Coastal Mangrove Herpetofauna

An Ecological Study of the Greater Sundarbans

by

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This book is dedicated to:

My late grandparents Sanatan and Kamala

My late parents Shaktipada and Anima

My late wife Krishna

My daughter Runa

My son Sumanta

My son-in-law Saptarshi

and

My daughter-in-law Sagarika

Table of Contents

A Few Unique Herpetofauna Photographed in Different Microhabitats of the Study Area

I. Amphibians

Photograph 1: A nocturnal aquatic Indian Five-fingered Frog *Euphlyctis hexadactylus*

Usually coming out of the brackish water at night primarily to rest, forage, hunt for food (insects and other invertebrates), and find a potential mate during the monsoon months.

Photograph 2: Nocturnal appearance of a true terrestrial toad *Duttaphrynus melanostictus*

II. Reptiles

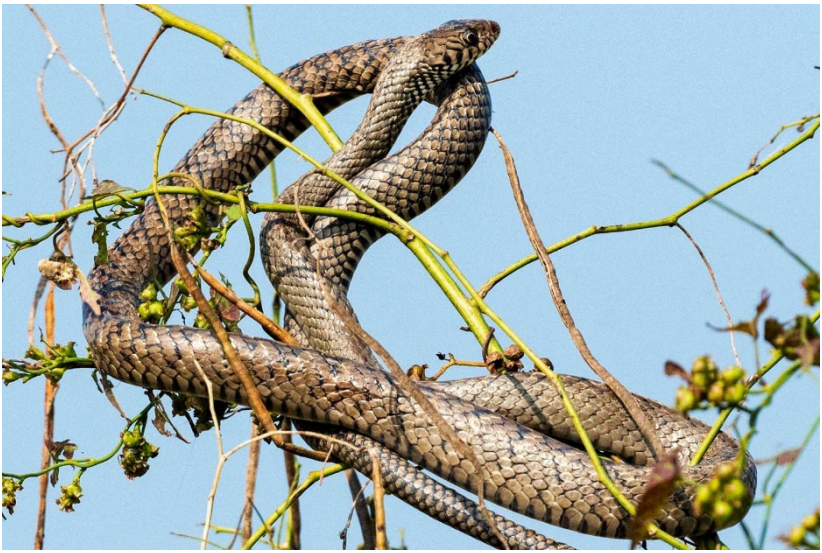
Photograph 3: Sad mortality of a Vulnerable Olive ridley sea turtle *Lepidochelys olivacea*

Every year, the adult females used to migrate from the Indian Ocean and its adjacent areas to the coastal Bay of Bengal including the sea-facing islands of the transboundary Sundarbans from November to May, with a peak in December and January for nesting (termed *Arribada*), when many of them often fall victim to the fishermen's illegal purse seine nets and occasional boat-collision other than illegal poaching and natural predation.

Photograph 4: A breeding pair of Critically Endangered Northern River Terrapin (*Batagur baska*) at the selected (the female being very choosy) nesting site in Sajnekhali Wildlife Sanctuary of Sundarban Tiger Reserve, showcasing a high sexual dimorphism- a male, in spite of having a longer and thicker tail, is usually smaller than a female, develops a jet-black head and neck while the dorsal surface and forelegs turning to dull peach or orange hues during the breeding season, mainly January-March, while the female retains a uniform green-grey shade. In spite of being an aquatic species, it uses terrestrial nesting grounds to deposit 10+ eggs in the shallow burrow dug by the female on the riverbank.

Photograph 5: A non-venomous Rock python (*Python molurus*) hunted an Axis deer, weighing c. 50 kg, by constriction, and then devoured it entirely resulting in stretched stomach over a significant portion of the barrel-shaped body and inability to move for a few days as a consequence of overeating. The abdominal diameter (engorged) and cavity length of this predator was roughly estimated to be ≺1.7 m. Astonishingly, digestion of a large prey like a deer can take several days or even a week when it is also vulnerable to predation, for example by the tiger.

Photograph 6: Breakfast of an ornate flying snake (*Chrysopelea ornata*) with a tree frog



Photograph 7: Ectothermic non-venomous Indian rat snake (*Ptyas mucosa*), is an adept climber and adapted to basking atop on a cold but sunny day to thermoregulate and maintain normal physiological processes.

Photograph 8: The rescued venomous Russell's viper (*Daboia russelii*), considered one of the most dangerous big four Indian snakes

Photograph 9: The silent predator of Mangroves prefers an ambient temperature of 20 to 28°C for basking during the winter months. The individual in the photograph is an exceptionally rare leucistic saltwater crocodile *Crocodylus porosus,* lying still on the riverbank at low tide but in the brackish waters, it is the top aquatic predator, the largest and heaviest living reptile in the world locally known as 'Dragon of the Sundarbans swamps'.

Photograph 10: First venture of an exquisite juvenile Bengal monitor *Varanus bengalensis,* a Critically Endangered species in the Sundarbans region (elsewhere Near Threatened), peeping through the nest-hole and monitoring the predator-prone external environment. The young monitor lizard is patterned with dark crossbars on the neck, throat, and back, and a white belly banded with dark crossbars and spotted with grey or yellow and more colourful as well as arboreal compared to the terrestrial adult, hunting on the ground.

Photograph 11: Predator-Prey face-to-face: A carnivorous Yellow or Golden Monitor (*Varanus flavescens*) encircling a young pond heron (*Ardeola grayii*) and waiting for the right time to attack and kill it.

Photograph 12: Carnivorous and non-poisonous Water Monitor (*Varanus salvator*)- A semi-aquatic hunter on the muddy river-bank with protruding longer, deeply forked tongue, reaching up to 16 cm, which is used as an olfactory organ for chemoreception of the prey species.

Photograph 13: When a breeding male Changeable lizard *Calotes versicolor* displays a vibrant red to crimson coloured head and shoulder with a black patch on the throat in contrast to the non-breeding dusky olive or brownish-buff.

Photograph 14: Indian Chameleon *Chamaeleo zeylanicus*- a highly specialised arboreal hunter, having tongs-like, bifurcated feet and a prehensile tail, both designed for an expert grip on the tree-branch.

Photograph 15: An omnivorous Jungle Myna (*Acridotheres fuscus*) hunted a Spotted House Gecko (*Hemidactylus parvimaculatus*) while foraging on the ground below and approached the cavity nest with the hapless prey, captured by using its sharp claws and beak, to feed her hungry chicks waiting inside.

Photograph 16: A ritualistic male Pondichéry fan-throated lizard (*Sitana ponticeriana*)- sighted on an elevated mud-embankment just like a stage-performance during the breeding season in the monsoon months with an expanded gular appendage, known as *dewlap,* displaying the tricoloured shades of blue, black and violet, simultaneously bobbing the head energetically, and occasionally standing on the hind legs to attract the females and ward off the rivals.

Photograph 17: Amphibians often fall prey to the higher vertebrates, here a Black-headed Ibis (*Threskiornis melanocephalus*)

Preface

Reptiles and amphibians are sometimes thought of as primitive, dull and dim-witted. In fact, of course, they can be lethally fast, spectacularly beautiful, surprisingly affectionate and very sophisticated.

-David Attenborough

The vibrant herpetofauna, encompassing the amphibians and the reptiles, play a crucial role in the fascinating evolution of Tetrapoda, with amphibians originated from the sarcopterygian (lobe-finned fish) ancestors approximately 365 million years ago and reptiles evolved from the early amniotes, approximately 300 million years ago during the Carboniferous period, showcasing remarkable ecological and morphological adaptations to thrive in a wide range of environments including the extreme habitats in the tropical and subtropical regions, which are characterised by consistently hot temperatures and high humidity.

Herpetofauna are significantly reliant on wetlands for their survival. These crucial habitats serve as sources of food, breeding grounds, and shelter for these animals throughout their life cycles. Some prominent global wetlands are-

Pantanal (Brazil, Bolivia, and Paraguay), 195,000 km^2 (151 herpeto-fauna species- 98 reptiles and 53 amphibians);

Hudson Bay Lowlands (Canada), 320,000 km^2;

Amazon River Basin Wetlands (South America), 2,000,000 km^2;

West Siberian Plain (Russia), 51,600 km^2;

Sudd (Africa), 42,000 km^2-90,000 km^2;

Everglades (USA), 20,000 km^2;

Okavango Delta (Botswana), 15,000 km^2;

Camargue (France), 930 km^2;

Kakadu Wetlands (Australia), 19,804 km^2;

Kerala Backwaters (India)(900 km coast);

Wasur National Park (Indonesia), 4,130 km^2;

Kafue (Zambia), 6,500 km^2; and

Sundarbans (India & Bangladesh), present study area.

Globally, approximately 43.4% of the herpetofaunal diversity is found in wetlands, highlighting their importance for conservation.

Ecological transformation of Western Sundarbans

The landscape/eco-region in the Greater Sundarbans is defined differently. On the Indian side (western Sundarbans), the inhabited part of the eco-region is defined by the extent of forest in 1828. By 1865, landfilling of the saltwater marshes for expansion of Calcutta (= Kolkata) town toward east had first been undertaken by the East India Company, when the dense Sundarbans forests extended up to the present-day localities of Central and South Kolkata (hinterland). Then the western limits of the Sundarbans were only about 12 km away from the present Kolkata. The upper portion of the south 24-Parganas district, that forms parts of the stable delta of the Sundarbans stretching from Thakurpukur in the West to Canning in the East and from Sonarpur in the North to Jaynagar in the South, had small sized settlements compared to those lying in the areas beyond Jaynagar, which have been christened as the active delta. A vast area lying on the western bank of river Hooghly falls in present community blocks of Baruipur, Mandir Bazar and Bhangar, where the average size of a village was <3 km^2. As the area per village increases in the south-west to 9-12 km^2, the location also changes towards the active delta spanning from the Kakdwip-Sagar Island in the West to Basanti in the East.

Sen and Banerjee (2016) studied Calcutta (Kolkata)(north-western part of erstwhile Sundarbans), Dum Dum (north-eastern part), Barrackpore (south-

eastern part) and Kolaghat (south-western part) lying between 22°N and 23°N 87°30'E to 88°30'E in the southern part of West Bengal, India at about 80 to 120 km inland from present coastline (Bay of Bengal) with the objective to identify distinct environment of deposition as freshwater mixed brackishwater to shallow marine to brackishwater mangrove swamp, brackishwater mixed freshwater swamp followed by colonisation of non-littoral species to freshwater swamp during Holocene. They observed:

> *The predominantly freshwater forest with some supralittoral taxa which initiated during ca 5000±yr BP continued for a long time and typical supralittoral geomorphological features enabled deposition of thick layer of peat (Peat I) above the clay sediments with wood logs deposited in an extensive area of Bengal basin both in India and Bangladesh. By 4500-3000±yr BP the shoreline and delta front geomorphology migrated to Namkhana (present western part of Sundarban Biosphere Reserve or SBR) about 90 to 60 km south of the locations mentioned above and about 30 to 20 km inland from present coastline.*

There have been significant alterations since that time and about one-third of SBR no longer bear the biodiversity characteristics of the eco-region. The larger part of the landscape is within this western portion including SBR in India encompasses 19 sub-districts (Blocks) with 190 village clusters (Gram Panchayats).

Ecological transformation of Eastern Sundarbans

Beveridge (1876) observed that the eastern half of Sundarbans lies in the district of Bákirganj and Noákháli and includes Sondip and the other islands in the estuary of the Meghna. In Bangladesh part too, based on the fixed distance of impact zone from Sundarban forest, there are seven sub-districts (Upazilas) with 75 village clusters (Unions).

Significance of the study

Sundarbans is recognised as a "Wetland of International Importance" due to its unique biodiversity including the lesser known herpetofauna and their

ecological value. Despite growing awareness of the large vertebrates in the mangrove swamps or coastal wetlands such as the transboundary Sundarbans (about 216.68 km^2 Reserve Forests laterally demarcated by the Rivers Ichhamati-Kalindi-Raimangal), the smaller species of reptiles and amphibians are still underappreciated. In recent decades, while continuously working in the field for status survey of the wildlife in the Greater Sundarbans (India and Bangladesh) including mammals (Mallick, 2011), the non-human primates (Mallick, 2019), biodiversity (Mallick, 2023a), mangrove tiger (Mallick, 2023b), and avifauna (Mallick, 2024), it was observed that the wild populations of many species of herpetofauna have not been sighted during the last 15 years, indicating that their diversity and population has been declined drastically. Under the circumstances, a thorough survey is considered indispensable so as to ascertain their present status and prescribe the preventive and restoration measures meant for the stakeholders to follow for future sustenance.

The unique Indian and Bangladeshi Sundarbans mangrove forests, spanning coastal, saline, freshwater and terrestrial realms, is a significant hotspot for herpetofauna supporting a diverse array of taxa under four orders- Anura, Crocodilia, Squamata and Testudines. Their contributions in the terrestrial and aquatic ecosystems have been largely understudied. In fact, the herpetofauna discovery in the eastern (Bangladesh) and western (India) Sundarbans, often called 'Lungs of Asia', is still low and has not yet described the herpetofauna community's species diversity exclusively mainly due to inaccessibility and hazardous environment of the world's only mangrove tiger (at least 101 adults in western part and 125 in the eastern part in addition to at least 21 cubs) land inasmuch as the pugmarks of tigers are found in every one-kilometre area on both sides of the creeks (1,800+ km thrust area in SBR), varying in width from a few metres to five kilometres. Moreover, about one-third of the total mangrove forests is covered by the aquatic ecosystem dominated by the vertical river channels, aka channel deformations, referring to changes in the riverbed's elevation due to water flow, sediment transport, and accumulation.

The Sundarbans estuarine system in India, classified as a macro-tidal delta, experiences a significant semi-diurnal tidal range, exhibiting a degree of

asymmetry, meaning the rising and falling periods of the tide are not equal, with a mean tidal range typically exceeding 4 m and reaching up to 8 m during spring tides, which occur when the sun and moon align, whereas during neap tides, which occur when the sun and moon are at right angles to each other, the tidal range is reduced. The tidal range tends to increase as it progresses inland, showing an average amplification of about 1.02 cm/km. The tidal amplitude (the difference between high and low tide) also varies seasonally, indicating a range between 1 and 6 m.

On the other hand, the Indian Sundarbans experiences strong tidal currents, with spring flood currents averaging 0.42-0.56 m/sec and ebb currents averaging 0.25-0.32 m/sec. Neap tides have less intensity than spring tides. The strong tidal currents play a crucial role in the Sundarban ecosystem, influencing sediment transport, nutrient distribution, and the distribution of various organisms including herpetofauna.

The extremely abundant tidal creeks are also crucial components of the Sundarbans estuarine system, serving as feeder rivers and habitats for various taxa of herpetofauna. Tidal creeks facilitate the transfer of materials between terrestrial and marine biomes vital for their survival. The diurnal tides significantly affect water levels and currents within the creeks meeting the larger waterways. Tidal inundation also plays a role in the vertical growth of the Sundarbans. The vertical accretion rate from tidal inundation is around 10 mm/year, but can increase to 180 mm/year in sediment-starved areas. In essence, the vertical and horizontal dimensions of the Sundarbans creek systems work together to create a dynamic and unique ecosystem for the lifeforms.

The regularly submerged mudflats bordering the islands in the Sundarbans also play a significant role in supporting herpetofauna, acting as a diverse and productive habitat. The mudflats, teeming with a variety of invertebrates, like crabs, molluscs, and worms, provide crucial food sources for many herpetofauna species. Mudflats also serve as important nursery grounds for many fish species, which are preyed upon by certain reptile and amphibian species. Snakes like the Krait and Cobras, as well as various lizard species, may forage in mudflats for their prey. The carnivorous frogs and toads also

hunt for invertebrates within mudflats. The soft, muddy substrate provides cover for reptiles and amphibians, allowing them to hide from predators and find refuge during extreme weather conditions. Some herpetofauna species use mudflats for nesting or laying eggs, taking advantage of the moist and sheltered environment.

The intermixing of freshwater from the rivers and saltwater from the Bay of Bengal creates a gradient of salinity within the creeks and waterways, which influences the plant and animal life in the area. Sundarbans is, therefore, divided into three distinct ecological zones described below.

- Oligohaline zone

The oligohaline zone, with salinities ranging from 0.5 to 5 practical salinity units (psu), often include various habitat types, such as tidal marshes, creeks, and open water areas, which provide a diverse array of microhabitats for herpetofauna. While many freshwater species cannot tolerate the higher salinity, some euryhaline species are adapted to this transitional environment. For example, some frog species, like those in the Dicroglossidae family, have been observed in oligohaline areas, while some lizards and snakes are also found in oligohaline zones, especially those species that are more tolerant of brackish conditions than others. Whereas species richness may be lower in the oligohaline zone compared to other areas, it can still support a diverse community of amphibians and reptiles. Some species may use this area as a migratory corridor, nursery, or feeding ground. The connectivity between oligohaline zones and other habitats, such as freshwater marshes and swamps, is important for such movement and survival of herpetofauna. In summary, the herpetofauna of the oligohaline zone is a fascinating group of animals that are adapted to the unique challenges and opportunities of this transitional environment.

- Mesohaline zone

The mesohaline zone refers to a salinity range of 5.0 to 18.0 parts per thousand (ppt) in an estuary. While amphibians are primarily terrestrial, some species or their larvae have evolved to tolerate the brackish environments,

particularly at the lower end of the mesohaline range, or have the ability to regulate their internal salt balance, but they are not abundant here.

Many reptiles including snakes, lizards, turtles, and salt water crocodiles can inhabit mesohaline areas or brackish environments by virtue of adaptations that allow them to tolerate varying salinity levels, such as specialised kidneys for regulating salt balance and skin that helps prevent water loss in high salinity environments.

- Polyhaline zone

Amphibians generally avoid polyhaline (high salinity) zones referring to a salinity range above 18 ppt due to the high osmotic stress they face in these environments. The high salt concentration can lead to water loss from amphibian bodies, dehydration, and other physiological problems. While some amphibian species have shown a degree of tolerance to moderate salinity, they often struggle with the extreme salinity levels found in polyhaline zones. The Sundarbans mangrove forest, for example, experiences increased salinity, potentially leading to the transformation of mesohaline areas into polyhaline areas, which may impact amphibian populations.

While there is no specific reptile species exclusively confined to polyhaline zone, certain reptiles, like sea snakes, saltwater crocodiles, and some turtles and lizards, have adaptations that allow them to tolerate saline environments and are found in areas with polyhaline salinity. These adaptations include salt glands that help them excrete excess salt ingested with seawaters.

Hence, studying mangrove herpetofauna is crucial for understanding the ecological functioning of these vital ecosystem as detailed below.

1. The roles of amphibians and reptiles within the food web as both predators and prey, and how these interactions affect other species and the overall stability of the ecosystem. All these inter- and intra-specific interactions influence the structure and function of the food web in mangrove ecosystems.

2. Herpetofauna play a significant role in nutrient cycling within ecosystems by transferring nutrients from lower trophic levels to higher levels. For example, amphibians consume insects, and reptiles prey on amphibians, thus moving nutrients through the food web. Whereas herpetofauna influence nutrient availability through their feeding habits, they excrete waste products that contain nutrients like nitrogen and phosphorus, which can be absorbed by plants and microorganisms in the soil. On the other hand, when herpetofauna die, their bodies decompose, releasing nutrients back into the environment. This process is vital for replenishing nutrient pools in the soil and water.
3. The role of herpetofauna in nutrient cycling is crucial for maintaining the overall health and stability of Sundarbans ecosystems. Since they are renowned for their sensitivity to environmental changes, their permeable skin makes them highly susceptible to pollutants, making them vital indicators of ecosystem health.
4. Herpetofauna conservation is crucial because these cold-blooded animals play vital roles in ecosystems. They are natural predators of insects, rodents, and other pests, helping to regulate populations and minimise damage to crops and other resources. Certain reptiles, like lizards, and amphibians can contribute to pollination and seed dispersal, which are essential for plant reproduction. Some herpetofauna species help improve soil quality by digging, aerating the soil, and contributing to nutrient cycling. A healthy and diverse herpetofauna contributes to the overall stability and resilience of ecosystems.
5. Intensive agriculture, deforestation, and urbanisation lead to the loss and fragmentation of herpetofauna habitats in the Sundarbans and reclaimed areas. Changes in temperature, precipitation patterns, and other climate-related factors can impact the distribution and abundance of herpetofauna. The use of pesticides and other pollutants also harm herpetofauna populations.
6. Conservation Strategies: The health and well-being of the hinterlands are inextricably linked to the health and resilience of the

Sundarbans. Protecting existing habitats and restoring degraded ones is essential for herpetofauna conservation. Adopting farming practices that minimise negative impacts on herpetofauna, such as reducing pesticide use and preserving natural vegetation, can help conserve these species. Understanding the ecology of herpetofauna is crucial for developing effective conservation strategies. Moreover, the transboundary Sundarbans mangrove ecosystem has been assessed as "endangered" using the IUCN Red List of Ecosystems framework, despite being recognised as a 'Protected Tiger Conservation Landscape' of global priority, highlighting the risk of its collapse due to historical mangrove clearing dating back to the 1800s, declining fish populations, reduced freshwater supply, increased salinity due to sea-level rise among other factors and understanding how herpetofauna are impacted by habitat degradation and climate change.