Influence of Prey Availability and Abiotic Factors on Habitat Utilization of Mugger Crocodile (*Crocodylus palustris*) and Interactions with Fishermen in the Moyar-Bhavanisagar Landscape

by

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Enrolment no: 50BB24A7019

Master's Dissertation

Submitted to Academy of Scientific and Innovative Research

For the partial fulfilment for the requirements of the degree

Master of Science
in
Wildlife Science

Under the supervision of

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भारतीय वन्यजीव संस्थान
Wildlife Institute of India

AcSIR

July 2026

Influence of Prey Availability and Abiotic Factors on Habitat Utilization of Mugger Crocodile (*Crocodylus palustris*) and Interactions with Fishermen in the Moyar-Bhavanisagar Landscape

DECLARATION

I hereby declare that the work conducted under the thesis entitled **"Influence of Prey Availability and Abiotic Factors on Habitat Utilization of Mugger Crocodile (*Crocodylus palustris*) and Interactions with Fishermen in the Moyar-Bhavanisagar Landscape"**, is a record of original and independent research work done by me and subsequently submitted for the award of the degree of **Master's in Wildlife Science** at the **Academy of Scientific and Innovative Research**. This research work has been carried out under the guidance and supervision of **Dr. Gopi G. V., Scientist- F**, and co-supervision of **Dr. Abhijit Das, Scientist- E** of Wildlife Institute of India, Dehradun. The work has not formed the basis for the award of any other degree, diploma, or any other qualification. I also declare that the thesis embodies my own work, analysis, observation, understanding and the particulars given in it are true to the best of my knowledge.

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CERTIFICATE

This is to certify that the thesis by **Bryan Rana Thompson** entitled **"Influence of Prey Availability and Abiotic Factors on Habitat Utilization of Mugger Crocodile (*Crocodylus palustris*) and Interactions with Fishermen in the Moyar-Bhavanisagar Landscape"** is an original and independent research work submitted to the **Academy of Scientific and Innovative Research**, for the award of the degree of **Master's in Wildlife Science**.

Bryan Rana Thompson has put one semester of research work embodied in this thesis under my guidance and supervision. The work presented in this thesis has not been submitted to any other University or Institute for the award of any degree, diploma or distinction.

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Acknowledgements

I would like to wholeheartedly thank my supervisors, Dr. Gopi G. V. and Dr. Abhijit Das for being so supportive and open to all my ideas, right from the first time I approached them in their offices back in the first semester, all the way until the completion of my thesis. I greatly appreciate the amount of time they let me spend in their offices discussing all kinds of topics covering different corners of the country (crocodiles being the only constant) until we finally landed on my thesis topic. I am especially grateful to Gopi sir for always connecting me with the right people, getting me out of any and all logistics-related jams and taking the time out to visit me at my field site.

I would like to extend my heartfelt gratitude to PCCF – Tamil Nadu, DFO – Sathyamangalam Tiger Reserve for allowing me to carry out my research work in the beautiful Moyar River. A special thanks to Thiru. A. Udhayan, PCCF and Director of AIWC, for supporting my research work and facilitating my recce visit to Bhavanisagar reservoir. My study would not have been possible if it were not for the tireless efforts of the Tamil Nadu Forest Department field staff. I would like to thank FRO Shankar especially for facilitating my stay and visits to the park. Working across the many beats of STR, I have had the pleasure to meet and work with amazingly skilled and kind-hearted frontline staff, who put their lives on the line every day to protect these wild spaces. Forest Guards Vignesh and Vimal who made sure I was comfortable and that I was fed. And the APWs and Watchers that accompanied me on field and helped me with cast netting, without whom, an entire objective of this study would not have come to fruition: Ponnusamy, Kumar, Nagesh and Banta, to name a few.

I would like to thank the DFO – Coimbatore, for allowing me to stay at the FRH at Mettupalayam for my reservoir visits. In the actual reservoir, it was the fishermen community at Pethikuttai that made my entire second objective possible. Kabali, the boatman who was always ready to give me the full reservoir experience, helping me with deploying experimental nets and always going the extra mile. Subramaniam, who was always of great support, a key source of information and made the process of gelling with the wider community much easier.

I would like to especially thank our Course Directors, Dr. Sutirtha Dutta and Dr. Amit Kumar for running the whole course so smoothly, and giving us the best experience anyone could ever ask for from WII.

I would like to thank Director, Dean and Registrar of Wildlife Institute of India and all the faculty members of WII for their contributions to our course, and for imparting their years of experience all in the span of three semesters. I would especially like to thank Tirtho sir for being so patient with all of us, all while tackling our stats problems back-to-back, which more often than not, keeps him in office way past working hours (as it did today) without ever losing his cool. I would also like to thank Dr. Parag Nigam for being a pillar of support and source of advice, throughout the course and especially for my second term paper.

I'd be remiss if I didn't mention my friends that made this hostel a home. Srajal (my roommate who very selflessly took me in), Srinjan, Gayathri, Tanya, Shreyas, Joshika and Mencho, to name a few. The last two years would have been a whole lot duller without the endless 'brainrot vocal tics', very serious late night deliberations on what to order, exploring (to my initial surprise) Dehradun's rock n' roll scene or just generally geeking out over the same stuff. I, of course, can't not mention the inviolable tradition of post-field McDonald's, and our divide-and-conquer approach to a Clement Town visit. A special mention to Pranay for the conversations on our mutual, yet separate relationships with the '*Maayaar*'.

I'd also like to thank my family for entertaining my animal obsessions all my life enough to be okay (*ish*) with me doing this course and most importantly for letting me take the car through all the rocks and streams of the STR jungle roads. I thank God for keeping me and everyone accompanying me in one piece, through all the many times things could have gone terribly wrong. And finally, I'd like to thank the crocodiles for being (and not being) at the right places at the right times.

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1. Executive Summary

Crocodilians are considered to be apex predators of freshwater ecosystems, yet little is known about the influence of prey availability on their habitat utilization. In shared landscapes, crocodilians often compete with fishermen over fish resources. This study aims to measure the influence of prey availability (fish biomass) and abiotic features on the habitat utilization of mugger crocodiles in the Moyar river and to quantify crocodile-caused net damages and the associated costs experienced by fishermen in the Bhavanisagar reservoir. Model selection revealed that fish biomass was the best fit model for crocodile habitat utilization, along with sandy banks (which was most preferred for basking) and wider river sections, which showed weaker model fit for habitat utilization. Questionnaire surveys involving fishermen and experimental net monitoring in the reservoir revealed that the perceived frequency of crocodile-caused net damage is approximately 2.2 times higher than the observed frequency of net damage. The mean estimate of losses experienced by fishermen over a four month period in the reservoir due to crocodiles was calculated to be approximately Rs. 32,029. Nets placed closer to the bank experienced more damage by crocodiles than nets placed further from the bank. This study highlights the importance of prey availability and scientific management and monitoring of habitat for crocodile populations and provides baseline information on fishermen-crocodile conflict and can aid in informing stakeholders in implementing mitigation measures and compensation schemes.

2. Introduction

2.1 Prey availability and habitat use:

Optimal foraging theory predicts that predators will prefer to inhabit high-prey areas for easier access to prey and reduce energy expenditure (Charnov, 1976). Studies on predators have revealed the importance of prey availability in their habitat utilization. Birds of prey such as barn owls (*Tyto alba*) that are sensitive to fluctuations in prey availability have been documented to prefer grassland-dominated areas, coinciding with higher rodent abundance (Buhler et al., 2023). Ambush predators such as timber rattlesnake (*Crotalus horridus*), inland carpet python (*Morelia spilota*) and Eurasian lynx (*Lynx lynx*) are also known to utilize habitats with high prey abundance. However, for ambush predators, habitat complexity and structure are also drivers of habitat selection, which makes it difficult to understand the importance of prey abundance alone, as the two variables are often correlated (Heard et al., 2004; Tutterow et al., 2021; Malcangi et al., 2026). Factors such as prey quantity and availability can influence movement, distribution patterns, feeding rates and ultimately reproductive success of predators (Beauchamp et al., 2007) especially in aquatic ecosystems. Population structure of aquatic predators such as the Arafura filesnake (*Acrochordus arafurae*) have been observed to be influenced by prey availability and abundance.

2.2. Competition between aquatic predators and humans:

In aquatic systems worldwide, aquatic predators are often in competition with human beings for prey resources such as fish. Piscivorous predators such as Ganges river dolphins (*Platanista gangetica gangetica*) (Paudel & Koprowski, 2020), Amazon river dolphins (*Inia geoffrensis*) (Da Silva & Best, 1996), Eurasian otters (*Lutra lutra*) (Bodner, 1995), smooth-coated otters

(*Lutrogale perspicillata*) (Kruuk, 1995), and several crocodilian species such as black caiman (*Melanosuchus niger*), spectacled caiman (*Caiman crocodilus*), Yacare caiman (*Caiman yacare*) (Recharte et al., 2023), and Nile crocodile (*Crocodylus niloticus*) (Aust et al., 2009) have been extensively documented to be competitors with fishermen over fish resources. Examining the factors influencing the habitat selection of crocodilians is important because these reptiles are widespread across tropical freshwater ecosystems and are frequently implicated in negative interactions with local fisher communities.

2.3. Crocodilians and habitat selection:

Crocodilians are large-bodied predators and are widely regarded to be the dominant apex predator in freshwater and coastal ecosystems, due to them occupying the top position in aquatic food webs (Somaweera et al., 2020). There are 26 (currently described) extant species of crocodilians, divided into three families: *Crocodylidae*, *Alligatoridae* and *Gavialidae* (IUCN, 2026). Species of Crocodylia are found in over 100 countries, yet empirical knowledge of their ecology is not well understood, despite their ubiquitous nature (Somaweera et al., 2020). Most crocodilian species are regarded to be habitat generalists, as they occupy a wide range of natural and anthropogenic habitats and do not show any affiliation to a specific landscape-level vegetation (Grigg, 2015). Although, at a smaller spatial scale, habitat features such as vegetation, water parameters, bank characteristics, etc. influence habitat use (Somaweera et al., 2019). Crocodilians have been known to show extreme site fidelity and homing behaviour (Read et al., 2007), further supporting the notion of having an affinity towards certain habitat features within their wider range.

The drivers of habitat selection of crocodilians on a local scale have been studied through correlations to certain habitat characteristics. American alligators (*Alligator mississippiensis*) exhibit clustering patterns of distribution on a population level scale within a mosaic of wetland habitats (Eversole et al., 2018). Habitat use of mugger crocodiles (*Crocodylus palustris*) in Nepal is influenced by deeper water, substrate type, bank slope and anthropogenic threats (Bhattarai et al., 2022; Phuyal et al., 2025; Lamichhane et al., 2022) Studies on mugger crocodiles in India have documented preferences for specific substrate types and bank slope as well (Choudhary et al., 2017). However, none of these studies have attempted to quantify prey availability as a determinant of habitat utilization.

Crocodilians use a wide range of tactics for capturing prey, but they are most commonly known to be sit-and-wait ambush predators (Grigg, 2015). Despite being considered to be opportunistic generalist predators, crocodilians sometimes show preferences for certain species, as seen in species of Amazonian caimans (Villamarin et al., 2017). The abundance of prey sources such as fish and active rookeries has been observed to influence habitat use of American crocodiles (*Crocodylus acutus*), in addition to nesting site availability and open water (Thorbjarnarson et al., 1986). Crocodilians feed on a wide range of vertebrate and invertebrate prey sources, although there is considerable ontogenic shift and variability across species (Cott, 1961, Tucker et al., 1996, Wallace & Leslie, 2008; Hanson et al., 2015). The intermediate size class of Nile crocodiles show a diet comprising mainly of fish (Cott, 1961; Wallace & Leslie, 2008), a marked shift from the hatchling and juvenile diet consisting mainly of invertebrates. Due to their high utilization of fish (Cott, 1961; Nala et al., 2017), they regularly come into conflict with fishermen, by raiding fish from and damaging gillnets (Chihona, 2014; McGregor, 2005, Aust et al., 2009).

2.4. Fishermen-crocodile interactions:

An understudied aspect of human-crocodile interactions is of interactions between crocodiles and fishermen communities. Aust et al., (2009) estimates that 71,500 nets are damaged annually within one particular region by Nile crocodiles. In Amazonia, three species of caiman are considered to be competitors with fishermen over fish resources (Recharte et al., 2023). Crocodiles have also been observed occupying areas surrounding fishermen camps, indicating a potential dependence on fishing activities (Ezat et al., 2025). In other regions, crocodiles have been theorized to follow the plastic floats on the nets in order to feed on the fish caught in the gill nets (Chihona, 2014) or even following motorized fishing boats, associating them with net setting activities (Aust et al., 2009). This behaviour has been recorded in mugger crocodiles in India as well (Gurjwar & Rao, 2018) although there have not been any studies focusing on this phenomenon. Therefore, there is a growing body of evidence to show that crocodiles can have a significant impact on fishermen communities across the world.

2.5. Mugger crocodile ecology:

There are three crocodilian species in India, namely, the mugger crocodile, the saltwater crocodile (*Crocodylus porosus*), and the gharial (*Gavialis gangeticus*). Among these, the mugger crocodile is the most widespread within the country, occurring in both natural and anthropogenic habitats (Bors et al., 2024; Da Silva & Lenin, 2010). Mugger (or marsh) crocodiles are distributed across the Indian subcontinent, with wild populations ranging from Iran, Pakistan, India, Sri Lanka and Nepal. (Da Silva & Lenin, 2010). Mugger crocodiles act as apex predators and are widespread habitat generalists having been found in rivers, lakes, marshes, estuaries and even man-made habitats such as reservoirs, irrigation canals, water retention ponds and paddy fields (Da Silva & Lenin, 2010; Bors et al., 2024). Muggers are medium sized crocodiles with maximum lengths reaching around 4 m. The entire courtship, breeding and nesting in South India occurs between the months of November – June. Mugger crocodiles are hole nesters, laying around 26 to 30 eggs in a single clutch (Whitaker & Whitaker, 1986). Their populations have recovered due to the Crocodile Conservation Project, involving rear and release programs, initiated by the Government of India, along with the United Nations FAO and UNDP (Jacobson, 1999). Mugger crocodiles are listed as Schedule I in the Wildlife Protection Act, 1972. They are currently listed as Vulnerable by the IUCN with a global population ranging from 5,771 to 8,781 adult individuals and an increasing population trend in India.

Figure 1: Mugger crocodile in the Moyar river.

2.6. Research attention and knowledge gaps:

Despite the success of this species recovery program, there has been little scientific attention given to the various aspects of their ecology. Surveys conducted during the Crocodile

Conservation Project in India have yielded a wealth of natural history knowledge on the mugger crocodile (Whitaker & Whitaker, 1986) although quantitative studies on fine-scale habitat usage of mugger crocodiles with respect to prey availability across size classes is lacking. Besides population assessments and human-crocodile conflict surveys (Trivedi et al., 2022; Gour et al., 2022; Vyas, 2012; Vyas & Stevenson, 2017), there have been few ecological studies on the mugger crocodile in recent times. Ecological patterns such as predator-prey interactions involving mugger crocodiles have not been given research attention. Niche partitioning of muggers is studied in regions where they overlap with gharials (Choudhary et al., 2017; Sharma et al., 2024). Scat analysis studies show that a major portion of mugger crocodile diet consists of fish, as evidenced by presence of fish scales in majority of scat analysed (Nala et al., 2017; Dave & Bhatt, 2021). Similar to Nile crocodiles (Chihona, 2014; McGregor, 2005; Aust et al, 2009), muggers have been reported to damage fishing nets and cause declines in fish populations, (Gurjwar & Rao, 2018) although this has not yet been quantified.

2.7. Study Rationale:

The relatively constant habitat features (on a larger spatial scale) of the Moyar river provide an ideal setting for studying the effect of prey availability on the habitat utilization of crocodiles, thereby reducing, but not eliminating variation in habitat features. Prey availability has been quantified using fish biomass, as previous studies have indicated that mugger crocodiles (and species of similar size class as adult mugger crocodiles) consume fish as their primary source of prey (Cott, 1961; Nala et al., 2017; Dave & Bhatt, 2021). The Moyar river is also a relatively shallow and narrow river, which allowed the easy sampling of fish, using cast netting method. Although known for its abundance of crocodiles, there is a dearth of studies on crocodiles from the Moyar. The only study on this population by Samson et al., (2021) reported 81 individuals across all size classes from 36 km downstream section.

The adjoining Bhavanisagar reservoir, with its high presence of commercial fishing activities, and stocking programs for rohu (*Labeo rohita*), present a good opportunity for understanding the interactions of crocodiles with fishermen. In India, there is largely no importance given to the economic losses associated with crocodiles with respect to commercial activities such as fishing. Investigating this phenomenon can also give insights on crocodile feeding behaviour in a human-altered landscape. Compensation schemes exist in India for cases of wildlife crop-raiding, livestock-lifting and human fatalities, yet there has been no attention given to this specific form of human-wildlife conflict.

2.8. Objectives:

The objectives of this study are as follows:

1. **To examine the influence of prey availability (fish biomass) on the habitat utilization of crocodiles in the Moyar river.**

   Research Questions:

   a) Does prey availability influence crocodile habitat utilization in the Moyar river?

      Hypothesis: Prey availability (fish biomass) influences the habitat utilization (encounter rates) of crocodiles in the Moyar river.

      Prediction: Sections of the river with higher fish biomass will have higher crocodile encounter rates (taken as proxy for habitat utilization).

   b) Do abiotic factors influence crocodile habitat utilization in the Moyar river?

      Hypothesis: Abiotic factors will not influence the habitat utilization (encounter rates) of crocodiles as much as prey availability (fish biomass) in the Moyar river.

Prediction: Prey availability (fish biomass) will explain more variation in crocodile encounter rates (taken as proxy for habitat utilization) than abiotic habitat features.

2. **To quantify crocodile-caused net damage and associated costs experienced by fishermen in the Bhavanisagar reservoir.**

   Research Questions:

   a) How frequently do crocodiles damage fishing nets in the Bhavanisagar reservoir?

   b) What are the costs associated with crocodile-caused net damages?

   c) Does perceived net damage (questionnaire data) match the observed net damage (experimental net data)?

   d) What factors influence crocodiles causing net damages?

   Hypothesis: Net damage is influenced by net placement and structural features of the reservoir.

   Prediction: Net damage observed will vary based on structural features such as depth of the water and distance from the bank.

3. Study Area

The Moyar river is around 102 km in length and is situated in the Nilgiris Biosphere Reserve. The river originates in the Upper Bhavani (Nilgiris district) at an elevation of approximately 2,054 m above sea level and drains into the Bhavanisagar reservoir (Erode district) at an elevation of approximately 254 m above sea level, while flowing through protected areas such as the Mudumalai TR and Sathyamangalam TR. This perennial river also acts as a boundary between the states of Tamil Nadu and Karnataka. The Moyar traverses different forest types, from montane evergreen shola grasslands in its upper reaches, to moist deciduous and dry deciduous forests closer to where it meets the Bhavanisagar reservoir. There is a dramatic temperature gradient seen across the length of the Moyar. The minimum and maximum annual average temperatures in this region vary from 14 °C - 30 °C in higher elevations, and 25 °C - 38 °C in the lower elevations. The vegetation at the banks of the Moyar in the downstream section comprises of important riparian trees such as *Terminalia arjuna* and *Syzygium cumini*. The proliferation of *Prosopis juliflora* is very prominent along the riverbank as well as in the surrounding forests. The river consists of runs, riffles and pools, with a maximum depth of approximately 4 meters and is approximately 15-40 m wide in the downstream sections. Habitat features include different bank substrates such as sand, mud and rock. Rocks present in the middle of the river and small islands can also serve as basking structures for crocodiles.

Figure 2: Moyar River

The river is an important source of water for the wildlife of this region. Observations through camera trapping during the study duration recorded chital (*Axis axis*), Indian gaur (*Bos gaurus*), langur (*Semnopithecus entellus*), bonnet macaque (*Macaca mulatta*), Asiatic elephant (*Elephas maximus*), striped hyaena (*Hyaena hyaena*), sloth bear (*Melursus ursinus*), tiger (*Panthera tigris*), and dhole (*Cuon alpinus*) along the banks of the river. The river is also utilized by smooth-coated otters (*Lutrogale perspicillata*) which overlap with crocodiles in both the Moyar as well as the Bhavanisagar backwaters. Several interactions between crocodiles and otters were also recorded from the camera traps. Villagers from Kallampalayam, Nandhipuram and Thengumarahada also frequent the river for fishing using cast nets and gill nets.

The Bhavanisagar Dam completed construction in 1955 and was built under the confluence of the Moyar River and the Bhavani River. The reservoir is situated at the boundary of the Sathyamangalam TR (Bhavanisagar and Vilamundi ranges) on its western and northern banks and is bordered by several Reserve Forests. The reservoir is also utilized by the wildlife of the region, especially during the drier months. As is the case with the surrounding forests and the Moyar river, *Prosopis juliflora* has completely invaded the banks of the reservoir's backwaters. The reservoir is flanked by settlements and plantations such as banana, coconut and eucalyptus on its eastern banks. The reservoir has a maximum depth of 105 feet with a length of around 9 kilometers. The water catchment area stretches out from the Erode district into the Coimbatore district.

Figure 3: Bhavanisagar Reservoir

The reservoir has a history of fish stocking programs for the economic development of the region. Commercial fish such as catla (*Labeo catla*), rohu (*Labeo rohita*), calbasu (*Labeo calbasu*), common carp (*Cyprinus carpio*), Tilapia (*Oreochromis mossambicus*), pearlspot (*Etroplus suratensis)* and mrigal (*Cirrhinus cirrhosus*) have been stocked since 1953. Currently, rohu is the only fish being stocked in the reservoir as seedlings every year. The reservoir supports the livelihoods of several families of fishermen and local businesses in the Bhavanisagar town and wider areas. In addition to being an important fisheries area, the Bhavanisagar backwaters supports nesting of several species of waterfowl such as Great Cormorant (*Phalacrocorax carbo*), Indian Cormorant (P. *fuscicollis*), Grey Heron (*Ardea cinerea*) and Oriental Darter (*Anhinga melanogaster*).

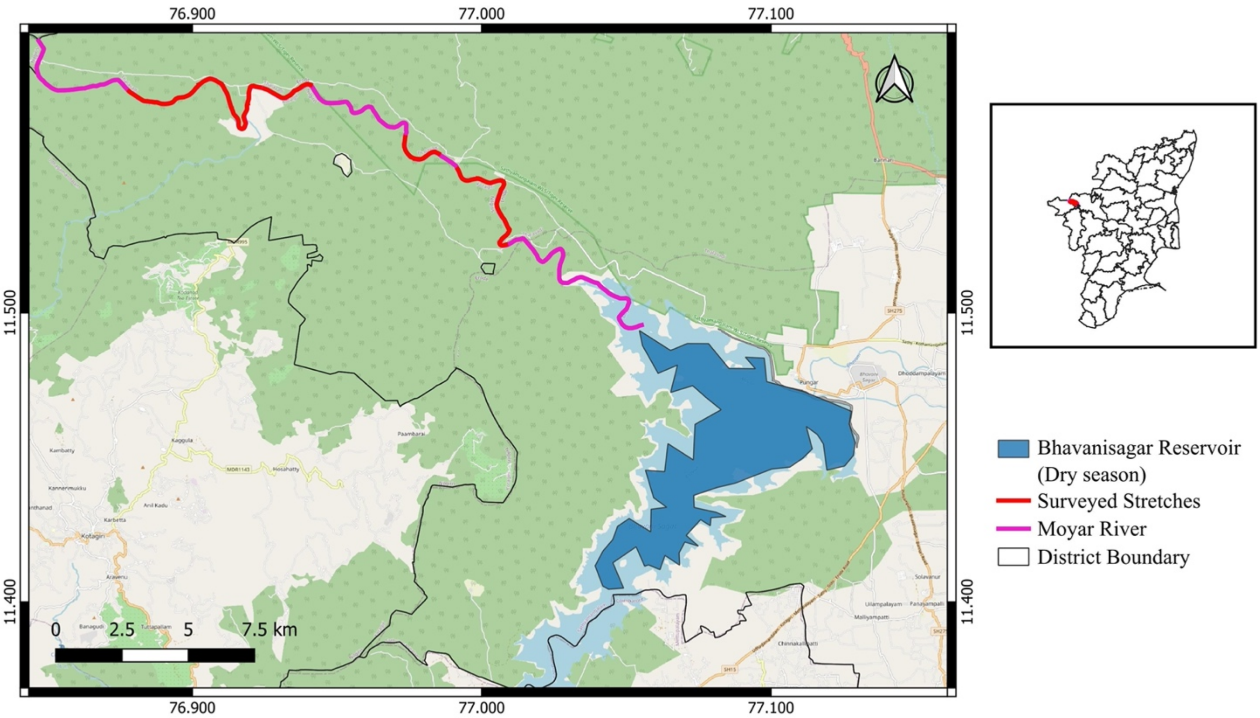


Figure 4: Map of study area: Bhavanisagar reservoir and Moyar river.

4. Methodology

4.1. Objective 1: To examine the influence of prey availability (fish biomass) on the habitat utilization of crocodiles in the Moyar river.

4.1.1. Prey availability and habitat characterization:

Habitat utilization of the crocodiles was studied in a 17 km long stretch of the downstream section of the Moyar river, where it meets the Bhavanisagar Reservoir. Three temporal replicates were done, resulting in 51 km of total effort. Temporal replicates were carried out once a month, to avoid pseudoreplication. Sections of the river were omitted due to field difficulties and logistics. Catch per unit effort (CPUE) sampling of fish was carried out throughout the study area, with cast netting. Fish were caught, weighed and swiftly released back into the river. GPS locations for each sampling point were taken as well. Survey covariates such as weather and ambient temperature were also taken. Cast netting was done with constant uniform effort throughout the transects (approximately 1 cast per 100 m). Mesh size of the cast net (35 mm) was kept constant throughout the study.

Figure 5: Cast-netting in Moyar river.

Habitat characteristics such as depth and width of the river, flow type (whether run, riffle or pool), bank substrate, vegetation along the bank, mid-river basking site presence and its substrate, prey species seen as well as signs (tracks, pellets, etc.) of prey species were collected every 200 meters for each transect. Depth of the river was measured using a depth sounder (Depthtrax H1), when accessed by coracle. Width of the river was measured using a rangefinder (Nikon Forestry Pro II). Survey covariates such as weather and ambient temperature were also taken.

4.1.2. Crocodile surveys:

Crocodiles were sighted along transects and recorded along with their size class. Classification of size classes were as follows: yearlings (<1 meter), subadults (1 - 2 meters), adults (>2 meters). If a crocodile was sighted while basking, substrate of basking site was recorded (sand, mud, rock, grass) and whether the basking site was on the bank or in the middle of the river. GPS location for each sighting was also recorded. Survey covariates such as weather and ambient temperature were also taken.

4.1.3. Analytical methods:

Habitat data collected every 200 m were consolidated for every 1 km long transect. Through this, the values for depth, width, proportion of substrate type, vegetation along bank and mid-river basking sites were derived for each transect. Pairwise Pearson correlation tests were performed for all habitat variables before model fitting to ensure predictor variables are not correlated. Generalized linear mixed models (GLMMs) with a Poisson error distribution and log link function were implemented to understand the influence of the predictor variables (fish biomass, habitat characteristics) on crocodile encounter rate data. All modelling was done in *RStudio* software using the package "*glmmTMB*". A set of biologically relevant candidate models were selected using various predictor variables. The following predictor variables were used for analysis: FishTotal (fish biomass), Depth (depth of river), Width (width of river), BankSand/BankMud/BankRock (proportion of sandy/muddy/rocky bank in transect), MidSand/MidMud/MidRock/MidNone (proportion of sandy/muddy/rocky/no mid-river basking sites in a transect), Tree/Shrub (proportion of tree or shrub along the bank in the transect), and presence of terrestrial prey species seen along the transect such as Chital and Langur. Model selection was done with the "*MuMIn*" package using the Aikake's Information Criterion corrected for small sample size (AICc). Models with ΔAICc < 2 were considered to have substantial support. The full set of candidate models is listed in *Appendix 2*.

Manly's selection ratios was used to evaluate basking substrate selection, calculated as proportion of substrate type use divided by the proportion of substrate type available, for each substrate type category. Substrate categories include : BankSand, BankMud, BankRock, MidSand, MidRock and MidMud. Values of ($w_i > 1$) indicated selection and values of ($w_i < 1$) indicated avoidance. Selection ratios were further standardized to obtain Manly's standardized selection indices which represent the relative preference for each substrate type after accounting for availability.

4.2. Objective 2: To quantify crocodile-caused net damage and associated costs experienced by fishermen in the Bhavanisagar reservoir.

4.2.1. Questionnaire surveys:

The interactions between fishermen and crocodiles were studied in the Bhavanisagar Reservoir. The Bhavanisagar reservoir supports approximately 30 fisher families that utilize the reservoir for fishing activities year round. Often multiple members of a family will take part in fishing activities together; therefore, a single interview is representative of a single family of fishers. A total of 23 interviews were conducted using a semi-structured questionnaire regarding the damage the fishermen experience from crocodiles to their nets. Interviews took place while fishermen collected the fish from their gill nets. Fishermen were asked which areas of the reservoir they experience damage, how often they experience net damage from crocodiles, whether nets are replaced after damage. Data regarding the financial value of the fish yield from a single net effort for each fisherman was calculated using the market price of the fish. The average fish yield caught by the fishermen in the reservoir was calculated from the catch of individual fishermen recorded on the days of conducting the interviews. Fishermen were asked for the proportion of fish yield lost when a crocodile raids and damages a net. Using this proportion, an approximate value of the financial loss incurred by the fishermen due to crocodiles can be calculated. The costs of buying the raw mesh, labour costs for preparing nets and other materials required for nets were collected to ascertain the total cost of a commercially used gill net.

4.2.2. Experimental net monitoring:

Gill nets were placed randomly in a section of the Bhavanisagar backwaters. Nets were placed across varying depths and distances from the banks, as well as in both reported and unreported damage sites. Experimental nets were placed with the help of local fishermen, matching the conditions and routines followed by fishermen regularly. Therefore, the experimental nets were devoid of any sort of bias and can be comparable to a normal gill netting done by the local fishermen. A total of 12 nets were placed overnight and were checked daily for damages. A total effort of 32 net days (days recorded for damages) was taken for the study. Depth of the water, distance from the nearest bank, total biomass of fish caught, and damages observed were the variables collected for each sample. From this data, the extent of crocodile damage to nets can be gauged and compared with findings from the questionnaire data.

Figure 6: Setting experimental nets with fishermen in Bhavanisagar Reservoir.

4.2.3. Analytical methods:

From the collected questionnaire data, the extent of crocodile-caused net damage experienced by fishermen within the period of the study duration (4 months) was extrapolated, so as to avoid assuming constant damage throughout the year.

To assess the differences between perceived and observed frequencies of crocodile-caused net damages, estimates from questionnaire data were compared with frequencies observed during experimental net deployments. Questionnaire responses regarding frequency of crocodile-caused net damage (daily, weekly, monthly, once in few months) were converted into the estimated number of damage events over the standardized four month study duration period (120 days). The proportion of fishing occasions associated with perceived crocodile-caused net damage was then calculated as the number of reported damage days divided by the total number of fishing days considered. Observed damage frequency was estimated from experimental net deployments by calculating the proportion of deployments in which crocodile-caused net damage was observed. Since experimental nets simulated the same conditions of normal gill nets set by local fishermen, the resulting proportions of crocodile-caused net damage were compared.

Poisson generalized linear models were run to understand the determinants of crocodile net damage occurrences. The variables used for analysis were Depth (depth of water where net was placed), Distance (distance of net from nearest bank), and FishBiomass (biomass of fish caught in the net). Modelling was done using base packages available in *RStudio*. Pearson correlation test was run to ensure that none of the predictor variables were correlated with each other. Model selection was done with the "*MuMIn*" package using the Aikake's Information Criterion corrected for small sample size (AICc). Models with ΔAICc < 2 were considered to have substantial support. The full set of candidate models is listed in *Appendix 3*.

5. Results

5.1. Objective 1: To examine the influence of prey availability (fish biomass) on the habitat utilization of crocodiles in the Moyar river.

5.1.1. Prey availability and habitat characteristics:

The mean crocodile encounter rate (crocodile count per 1 km transect) across the study duration is 0.61 crocodiles/km (± 0.15). Pairwise Pearson correlation coefficients among all predictor variables were examined prior to model fitting. Variables such as Trees/Shrubs and Run/Riffle showing strong correlation ($|r|>0.7$) and hence, were not used in candidate models. Pearson correlation matrix for the variables used is included in *Appendix 4.* The random effect variance for transect was 0.48 indicating substantial variation in crocodile habitat utilization across transects independent of fish biomass. Six candidate models received substantial support ($\Delta AICc < 2$). Fish abundance was included in all six highly ranked models, indicating that fish biomass is the strongest and most precise predictor of crocodile habitat utilization. Additional habitat variables such as depth and width of river, mid-river rocks, and sandy banks showed marginal, yet weak and imprecise improvements to model fit. Although there is considerable uncertainty in model selection, the univariate FishTotal model was selected, since it is the simplest model and is also ecologically relevant.

S. No.	Predictor(s) Included	Deviance (-2logLik)	K (parameters)	ΔAICc	Akaike Weight
1	FishTotal	94.30	3	0.00	0.163
2	FishTotal + Width	91.95	4	0.02	0.162

3	FishTotal + MidRock	92.58	4	0.64	0.119
4	FishTotal + Depth	92.91	4	0.97	0.101
5	FishTotal + BankSand + FishTotal × BankSand	90.85	5	1.38	0.082
6	FishTotal + Width + FishTotal × Width	91.41	5	1.94	0.062

Table 1: Model selection table for factors influencing habitat utilization of mugger crocodiles.

Model	**FishTotal**	**Width**	**Depth**	**MidRock**	**BankSand**	**FishTotal × BankSand**	**FishTotal × Width**
1	0.592 ± 0.146	–	–	–	–	–	–
2	0.533 ± 0.144	0.079 ± 0.053	–	–	–	–	–
3	0.630 ± 0.147	–	–	1.654 ± 1.290	–	–	–
4	0.589 ± 0.148	–	0.608 ± 0.532	–	–	–	–
5	1.658 ± 0.612	–	–	–	1.224 ± 1.325	−1.979 ± 1.075	–

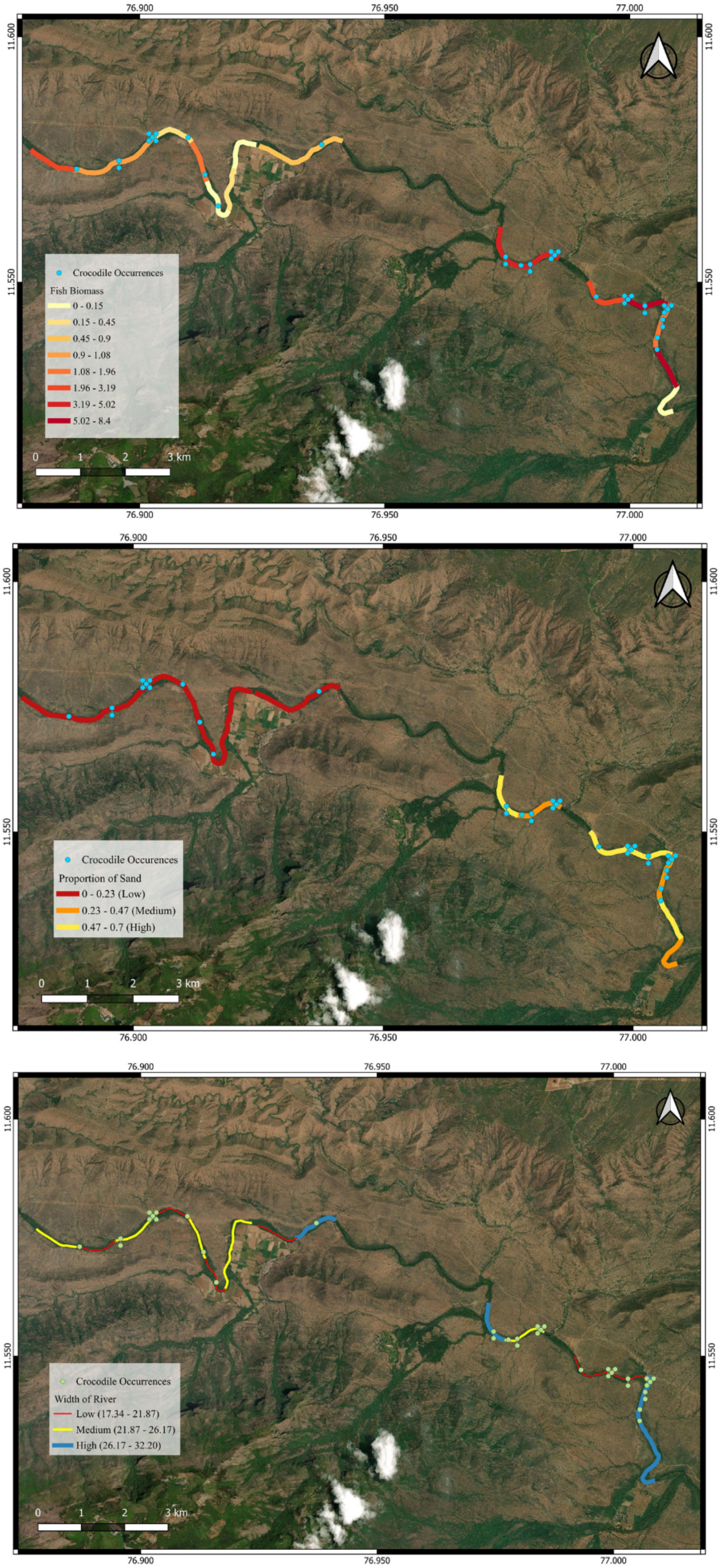
6	1.154 ± 0.872	0.116 ± 0.074	–	–	–	–	−0.025 ± 0.034

Table 2: Model summary table of selected models (ΔAICc < 2) for habitat utilization, with estimate and standard errors.

(a)

(b)

(c)



76.900
76.950
77.000
11.600
11.550
Crocodile Occurrences
Fish Biomass
0 - 0.15
0.15 - 0.45
0.45 - 0.9
0.9 - 1.08
1.08 - 1.96
1.96 - 3.19
3.19 - 5.02
5.02 - 8.4
0
1
2
3 km
Crocodile Occurences
Proportion of Sand
0 - 0.23 (Low)
0.23 - 0.47 (Medium)
0.47 - 0.7 (High)
Crocodile Occurrences
Width of River
Low (17.34 - 21.87)
Medium (21.87 - 26.17)
High (26.17 - 32.20)

Figure 7: Gradient of (a) fish biomass (in kg) per transect, (b) proportion of sand and (c) width of river (in m) along with crocodile occurrences across study area.

5.1.2. Basking site selection:

A total of 31 basking observations of crocodiles were recorded and compared with substrate availability across the study area. Manly's selection indices revealed that crocodiles showed strongest preference for sandy substrates. Mid-river rocks were also moderately preferred, whereas muddy substrate in mid-river islands were used approximately in proportion to their habitat. However, banks with muddy and rocky substrates were strongly avoided. Basking site preferences must be interpreted with caution, due to the low sample size of crocodile basking observations and substrates such as mid-river sand and mud.

Habitat Category	Availability	Use	Availability Proportion	Use Proportion	Manly's Selection Ratio (w)	Standardized Manly Index (B)
Bank Mud	93	5	0.396	0.161	0.41	0.053
Bank Rock	45	1	0.191	0.032	0.17	0.022
Bank Sand	38	15	0.162	0.484	2.99	0.389
Mid-River Mud	8	1	0.034	0.032	0.95	0.123

Mid-River Rock	47	8	0.200	0.258	1.29	0.168
Mid-River Sand	4	1	0.017	0.032	1.90	0.246

Table 3: Values of Manly's selection ratios for basking substrate used by crocodiles.

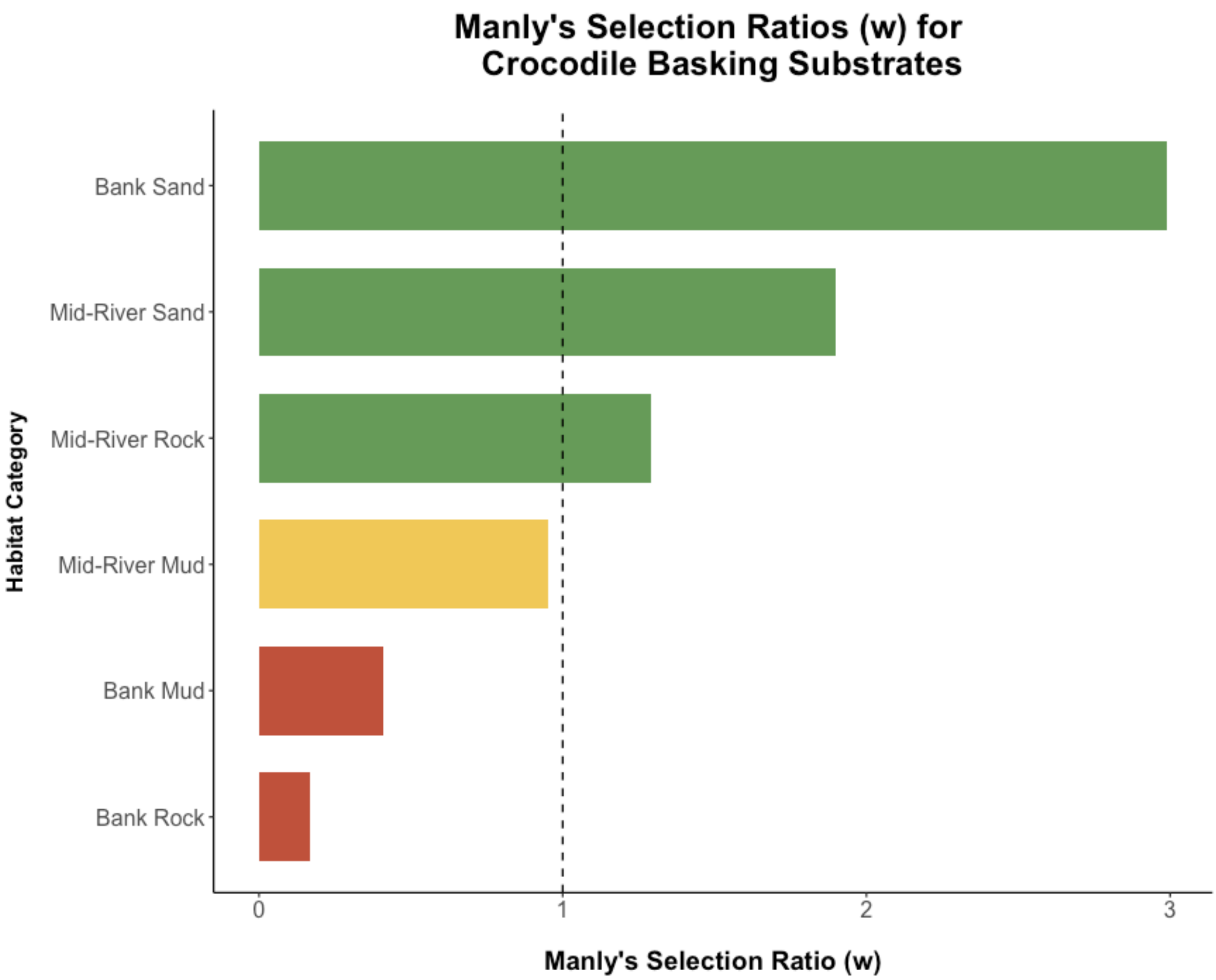


Figure 8: Manly's selection ratios (w) for basking substrate used by crocodiles.

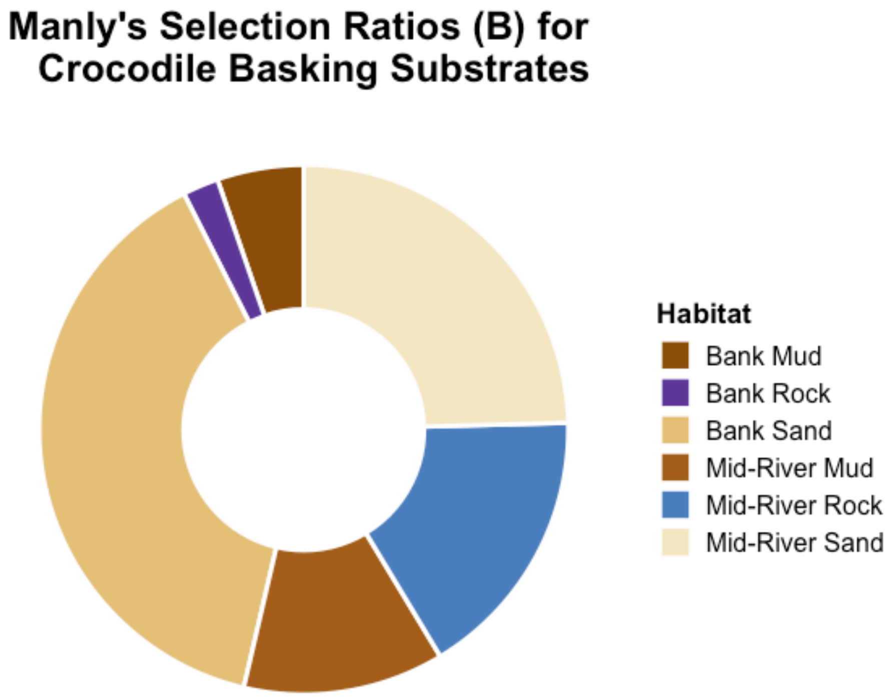


Figure 9: Manly's selection ratios (B) for basking substrate used by crocodiles.

5.2. Objective 2: To quantify crocodile-caused net damage and associated costs experienced by fishermen in the Bhavanisagar reservoir.

5.2.1. Frequency of crocodile-caused net damages:

A total of 23 fishermen were interviewed using a semi-structured questionnaire. The frequency of crocodile-caused net damage reported through the questionnaires is represented in *Figure 9*.

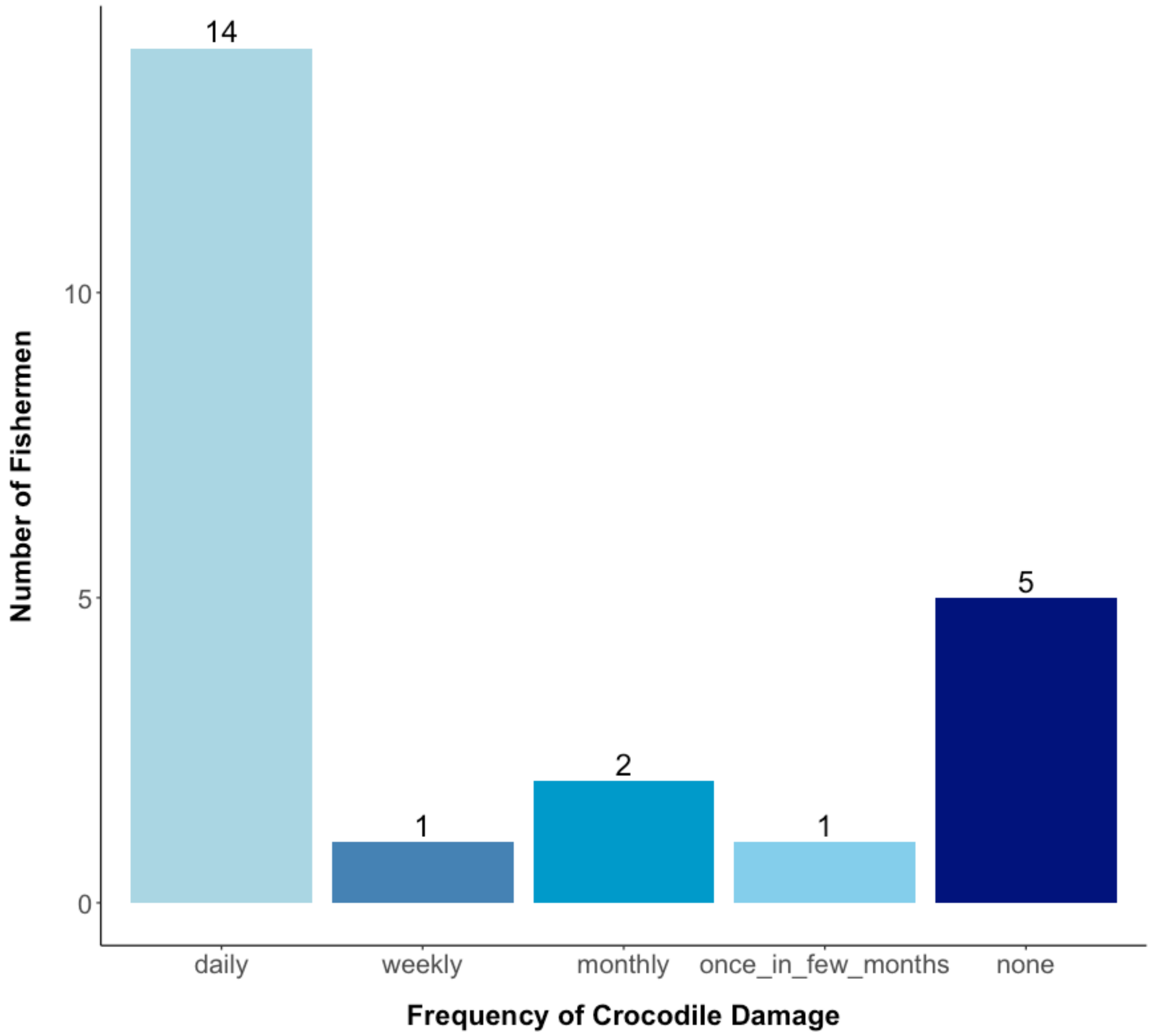


Figure 10: Frequency of crocodile-caused net damages experienced by fishermen according to questionnaire data.

5.2.2. Costs associated with crocodile-caused net damage:

The approximate estimates of costs associated with crocodile-caused net damages experienced by fishermen have been calculated from questionnaire data. All mean estimates of revenue and losses are taken over a 120 day (4 month) period. Losses of fish and losses of nets were calculated separately, and cumulative losses were calculated for each fisherman. Confidence intervals for the means were estimated using the Student's t-distribution under a parametric framework. The mean estimates and the confidence intervals for each variable is given in *Table 4*.

Variable (4-month period)	Mean (₹)	95% CI (₹)
Gross revenue	76,774	53,021 – 1,00,527
Loss of fish	18,986	12,508 – 25,463
Cost of new nets	13,044	7,331 – 18,756
Total losses	32,029	21,649 – 42,409
Net revenue	44,745	34,365 – 55,125

Table 4: Estimates for costs associated with crocodile-caused net damages experienced by fishermen.

5.2.3. Perceived v/s observed net damage:

The average frequency of crocodile-caused net damage reported by fishermen from questionnaire data was approximately 61.7% (74 out of 120 days (standardized four-month duration)). Contrastingly, the observed frequency of crocodile-caused net damage from the experimental net data was approximately 28.1% (9 out of 32 days). Therefore, the perceived crocodile-caused net damage is approximately 2.2 times higher than the observed crocodile-caused net damage.

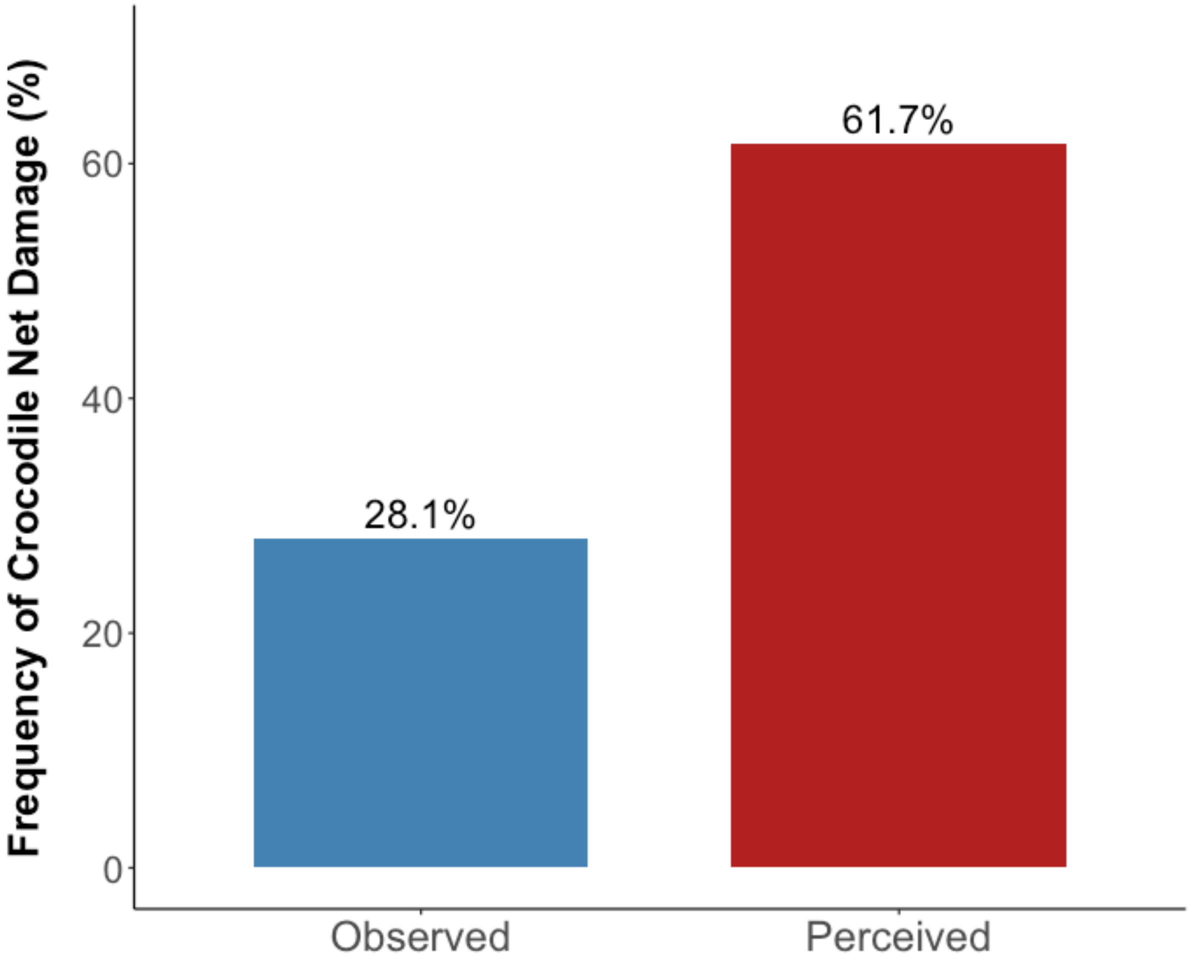


Figure 11: Frequency of perceived and observed crocodile-caused net damage.

5.2.4. Factors influencing crocodile-caused net damages:

Pairwise Pearson correlation coefficients among all predictor variables were examined prior to model fitting. No pair of predictors showed a strong correlation (all $|r|<0.7$) therefore multicollinearity is not a concern. Pearson correlation matrix for the variables used is included in *Appendix 5*. Poisson generalized linear models revealed increasing distance from the nearest bank is negatively associated with crocodile-caused net damages, meaning that nets placed closer to the bank experienced more damages than nets placed further from the bank. Model selection indicated that distance from the nearest bank was the most substantial indicator of crocodile-caused net damages. However, additive and interactive effects with fish biomass and depth of the water also shows marginal support to model fit, since all models fall within ΔAICc < 2. The results indicate that while distance from the nearest bank is the most consistently supported predictor, depth and fish biomass may also explain variation in crocodile-caused net damages. The univariate Distance model is selected as the best fit model despite model selection uncertainty, since it is the strongest and most precise predictor and is the most parsimonious model.

S. No.	**Predictor(s) Included**	**Deviance (-2logLik)**	**K (parameters)**	**ΔAICc**	**Akaike Weight**
1	Distance	60.06	2	0.00	0.294
2	Distance + Fish Biomass + Distance × Fish Biomass	55.33	4	0.34	0.248
3	Depth + Distance	59.11	3	1.50	0.139
4	Fish Biomass	61.93	2	1.87	0.115

Table 5: Model selection table for factors influencing crocodile-caused net damages.

Model	**Distance**	**FishBiomass**	**Depth**	**Distance × FishBiomass**
1	−0.0069 ± 0.0027	–	–	–

2	−0.0021 ± 0.0037	0.6773 ± 0.3621	–	−0.0146 ± 0.0085
3	−0.0064 ± 0.0026	–	0.1781 ± 0.1846	–
4	–	0.4832 ± 0.1996	–	–

Table 6: Model summary table of selected models (ΔAICc < 2) for factors influencing crocodile-caused net damages, with estimates and standard errors.

6. Discussion

6.1. Objective 1: To examine the influence of prey availability (fish biomass) on the habitat utilization of crocodiles in the Moyar river.

6.1.1. Prey availability and habitat utilization:

Fish biomass was the best fit model for explaining variation in crocodile encounter rates (taken as proxy for habitat utilization). Although adult crocodiles are known to consume other vertebrates, fish was taken as the main prey type to be quantified in this study, due to its relative importance to crocodiles (Cott, 1961; Nala et al., 2017; Dave & Bhatt, 2021). Models fitted using other vertebrate prey species such as chital and langur, showed no significance with crocodile occurrences. The considerable variation in prey selection of mugger crocodiles across its range (Nala et al., 2017; Dave & Bhatt, 2021; Vyas et al., 2024), suggests that the result of this study is context-dependant and caution must be exercised when interpreting the findings beyond the Moyar river system. However, this study gives us insights into the spatial arrangement of a major prey source and apex predator of this freshwater ecosystem. Although there have been studies quantifying spatial patterns and habitat utilization of other predator and prey systems (Heard et al., 2004; Tutterow et al., 2021; Buhler et al., 2023), there have been few similar studies done on crocodilians. The difficulty in quantifying prey availability for crocodiles (predominantly opportunistic generalist species) has prevented exploration into this aspect of crocodilian ecology. Somaweera et al., (2011) revealed that habitats with higher food availability (invertebrates) harboured more hatchling freshwater crocodiles (*Crocodylus johnstoni*), and hatchlings in these areas also had higher feeding rates than other areas. This indicates similar relationships in adult crocodilians as well, mirroring the results of the present study and highlighting the need for further studies in other crocodile habitats.

6.1.2. Abiotic habitat factors:

Sand bank, mid river rocks, river width and depth provided weaker support for explaining variation in crocodile encounter rates (taken as proxy for habitat utilization). Sand banks are also the most strongly preferred substrate type used for basking by crocodiles in the study area. Similar studies have observed mugger crocodiles mostly utilizing sand banks (Choudhary et al., 2017), although found to not be a significant predictor of habitat selection (Nishan et al., 2023). These studies were conducted in habitats where mugger crocodiles occur along with gharials, which prefer sandy banks more than mugger crocodiles due to their smaller limbs and reduced mobility (Nishan et al., 2023). Therefore, in a habitat devoid of gharials, mugger crocodiles may utilize sandy banks more than in habitats with gharials. Sandy banks may also be sought after by crocodiles for nesting. The breeding season of mugger crocodiles in this region coincide with the study duration, leading to crocodiles occupying potential nesting areas. The inclusion of river width and depth in some supported models may simply be a result of wider and deeper sections of the river providing more space for crocodiles to occupy, thereby resulting in higher sightings in these stretches. Wider and deeper sections of river could also support higher fish abundance, resulting in the positive association with crocodiles.

6.1.3. Human impact:

Crocodiles were encountered throughout the study area but were sighted less in the vicinity of the Thengumarahada village. Fish biomass in these areas was also very low, probably due to the fishing practices of the local residents of Thengumarahada. The effect of human disturbance along the transects was not taken into consideration for the Moyar river, as the majority of the stretch is completely undisturbed. Throughout the surveys, Thengumarahada locals were encountered a few times fishing in the river. Crocodiles in the Moyar appear to be incredibly sensitive to human presence, often retreating into the water as soon as humans are detected even from relatively long distances. Due to this fact, the effect of human presence, however miniscule, on the detection of crocodiles cannot be ignored. Although, transects (devoid of human presence) which once had a good abundance of fish and crocodiles, had fewer fish and consequently lesser crocodile encounters on repeated surveys (temporal replicates).

6.1.4. Influence of fish stocking:

The downstream sections of the Moyar river, closer to the Bhavanisagar reservoir had higher abundance of fish, which resulted in the higher encounter rate of crocodiles. This could be due to the fish stocking programs of the Bhavanisagar reservoir, which release seedlings of rohu every year into the reservoir. Rohu is not native to the Moyar river system (Dahanukar, 2010) and has been introduced through such stocking programs but has established itself throughout the surveyed stretch of the Moyar, as far as 25 kilometres upstream from the mouth of the river. Crocodiles seeking out areas with high fish abundance such as rohu could also explain the pattern of net-raiding seen in the Bhavanisagar reservoir by crocodiles.

6.1.5. Conservation implications:

The study offers additional context to the habitat quality and conditions of high crocodile density areas across their range. Due to the success of the Crocodile Conservation Project, mugger crocodiles have recovered in parts of India, but the species remains of conservation concern across its range. The findings of this study highlight the need for scientific monitoring of crocodile habitat and prey availability to ensure the long-term viability of the species. The study can also inform further management decisions for other crocodilians such as the critically endangered gharial, for which reintroduction and restocking efforts are still ongoing for several years, without much establishment of rewilded populations. Currently, there are no protocols of quantifying prey availability in prospective release sites. The inclusion of this criterion into the habitat feasibility analysis (an important component of reintroductions) would be beneficial for the continued survival and establishment of apex predators such as the gharial, in addition to other components of habitat.

6.1.6. Limitations:

Although prey availability has been quantified, the study could not quantify the actual prey use by the crocodiles using isotopic analysis or scat analysis, due to limited funding and study duration. Further stretches of the Moyar river could not be surveyed due to field difficulties and logistics. Continuous surveys throughout the entire Moyar river could give information on the effects of altitudinal variations within a single population of crocodiles. Due to the limited duration and effort, the study has a limited sample size. Therefore, the study may not fully capture the broader ecological patterns relating to crocodile-prey interactions and so, the results of this study must be interpreted with caution. The extreme shy nature of the crocodiles in the Moyar made it much more difficult to detect crocodiles, compared to those in other regions in the country. As a result, the detections of crocodiles from this study cannot be used as an exact figure of population abundance.

6.2. Objective 2: To quantify crocodile-caused net damage and associated costs experienced by fishermen in the Bhavanisagar reservoir.

6.2.1. Crocodile-caused net damages:

Since crocodiles consume fish as a primary source of prey, and encounter rates of crocodiles in the Moyar river was significantly influenced by increased fish biomass, the gill nets in the adjoining Bhavanisagar reservoir could potentially serve as easy sources of food for crocodiles. Crocodiles hunt using integumentary sensory organs (ISOs) which can sense vibrations caused by the movement of prey animals in the water. Fish typically thrash violently when caught in gill nets, which could attract crocodiles. The behaviour of net raiding and its subsequent impacts have been documented extensively in Nile crocodiles (Chihona, 2014; McGregor, 2005; Aust et al, 2009), however this behaviour is poorly understood in mugger crocodiles, although it has been reported in the Chambal River population (Gurjwar & Rao, 2018). Experimental net data revealed that crocodiles damage fishing nets on 9 occasions out of a total 32 days. Multiple damages are recorded occurring on a single net, indicating that crocodiles revisit the same nets, even after initial damage. The frequency of observed damage indicates that multiple crocodiles in the reservoir exhibit net-raiding behaviour, as the observed frequency is inconsistent with crocodile (ectotherm) feeding frequencies, which do not need to feed as frequently as endotherms.

Figure 12: Experimental gill nets damaged by crocodiles in Bhavanisagar reservoir.

6.2.2. Comparisons with otter-caused net damages:

Data collected on otter-caused net damages from both questionnaire surveys and experimental net monitoring in this study reveal that otters raid fishing nets more frequently than crocodiles. The perceived conflict of otters, derived from questionnaires is approximately 95 out of 120 days (78.8%). Observed conflict from experimental net data revealed that otters damage nets 10 days out of a total 32 net occasions. This points to the increased energetic demands of endothermic mammals like otters compared to that of ectothermic reptiles such as crocodiles. Otters use their dextrous paws to hold on to and remove fish from the nets, which cause smaller tears in the nets. On other occasions, otters have been known to consume parts of the fish, while still attached to the nets. A characteristic behaviour of otters is to consume the head of a fish and leave the remains of the body on the net (*as seen in Figure 13*). Although otters damage nets more frequently than crocodiles, the extent of their damage is relatively lower than that of crocodiles, due to the nature of these damages.

Figure 13: Smooth-coated otter feeding on fish in Bhavanisagar reservoir.

Figure 14: Damage to fish catch (tilapia) in experimental nets by otters in Bhavanisagar reservoir.

6.2.3. Perceived v/s observed net damage:

Although the perceived net damages due to crocodiles is approximately 2.2 times higher than the observed net damage, crocodiles in the reservoir still cause significant losses in terms of both fish lost, as well as the net itself. The high losses borne by the fishermen could cause respondents to perceive frequency of net damage to be higher than actual net damage frequencies. 'Severity-weighted perception' could also influence respondents to remember certain events (those which resulted in financial losses) over days with no damages. However, fishermen that set multiple nets could experience crocodile-caused net damages on different nets daily. Damage on nets were observed both in reported and unreported sites. Since nets can also be revisited by crocodiles, this may completely deplete fish catch.

6.2.4. Factors influencing crocodile-caused net damages:

Crocodile-caused net damages were negatively associated with distance from the bank. This indicates that sections closer to the bank are the most utilized by crocodiles raiding nets. There is scant information on the foraging behaviours of crocodiles (Grigg, 2015). Some of the feeding strategies employed by crocodiles are ambushing prey along the bank, corralling or tail slapping fish into a tight corner close to the bank, or floating on the surface of the water with their forelimbs outstretched while approaching prey. Crocodiles have been often documented surfacing and bringing prey towards the edge of the water (or) the bank to consume it (Grigg, 2015; Vyas et al., 2024). This could potentially be an explanation for crocodiles raiding more nets closer to the banks of the reservoir. Deeper sections of the reservoir could also harbour higher fish abundance, resulting in more frequent damages from crocodiles. Influence of fish biomass caught in the net on crocodile raiding could not be adequately estimated due to the fish in the net being consumed by crocodiles before sampling could be done.

6.2.5. Economic losses associated with crocodile-caused net damages:

Although the Moyar-Bhavanisagar landscape supports a large population of crocodiles and people utilizing the same resources, there has been very few reported incidents of crocodile attacks on human beings. However, crocodiles and human beings in this landscape are in competition with each other over the fish resources in the Bhavanisagar reservoir. The study uses extrapolations of frequency of damage, proportion of loss from each damage event, costs of nets and market value of fish obtained from questionnaire data and key informant interviews. At present, there is little information on the interactions between crocodiles and fishermen. This study aims to understand the extent of crocodile-caused net damage, rather than provide an exact figure of loss experienced by each fisherman in the reservoir. However, the results of this study provide an informed estimate of the economic losses associated with crocodile-caused net damages, which can aid in the scientific management of fisheries, as well as this unique form of human-wildlife conflict. The fishermen in the Bhavanisagar reservoir do not take any measures to mitigate crocodile-caused net damage or retaliate in any way. Mitigation and preventative measures for otter-caused net damage implemented worldwide include noise emitters, changing the time of net placement, more frequent checking of nets and guarding nets (Václavíková et al., 2011; Akpona et al., 2014). However, these measures may not be feasible to implement for crocodiles and may be too time consuming for fishermen. Compensation schemes for otter damages to fishing nets are in place in several European countries (Václavíková et al., 2011), although there are no frameworks for compensation schemes for affected fishermen anywhere in the country. Therefore, this study provides baseline information on the widely unexplored economic dimensions of human-crocodile conflict, which could inform scientific mitigation measures and compensation schemes.

6.2.6. Limitations:

Questionnaire surveys yielded coarse information regarding the frequency and economic losses associated with crocodile-caused net damages, and exact estimates could not be ascertained for this phenomenon. Respondent bias and overextrapolation could have resulted in higher estimates of loss due to crocodiles. Sample size of experimental net data was relatively low due to the high costs of each gill net used for the experimental observations and the limited funding of the study. Annual estimates of loss could not be estimated due to the lack of data from multiple seasons (monsoon and pre-monsoon).

7. Conclusion

The results of the study showed that fish biomass was positively associated with crocodile encounter rates, which was taken as a proxy for habitat utilization. Banks with sandy substrate, (which are most preferred for basking), and wider sections of river also provide weak support in explaining variation in crocodile encounter rates. The perceived frequency of crocodile-caused net damages was approximately 2.2 times higher than the observed frequency documented through experimental net monitoring. Experimental net data also revealed that nets placed closer to the bank experienced more damage due to crocodiles. These findings suggest that fish abundance (prey availability) plays an important role in shaping the habitat utilization of crocodiles on a population level. Although sensitive to human presence, the crocodiles take advantage of the fish in the reservoir by raiding gill nets, which serve as an easy source of food. These findings give us insights into patterns of mugger crocodile foraging behaviour, which is an understudied aspect of crocodilian ecology in India.

From a management perspective the study highlights the importance of healthy fish populations and overall habitat quality for abundant populations of mugger crocodiles. Although no longer dependant on conservation efforts in some parts of its range, the key to the continued survival of mugger crocodile populations throughout the country is the scientific management and systematic monitoring of wetland and river ecosystems. Fisherman-crocodile conflict is an often neglected component of human-wildlife interactions. The findings of this study provide estimates of the extent of crocodile-caused net damages and may assist conservationists, fisheries and forest department managers in making informed decisions regarding compensation schemes and mitigation measures for affected fishermen communities. Although prey availability seems to influence the habitat utilization of crocodiles in this study, there must be more attention given to this topic in other populations of crocodiles across a larger spatial and temporal range. Future studies must also be carried out in other important fisheries areas in which crocodiles occur such as the Amaravathi reservoir (Whitaker & Whitaker, 1986) to evaluate the wider influence of crocodiles on fisheries. Through improving our understanding of the trophic interactions in freshwater ecosystems, the findings of this study provide a foundation for evidence-based management of rivers and wetlands and contribute to the long-term conservation of crocodilians and the communities that share spaces and resources with wildlife across the country.

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9. Appendices

1. Natural history observations

The study was conducted during the breeding season of mugger crocodiles (February to May). One large adult crocodile (presumed to be male) was found with multiple injuries on its right lateral side (along flank and on limbs), including a very deep wound on the right forelimb. The injuries are thought to be the result of male-male combat probably for access to territories and/or mates. Camera trapping during the study also revealed clashes between individuals over basking sites. An individual basking on a sandy bank was chased into the water by another individual to claim the bank for basking. Although mugger crocodiles are seen basking alongside other individuals in other regions. Across the study, the maximum number of crocodiles seen together at once were two individuals (from both direct observations and camera trap observations). This could potentially hint at these individuals being mating pairs. Crocodiles in this area could be showing extreme basking site fidelity. One individual was seen basking in the exact same spot (almost in the exact same position) on three consecutive days. Although camera trapping was not successful at this site (due to damage by elephants), more investigation into this phenomenon is needed to prove the extent of fidelity to a particular site for basking by crocodiles.

Stretches with high crocodile observations also yielded opportunistic sightings of smooth-coated otters. This could be explained by the high fish abundance also found in these stretches. Camera trapping and direct observations documented interactions between crocodiles and otters on several occasions; wherein otters (either single or in groups) will mob a crocodile to drive it away from the bank. The crocodile would usually react by swinging at the otters to chase them away. This behaviour is consistent with many observations of crocodile and otter interactions worldwide.

Figure 15: Large, wounded mugger crocodile in the Moyar river.

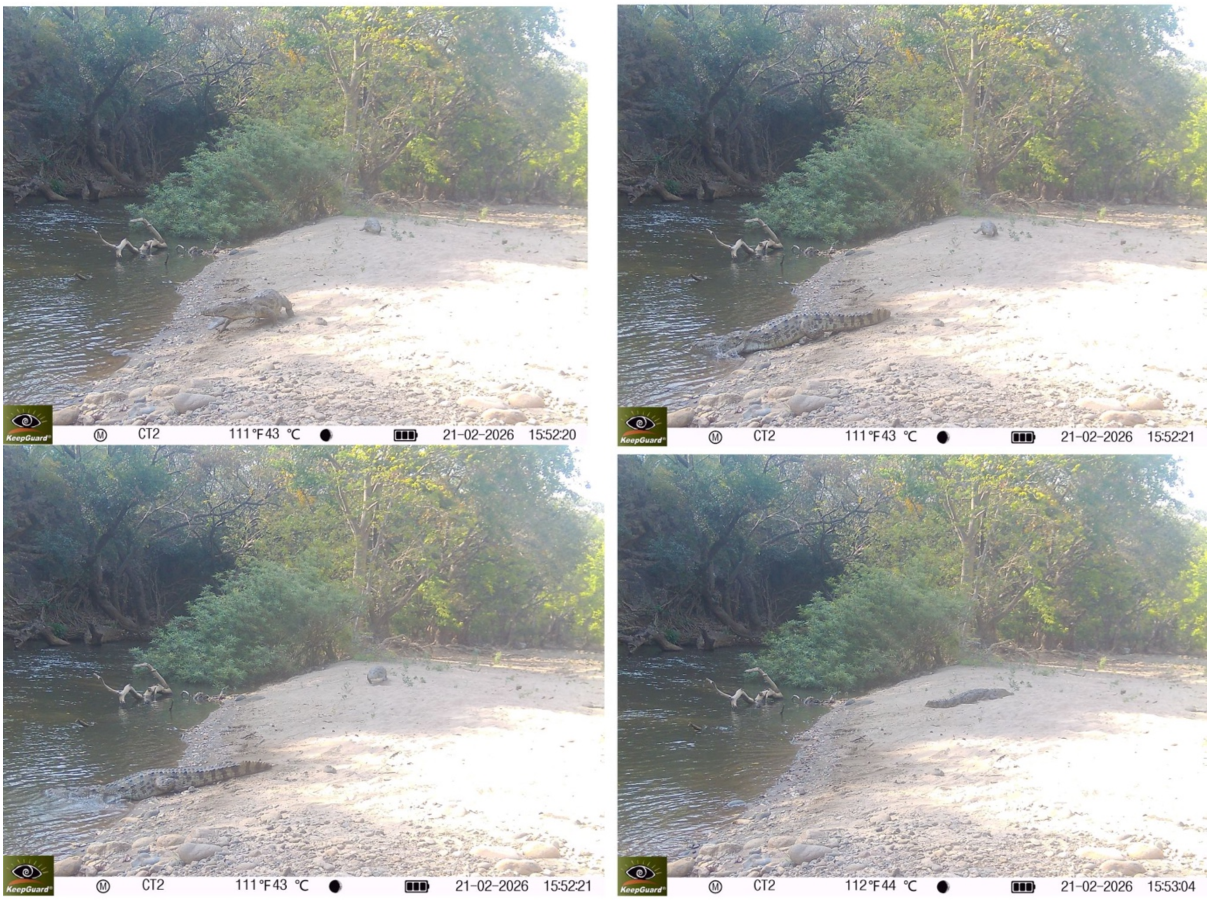

Figure 16: Mugger crocodile chasing another individual away from basking site.

Figure 17: Interactions between mugger crocodiles and smooth-coated otters in the Moyar river.

2. Candidate models used for habitat utilization of mugger crocodile in Moyar River.

Model	Fixed Effects	df	logLik	AICc	ΔAICc	Akaike Weight
mix1	FishTotal	3	-47.149	100.8	0.00	0.163
mix5	FishTotal + Width	4	-45.977	100.8	0.02	0.162
mix16	FishTotal + MidRock	4	-46.288	101.4	0.64	0.119
mix13	FishTotal + Depth	4	-46.453	101.8	0.97	0.101
mix7	FishTotal × BankSand	5	-45.425	102.2	1.38	0.082
mix4	FishTotal × Width	5	-45.706	102.7	1.94	0.062
mix9	FishTotal × BankSand + Width	6	-44.462	102.8	2.03	0.059
mix14	FishTotal + MidSand	4	-47.034	102.9	2.13	0.056
mix8	FishTotal + BankSand + Width	5	-45.854	103.0	2.23	0.053
mix6	FishTotal + BankSand	4	-47.144	103.2	2.35	0.050
mix17	FishTotal × MidRock	5	-46.238	103.8	3.00	0.036
mix12	Width + LeftBank	4	-47.485	103.8	3.03	0.036
mix15	FishTotal × MidSand	5	-46.946	105.2	4.42	0.018
mix3	Width	3	-52.022	110.6	9.75	0.001
mix11	BankSand + Width	4	-51.626	112.1	11.31	0.001
mix10	BankSand × Width	5	-51.612	114.6	13.75	<0.001
mix2	BankSand	3	-54.494	115.5	14.69	<0.001

3. Candidate models used to investigate factors affecting crocodile-caused net damages

Model	Fixed Effects	df	logLik	AICc	ΔAICc	Akaike Weight
g2	Distance	2	-30.029	64.5	0.00	0.294
g7	Distance × FishBiomass	4	-27.666	64.8	0.34	0.248
g4	Distance + Depth	3	-29.556	66.0	1.50	0.139
g8	FishBiomass	2	-30.966	66.3	1.87	0.115
g6	Distance + FishBiomass	3	-29.853	66.6	2.09	0.103
g1	Distance + Depth + FishBiomass	4	-29.345	68.2	3.70	0.046
g5	Distance × Depth	4	-29.552	68.6	4.11	0.038
g3	Depth	2	-32.842	70.1	5.62	0.018

4. Pairwise Pearson correlation matrix for predictor variables of habitat utilization

Variable	Fish Total	Width	Depth	MidRock	Mid Mud	Bank Sand	Bank Rock	MidSand	Trees	Shrubs	Grass	Riffle	Run	Pool	Chital	Langur	Macaque
FishTotal	1.00	0.15	-0.26	-0.10	-0.11	**0.74**	-0.09	0.53	0.06	-0.02	-0.19	0.27	-0.24	-0.14	0.19	-0.24	0.13
Width	0.15	1.00	-0.53	0.27	0.31	0.35	-0.18	0.49	0.00	0.01	-0.15	0.11	-0.12	0.07	-0.20	-0.11	0.41
Depth	-0.26	-0.53	1.00	0.07	-0.16	-0.32	-0.47	-0.34	-0.10	0.05	0.19	-0.37	0.38	-0.04	-0.11	-0.08	-0.33
MidRock	-0.10	0.27	0.07	1.00	-0.20	0.07	-0.29	-0.31	-0.02	-0.01	0.13	0.14	-0.16	0.13	-0.17	0.05	0.15
MidMud	-0.11	0.31	-0.16	-0.20	1.00	0.04	0.11	0.26	-0.22	0.25	0.01	-0.04	0.00	0.22	-0.31	-0.35	0.57
BankSand	**0.74**	0.35	-0.32	0.07	0.04	1.00	0.01	0.65	0.12	-0.07	-0.28	0.47	-0.43	-0.21	0.47	-0.18	0.41

BankRock	-0.09	-0.18	-0.47	-0.29	0.11	0.01	1.00	-0.10	0.28	-0.10	-0.41	0.52	-0.50	-0.11	0.34	-0.19	0.29
MidSand	0.53	0.49	-0.34	-0.31	0.26	0.65	-0.10	1.00	0.00	-0.03	-0.16	0.15	-0.12	-0.12	0.12	-0.29	0.33
Trees	0.06	0.00	-0.10	-0.02	-0.22	0.12	0.28	0.00	1.00	**-0.92**	-0.29	0.18	0.00	**-0.83**	0.05	0.12	0.17
Shrubs	-0.02	0.01	0.05	-0.01	0.25	-0.07	-0.10	-0.03	**-0.92**	1.00	-0.10	-0.06	-0.14	**0.92**	-0.01	-0.32	-0.10
Grass	-0.19	-0.15	0.19	0.13	0.01	-0.28	-0.41	-0.16	-0.29	-0.10	1.00	-0.28	0.30	-0.08	-0.19	0.48	-0.17
Riffle	0.27	0.11	-0.37	0.14	-0.04	0.47	0.52	0.15	0.18	-0.06	-0.28	1.00	**-0.98**	-0.12	0.24	-0.20	0.33
Run	-0.24	-0.12	0.38	-0.16	0.00	-0.43	-0.50	-0.12	0.00	-0.14	0.30	**-0.98**	1.00	-0.10	-0.21	0.25	-0.32
Pool	-0.14	0.07	-0.04	0.13	0.22	-0.21	-0.11	-0.12	**-0.83**	**0.92**	-0.08	-0.12	-0.10	1.00	-0.14	-0.20	-0.05
Chital	0.19	-0.20	-0.11	-0.17	-0.31	0.47	0.34	0.12	0.05	-0.01	-0.19	0.24	-0.21	-0.14	1.00	-0.03	0.08
Langur	-0.24	-0.11	-0.08	0.05	-0.35	-0.18	-0.19	-0.29	0.12	-0.32	0.48	-0.20	0.25	-0.20	-0.03	1.00	-0.39
Macaque	0.13	0.41	-0.33	0.15	0.57	0.41	0.29	0.33	0.17	-0.10	-0.17	0.33	-0.32	-0.05	0.08	-0.39	1.00

5. Pairwise Pearson correlation matrix for variables influencing crocodile-caused net damages

Variable	FishBiomass	Distance	Depth
FishBiomass	1.00	-0.60	0.01
Distance	-0.60	1.00	0.22
Depth	0.01	0.22	1.00