Bhuj	236	60	5936	0.040	3.9
Mandvi	125	27	1573	0.079	4.6
Nakhatrana	33	12	2135	0.015	2.8
Abdasa	9	8	2535	0.004	1.1
Mundra	5	6	1098	0.005	0.8
<b>Totals</b>	<b>408</b>	<b>113</b>	<b>13,277</b>	<b>0.031</b>	<b>3.6</b>
<b>Totals</b>	<b>408</b>	<b>163</b>	<b>22,196</b>	<b>0.018</b>	<b>2.5</b>

Results of surveys are summarized as:

1. A total of 408 crocodiles was sighted at 113 of the 186 sites surveyed (Table 1), and no crocodiles were sighted at 50 sites (23 sites were considered non-viable because of recent human interference such as excavation for building materials or aggressive water pumping by nearby farms).
2. Relative density was 0.031/km<sup>2</sup> for the 113 sites at which Muggers were sighted. Including the 50 sites at which none were sighted, the overall relative density for 163 sites was 0.018/km<sup>2</sup> (Table 1).
3. Numbers of Muggers per site varied between 0 and 180 (mean= 2.5/site, N= 163 sites), with the largest population (180) recorded in Pragsar Lake at Chadva Rakhaal.
4. An additional 421 Muggers were reported from survey sites, based on multiple sources of information, including local naturalists, wildlife enthusiasts, residents at various sites who have encountered the crocodiles first-hand, and Forest Department staff who cover these sites in their regular duties.
5. Approximately 60% of sightings were in small ponds. Larger populations were found only in dams and reservoirs, as Kutch has no perennial rivers.
6. 30% of crocodiles were within 1 km of human settlements, while 7% were residing within settlements themselves.
7. According to Forest Department records, there have been no human fatalities recorded in several decades. Kutch has the lowest number of human-crocodile conflicts (Vyas and Stevenson 2017) in Gujarat. While there are a high number of Muggers rescued every monsoon and summer, actual attacks on humans and fatalities have not been recorded. One “fatality” recorded in the past 20 years, was later determined by the Forest Department to be a natural death after examination of the body. Inversely, there are frequent crocodile deaths on roads and railways (Vyas and Vasava 2019).
8. Muggers of Kutch have shown a remarkably low level of aggression relative to their counterparts on mainland Gujarat, Tamil Nadu, etc. This observation has been confirmed by people who live near crocodile habitats, as well as Forest Department personnel who work with crocodile rescue and release. We found that most people living near crocodile habitats, or where crocodiles lived within central village ponds, were quite tolerant of the animals and did not consider them a danger or a nuisance (Fig. 6).
9. At least 54% of sites were polluted with plastic waste (Fig. 7) and 36% of sites had unsafely discarded industrial materials. Some residents near a river that hosts over 30 crocodiles claimed that it was a dumping ground for a chemical company. Many crocodile populations that are near or sometimes within temples, or near settlements built around temples, are exposed to very high levels of pollution, especially plastic refuse and small statues and

idols often painted with paint containing lead.



Figure 6. Fisherman spreading a net as a crocodile swims nearby. This water body contained 16 adult Muggers.



Figure 7. Mugger observed repeatedly biting a plastic bag.

10. 44% surveyed sites were within 500 m of wind turbines.

In central Kutch, effective areas for wind turbines seem to intersect deeply with the largest clusters of crocodile populations. In the 12+ months since the survey, an additional 40 turbines and associated service roads were constructed in this region. We have recommended further study of these areas and the impact of wind turbine installations on the habitat, as well as the potential for conflict, to the authorities.

11. Kutch is seeing accelerated growth, which in turn is causing large-scale, aggressive habitat loss for wildlife; 62% of surveyed sites were within 500 m of ongoing construction.

12. Water is a hotly contested commodity in this arid region.

Farmers near ponds and reservoirs employ aggressive, unregulated water pumping. This leads to early depletion of the water bodies ahead of the dry season. At least 25% of surveyed sites had at least one water pump.

13. Feral dogs were routinely observed, both during the survey (at 49% of surveyed sites; Fig. 8) and in our observations over the last 6 years, to predate on crocodile nests and hatchlings as they get better access from the plummeting water levels.



Figure 8. Feral dog preparing to attack a juvenile Mugger.

## Conclusions

The Mugger population in Kutch district is estimated to be around 1000 individuals, which is significantly higher than the previous 1997 estimate of 176 animals (Vyas and Stevenson 2017). However, crocodiles and their habitat remain vulnerable. We believe there are at least 50 additional sites that need to be investigated, especially closer to the desert.

The survey also indicated widespread destruction of crocodile habitats. We intend to repeat the survey at regular intervals, and are currently investigating additional sites and data points to increase the efficacy of the next survey.

Authorities are using the survey data to improve protection of crocodile habitats and rescue and release operations. Data from the survey has also been useful for broader conservation efforts for crocodiles (Mobaraki *et al.* 2021), as well as our own ongoing behavioural studies. We hope to share results from these studies in the near future.

## Acknowledgements

We would like to thank the Kutch (West) Forest Division and Deputy Conservator of Forests Dr. Tushar Patel, for their cooperation and extensive support, the Forest Department staff for providing additional data, observations, and relevant information from patrols and rescues, and all the volunteers who helped execute this survey. We would also like to thank Rom Whitaker, Nikhil Whitaker and Madras Crocodile Bank and Trust for their support, guidance, and encouragement.

## Literature Cited

De Silva, A. and Lenin, J. (2010). Mugger Crocodile *Crocodylus palustris*. Pp. 94-98 in Crocodiles. Status Survey and Conservation Action Plan. Crocodile Specialist Group: Darwin, Australia.

Mobaraki, A., McCaskill, L., Schepp, U., Abtin, E., Masroor, R., Pandhi, D., Desai, B., Mukherjee, S., Rasheed, T., Razzaque, S.A., de Silva, A., Stevenson, C., Rauhaus, A., Le, M.D., Rödder, D. and Ziegler, T. (2021). Conservation

status of the Mugger (*Crocodylus palustris*): Establishing a task force for a poster species of climate change. Crocodile Specialist Group Newsletter 40(3): 12-20.

Mukherjee, S., Ghosal, R., Datt, M. and Desai, B. (2020). Preliminary assessment of use of dorsal scute patterns to identify wild muggers in human-dominated landscapes of central Gujarat, India. Crocodile Specialist Group Newsletter 39(2): 15-18.

Pai, D.S., Rajeevan, L.S.M., Sreejith, O.P., Satbhai, N.S. and Mukhopadyay, B. (2014). Development of a new high spatial resolution long period (1901-2010) daily gridded rainfall data set over India. MAUSUM 65(1): 1-18.

Vyas, R. and Stevenson, C. (2017). Review and analysis of human and Mugger crocodile conflict in Gujarat, India from 1960 to 2013. Journal of Threatened Taxa 9(12): 11016-11024.

Vyas, R. and Vasava, A. (2019). Mugger crocodile (*Crocodylus palustris*) mortality due to roads and railways in Gujarat, India. Herpetological Conservation and Biology 14(3): 615-626.

Dax Pandhi<sup>1</sup>, Parvez Ansari<sup>2</sup> and Himani Shah<sup>3</sup>; *Mahim Pandhi Wildlife Foundation, Bhuj, Gujarat, India*; <sup>1</sup>dax@pandhi.org; <sup>2</sup>parvez@pandhi.org; <sup>3</sup>himani@pandhi.org.

**REVIVAL OF NATURAL BREEDING OF GHARIAL (*GAVIALIS GANGETICUS* GMELIN, 1789).** Odisha is the only state of India with all three species of crocodilian; Gharial (*Gavialis gangeticus*), Mugger (*Crocodylus palustris*) and Saltwater crocodile (*Crocodylus porosus*). The Mahanadi is one of the major rivers of India, and the southernmost distribution of the critically endangered Gharial. Once found throughout the entire Mahanadi River, only five Gharials (2M: 3F) were sighted in a survey in 1974, in the Satkoshia Gorge, lapped between the Eastern Ghat Hill Range on its south and Chhotanagpur Plateau on the north. To conserve the Gharials, a rearing centre was established at Tikarpara and a captive breeding centre at Nandankanan Biological Park, Bhubaneswar, in 1975.

From 1977 to 2017, 860 Gharials were released into the Mahanadi River, but survival was disappointing, with only 8 Gharials being recorded in 2018-19. The major threats to survival appear to have been deleterious fishing activities, disturbed habitat, and perceived interspecific conflict between Gharials and Muggers (Maharana and Mohapatra 2021).

At present, five Gharial subpopulations [Chambal River; Katerniaghata Reservoir (Girwa River); Chitwan National Park, Nepal; Corbett National Park; Gandak River] are breeding in the wild, and nesting of the subpopulation in Bardia National Park (Nepal) is expected in the future. The Gharial population of the Mahanadi River was included as one of eight minor sites with no evidence of breeding in the recent past (Lang *et al.* 2019).

Tikarpara rearing centre ceased producing hatchlings by 1981 and Nandankanan Biological Park continued breeding and releasing Gharial into the Mahanadi River, but there arose a need to rethink the release program in 2019. A new project named “Species Recovery of Gharial (*Gavialis gangeticus*, Gmelin) in the River Mahanadi” was implemented with stricter conservation measures. This ambitious project was conceptualized and commissioned in July 2019 (Paul 2019). It has provision for an updated assessment of Gharials in the Mahanadi River and evaluation of problems affecting their survival. The present situation demanded some unprecedented steps, with the involvement of 10 Divisional Forest Officers on either side of the Mahanadi River, from the Hirakud Dam to the Bay of Bengal, for: rigid protection; enforcement of a “No Fishing Zone” in 10 km of Gharial habitat in the Satkoshia Gorge where the present Gharial population exists; spreading awareness among local people; provision of compensation for damaged fishing nets; reward of Rs. 1000 on return of live Gharial caught in nets; and, a comprehensive study of river physiography, Gharial ecology, and monitoring of dispersal and survival of transmitter-fitted Gharials.

The last Gharial nest in Satkoshia Gorge was recorded in 1981, 2 km downstream of the Tikarpara rearing centre at Ramagaonbali, on the left bank of the river. The nest was found open with broken egg shells, and with no evidence of hatchlings. With implementation of the project and stated interventions, the habitat at Satkoshia Gorge became amenable for Gharial breeding. Courtship was observed in November and December of 2019 and 2020, that resulted in 28 hatchlings from 28 eggs in one nest on 22 May 2021 (Fig. 1).



Figure 1. Excavated nest, female Gharial and hatchlings in the Mahanadi River. Photograph: R.K. Mohapatra.

The first female Gharial to breed in captivity, in 1980 at Nandankanan Biological Park, laid 25 eggs (Bustard and Maharana 1980, 1985), compared to the wild Gharial in 2020 that laid 28 eggs. The wild nest was located in sand on the left (northern) bank of the Mahanadi River, 13.5 m away from the water's edge, at a height of 7 m from the water surface. Its circumference was 2.5 m, and depth of the excavated nest was 70 cm, and contained roots of nearby trees (*Barringtonia*