Geographical Occurrence of Mugger Crocodile (*Crocodylus palustris*, Lesson 1831) across Goa with special emphasis on Nesting assessment and cultural significance

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By

VAISHNAVI RAJESH NAIK

21P044026

Under the supervision of

Dr. NITIN S. SAWANT

School of Biological Sciences and Biotechnology

Discipline: Zoology

GOA UNIVERSITY

APRIL 2023

Examined by:

Dr. Minal Shirodkar 09/05/23

Dr. Shanti N. Dessai

9/5/2023 [Dr. Shamshad Shaikh]

Dr. Ardyo D'Costa.

Dr. Nitin S. Sawant

(Mrs. Gandhita Kudaikar) (Dr. Preeti Pereira)

Seal of the School

SBSB, M.Sc., Zoology
Taleigao Plateau, Goa 403206
GOA UNIVERSITY

DECLARATION BY STUDENT

I hereby declare that the data presented in the Dissertation report entitled, **"Geographical Occurrence of Mugger Crocodile (*Crocodylus palustris*, Lesson 1831) across Goa with special emphasis on Nesting assessment and cultural significance"** is based on the results of the investigations carried out by me in the Discipline Zoology at the School of Biological Sciences and Biotechnology, Goa University under the supervision of Dr. Nitin S. Sawant and the same has not been submitted elsewhere for the award of a degree or diploma by me. Further, I understand that Goa University or its authorities will not be responsible for the correctness of the observations/ experimental or other findings given the dissertation.

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Vaishnavi Rajesh Naik

21P044026

Discipline Zoology

School of Biological Sciences and Biotechnology

Date:

Place: Goa University

COMPLETION CERTIFICATE

This is to certify that the dissertation report **"Geographical Occurrence of Mugger Crocodile (*Crocodylus palustris*, Lesson 1831) across Goa with special emphasis on Nesting assessment and cultural significance"** is bonafide work carried out by Miss. Vaishnavi Rajesh Naik under my supervision in partial fulfillment of the requirements for the award of the degree of Masters of Science in the Discipline Zoology at the School of Biological Sciences and Biotechnology, Goa University.

Date: 24/04/23

Dr. Nitin S. Sawant
Assistant Professor
Discipline: Zoology

Prof. Savita Kerkar 24/4/23
Dean
School of Biological Sciences and Biotechnology
Date:
Place: Goa University

SBSB, M.Sc., Zoology * GOA UNIVERSITY * Taleigao Plateau, Goa 403206
School Stamp

Dean of School of Biological Sciences
& Biotechnology
Goa University, Goa-403206
Office Ph. 8669609246

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INTRODUCTION

The ferocious apex predators of the Freshwater Ecosystem and the largest semi-aquatic reptiles known to inhabit the planet Earth, are the Crocodiles. According to the Indian Mythology, Crocodiles, popularly known as 'Magar-mach' is considered as the ride of River Goddess Ganga and The God of ocean and rain, Varun Dev (Patil, S. R., 2012). From the fossil records it has been reported that the first crocodile-like ancestors appeared about 240 million years ago (Rao 1994; Masum, K. M., et al., 2012).

Globally found 27 extant crocodilian species (Hekkala et al., 2011; Shirley et al., 2013, 2018; Murray et al., 2019; Stevenson 2019; Chavan & Borkar 2022), contribute to the occurrence of three species in the Indian subcontinent; *Crocodylus porosus* (Schneider, 1801) known as Saltwater Crocodile, *Gavialis gangeticus* (Gmelin, 1789) known as Gharial and *Crocodylus palustris* (Lesson, 1831) known as Mugger Crocodile. The Order Crocodilia includes three families; Family- Crocodylidae (The True Crocodiles), Family- Alligatoridae (The Alligators and Caimans) and Family- Gavialidae (The Gharial and False Gharial). Most widely and commonly found species amongst them in India is the *C. palustris* which was, Whitaker (1984) & Whitaker (1987) reported in India, at highest altitude of 420m a.s.l. in Corbett Tiger Reserve, however according to Daniel (1983) & Rao (1993), Mugger Crocodiles are found even at the altitude of 700m a.s.l in lower hill streams.

Crocodylus palustris is native to India, Sri Lanka, Nepal, Iran and Pakistan (Daniel 2002; Choudhury & de Silva 2013). Past reports emphasize that the Mugger Crocodile wild population is extinct from Bangladesh, Bhutan and Myanmar (Zafar, M., & Malik, M, F., 2018). During the late 1960's, the occurrence of this species declined across its entire distributional range due to increasing Human-induced threats, such as fishing, illegal hunting

and Habitat loss (Whitaker and Andrews, 2003). Throughout India, Mugger Crocodiles are found in altogether twelve states (Joshi et al., 2011). According to a recent updated information by Wildlife Institute of India (WII), Mugger Crocodile distribution is spread across 15 states in India. The wild population of *C. palustris* is roughly estimated as 2500 to 3500 non-hatchlings (Whitaker and Andrews, 2003).

One out of three species of Crocodiles is found in the state of Goa, i.e., the Mugger/ Marsh/ Swamp Crocodile. Several studies were and are still being conducted on this species in accordance to their ecological, eco-theological, contemporary status, territorial defense, conservation and many other facets. Goa's freshwater habitats favor the suitability to Mugger crocodile existence. The shallow water banks, sluice gate, Bundhs and isolated mining pits are assuring the nesting safety to the ferocious *C. palustris.* Ethnically, Crocodiles have owned their place in community conservation efforts. The famous and unique ritual of 'Maange Thaapni' in Goa, attracts many herpetologists, wildlife conservationist; environmentalist and budding researchers to highlight this, age-old uncharted tradition. Many organisations and Departments like Goa Forest Department (GFD), Animal Rescue squad, Mugger Tales and Study and Awareness of Wildlife and Environment (SAWE) are committing their valuable efforts towards awareness and conservation of this freshwater natatorial crocodile.

The Marsh/ Mugger Crocodile is a keystone species which balances and maintains the structure and function of Freshwater Ecosystem (Chang, et. al., 2013). *C. palustris,* is A True Crocodile with broad snout, medium sized body who prefers stagnant and stumpy water and inhabits all forms of freshwater habitats like lakes, marshes, artificial ponds, rivers, artificial

reservoirs, irrigation canals, hill streams and recently, even the coastal saltwater lagoons and estuaries (Whitaker & Andrews, 2003; Whitaker 1987; Whitaker and Whitaker, 1989; Zafar, M., & Malik, M. F., 2018). They possess great resilience towards aquatic environments with varied saline concentrations (Zafar, M., & Malik, M. F., 2018). Their streamlined body and powerful jaws make them good swimmers and opportunistic carnivores.

The International Union for Conservation of Nature (IUCN) recognizes the Conservation status of Mugger Crocodiles as being 'Vulnerable' species under the Red List of Threatened Species data. In India, it is assigned and protected under 'Schedule 1' category of Wildlife Protection Act of 1972 (Da Silva and Lenin, 2010; Vyas, 2018; Debata, S., 2018). Throughout its range, the mugger is highly adaptable and has been found to co-exist with humans in urban landscapes (Vyas, 2012). *C. palustris* is a carnivorous species that has been thriving in close vicinity to humans, allowing for remarkable case studies of the Human-Mugger Relationships (Vyas, 2018). This poikilothermic amphibious reptile shuttles between land and water to regulate its body temperature and to maintain its thermal demands (Chavan, U. M., & Borkar, M. R., 2022). In the past during 1950s to 1960s, the principal threat to Marsh Crocodile was illegal skin trade along with habitat destruction and fragmentation, drowning in fishing nets, egg predation by people and use of crocodile body parts for medicinal purposes (Groombridge 1982; da Silva & Lenin, 2010).

Chapter 2

REVIEW OF LITERATURE

Over the span of decades, many researchers have worked on the Mugger Crocodiles in different arrays of field studies. Rao in 1994 reported in his paper that via fossil records of Crocodilians, first crocodile like ancestor appeared about 240 Mya. Chang, M.S., et al., (2012) mentioned that *Crocodylus palustris* is a top predator and one of the keystone species in aquatic ecosystem which plays an integral role in preserving the structure and function of fresh water ecosystem. Rathore, H. S., et al., (2021) & Grigg (2015) states that *C. palustris* is one among the 27 extant crocodilian species found across the world. The world-wide population of *C. palustris,* in accordance to the study of Choudhury & de Silva (2013), is dispersed across five countries namely; Iran, Pakistan, Nepal, India and Sri Lanka.

Santiapillai and de Silva, (2000) revised that the historic range of mugger crocodile extended from Iran in the west to Bangladesh in the east, comparing it to the present geographic distribution, occurring throughout the Indian subcontinent from Baluchistan in the west to Assam in the east, and from Nepal in the North to Sri Lanka in the South. Daniel (1983) also recorded Mugger crocodile in Iran and Myanmar however the species in this range is now locally extinct with viable population only restricted to the protected areas.

Romulus Whitaker (1977;1978; 1979; 1984; 1987; 1989; 2003; 2007; 2008) in his subsequent examinations on different aspects and life cycle of *Crocodylus palustris,* conducted their preliminary surveys and studied reproductive biology, Human-Crocodile conflict, Crocodile conservation and management, Crocodile ecology, nesting ecology, etc. Whitaker and Andrew (2003); Whitaker, R., (1987) & Whitaker, R., and Whitaker, Z., (1989), reported that Mugger or so known as Swamp Crocodile occupies all types of freshwater habitats including rivers, lakes, marshes, reservoirs, irrigation canals, man-made ponds and hill streams.

Additionally, they were seen to be well-adapted to coastal saltwater lagoons and estuaries. Da silva and Lenin (2010) specified that *C. palustris* are India's most widely distributed and adaptable crocodilian species, found in both, forests as well as human-dominated areas. Whitaker & Whitaker (1984) & Whitaker (1987) reported the occurrence of *C. palustris* in India from highest altitude of 420m a.s.l. in Corbett Tiger Reserve as well as hill streams of up to 700m a.s.l. according to Daniel (1983) & Rao (1993).

A cumulative study of different researchers testified that India is a home to three crocodilian species. Among the three Indian crocodilian species, Mugger or Marsh Crocodile; *Crocodylus palustris* (Lesson, 1831) is the one with a widespread distribution across the Indian subcontinental region. They are appearing either as secluded populations or communal aggregations in estuarine and riverine ecosystems (Deraniyagala 1939; Whitaker & Whitaker 1989; Da Silva & Lenin 2010). Their distribution is influenced by the density and diversity of prey, accessible nesting habitats, accommodation for juveniles and adults, thermal surroundings, seasonal changes, and competition among species. (Ross, 1998, Holiday and Adler, 1989)

In 1990's and early 2000's, in the state of Goa, Dr. Manoj R. Borkar has worked on ecological, eco-theological, contemporary status, territorial defense, conservation and many such aspects of Mugger Crocodile. Back in 2003, Dr. Manoj Borkar published his chapter on 'Ecological History, Contemporary status and Conservation future of Marsh Crocodile *Crocodylus palustris* in Goa' in the book "Recent Advances in Environmental Science by Dr. K. G. Hiremath. "In 2019, an article published in Goan newspaper by Dr. Manoj Borkar revealed that he published his first ever technical report on Conservation status of Mugger

Crocodiles in the Cumbarjua canal of Goa. He along with his team studied on captive crocodile population in Bondla Wildlife Sanctuary of Goa and recommended measures for enclosure enrichment.

As per the work of Lang, (1976; 1987) the land-water movement of Mugger crocodiles is provoked by light-cued circadian rhythm and the amphibious life of crocodiles. According to Trivedi et al., (2022) study on status of Mugger crocodile and Human-crocodile interaction in Surat, seasonality has been known to influence the animal activity and behavior. According to Whitaker and Whitaker (1979), the plentiful literature review on Mugger crocodiles from salt pans in Sri Lanka states that crocodiles are able to tolerate higher concentration of salt than sea water for long periods. They have associated this inference to the attraction of crocodiles to shallow Salt Lake habitats during drought when fish die in large number because of increase in salinity.

Whitaker & Whitaker, (1984; 1987) studied on Reproductive biology of Mugger and observed that Mugger is a hole-nesting crocodilian species known to dig burrows. The female attain maturity at approximately 1.8-2m body length and lay approximately 25-30 eggs in a single clutch. While in captivity, they lay two clutches per year. The egg-laying takes place during annual dry season with nests built and located at wide variety of habitats. According to the study of B. C. Choudhury, pers. Comm., nests were even built at opening or inside of their burrows. These burrows could also be used to survive the harsh hot climates as per Whitaker et al., (2007). As assessed by Mobaraki, A, et al., (2013), the peak nesting is seen in the month of May and consequently the eggs hatch in July, but the nesting season could be

extended. Choudhury, B. C., (2007) stated that females are sometimes found localized inside or at the opening of the nest burrow.

Mobaraki, A., et al., in 2013, studied on reproductive biology of Mugger Crocodile in Iran and found a total of 13 nests in their study area. They observed that all the nests were positioned in the shade of tree and thick vegetation lining the edges of the water body. The nesting season of *C. palustris* in Iran was observed from April to May. The authors also noted predation on crocodile nests or hatchlings.

Geiger., (1929) translated and reviewed the mentions of crocodiles in the early literatures of Sri Lanka in Buddhist Jataka Stories. As stated by Ganesan, N. (2011; 2016), all crocodilian species in Indian literature are known as makara, and are found in temple sculptures of south India as door lintels, ride of the river Ganges, water spouts of Śiva-sanctums (Shiva-Lingas), and also as makara banner of the love god, Kamadeva. In different languages like Hindi, Gujarati, Marathi, and Sindhi, the crocodile is called ‘Magar’, while in Panjabi and Kashmiri ‘Magarmacch’ and in Bengali and Nepali, ‘Makar’. Telugu literature calls it ‘Makaramu’, while in Tamil it is called ‘Makaram’.

The vedic Hindu literature of Mahabharat mentions the scene, when Draupadi is kidnapped by the king of Sindhu, Jayadratha, she curses him by saying that “You will see the army of yours scattered by the sons of Pandu and all its warriors slain as a jewel-laden ship in the ocean breaks asunder on the back of a makara.” Here she refers to the Saltwater crocodiles representing makara as fantastical sea-monster of the ocean intimidating the mariners with ship wreckage and death. Panchatantra stories talking about makara and monkey are portrayed in Buddhist temples near Borobudur, clearly display makara as crocodile.

Indus crocodile religion in Tamil Nadu symbolizes graffiti from Sāṇūr and Sūlūr as linguistic sign for the crocodile deity in their literature. The names for crocodiles in the Indus region have the Proto-Dravidian root word called, 'Mokaray' from which Sanskrit makara ("mugger crocodile") is derived. In the Indus valley civilization, the crocodile was considered a characteristic of the horned deity and is often shown as a "Master of Animals" in a variety of mass-produced mould and seals.

The review of Athale, U., (2019) discusses about Crocodiles in Hindu Mythology. The fishermen and farmers are linked the closest to this water reptile. The crocodile is referred in many ways in different scriptures. To mention a few, A vehicle of the God, 'Makara' as the name arise, denotes a hybrid creature with jaws of crocodile. It is believed to be the vehicle of River Goddess Ganga, Narmada; God of Rains and Ocean, Varun and God of Love, Kamadev. In astrological science, Crocodile is considered equivalent to Capricorn zodiac sign in Hindu calendar. The story of Gajendra Moksha from Bhagwat Purana mentions Gajendra (The King of Elephants) and a crocodile catching leg of it, as explained by Mr. Devdutt Pattanaik refers to liberation from materialistic love by a soul, after Gajendra offers lotus (devotion) to the Lord. The son of Hanuman (The Monkey Lord) and makara is known as Makardhwaja, who was born when a drop of Lord hanuman's sweat fell into the mouth of makara. In Indian states of Gujrat, Maharashtra, Rajasthan and Madhya Pradesh, temples are dedicated to this god. A blog of Shah, A. (2019) states about earliest depictions of crocodiles across India, which is probably seen in the carvings of Mohenjodaro dynasty, with pictures of crocodile with a fish in its mouth. Makara is also seen to be resembled to the Dark age of Kali Yuga, in Skanda Purana. However, Makara is also considered as the 'Ashtanidhi' (The eight symbols of prosperity) and the 'King of all aquatic species.' The Patel community of Gujrat worships a deity called Khodiyar Mata, which is seen riding a crocodile.

The small state of Goa, holds a famous worshiping ritual of Mugger Crocodile every year. In a newspaper article, the Zoologist and the person who conducted first study of its kind on Goan Marsh crocodile, Dr. Manoj Borkar, attributes its theology to pagan animism. He says that the crocodile is the guardian spirit of the village. In the ritual of Maange Thaapni, crocodile is worship to mollify Varundev.

There exist numerous studies on threats to the population of *C. palustris* across the world. As forementioned, many researchers have noted the threats like increase in agricultural practices, construction of dams, diversion of water channels for irrigation purpose, habitat destruction and fragmentation (Zafar, M. & Malik, M. F., (2018); Da Silva & Lenin, 2010; Groombridge, 1982; Chang, M. S., et al., (2012); Javed and Rehman, 2004) which affects the *C. palustris*.

**Refer Annexure 2 for images of cultural depiction of Mugger crocodile*

Chapter 3

OBJECTIVES

i. To study the geographical occurrence of Mugger Crocodile (*Crocodylus palustris*) across the state of Goa.

ii. Case study to assess the nesting behavior of Mugger Crocodiles at Carambolim Lake.

iii. To understand the cultural significance of Mugger Crocodile and conservations practices of locals in Goa.

Chapter 4

MATERIALS AND METHODOLOGY

Study Area: Across and within the state of Goa, micro- and megafauna dwells peacefully. Occupying the Western India belt with coastline extending along the Arabian Sea, Goa is one among the wealthiest hotspots of Bio-diversity. To amplify the ecological balance and shoreline stabilization, Freshwater Ecosystems are essential. These freshwater ecosystems regulate the food web and contribute a significant role against climate fluctuations. The need of freshwater in Goa is satisfied with the presence of eleven major Rivers namely; Mandovi, Zuari, Terekhol, Baga, Colval, Saleri, Sal, Talpona, Mandre, Harmal and Galjibag. Most of these salient rivers originate from thick forests, sanctuaries of Western Ghats and drain into the Arabian Sea. Depending upon the instabilities occurring within these Rivers and their associated tributaries, riparian wetland undergoes desired changes to form a wetland. Once a wetland is shaped there exist numerous biotic components which co-exist and adapt to the accessible environment, forming different trophic levels and maintaining the balance in food web via energy flow. Among the biotic components, Herpetofauna, and specifically the Crocodiles depend on Aquatic Ecosystem for feeding and breeding purpose.

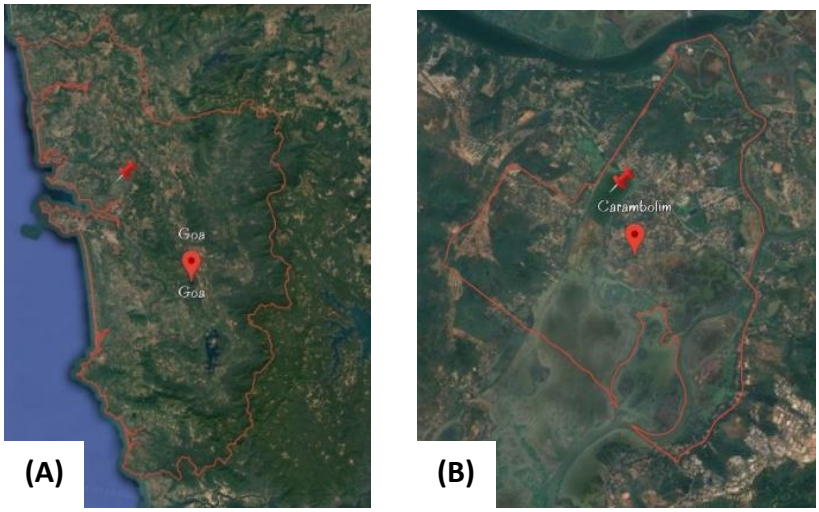


Figure 1: Study area for Objective 1 **(A)** Goa as the study area **(B)** Carambolim Village in Tiswadi Taluka (Source: Google Maps App)

Carambolim Lake is a man-made freshwater lake and a Khajan land, situated 12 km away from the capital city of Panaji. According to ENVIS Centre of Wildlife and Protected Areas, Carambolim lake is approximately spread over an area of 72 hectares and is surrounded by marshy wetland, agricultural fields and dense vegetation. Located within the Tiswadi taluka of North Goa district, Carambolim lake is an Important Bird & Biodiversity Area by being a comfortable abode to many migratory avifauna. It encapsulates varied co-existing forms of faunal and floral interactions. It is an important ecological hotspot in this region. The assessed report of Bird Life International from 2013 asserts that the water depth of Carambolim lake is around 1.5m to 3m, relaying upon season of the year.

Figure 2: Carambolim lake with three marked nesting sites of *C. palustris* (Source: Google Earth Pro)

Data Collections for objective 1: This research is of quantitative and qualitative background as the data is collected and analysed to find patterns, correlations and predictions.

Primary survey: In this survey primary data was collected based on online-interview survey (Ref., Annexure 1) and interactions with locals living in and around Mugger Habitat. Information from rescue teams also aided in locating some of the confirm Mugger crocodile habitats.

Secondary survey: In this survey, locations were manually visited and direct sighting (Debata, S., 2018) and indirect evidences (Joshi, R., et al., 2011) (Chang, M. S., et al., 2012) were searched upon to confirm the presence of Mugger Crocodile and then to report that location as the confirmed habitat of *Crocodylus palustris*. Interactions with nearby locals revealed other important notions of sightings like activity of mugger in water, water dependency of locals, fishing practices, etc. Using GPS camera app and DSLR camera, Geo-tagged images were captured of the specific locations and of mugger activity.

Data Collections of objective 2:

Day-time Ground based Survey: By referring to the methodology of Joshi, R., et al., (2011) for the second objective, regular visits to sites (ref, Figure 3) were carried out (Patil, S. R., et al., 2012) only during active nesting behavior of Mugger Crocodile. This data was collected as a part of animal monitoring activity. Weekly twice in a month, the habitat was monitored for specific duration of the year. Monthly observations were noted and analysed. The site was visited twice a day i.e., 7:30 AM to 8:30AM and 4:30PM to 5:30PM to note any nesting related behavior and predatory interactions. Using Celestron 71256 G2 10x50 Up-close Wide-Angle Porro Binocular, Sony Handycam HDR-CX350 and Canon EOS 1200D direct observations were noted.

Data Collections of objective 3:

To achieve the third objective, interactions with targeted locals were done on the day of rituals; People from same background/ experience gathered on the day of ritual and a descriptive group- discussion with Fisherman and farmer communities, helped gather the data. Newspaper articles, information from forest officials, Wildlife rescue committees and research scholars, were helpful in analyzing the data.

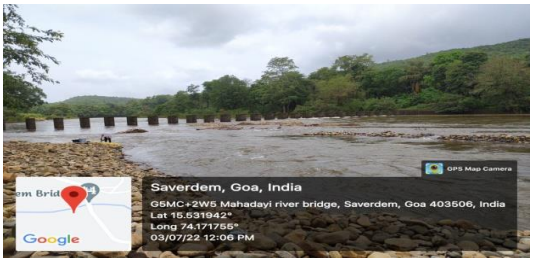
Different Parameters assessed to confirm a site as Mugger Crocodile habitat

a) Types of Aquatic Habitats used by Mugger Crocodile

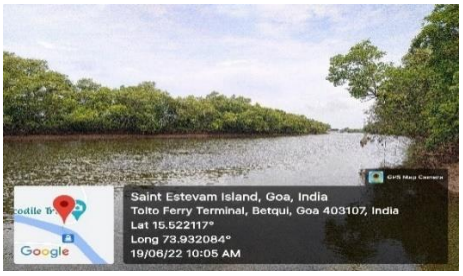
Mining Pit

Sluice Gate

Lake



River



Mangrove

Stream

Figure 3: Different habitat types of *Crocodylus palustris* reported in Goa

b) Indirect signs of Mugger Crocodile

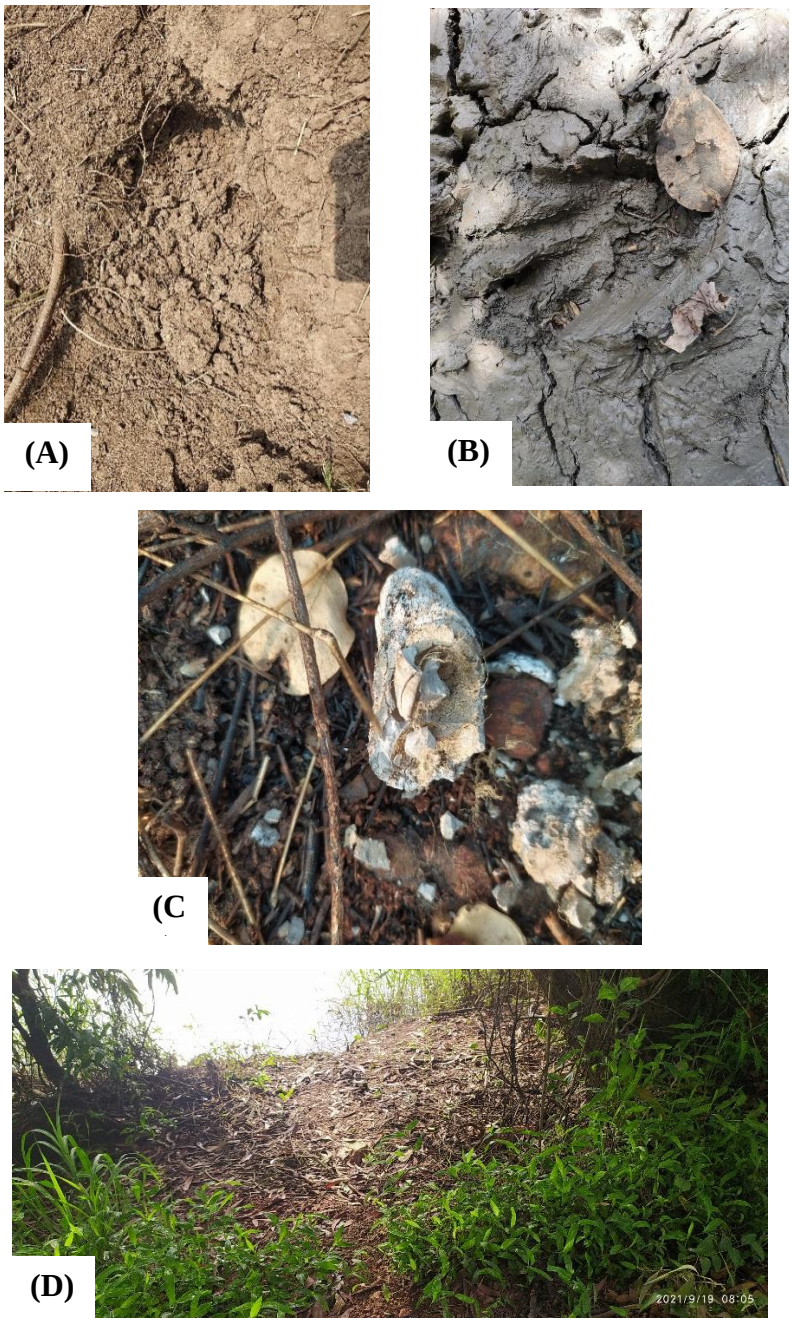


Figure 4: Different Indirect evidences used to confirm a crocodile habitat. **(A)** Abandoned Nest at Aksan, Madkai **(B)** Footprints of Mugger crocodile; **(C)** Scat spotted at Dhaddo manas **(D)** Basking site of Mugger crocodile

Chapter 5

RESULTS AND OBSERVATIONS

Geographic Occurrence of Mugger Crocodile across Goa

Table 1: Recording of Mugger Crocodile occurrence in different type of water bodies across Goa. Information also mentions the coordinates and source of data collection.

Sr. No.	Name of the place	Taluka	Latitude	Longitude	Water body type	Type of data
1	Satarda Bridge, Naibag	**Pernem**	15.736207	73.805375	River*	Reported by locals
2	Khareban		15.725037	73.785893	River*	Direct sighting
3	Carambolim	**Tiswadi**	15.48634	73.927916	Lake	Direct Sighting
4	Dhaddo		15.475484	73.950811	Sluice gate	Direct sighting
5	Tolto ferry terminal, St. Estevam Island		15.522121	73.932071	Mangrove	Indirect sighting
6	Narve- Tikhazan Marsh		15.55277	73.912887	Swampy Marsh	Reported by locals
7	Narve		15.548628	73.918925	Sluice gate	Reported by locals
8	Amaya wada, Tonca, Marcel		15.527996	73.9563	Sluice gate	Indirect sighting
9	Amona Bridge, Candola		15.527077	73.967141	River*	Reported by locals
10	Divar		15.490782	73.904567	Sluice gate	Direct sighting
11	Bondval, St. Cruz		15.462515	73.840709	Lake	Reported by locals
12	Deccan Chemicals		15.494399	73.941867	Pond	Direct sighting
13	Swimsea-Miramar		15.464179	73.803981	Beach	Direct sighting
14	Gaunalim bridge		15.515331	73.940733	River*	Reported by locals
15	Velha, Siridao		15.438743	73.867086	Pond	Reported by locals
16	St. Cruz, Neugi Nagar		15.486231	73.843649	Bundh	Direct sighting

Sr. No.	Name of the place	Taluka	Latitude	Longitude	Water body type	Type of data
17	Sarmanas Ferry	**Bicholim**	15.536694	73.962914	Mangrove	Indirect sighting
18	Advalpale-Nanoda		15.636408	73.910659	Stream	Indirect sighting
19	Dhabdhaba, Sarvan HXF5-X35, Bicholim		15.574845	73.960442	Stream	Indirect sighting
20	HXG3-P97, Bicholim		15.576628	73.953339	Mining pit	Indirect sighting
21	Ameshiwada, Amona		15.542505	73.979699	Sluice gate	Direct Sighting
22	Bhatwadi, maem		15.572543	73.933961	Lake	Direct Sighting
23	Advalpale		15.646455	73.907482	Mining Pit	Direct sighting
24	Valvanti river		15.574352	74.018149	Dam	Reported by locals
25	Salem		15.699458	73.930586	River*	Reported by rescuers
26	Donwaddo, Salvador Do Mundo	**Bardez**	15.522429	73.84859	Bundh	Indirect sighting
27	Penha De Franca, Pomburpa		15.529146	73.859587	Sluice gate	Direct sighting
28	Torda		15.532272	73.844435	Lake	Direct sighting
29	Aldona-Corjuem cable bridge		15.593391	73.876808	River*	Direct sighting
30	Siolim-Opposite fish market		15.632595	73.762727	Mangrove	Reported by locals
31	Codli- Somnath Mandir	**Dharbandora**	15.357751	74.124179	Stream	Direct sighting
32	Nirankal		15.358212	74.110966	River*	Reported by locals

Sr. No.	Name of the place	Taluka	Latitude	Longitude	Water body type	Type of data
33	Datta Mandir, OpaCandepar	**Ponda**	15.419636	74.048116	River*	Indirect sighting
34	Parampai, madkai		15.406899	73.94481	River*	Reported by locals
35	Karnaale, New Bandora bridge		15.411904	73.958581	River*	Direct sighting
36	Codar, Nirankal		15.380088	74.095527	River*	Direct sighting
37	Dharzo, Kundai		15.44466	73.951215	Sluice gate	Direct sighting
38	Baibhat-Madkai-Kundai Link rd		15.437804	73.952356	Swampy Marsh	Direct sighting
39	Aksan		15.42681	73.930618	Sluice gate	Direct sighting
40	Undir		15.405649	73.962888	Sluice gate	Reported by locals
41	Adpai ferry terminal		15.370281	73.966725	Mangrove	Reported by locals
42	Adulshem, Talaulim-Borim		15.365732	73.985808	Sluice gate	Direct sighting
43	Cuncolim	**Salcete**	15.167176	74.01	Stream	Direct sighting
44	Rachol		15.303975	74.011972	River*	Reported by locals
45	Quepem Bridge	**Quepem**	15.215452	74.072388	River*	Reported by rescuers
46	Balli- Fatorpa		15.154533	74.014348	River*	Reported by rescuers

Sr. No.	Name of the place	Taluka	Latitude	Longitude	Water body type	Type of data
47	Ordofond WaterDam	**Canacona**	14.998404	74.092276	Dam	Reported by locals
48	Sadolxem		14.993974	74.058499	River*	Reported by rescuers
49	Dhonkalwada, Pissurlem	**Sattari**	15.539231	74.05573	Stream	Reported by locals
50	Saverdem		15.531942	74.171755	River*	Reported by locals
51	Sanvorcem, Birondem VP		15.500863	74.129437	Mining Pit	Direct sighting
52	Kiwar, Dhamshe		15.477234	74.11844	River*	Direct Sighting

'' highlights river habitats*

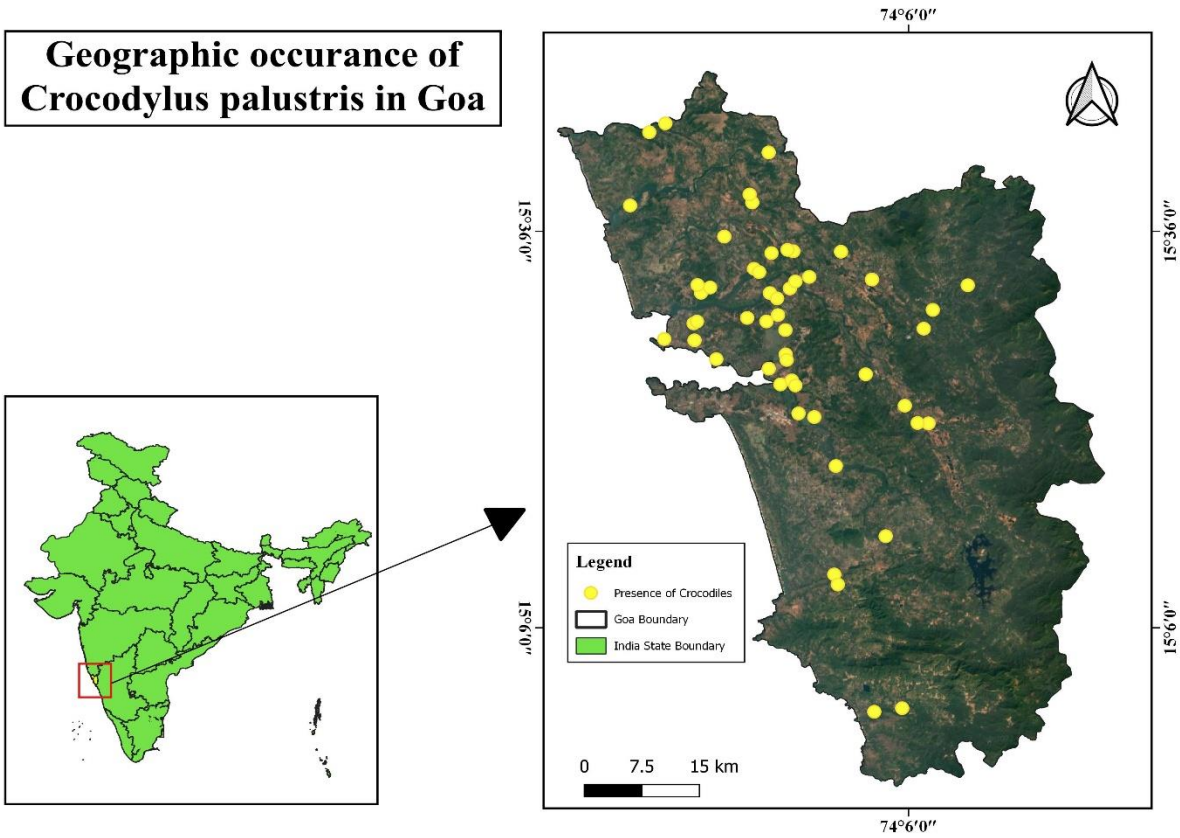


Figure 5: Map showing study area along with reported geographical locations of Mugger Crocodile across Goa (Source: QGIS.org, %Y. QGIS Geographic Information System. QGIS Association. http://www.qgis.org)

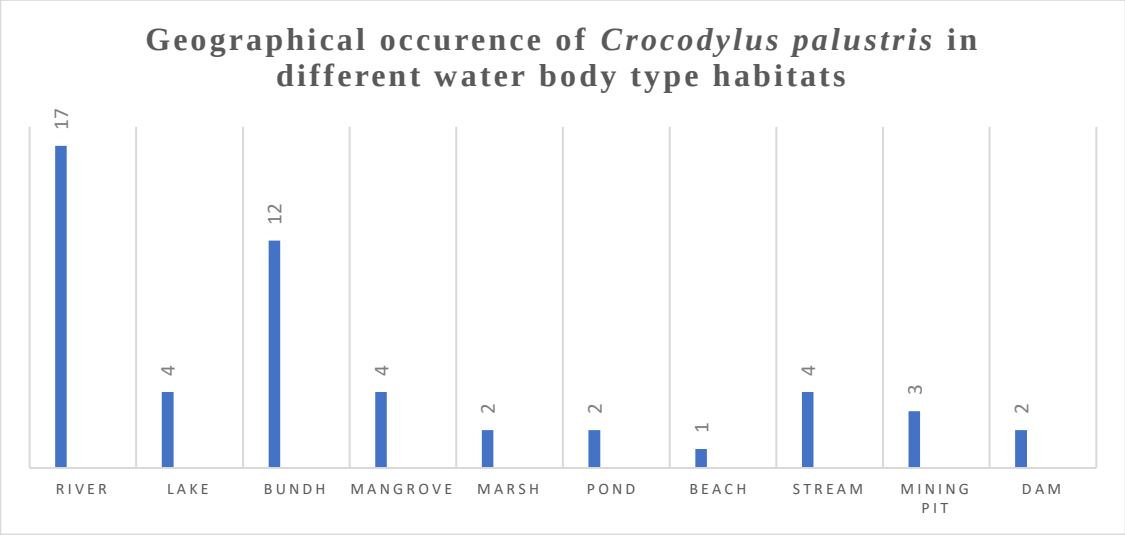


Figure 6: Graph representing geographical occurrence of *C. palustris* in different water body types

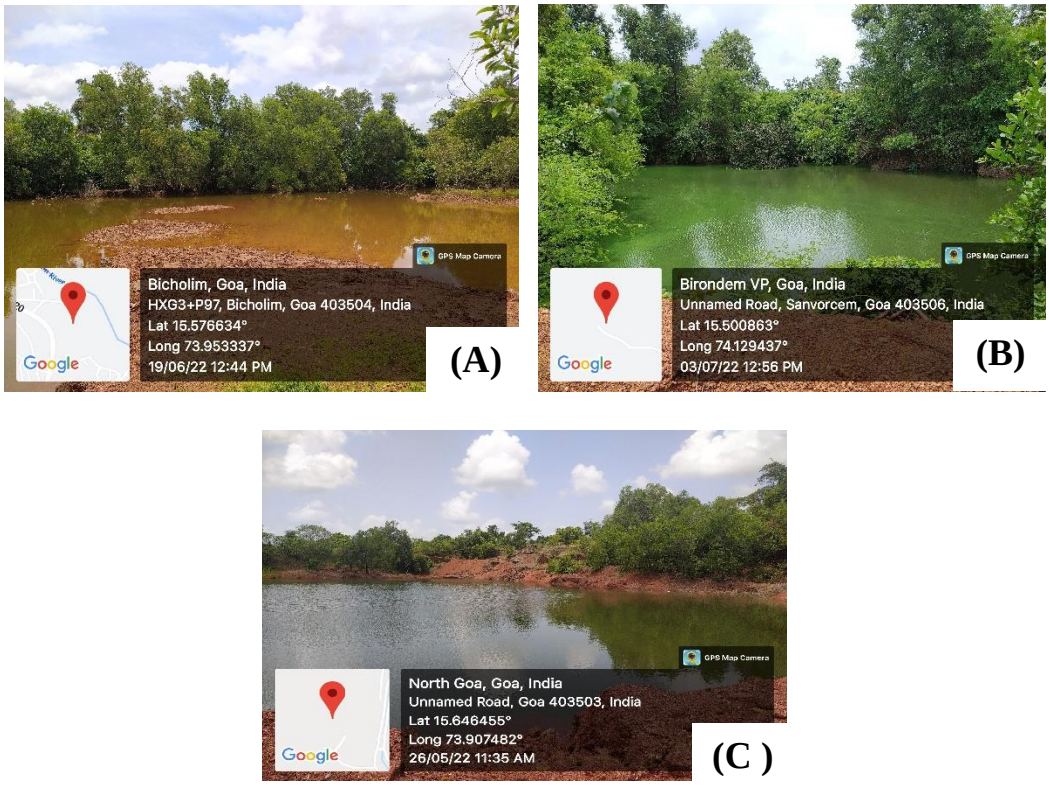


Figure 7: Mining pit habitats of Mugger Crocodile (**A):** Dhabdhabe mining pit lake (Bicholim) **(B):** Sanvorcem mining pit lake (Sattari); **(C):** Advalpale mining pit lake (Bicholim)

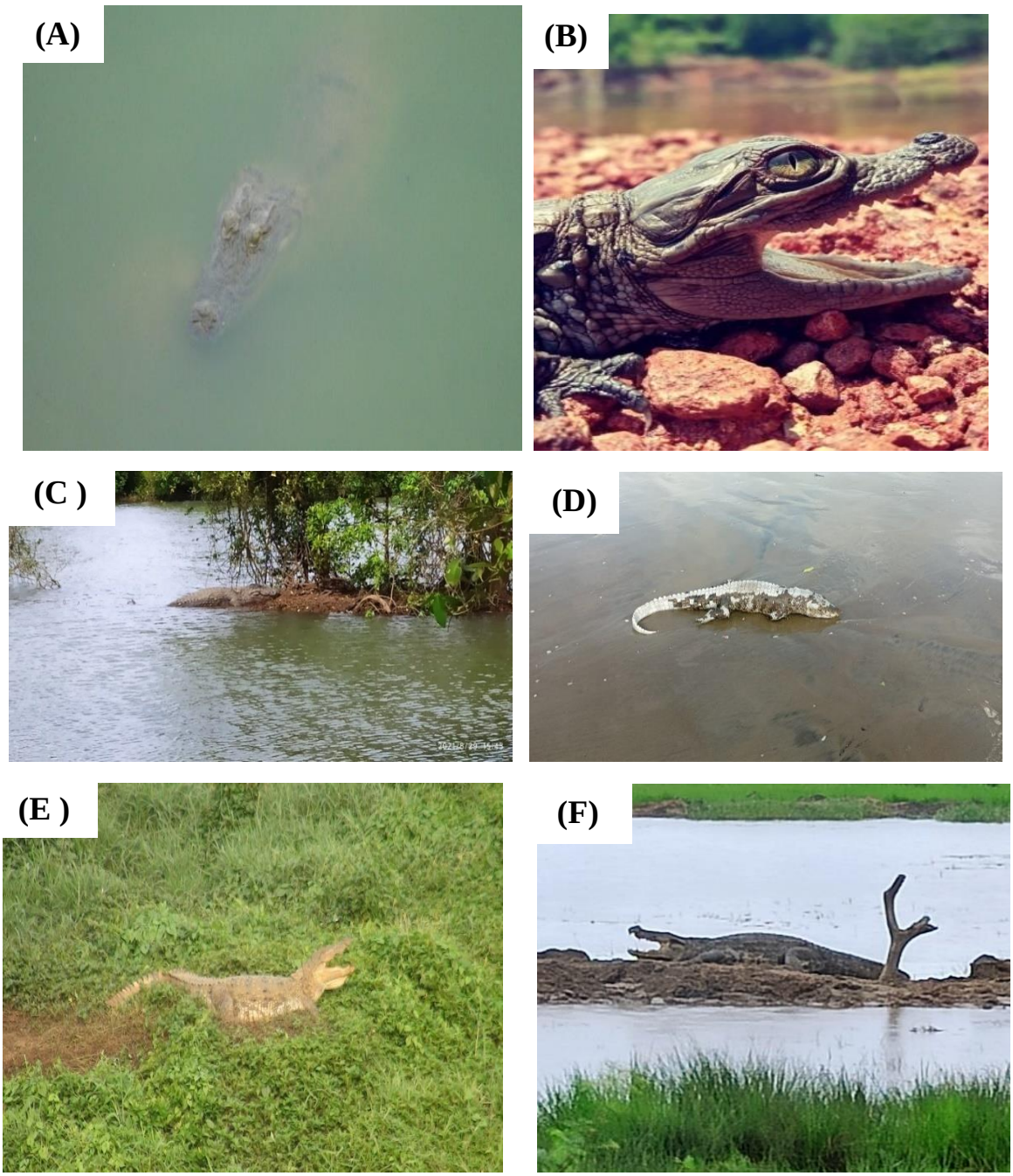


Figure 8: Direct of Mugger Crocodile **(A):** Surface bask of Mugger Crocodile; **(B):** Mugger Crocodile hatchling sighted at Advalpale, Bicholim; **(C):** Mugger Crocodile sighted basking at Dhaddo Bundh; **(D):** Mugger Crocodile spotted at Miramar Beach; **(E):** Mugger Crocodile sub-adult basking on soil with vegetation bank (Island 1; Ref Figure: 13) **(F):** Mugger Crocodile sighted at Neugi Nagar, St. Cruz Sluice gate

Table 2: River-wise geographic distribution of Mugger Crocodile in Goa

Sr. No.	River	Tributary	Source	Sink	No. of locations obtained
1	**Mandovi**		Bhimgad (Karnataka)	Arabian Sea	07
1.1		Mapusa	Dumacem &Amthane (Bicholim)	Mandovi River at Penha de France (Bardez)	04
1.2		Nanoda		Assonora→Mapusa	01
1.3		Valvanti		Mandovi	01
1.4		Bicholim	Curchirem	Valvanti River	02
1.5		Cudnem	Amona (Bicholim)	Valvanti	02
1.6		Cumbarjua Canal	Mandovi	Zuari	08
1.7		Mhadei		Mandovi	07
1.8		Rio de Ourem		Mandovi	02
				TOTAL	**34**
2	**Zuari**		Karnataka	Arabian Sea	07
2.1		Kushavati		Zuari	01
				TOTAL	**08**
3	**Talpona**		Nane and Kuske (Canacona)	Arabian Sea	02
				TOTAL	**02**
4	**Terekhol/ Tiracol**		Maharashtra (Patradevi)	Arabian sea	02
				TOTAL	**02**
5	**Colval/ Chapora**		Ramghat (Maharashtra)	Arabian Sea	02
				TOTAL	**02**
6	**Sal**		Cavelossim	Arabian Sea	02
				TOTAL	**02**
				GRAND TOTAL	**50**

The observations on geographic occurrence of Mugger crocodile reports their presence in altogether 10 talukas of Goa, 05 from North and 05 from South district. Eleven major rivers of Goa flows through multiple talukas. Mugger crocodile was reported from 06 major rivers namely; Mandovi, Zuari, Talpona, Terekhol, Colval and Sal. All rivers form estuarine zones with tidal water inflow and outflow. River wise Mugger crocodile distribution in its main river basin and their tributaries were observed and noted. 50 out of 52 locations were showing direct or indirect connection to the main river water body. Among the different water body types of freshwater habitats of Mugger Crocodile reported, riverine and Bundh locations were maximally encountered. The occurrence of Mugger crocodile on one habitat of Miramar Beach was reported as the least water body type habitat, since annually Mugger crocodiles were most of the time spotted by the locals and tourists in the rainy season. The reason could be because of flooding of Mugger Crocodile's natural habitat invoking them to flow and accidently reach to such higher saline areas.

Direct sighting of Mugger Crocodile's basking, feeding and swimming were noticed in their locations. Indirect evidences of Mugger Crocodile presence were also detected. Footprints, dry scat, abandoned and successful nests, eggs, juveniles were noted as some of the indirect sightings.

Out of many freshwater habitats documented by Crocodile researchers and their studies, Mining pit in this study, was specifically noted to be an actively and increasingly used habitat. Despite the fact that mining is currently restricted to only four talukas of Goa; Bicholim (in North district) and Sanguem, Salcete, Quepem (in South district), Mining pits were noticed to be favorable site for Mugger crocodile. Mining pits were observed to be directly or indirectly connected to a main water body; mainly river. Mining pits in recognized locations were abandoned and isolated sites.

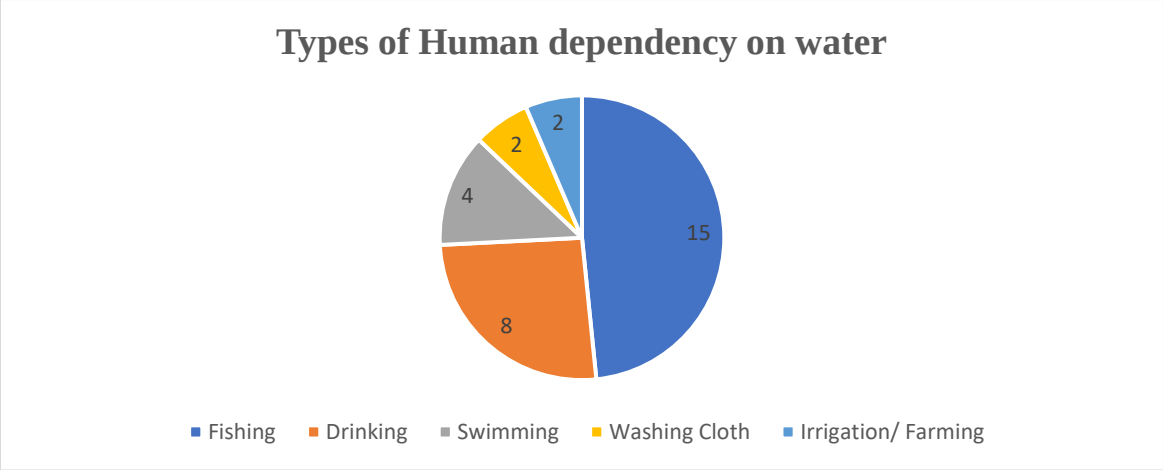


Figure 9: Pie chart showing types of human dependency on the water bodies inhabited by Mugger Crocodile

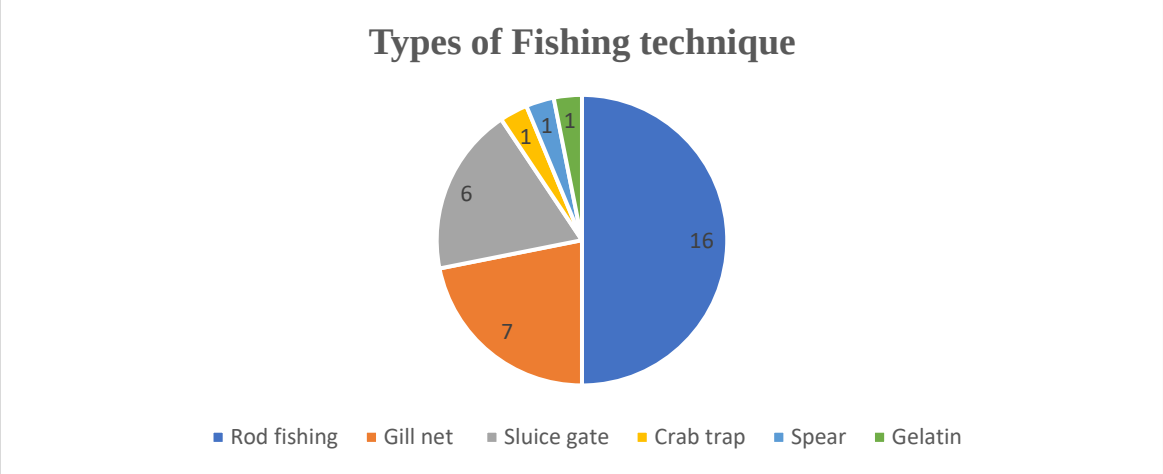


Figure 10: Pie chart displaying different types of fishing practices employed in the water body of Mugger Crocodile habitats

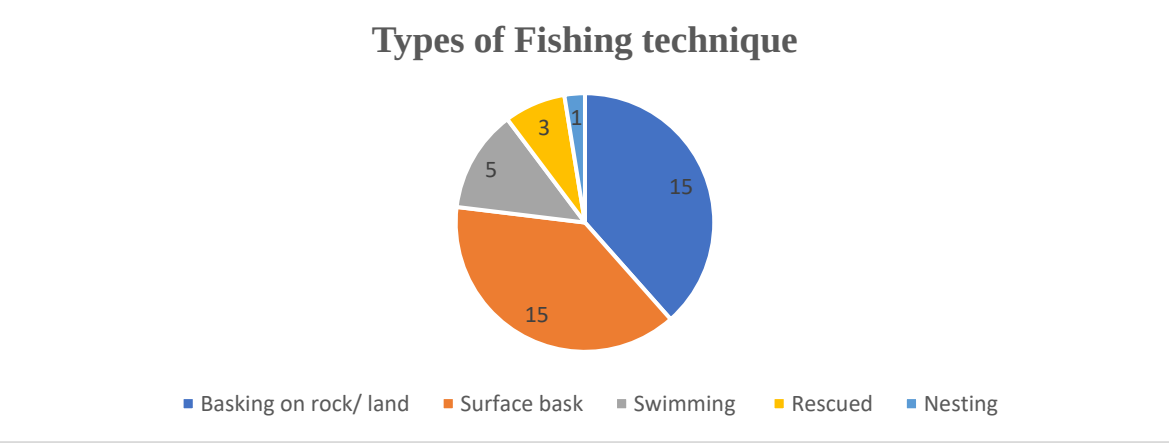


Figure 11: Pie chart representing different activities of Mugger Crocodile

Table 3: Locations of Mugger Crocodile obtained from virtual survey

Sr. No.	Location name with Taluka	Taluka	Sr. No.	Location name with Taluka	Taluka
1	Terekhol river	Pernem	12	Torda	Bardez
2	Sanquelim	Bicholim	13	Dongri	Tiswadi
3	Sanquelim, Virdi	Bicholim	14	Tivrem	Tiswadi
4	Bicholim	Bicholim	15	Cumbarjua	Tiswadi
5	Advalpal	Bicholim	16	Carambolim	Tiswadi
6	Guleli	Sattari	17	Marcel	Tiswadi
7	Bhumika temple Poriem	Sattari	18	Divar	Tiswadi
8	Cuncolim	Salcete	19	Banastari	Tiswadi
9	Colvale	Bardez	20	Savoi verem	Ponda
10	Assnora	Bardez	21	Parampai	Ponda
11	Amthane dam	Bardez			

An online-interview based survey conducted during initial time-frame of the study, reported 21 different Mugger crocodile locations (ref., Table 3). Altogether, a total of 41 responses were received and analyzed. Human dependency on water bodies were noticed like for fishing, swimming and bathing, washing clothes, irrigation and drinking (Ref., Image 9). Within these locations varied forms of fishing techniques were performed. Fishing techniques like Rod fishing, crab trap, line fishing, gill net fishing, spear fishing, fishing at sluice gate and gelatin fishing (Ref., Image 10). This fishing techniques can be related to the amount of human-Crocodile interaction.

Respondents also reported about some Mugger Crocodile activities that they witnessed, like swimming, basking on different substrates, Surface bask, Feeding, nesting, rescue, net-traps and dead bodies. This survey aided in locating more crocodile habitats with the involvement of targeted local individuals (Ref., Image 11).

Nesting Assessment of Mugger Crocodile at Carambolim Lake

Habitat Description

a. ***Habitat:*** Carambolim lake is an artificial freshwater body which was ideally utilized as a paddy field in earlier times, though recently this man-made lake, was utilized for the main purpose of agricultural irrigation.

b. Geographical Coordinates

Latitude: 15.48634˚N; Longitude: 73.927916˚E

c. Towards its **North**, it is bound by muddy bank and grassy edge majorly visited and occupied by waders and ducks. No much human interference is observed.

d. Towards the **East,** the lake shares close boundary along dispersed human habitation. Human interaction occurs via, three bird watching towers which attracts many birders and villagers.

e. Towards the **South,** the tar road seperates the lake from agricultural field. Fishermans usually prefer this side of the lake for fishing.

f. Towards the **West,** railway route runs parallelly. Damp soil with leaf litter on the bank with kaccha road accessible to humans along the edge.

g. ***Study period:*** January 2022- July 2022 & January 2023- March 2023

Figure 12: Three nesting sites of *Crocodylus palustris* at Carambolim Lake

Island Description

- The study area contains three naturally occurring small recursive islands structures which are resourced by many micro and mega, flora and fauna. Wetland birds are actively seen feeding, roosting and basking on the trees and grasses of these islands (Ref., Image 12).

  Island 1: Situated at North-West border of the lake at a distance of approximately 60m from the mainland.

  Island 2: Situated at North-East border of the lake near bird watch tower 2 at a distance of approximately 75m from the mainland.

  Island 3: Situated at South-East border of the lake near bird watch tower 1 at a distance of approximately 40m from the mainland.

19 April 2022 19 April 2023

Figure 13: Comparative pictures of Carambolim lake, Island 1 in the span of 1 year

- Throughout the course of the study, 31st July 2022 was the lowest water level phase of the lake. January till July 2022, crocodiles' movement and activity were monitored in and around the island sites. Next batch of observation began in January 2023 and continued till March 2023. Following table is a collective observation data at three nesting sites.
- Some generalized mugger crocodile behaviors were observed during the study. Some adult muggers were seen feeding solitarily while some in group. Some adult crocodiles were observed safe-guarding the island. Sometimes, while swimming, crocodiles were seen regularly visiting the island and returning back to water.
- Predators like White-bellied Sea eagle (*Haliaeetus leucogaster*), Indian grey Mongoose (*Herpestes edwardsii*), Dogs (*Canis familiaris*), Black Kite (*Milvus migrans*), Domestic water Buffaloes (*Bubalus bubalis*) (Ref. Image 14 (D)) were seen disturbing and attempting to prey on adult and juveniles of Mugger Crocodile.

Table 4: Descriptive observation of nesting behavior of *C. palustris* at Carambolim lake

Sr. No.	Month, Year	Crocodile Behavior		
		Island 1	**Island 2**	**Island 3**
1	January-February 2022	No nest or crocodile activity observed although some were seen swimming nearby	Walking or basking trail was visible with some crocodile occasionally swimming	1 hole was visible towards the interior side with some crocodiles actively swimming towards south
2	March 2022	3 Crocodiles on island with facing towards interior; 1 out of 2-3 one's was swimming near island to protect it and was visiting the island frequently; 1 was surface basking near railway side by coming up on surface in specified time gap; On 25th March 10-12 buffaloes reached the island and tried shooing away the crocodile.	3-4 Crocodiles seen swimming	Not much crocodile activity was seen. 3-4 crocodiles were vertically seen swimming from North-right to South-right corner.

3	April 2022	2 adult and 1 sub-adult crocodiles basking on island with mouth facing North side of the lake; 4-5 crocodiles swimming in periphery of the island; 2 surface basking in water and 2 basking on muddy rocks.	1-2 crocodiles visible in full body bask on bare muddy soil in sun; 2 holes were visible.	No crocodile activity observed
4	May 2022	2 crocodiles basking on south side while 1 on west, with their mouth open; Towards north zone 4-5 crocodiles seen complete basking, feeding on crab and swimming.	6 crocodiles actively basking in between Island 1 & 2; 2 Crocodiles basking below island 2	2 crocodiles swimming up and down from North right to south side.
5	June 2022	4 crocodiles on island; 3 crocodiles seen prebask near west-side	14-15 crocodiles visible swimming, feeding on fish, basking and surface basking in water.	1 crocodile observed on island; 2 basking near south side on bare soil with vegetation.
6	July 2022	Due to low water level, 3 crocodiles sitting on island; 22 crocodiles in water swimming, feeding; 2 crocodiles near North- west bank	Hardly any activity was visible due to human disturbance and dogs visiting.	1 crocodile seen swimming nearby

7	January 2023	Due to high water level, the island was flooded and no crocodile presence or movement was seen	The walking trail of crocodile on outer east side of island had dried scat and a hole was observed; 2-3 crocodiles swimming nearby	Black-crowned night heron family was identified with many birds resting near crocodiles; 2 crocodiles spotted on island resting in shade
8	February 2023	No activity observed	Roosting colony of cormorants increased in amount with 2-3 crocodiles resting on island in shade	3 crocodiles observed in close vicinity with 2 holes on upper side of the island; 2 more crocodiles were seen climbing and sitting on the island
9	March 2023	No activity observed	Kingfisher pair was located near hole opening; 4 crocodiles on island and 2 crocodiles swimming actively near periphery	Crocodiles were seen actively moving within the island; 4-5 adult crocodile spotted.

The observations on three study sites reveals a relation between choice of nesting site by Mugger crocodile in relation to nesting site type and water lever of the lake. In the first cycle of nesting behavior observed in January 2022- July 2022, direct sighting of crocodile increased as the water level was decreasing (before rains). They strongly preferred Island 1 for nesting and basking since least human interference was possible and the recursive island was elevated at a much favourable height. As in second cycle of nesting observed next year, from January 2023 till March 2023, not even a single crocodile was observed on or near

Island 1 due to increased water level. As seen in Image 14, the difference in water level can be estimated and Island 1 can be seen majorly submerged in the year 2023. The crocodiles preferred Island 2 and 3 for their successive year of breeding. These islands were comparatively more interfered by humans. Island 2 showed presence of three active hole nest and Island 3, showed two.

Interestingly, some curious and noteworthy observations were made throughout the study period. To mould the study towards Mugger Crocodile interspecies relationships, many other animal species were observed to be peacefully existing along with them during their breeding season. Birds like, White-throated Kingfisher (*Halcyon smyrnensis*) were seen nesting near Mugger crocodile nest (Ref., Image 16 (B)), a family of juvenile and adult male of Black-crowned night Heron (*Nycticorax nycticorax*) were spotted on Island 3, Indian Pond Heron (*Ardeola grayii*), White-breasted waterhen (*Amaurornis phoenicurus*), Red-wattled lapwing (*Vanellus indicus*) and Purple Heron (*Ardea purpurea*) were detected near the nest and islands occupied by Mugger crocodile.

Mugger Crocodile was witnessed feeding on crabs, tilapia and Indian Cormorant.

Table 6 mentions the other nesting sites documented while achieving first objective. The table gives brief information about nest, eggs, juveniles and indirect evidences noticed.

Table 5: Number of individuals of *C. palustris* reported at nesting site during assessment.

Sr. No.	**Month, Year**	**Observations**					
		Island 1		**Island 2**		**Island 3**	
		No. of *C. palustris* observed on Island	**No. of *C. palustris* observed surrounding the Island**	**No. of *C. palustris* observed on Island**	**No. of *C. palustris* observed surrounding the Island**	**No. of *C. palustris* observed on Island**	**No. of *C. palustris* observed surrounding the Island**
1	January-February 2022	0	0	0	0	0	1-2
2	March 2022	3	3	0	3-4	0	3-4
3	April 2022	3	8-9	0	1-2	0	0
4	May 2022	0	7-8	0	8	0	2
5	June 2022	4	3	0	14-15	1	2
6	July 2022	3	24	0	0	0	1
7	January 2023	0	0	0	2-3	0	2
8	February 2023	0	0	2-3	1	2	3
9	March 2022	0	0	4	2	4-5	0

5 crocodile individuals visible in red circle; 4 visible in yellow circle and 2 in black

(A)

(B)

(C)

(D)

Figure 14: Nesting behavior at Island 1 **(A)** Two Mugger Crocodile basking on the bare soil near Island 1; **(B)** Mugger Crocodile basking on soil with vegetation of Water Hyacinth; **(C)** Sub-adult (Juvenile) of Mugger Crocodile basking on Island 1; **(D)** Male buffalo trying to threaten away Mugger Crocodile

Two holes visible on island 2 in yellow circles

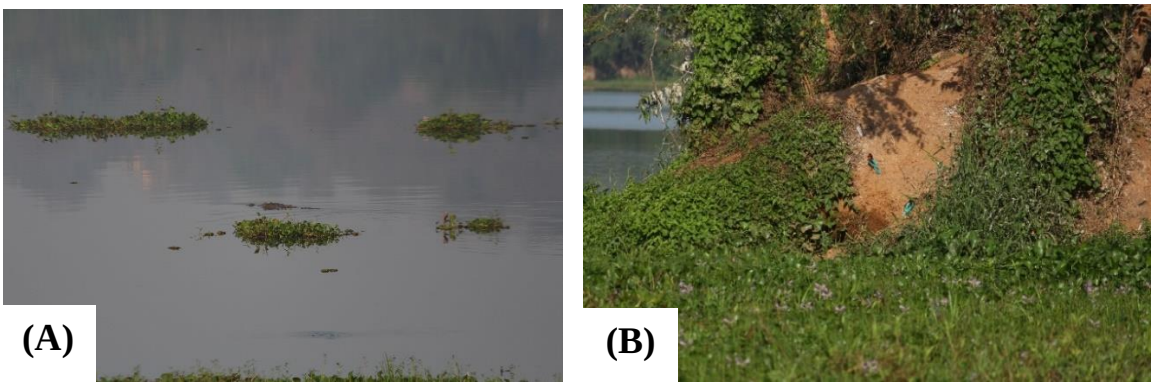


Figure 15: Nesting behavior at Island 2 **(A)** Mugger crocodile actively swimming near Island 2; **(B)** White-throated Kingfisher pair seen near Mugger crocodile hole nest 3

One nest hole visible on Island 3 in white circle

(A)

(B)

Figure 16: Nesting behavior at Island 3 **(A)** Adult Mugger Crocodile actively guarding the Island 3; **(B)** Three Mugger Crocodiles basking in shade

Table 6: Other nesting locations of *C. palustris*

Sr. No	Date	Location	Taluka	Water body type	Number of nests	Number of active nests	Number of eggs
1	19 June 2022	Dhabdhabe	Bicholim	Mining pit	2	1	12-14
2	19 March 2022	Aksan	Ponda	Sluice gate	3	1	2
3	26 May 2022	Advalpale	Bicholim	Mining pit	2	1	2
4	6 August 2022	Neugi nagar	Tiswadi	Bundh	1	1	2
5	3 July 2022	Sanvorcem	Sattari	Mining pit	1	1	1
6	20 January 2022	Divar	Tiswadi	Sluice gate	2	0	0
7	26 May 2022	Advalpale	Bicholim	Stream	1	0	0

Table 7: Tabular data on month-wise, pre-monsoon encounter rate of *C. palustris* at two locations

Pre-Monsoon Encounter Rate			
CARAMBOLIM		**DHADDO**	
Month (Year 2022)	No. Of sightings	Month (Year 2023)	No. Of sightings
26 February	07	12 February	08
27February	10	13 February	11
19 March	12	5 March	06
20 March	18	6 March	03
23 April	15	9 April	10
24 April	23	10 April	12
21 May	38	7 May	07
22 May	44	8 May	09

Table 8: Tabular data on month-wise, post-monsoon encounter rate of *C. palustris* at two locations

Post-Monsoon Encounter Rate			
CARAMBOLIM		**DHADDO**	
Month (Year 2022)	No. Of sightings	Month (Year 2022)	No. Of sightings
28 August	03	21 August	04
29 August	06	22 August	02
18 September	04	4 September	06
19 September	11	5 September	05
30 October	08	16 October	02
31 October	12	17 October	02
20 November	11	6 November	04
21 November	07	7 November	06

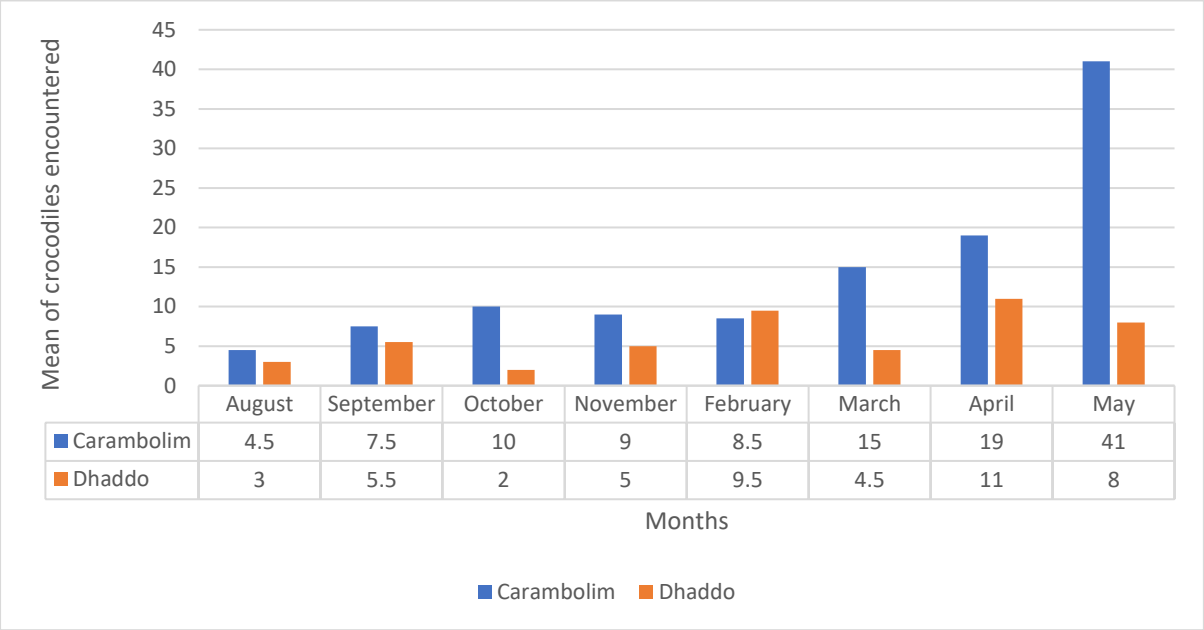


Figure 17: Graph depicting comparison on encounter rate of *C. palustris* at two study sites

An eight-month encounter rate study in 2022 on Mugger Crocodile sighting rate at two different habitat types and study sites was conducted. The chosen locations were, Carambolim Lake (Man-made Freshwater) and Dhaddo Bundh (Mangrove and estuarine zone). Pre-monsoon months were February 2022 till May 2022 whereas post-monsoon months were August 2022 to November 2022. June 2022 to July 2022, spotting and counting Mugger crocodile was difficult due to heavy rainfall. A relation between Mugger crocodile sighting and water level was attempted to study. A post-monsoon observation denoted a smaller number of direct sightings due to rise in water level. While in Pre-monsoon period of four months recently, Mugger crocodiles were more visible due to less water level.

Community conservation ritual of Maange Thaapni in Goa

Figure 18: Clay sculpture of ‘Maange’; *Crocodylus palustris.* Celebration of ‘Maange Thaapni’ at Adulshem, Talaulim, Borim, Ponda- Goa.

Adulshem village at Borim, Shiroda, Ponda- Goa, celebrates one of the beautiful and meaningful ritual for peaceful co-existence of Humans with *Crocodylus palustris.* This ritual has an unknown origin and an endless future. The Khajan land is a community managed, integrated agro-aqua ecosystem culture based in Goa (Ansari, Z. A., et al., 2012). These khajan lands are categorized into four major components namely; Bundh (Dyke), Manas (Sluice Gate), Rice field (elevated land for farming) and Poiim (Internal water body containing drainage channels). Khajans are agro-lands often flooded by river tides and protected by Bundhs. Another savior to our Khajan lands is our Mugger Crocodile (*Crocodylus palustris*).

C. palustris is a semi-aquatic reptile inhabiting favorable shallow freshwater habitats in Goa. In addition to that, they are also observed resilient towards salinity fluctuations in estuarine ecosystems of Khajan lands of Goa.

C. palustris plays a major role of Apex predator and keystone species in these Freshwater Ecosystem. The Bundh (Embankment to prevent flooding) have ‘Maanas’ made up of concrete or wood, which regulates the water flow rate of that water body in a Khajan Land. This regulated outflow of water aids in preventing flooding of agro-aquatic vegetation of Khajans.

Depicting Hindu Mythology is the Varun Dev; the God of Ocean and Rain, who rides on ‘Jaladhi Makara’ (i.e., a Crocodile). Crocodile is believed to be the ‘Rakhandaar’ (Protector of Crops and Maanas) of the Khajan Land. To offer our gratitude, and pray for good crop and fish yield, an eco-theological ritual is celebrated as a unique festival in Goa, to conciliate God Varun. This practice is popularly known as ‘Maange Thaapni’ (Sculpturing of Crocodile). This custom is anticipated to have originated from the time agriculture took birth in the state of Goa.

Similarly, throughout the year, this gratitude is also extended to the ‘Devchaar’ (Spirit of the Area), recognized as, “Gaondadeshwar” who protects the fields. Elders of Adulshem village presume that the earlier Goan rulers; Rajahs, Maharajahs, introduced this ritual of celebrating the divine aquatic prime predator.

This ritual is particularly focused in habitats like, Khajan Lands, Local coastal floodplains, etc. (Banerjee, Ananda, “A prayer for the crocodile.” *Mint*, 2016). This natural conservational approach by locals is celebrated at many places in Goa; Bhoma, Durbhat, Adulshem, Tamshirem and Talauli.

This festival is to be celebrated before the completion of Last day/ First New Moon (Amavasya) day of Lunar Calendar month: Paush/ Mhalun (January). This particular season of the year coincides with threshing period of paddy field harvesting. In earlier times, the tribal locals of the villages, wore traditional ‘Kashti’ (Loin cloth) and performed the whole ritual of Maange Thaapni. Majorly it’s the Fishing and Farmer Communities who are devoted and determined to carry out the concerned ritual. Using the mud clay from the bank of Bundh, an effigy of *C. palustris* is carved. With the hand modelling skills, the Crocodile model are patterned systematically to resemble the rough outer skin of the crocodile. Clamshells are used to make scales and eyes while sticks are used to make nails/ claws and teeth.

Using Vermilion (Sindur/ Pinjar), Flowers, and incense sticks, the crocodile model is worshipped by the Jalmi. The ‘JeevDaan’ (offerings) to the Crocodile deity is made of live chicken/ egg to signify the sacrifice of a life and fertility of crocodile. Puffed rice with coconut and Jaggery is offered to everyone as a Sacred Food/ Prasadam. Altogether this whole tradition of Goan local communities pertaining to Khajan lands is to absolutely detach the fear of *C. palustris* with a positive outlook towards co-existence as well as to offer our respect towards the protector.

21 January 2023- Saturday- Adulshem, Borim, Ponda- Goa

This year in the Month of January (Paush), Maange Thaapni was celebrated at Durbhat and Adulshem village at Talaulim in Ponda Taluka. The head of the village, known as 'Jalmi' is the one who takes care of the village and commences any festival or custom. It takes maximum 1-2 hours for the whole ritual to finish.

It began with sculpturing Crocodile clay model, decorating it with shells, flowers and sticks by the locals (Ref., Image 19). Marish Sadanand Muli, a local resident of Adulshem and the Jalmi appointed to undertake the ritual this year, conducted a pooja to pray for good health and protection of Khajan Land by worshiping the clay model of *C. palustris* (Ref., Image 19 (B)). They assure that rituals and customs like these, help people leave harmoniously with their ambient fauna and flora species. After the completion of whole ritual, the Prasadam was distributed and Vermilion was applied on forehead of respective family members followed by everyone present there. An attendance was taken of the committee members using a red thread tied to a common rope with their respective number mentioned on it and upon absence, a knot was tied to the thread and a fine was charged on the upcoming festival. These small regulations positively adhere the locals of villages for the conservation of *C. palustris*. This unique ritual showcases our gratefulness to the mother nature thereby not only conserving targeted Herpetofauna (*C. palustris*) but also their habitat and entire ecosystem.

Figure 19: Maange thaapni ritual at Adulshem, Ponda **(A)** Locals moulding crocodile effigy using mud clay; **(B)** Jalmi performing rituals and offering flower to the Crocodile god; **(C)** Threads on thread representing one member or its family from the committee. Incharge taking attendance of whole committee.

Pernem Crocodile shrine

Figure 20: Shrine and idol of *Crocodylus palustris* at Poroscodem, Pernem- Goa.

Near Satarda bridge at Naibag in Pernem, locals unified to build a Crocodile shrine with idol to resume *C. palustris* worshipping. The renowned environmentalist of Goa, Mr. Rajendra Kerkar, published a newspaper article about 'India's First Crocodile Shrine' in Goa at a convergence of two rivers in the village of Poroscodem in Pernem Taluka. The locals there, worship crocodiles for better winter crop yield. The Mugger Crocodile were sighted basking near the water bodies but the recent highway expansion in 2016 disturbed and destroyed the basking sites of *C. palustris*. In this taluka, Maange Thaapni was celebrated at 'Susaricho Bundh.' Now, the villagers built the shrine near the then basking site of *C. palustris* (Ref., Image 20) and continued the tradition of worshipping the Crocodile idol. The villagers adorn the Crocodile idol with flower Garland and conduct a pooja once in a year. This 'Folk Deity' is understood as a protector of field and Bundh. Locals still follow this tradition to hope for good yield and no harm from *C. palustris.*

Chapter 6

DISCUSSION

Crocodylus palustris is a semi-aquatic, natatorial, amphibious, territorial, oviparous, hole nesting, gonochoric, carnivorous ambush predator which is most well adapted species among the three found in India (Jacobson, 1999; Da Silva and Lenin, 2010). In the present study, we have investigated the geographical occurrence of Mugger Crocodile in the state of Goa, India. Our findings from table 1 infer that Mugger Crocodile is indeed present in Goa, particularly dispersed throughout the riverine ecosystem. Apart from the freshwater habitats mentioned in the research studies of Whitaker and other researchers, in Goa Mugger Crocodiles are witnessed inhabiting marshy estuarine waters as well as acidic and chemically contaminated waters of Mining pit lake. Recently, due to sustainable mining activities restricted to few talukas of Goa, numerous mining pits present from earlier are now evacuated and abandoned. These mining pits were and are still sharing some indirect channelized connections with river water bodies. As mentioned by Vyas., (2001; 2003), muggers have propensity to locomote overland between water bodies during unfavorable conditions, in search of food and water. Locals similarly be certain of this reason for crocodile's occurrence in mining pits, and finding their comfort in these isolated patches. Since there is least human interference and favourable elevations and conditions required by Mugger crocodile to thrive, they are certainly utilizing these mining pits as their breeding grounds.

Presence of Mugger crocodile population in Goa is very significant for many reasons. Firstly, it highlights the essentiality of conserving the mugger habitats, as 'Mugger' is recognized as a Vulnerable species by IUCN. Secondly, despite the fact that Mugger crocodile is less aggressive species in comparison to its other cousin species, their presence and increasing population in certain habitats might have certain negative implications on Human-Crocodile interactions. Hence, awareness about crocodile occurrence in the state of Goa is of importance among the locals. People must be educated about how to minimize human

encroachment in mugger habitats and how to avoid conflicts and rather co-exist peacefully with the species.

In addition, our study suggests that there might exist other areas in Goa where Mugger Crocodile are present but are not yet documented. Therefore, future research is expected to fully understand the distribution pattern and abundance ratio of this species in the state.

From the results and observations on nesting assessment of Mugger crocodile at Carambolim lake, we understood that the viable population of *C. palustris* have their functional niche in the study site where they reproduce and survive, despite of their varied realized niche. Back in 2000's, this IBA was a pure Khajan land maintained by four different tenant organizations of Carambolim village. And previously, this very fact aided in positioning the Village of Carambolim to be recognized as 'The rice bowl of Goa.' The tranquilly living populations of Mugger Crocodile have been successfully breeding, nesting and co-existing with other lower species. As seen from the observations of two cycles of nesting at Carambolim lake, depending upon the rainfall and water level, mugger crocodile prefers and exploit any one or two recursive islands as per the need of fertile females. As per the research of Santiapillai, C. & de Silva, M., (2001), increased soil erosion and consequent floods destroy crocodile nests and eggs. Referring to this statement, conclusion can be obtained that Mugger crocodile examine and choose specific sites for nesting. This objective examines how mugger crocodile cope and locally migrate or congregate themselves in the favourable regions to facilitate every type of safety to their hatchlings and complete their cycle of reproduction.

The Mugger crocodile also known as Indian Crocodile, holds significant amount of cultural and religious importance not only in India but in other parts of the world as well. Although the results obtained till date are a clear indication of the fact that, local communities of Goa, and mainly the Khajan land organizations have good involvement and progress in

establishing the interest and culture of crocodile conservation in their upcoming generations via celebration of rituals. Conservation efforts from any community shall aim to maintain and protect the Mugger Crocodile habitat as well as minimize the negative consequence on Human-Crocodile relation. This objective can be achieved by implementing proper management strategies and spreading the knowledge of co-existence. It is equally important to ensure the survival of biotic species of our nature along with safety of humans.

Chapter 7

CONCLUSION

This study was based on Mugger/ Marsh Crocodile i.e., *Crocodylus palustris*. It is the only species found in Goa. Its geographical occurrence was observed in 10 out of 12 talukas and 8 out of 11 rivers of Goa. Maximum number of locations had direct sightings from Riverine and Bundh ecosystem. The Mugger was seen inhabiting freshwater habitats like, lakes, rivers, creeks, bundhs, dams, as well as brackish water estuaries and acidic waters of Mining pits.

Mugger crocodiles nesting assessment at Carambolim lake concludes that *C. palustris* are indeed hole nesting species who dig burrows on soil bank of recursive islands of the Lake. Depending upon the rainfall and water level existing before nest laying process, females along with some alpha males select a particular area for nesting. They dig burrows, lay eggs and eventually start monitoring and defending that area. Some interspecies interactions do exist. Places like Carambolim lake, which can provide sufficient feed, favorable basking sites, more area of movement, hiding or burrowing regions and less human interference could be the criteria's used by *C. palustris* to utilize an area for breeding and nesting purpose.

Culturally, many fishing and farming communities in Goa are actively involved in worshiping this apex and ambush predator. Rituals like Maange Thaapni were celebrated from time immemorial and is still practiced in remote hamlets of rural regions of Goa. Along the North side, people in Pernem taluka built a shrine of crocodile to continuously remember and celebrate this Rakhandaar to protect their fields and Khajan lands and to form a strong eternal bondage of love with the crocodiles.

The study on Geographical occurrence of Mugger crocodile can open various doors to future research. Population dynamics can be studied depending on distribution pattern. Further research is needed for long-term monitoring and population assessment of the species. This information will help understand status, geographic range, distribution pattern and habitat

requirements of Mugger crocodile. By doing habitat assessment, potential threats could be identified and conservation strategies could be framed and recommended to the higher conservation authorities to implement. Genetic studies can further aid in recognizing gene pool and genetic diversity of Mugger crocodile in Goa. The inclining human activities on wetland habitats and degradation of potential favorable habitats of *C. palustris* might lead to Human-crocodile conflict. Future research can focus on assessing impact and consequences of human activities on Mugger crocodile population.

Studying nesting assessment of Mugger crocodile can facilitate valuable insights into reproductive ecology, nesting ecology, nest monitoring and population dynamics. Imminent research could examine nesting sites, nest construction strategy, incubation period and conditions, clutch size, change in sex ratio due to temperature variations, parental care and so on.

Mugger crocodiles have always been culturally significant to many communities across its geographic range. Their depictions and mentions in arts, mythology and folklore have played an important role in inculcating the conservational ideology among many communities. Some possible future research related areas in cultural significance of Mugger crocodile could be understanding of indigenous knowledge, cultural heritage, eco-tourism, education and outreach and to a broader extent, Ethnozoology.

Chapter 8

REFERENCES

Bibliography

Alderton, D., 1991. Crocodiles and Alligators of the world. Facts on file, New York.

Ansari, Z. A., Pandiyarajan, R. S., & Ayajuddin, M. (2012). Khazan land of Goa and its fishery potential. *Fishcoop. NIO Goa*, 3-6.

Burton, R, F. (1877). “IV. Clifton, Ghisri Bandar, The Alligator Tank”. Sind revisited. Vol. 1. London: Richard Bentley and Son. Pp. 82-106

Chang, M. S., Gachal, G. S., Qadri, A. H., Jabeen, T., Baloach, S., & Shaikh, M. Y. (2012). Distribution and population status of marsh crocodiles, Crocodilus Palustris in Nara Desert wildlife sanctuary (NDWS) Sindh, Pakistan. *Sindh University Research Journal-SURJ (Science Series)*, *44*(3).

Chavan, U. M., & Borkar, M. R. (2022). Population trends of Mugger Crocodile and human-crocodile interactions along the Savitri River at Mahad, Maharashtra, India. *Journal of Threatened Taxa*, *14*(11).

Choudhury, B.C., 2007. Thorbjarnarson, Gavialis gangeticus. IUCN Red List of Threatened Species. Crocodile Specialist Group (CSG). Crocodile survey in Sindh and Balochistan in January 2009-March 2009, (Vol. 28 Number 1).

Choudhury, B.C. & de Silva, A. (2013). Crocodylus palustris. The IUCN Red List of Threatened Species 2013. DOI:10.2305/ IUCN.UK.2013-2.RLTS.T5667A3046723.en. Downloaded on 23 December 2020

Crocodiles: Flagship species of Cumbarjua Tidal Wetlands Goa (Published by Aapala Paryavaran Co-authored with Mrinal Borkar Pg no. 27-28, 2nd February 2020)
Cumbarjua Crocodiles: Victims of apathy (Column in The Goan Every day, 25th Jan.., 2019)

Daniel, J.C., 1983. The book of Indian Reptiles. Oxofrd University Press, Bombay

Daniel, J.C. (2002). dhe book of Indian Zeptiles and ———————————————
mphibians Bombay Natural History Society, Oxford, 252 pp

Das, U. K., Pradhan, R. K., Dash, A. P., & Panth, S. (2021) Study on habitat preference and conservation of mugger crocodile (*Crocodylus palustris lesson 1831*) in Ghodahada dam of ganjam district, odisha, india.

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

Debata, S. et al. (2018) "mugger crocodile Crocodylus palustris lesson, 1831 (Reptilia: crocodilia: Crocodylidae) in River Saberi of Godavari system in southern Odisha, India:

Conservation implications," Journal of Threatened Taxa, 10(6), p. 11770. Available at: https://doi.org.10.11609/jot.3974. 10. 6. 11770-11774.

Deraniyagala, P.E.P. (1939). dhe detrapod Zeptiles of eylo̱n destudinates and Crocodilians – Vol. 1. National Museums of Sri Lanka, Colombo, 412 pp.

de Vos, A. (1984). Crocodile conservation in India. *Biological conservation*, *29*(2), 183-189.

Fischer, E. & Shah, H. (1971). Mogra Dev, Tribal Crocodile Gods: Wooden Crocodile Images of Chodhri, Gamit, and Vasava Tribes, South Gujrat (India). Art for tribal rituals in South Gujrat. Ahmedabad: Gujrat Vidyapith.

Ganesan, N. (2011). A Dravidian Etymology for Makara–Crocodile. *Prof. VI Subramanian Commemoration Volume*.

Ganesan, N. (2016). Indus Crocodile Religion as Seen in the Iron Age Tamil Nadu. In *16th World Sanskrit Conference Proceedings, Bangkok, Thailand. https://archive. org/details/IVCReligionInIronAgeTamilNaduByNGanesan-2016-16thWSC*.

Grigg, G. (2015). *Biology and Evolution of Crocodylians.* Melbourne, CSIRO Publishing, 11 pp.

Groombridge, B. (1982). The IUCN Amphibia-Reptilia Red Data Book. IUCN: Gland.

Gurjwar, R. K., & Rao, R. J. (2018). Impact of Crocodile Conservation on Livelihoods in North, Madhya Pradesh, India. *Conservation Biology*, *1*, 2.

Halliday. T and Kreig Adler (edit).1989, Encyclopedia of Reptiles and Amphibians, Facts on File Inc. U.S.A. 134-143 pp.

Hass, C.A., Hoffman, M.A., Densmore, L.D., & Maxson, L.R., 1992. Crocodilian evaluation: insights from immunological data. Mol PhylogenetEvol, 1(3): 19-201.

Hekkala, E., M.H. Shirley, G. Amato, J.D. Austin, S. Charter, J. Thorbjarnarson, K.A. sliet, M.L. Houck, R. Desalle & M.J. Blum (2011). An ancient icon reveals new mysteries: mummy DNA resurrects a cryptic species within the Nile crocodile. Molecular Ecology 20(20): 4199–4215. https://doi.org/10.1111/j.1365-294X.2011.05245.x

Javed HI, Rehman H (2004). Status of marsh Crocodile (Crocodylus palustrius) in Sindh. Rec. Zool.

Jacobson C. (1999) Reintroduction of the Mugger Crocodile, *Crocodylus palustris,* in India. University of Minnesota, department of Horticultural Science, https://hdl.handle.net/11299/59291.

Jayson, E. A., Sivaperuman, C., & Padmanabhan, P. (2006). Review of the reintroduction programme of the Mugger crocodile Crocodylus palustris in Neyyar Reservoir, India. *The Herpetological Journal*, *16*(1), 69-76.

Joshi, R., Singh, R., & Negi, M. S. (2011). First record of mugger crocodile Crocodylus palustris (Lesson, 1831) from the Rajaji National Park, North India. *International Journal of Biodiversity and Conservation*, *3*(9), 444-450.

Kalin, J.A., 1955. ZurStammesgeschichtederCrocodilia. Rev Suisse Zool, 62: 347-356

Kipling, R, (1895). “The Undertakers”. The Second Jungle Book. Garden City, NY: Doubleday, Page & Co. pp. 109-144.

Lang J. W. 1976. Amphibious behavior of *Alligator mississippiensis:* roles of circadian rhythm and light. *Science* 191: 575-577.

Lang J. W. 1987. Crocodilian thermal selection. In: Wildlife management: crocodiles and alligator spp: 301-317. G. J. W. Webb, S. C. Manolis & P. J. Whitehead (Eds). Surrey Beatty and Sons Pty Limited/Conservation Commission of the Northern Territory, Chipping Norton

Manoj R. Borkar and Meenakshi Mallya v (1992). Eco-theological basis of Crocodile conservation in Goa. *Biology Education (ISSN: 0970-5961) Vol. 9, 4 Oct-Dec, P. 297-98*

Manoj R. Borkar and Meenakshi Mallya (1995). Crocodiles in territorial defence in pre-Portuguese Goa.*Hornbill 1995(1) p 20-22.*

Manoj R. Borkar (2003). Ecological history, contemporary status and conservation future of Marsh Crocodile *Crocodylus palustris* in Goa. pp 256-277.In: *Recent advances in Environmental Science* (ISBN: 81-7141-679-9). Ed. K.G. Hiremath, Discovery Publishing House

Manoj R. Borkar (2004). Estuarine Crocodiles of Goa. A chapter in the book *'Know our shores* 'Pgs 137-145., Edited by A. G. Untawale. A WWF Publication sponsored by Department of Science & technology, Govt. of Goa. PP 185.

Manoj R. Borkar (2004). *Marine Mammals, turtles and crocodiles-A field manual.* Editors: V.K. Dhargalkar and X.N. Verlekar. Published by National Institute of Oceanography (NIO) with financial support from MoE&F, Govt of India, New Delhi.

Masum, K. M., Rahman, Z. M. M., Alamgir, M., Mamun, A. A., & Abdullah-Al-Mamun, M. M. (2012). Breeding difficulty of Marsh Crocodile (Crocodylus palustris, Lesson, 1831) in Safari Park of Bangladesh. *Journal of Forest and Environmental Science*, *28*(4), 220-226.

Mobaraki, A., Abtin, E., Kami, H. G., & Kiabi, B. H. (2013). Reproductive biology of the Mugger Crocodile, Crocodylus palustris, in Iran (Reptilia: Crocodylidae). *Zoology in the Middle East*, *59*(3), 207-213.

Mobaraki, A., Silva, M. R., & Abtin, E. (2015). Sustainable Management and conservation of the Mugger Crocodile (Crocodylus palustris) in Iran. *Baeza: International University of Andalusia*, 1-2.

Murray, C.M., P. Russo, A. Zorrilla & C.D. McMahan (2019). Divergent morphology among populations of the New Guinea Crocodile, Crocodylus novaeguineae (Schmidt, 1928): diagnosis of an independent lineage and description of a new species. Copeia 107(3): 517–523.

Patil, S. R., Atigre, R. H., & Patil, S. V. (2012). First Record of Mugger Crocodile Crocodylus Palustrius (Lesson, 1831) from River Kadavi at Sarud, Tal, Shahuwadi, Dist. Kolhapur, MS, India. *International Proceedings of Chemical, Biological & Environmental Engineering*, *47*.

Porras Murillo, L.P. and E.M. Cambronero. 2020. Analysis of the interaction between humans and crocodiles in Costa Rica. South American Journal of Herpetology 16: 26–33. https://doi.org/10.2994/SAJH-D-18-00076.1.

Pough, F. H. 1983. Amphibians and reptiles as low energy systems. In: Behavioural energetics: the costs of survival in vertebrates. pp: 141-188. W. P. Aspey& S. I. Lustick (Eds). Ohio State Univ. Biosciences Colloquia, No. 7. Ohio State Univ. Press, Columbus, Ohio

Rafsanjani, A. K., & Karami, M. (2011). Eco-tourism necessity to preserve and maintain endangered species: A case study of mugger crocodile. *Journal of Geography and Regional Planning*, *4*(14), 708.

Rai, R. K., & Raj, B. S. (2015). Conservation of Crocodylus palustris in Kotmi Sonar of Janjgir-Chamapa (CG) India. *IOSR Journal of Environmental Science, Technology, and Food Technology*, *1*(3), 24-29.

Rao, M.V.S. (1993). A Handbook of Indian Crocodiles. Vishakapatnam, India, Andhra University Press and Publications, 18 pp

Rao, R.J., 1994. Ecological studies of Indian crocodiles, an overview. In crocodiles Proceedings of the 12th working Meeting of the crocodile specialist group. IUCN, Gland, Switzerland, 259-273.

RATHORE, H. S., PATI, J., DAS, A., & PANDAV, B. (2021). Population status and distribution of mugger crocodile Crocodylus palustris in the Similipal Tiger Reserve, Odisha, India. *Herpetological Bulletin*, *156*, 28-30.

Ross J.P. (Edit). 1998, Crocodiles, status survey and Conservation Action Plan, 2nd Edition, IUCN/SSC crocodile specialist Group, IUCN, Gland and Cambridge, UK.

Santiapillai, C., & de Silva, M. (2001). Status, distribution and conservation of crocodiles in Sri Lanka. *Biological Conservation*, *97*(3), 305-318.

Shirley, M.H., K.A. sliet, A.N. Carr & J.D. Austin (2013). Rigorous approaches to species delimitation have significant implications for African crocodilian systematics and conservation. Proceedings of the Royal Society B: Biological Sciences 281: 20132483. https://doi. org/10.1098/rspb.2013.2483

Singh, H., & Rao, R. J. (2017). Status, threats and conservation challenges to key aquatic fauna (crocodile and dolphin) in National Chambal Sanctuary, India. *Aquatic Ecosystem Health & Management*, *20*(1-2), 59-70.

Singh, L. A. K. (1999). Significance and achievements of the Indian crocodile conservation project. *ENVIS (Wildlife & Protected Area)*, *2*(1), 10-16.

Stevenson, C. (2019). Crocodiles of the world: A complete guide to Alligators, Caimans, Crocodiles and Gharials New Holland Publishers, 287pp.

Thorbjarnarson, J., 1992. Crocodiles – An action plan for their conservation. IUCN, Gland, Switzerland.

Trivedi, K., Patel, C., & Goyani, M. (2022). Status of Mugger Crocodile (Crocodylus palustris) and human-crocodile interaction in Surat, India. *Reptiles & Amphibians*, *29*(1), 329-334.

Vyas R. (2001), "Mass migration of muggers in Gir forest," Crocodile Spec. Group Newslett., 20(1), 8 – 9.

Vyas R. (2003), "Crocodile survey in and around the Barada Wildlife Sanctuary, Gujarat, India," Crocodile Spec. Group Newslett., 22(2), 14 – 17

Vyas, R. 2005. Recent notable incidences of conflict between Mugger and humans in Gujarat. CSG Newsletter 24(2): 7–8.

Vyas, R. (2014). ROADS AND RAILWAY: CAUSE FOR MORTALITY OF MUGGERS (Crocodylus palustris), GUJARAT STATE, INDIA. *Russian Journal of Herpetology*, *21*(3).

Vyas, R. (2018). Results of the 2015 Mugger Crocodile (Crocodylus palustris) Count at Vadodara, Gujarat, India. *Reptiles & Amphibians*, *25*(1), 20-25.

Vyas, R. and C. Stevenson. 2017. Review and analysis of human and mugger crocodile conflict in Gujarat, India from 1960 to 2013. Journal of Threatened Taxa 9: 11016–11024. https://doi.org/10.11609/jott.3790.9.12.11016-11024.

Whitaker, N. (2007). Survey of Human/Crocodile Confl ict in India, Maharashtra State, December 2007. Available at www.iucn.org//ph1/modules/Publications/reports.html.

Whitaker, N. 2008. Survey of human-crocodile conflict in Gujarat and Rajasthan: Trial of conflict mitigation education materials and further information on conflicts. Unpublished report to UNDP/GEF/SGP Project "Community based mitigation of human-crocodile conflict in India."

Whitaker, R. (1977). Note on the status of Gir crocodiles. J. Bombay Nat. Hist. Soc. 75(1): 224-227.

Whitaker, R. (1987). The management of crocodilians in India. Pp. 63-72 in Wildlife Management: Crocodiles and Alligators, ed. by G.J.W. Webb, S.C. Manolis and P.J. Whitehead. Surrey Beatty and Sons: Sydney.

Whitaker, R., & Andrews, H. (1989). First record of a skin nematode on an Indian mugger crocodile (Crocodylus palustris). Journal of the Bombay Natural History Society, 86(1).

Whitaker, R. & Daniel, J. C. (1978). The status of Asian crocodiles. *Tiger Paper* ***5,*** *6.*

Whitaker, R. and H.V. Andrews. 2003. Crocodile conservation, Western Asia region: An update. Journal of Bombay Natural History Society 100(2&3): 432–445.

Whitaker, R. and Whitaker, Z. (1979). Preliminary crocodile survey - Sri Lanka. J. Bombay Nat. Hist. Soc. 76(1): 66- 85

Whitaker, R. and Whitaker, Z. (1984). Reproductive biology of Mugger. J. Bombay Nat. Hist. Soc. 81(2): 119-127

Whitaker, R., and Whitaker, Z., 1989. Ecology of the mugger crocodile. In: crocodiles. Their Ecology, Management and conservation. A Special Publication of the Crocodile Specialist Group. ICUN, Gland, Switzerland, 276-297.

Zafar, M., & Malik, M. F. (2018). A review on status and conservation of mugger crocodile. *environment*, *19*(20), 21.

Webliography

https://mygoldengoa.com/ep-10-maange-thapne-a-ritual-performed-symbolizing-crocodile

https://timesofindia.indiatimes.com/entertainment/events/goa/ritual-that-teaches-us-co-existence-with-nature/articleshow/81231138.cms

https://timesofindia.indiatimes.com/city/goa/in-borim-farmers-follow-curious-ritual-of-sculpting-a-crocodile-from-silt/articleshow/80940786.cms

https://www.livemint.com/Politics/XT3XAh4KoIjxWqOY4dgwcO/A-prayer-for-the-crocodile.html

https://www.navhindtimes.in/2023/01/21/magazines/zest/in-worship-of-the-water-beast/

https://www.knocksense.com/goa/head-to-goas-backwaters-for-maange-thapnee-behold-the-traditional-worship-of-crocodiles

https://forest.goa.gov.in/sites/default/files/2022-06/ch7_man.pdf

https://www.indiawaterportal.org/articles/lost-khazans-goa

http://www.wiienvis.nic.in/Database/IBA_8463.aspx

https://www.wii.gov.in/nmcg/priority-species/reptiles/marsh-crocodile#:~:text=In%20India%2C%20it%20is%20reported,Madhya%20Pradesh)%20and%20in%20Gujarat.

https://pdf.usaid.gov/pdf_docs/pnaar887.pdf

https://www.biodiversitylibrary.org/part/153660

https://www.thetimes.co.uk/article/worshippers-mourn-death-of-gods-own-vegetarian-crocodile-9tj6xc90f

ANNEXURE 1: Questionnaire of preliminary virtual survey

Sighting of Mugger Crocodile in Goa

Goa has one species of Crocodile; Mugger/ Marsh Crocodile (Crocodylus palustris).
This is a virtual preliminary survey conducted for M. Sc. dissertation purpose of Miss. Vaishnavi Rajesh Naik.
She is currently pursuing her Master's degree in Zoology from Goa University.
Your name and identity wont be disclosed.

* Indicates required question

About you

1. Name *

2. Occupation *

3. Taluka *

Mark only one oval.

- Pernem
- Bicholim
- Ponda
- Tiswadi
- Quepem
- Sanguem
- Canacona
- Marmugao
- Bardez
- Dharbandora
- Sattari

4. Type of Area *

Mark only one oval.

- Urban
- Rural

5. Village/ Ward name

6. Contact number *

Mugger Crocodile sighting

7. Do you know Mugger Crocodile (Crocodylus palustris) ? *

Mark only one oval.

- Yes
- No

8. Have you seen Mugger Crocodile in YOUR area? *

Mark only one oval.

- Yes
- No

9. If yes, Please mention Water body TYPE

Mark only one oval.

- River नद्य
- Lake तळे
- Stream व्हाळ
- Pond डबके
- Sluice Gate मानस
- Bundh बांध
- Mining pit

10. Please mention water body NAME

11. Human dependency on water

Mark only one oval.

- Yes
- No
- Maybe

12. If yes, For....

Mark only one oval.

- Fishing
- Swimming/ Bathing
- Washing clothes
- Irrigation/ farming
- Drinking

13. Type of Fishing employed

Mark only one oval.

- Rod fishing गोरोवप
- Crab Trap कोबळी
- Line fishing पोळेर
- Gill net fishing काटाळी
- Spear fishing (Scuba/ Free dive)
- Sluice Gate मानस
- Gelatin fishing (Blasting bombs and bleaching powder)

14. When do you sight Mugger Crocodile?

Mark only one oval.

- Daily
- Thrice a week
- Rarely
- Sighted Once

15. Approximate COUNT of sighted Mugger crocodile

Mark only one oval.

- 1
- 2-3
- more than 3

16. Approximate SIZE of the sighted mugger crocodile

Mark only one oval.

- Less than 2ft
- 3-4 ft
- above 6ft

17. Activity seen of Mugger Crocodile

Mark only one oval.

- Swimming
- Basking on rock/ land/ open mouth
- Floating still in water
- Hunting/ Feeding
- Nesting
- Rescued
- Catch in fishing nets
- Dead

Mugger Crocodile sighting in OTHER locality

To be filled if you have seen at other than your locality/ Bondla captivity

18. Did you sight Mugger Crocodile at OTHER than your locality?

Mark only one oval.

- Yes
- No

19. Location name with Taluka

20. When you sighted there?

Mark only one oval.

- Few days back
- Last week
- Last month
- Many years back

21. Activity seen of Mugger Crocodile

Mark only one oval.

- Swimming
- Floating still in water
- Basking on rock/ mud/ open mouth
- Hunting/ feeding
- Nesting
- Dead
- Rescued
- Catched in fishing nets

Your take on Mugger Crocodile

22. Any information on Mugger Crocodile (Stories/ Incidences) *

23. Are Mugger Crocodile Culturally important in Goa? *

Mark only one oval.

- Yes
- No
- Maybe

24. Are you aware about Mugger Crocodile conservation laws? *

Mark only one oval.

- Yes
- No
- Maybe

25. Have you witnessed/ heard about hunting/killing of Mugger Crocodile? *

Mark only one oval.

- Yes
- No

26. What do you think is the DIET of Mugger Crocodile? *

Tick all that apply.

- [ ] Fishes
- [ ] Small animals
- [ ] Large animals
- [ ] Others

Thankyou for filling up the form

We hope you enjoyed filling this form.
Hoping for continued cooperation.
Grateful for your help.

ANNEXURE 2: Depictions of Mugger Crocodile in different cultures

(i)

(ii)

(iii)

(iv)

(v)

Figure A: Crocodile worshipped in different cultures **(i)** 'Makara' as crocodile shown as ride of Varun Dev; **(ii) '**Mogra Dev' wooden sculpture as a deity is worshipped among Choudhary tribe of Gujrat; **(iii)** Khodiyar mata worshipped by Patel community of Gujrat; **(iv)** Vishnu dev incarnation of Matsya avatar with crocodile, in Ahar museum of Rajasthan; **(v)** Makardwaj temple at Porbandar, Gujrat (Source of A.i, A.ii, A.iii, A.v: Wikipedia Creative commons)