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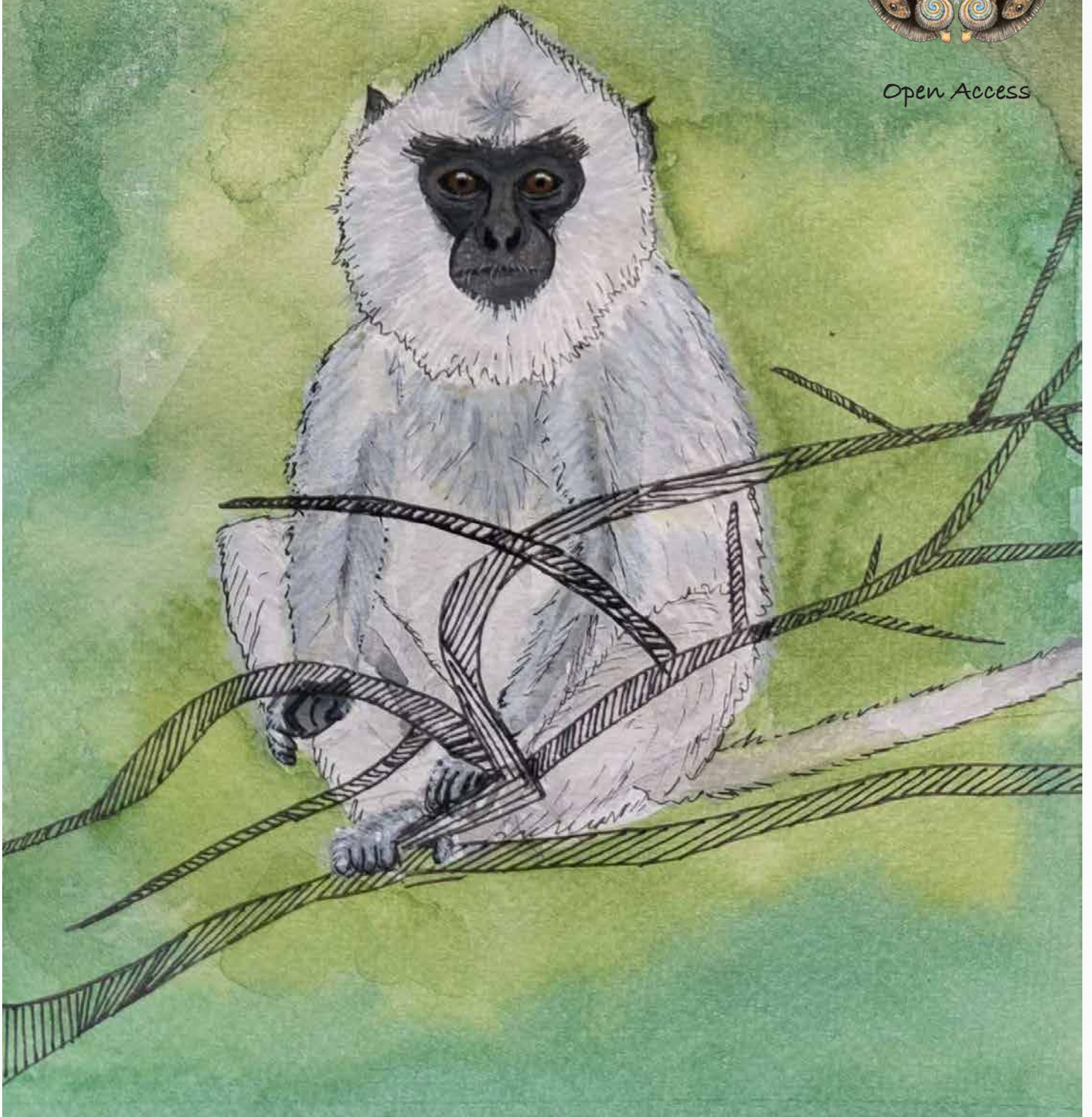
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43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

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Cover: Coromandal Sacred Langur *Semnopithecus priam* - made with acrylic paint. © P. Kritika.



Observations on cooperative fishing, use of bait for hunting, propensity for marigold flowers and sentient behaviour in Mugger Crocodiles *Crocodylus palustris* (Lesson, 1831) of river Savitri at Mahad, Maharashtra, India

Utkarsha M. Chavan¹ & Manoj R. Borkar²

¹Department of Zoology, Hazarimal Somani College, Chowpatty, Mumbai, Maharashtra 400007, India.

²Biodiversity Research Cell, Department of Zoology, Carmel College of Arts, Science and Commerce for Women, Nuvem, Goa 403604, India.

¹utkarsha6829@gmail.com, ²borkar.manoj@rediffmail.com (corresponding author)

Abstract: As far as animal cognition is concerned, in comparison with mammals and birds, reptiles have been underestimated and research in reptilian cognition hasn't progressed much due to this bias. Though crocodiles are generally stereotyped as lethargic and lacking social interactions except for territoriality, parental care and prey ambush, they demonstrate discrete behavioural repertoire in a variety of situations suggestive of refined cognition. The observations presented here were recorded during a long-term study on Muggers *Crocodylus palustris* of Savitri River in Maharashtra, and indicate social behaviour of remarkable acuity among Muggers to optimize foraging, which clearly hints at cooperative fishing. Also, on many occasions here, the Muggers were seen to have sticks on their snouts or lay still in the vicinity of floating twigs presumably to lure birds that desperately scouted for nesting material; though only on one occasion the unsuspecting bird was ambushed successfully. Flight initiation distances (FID) of birds that forage and nest in crocodilian habitat have been measured to assess their wariness towards crocodile's presence. We report the attraction of free ranging Muggers here to the yellow Marigold *Tagetes erecta* flowers. We also remark on apparent sentience involving a dog that was chased into the river by a pack of feral dogs, the 'aquatic refugee' having been seemingly nudged and escorted to safety of the bank by crocodiles. All these behaviours are discussed in the light of previous reports involving other crocodilian species elsewhere, to assess the cognitive faculty of this species.

Keywords: Avian wariness, cross-species empathy, group fishing, hunting lures, reptilian cognition, topical pathogens.

Marathi: सर्वसाधारणतः सरीसृप प्राण्यांच्या आकलन क्षमते विषयी गैरसमज आहे, जेणेकरून त्यांच्या व्यवहार आणि वर्तनाबद्दल संशोधकांचे दुर्लक्ष झालेले आढळते. मगर एक सुस्त प्राणी असून, ह्या प्रजाती मध्ये सामाजिक वर्तनाचा अभाव असतो अशी धारणा आहे. वास्तव्याच्या क्षेत्राचे संरक्षण, आणि अंडी व पिल्लांचा बचाव ह्या मगरींच्या दोन स्वभाव-वैशिष्ट्या व्यातिरिक्त इतर स्वभाव पैलूंचा क्वचितच अभ्यास झाला आहे. सामाजिक परस्पर-संवादाचा अभाव म्हणून रूढ केले जात असले तरी, परिष्कृत अनुभूतीचे सूचक असलेल्या विविध परिस्थितीमध्ये मगरी स्वतंत्र वर्तणुकीचा संग्रह प्रदर्शित करतात. येथे सादर केलेली निरीक्षण महाराष्ट्रातील सावित्री नदीच्या मगरीवरील दीर्घकालीन अभ्यासा दरम्यान नोंदवली गेली आहेत. मासे एकत्रित करण्यासाठी मगरी ज्या उल्लेखनीय तीक्ष्णतेचे सामाजिक वर्तन दर्शवते, त्यात सहकार्याच्या छटा स्पष्टपणे दिसून येतात. विणीच्या हंगामात घरटी बांधण्यासाठी पक्ष्यांना लागणाऱ्या काढक्या स्वतःच्या शरीरावर ठेवून मगरी आपल्या भक्ष्याला आकर्षित करतात असे ही दिसून आले आहे. मगरींच्या सभोवताली वावरणाऱ्या विविध पक्ष्यांच्या प्रजातींचे 'उड्डाण प्रारंभ अंतर' मोजण्यात आले आहे. सावित्री नदीतील मगरींना झेंड्याच्या फुलांचे खास आकर्षण आहे असे वाटते. जंगली कुत्र्यांच्या टोळीने नदीत पाठलाग केलेल्या जल-निर्वासित कुत्र्याचे मगरींनी सामूहिकरित्या केलेल्या सुटकेचे शास्त्रीय विश्लेषण हा सुद्धा ह्या शोध निबंधाचाच महत्त्वाचा विषय आहे.

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Author details: Utkarsha Chavan is an assistant professor of zoology and a popular nature educator with keen interest in outdoors. She has been pursuing her research in herpetology for more than a decade and a half, and is currently a PhD guide of Mumbai University. MANOJ BORKAR is a senior academic and popular science writer. He has to his credit the first study on conservation of Mugger crocodiles in Goa. He is the founder of Biodiversity Research Cell and has served on Goa State Biodiversity Board, Goa Wildlife Advisory Board, Goa SEAC. Currently he pursues research on functional morphology of arachnids.

Author contributions: UMC has conducted and supervised field studies, collected technical literature and assisted in data collation and analysis. MRB has conceptualized the research problem, collated and analyzed data, perused pertinent literature, written and revised the research manuscript.

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INTRODUCTION

Mugger or Indian Marsh Crocodile *Crocodylus palustris* (Lesson, 1831) is a ubiquitous reptile of the Indian subcontinent, occupying freshwater habitats like rivers, lakes, and marshes (Chavan & Borkar 2022a,b); as well as man-made reservoirs and irrigation canals (Kpe'ra et al. 2014; Gurjwar & Rao 2018). This species has also adapted well to estuarine waters in India and Sri Lanka (Whitaker & Whitaker 1989; Da Silva & Lenin 2010).

On a scale of social behaviour, it is a reductionist approach to fix animals as being strictly solitary or overtly social, as every species is compelled to interact with conspecifics on its life trek for various reasons; only the scales of interaction varying in degree and frequency (Tinbergen 1953; Alexander 1974). Among vertebrates, the groups that have social aggregations and invest in parental care are generally known to display diverse and complex social behaviour. It is a largely held opinion that reptiles are solitary and aggressive, and show little display of social behaviour except that involving hierarchical assertion and defense of territory (MacLean 1990; Wilkinson et al. 2010). However, their 'non-social' status (Brattstrom 1974; Wilkinson & Huber 2012; Doody et al. 2021) is a flawed and undeserving attribute of the reptilian species. Hence such chronic neglect and bias against reptilian social behaviour merits an explanation. In fact, researchers have recorded complex reptilian behaviour of great survival as well as altruistic values (Doody 2011; Clark et al. 2012).

While this gap is emphatic, perhaps the most plausible reason for this neglect could be the bias of ethologists favouring the more colourful and vocal birds, and mammals with facial expressions that are easy to observe; as against the dull coloured reclusive reptiles that lie still and inactive for long periods (Gaston & May 1992; Kellert 1993; Pawar 2003; Chavan & Borkar 2022b). That such 'taxonomic chauvinism' has certainly delayed our understanding of reptilian behaviour is a view corroborated by Bonnet et al. (2002).

In this paper we have attempted to highlight crocodilian behaviours that hitherto have not received much attention, and could assist in cognitive assessment of this reptilian group.

Thus far, researchers have focused more on their ecology and conflict potential, and very little attention has been given to the ethology of this species. Studies on crocodilian behaviour are in its nascent stages in India, and most of their reported behaviour has been studied by observing captive animals (Clark et al. 2012;

Burghardt 2013). In this paper we report definitive instances of cooperative fishing, use of hunting lures, a curious propensity of free ranging Muggers of river Savitri for Marigold *Tagetes erecta* flowers and an instance of plausible cross species empathetic behaviour involving a dog.

METHODOLOGY AND FIELD PROTOCOLS

The present study was a component of a long-term monitoring of Mugger population of Savitri River in Mahad town of Raigad district of Maharashtra, India; since 2014 (Chavan & Borkar 2022a, b). All the naturalistic observations were carried out in river stretches corresponding with four stations namely at Kemburli (18.0661°N; 73.4138°E), Mohalla (18.0725°N; 73.4188°E), Dadli (18.0697°N; 73.4311°E), and Smashaan (18.0669°N; 73.4411°E).

Muggers of Savitri River have been studied by naturalistic observations in field – without compromising on safety of researchers and territorial limits of the reptile. Crocodilian behaviour presented here has been documented by a team of five observers during every visit; between 0600 h & 1200 h and 1400 h & 1800 h, as well as night time from 1900 h to 2300 h. Observations were recorded using binoculars (Model Galileo 30 x 60) as well as photo-documented, by sitting on a bank elevation and in a boat for understanding patterns of their maintenance behaviour, as well as their interactions with conspecifics and other species. In this study we have also assessed flight initiation distance (FID) as a measure of wariness of birds towards the Mugger. A total of 26 species of birds belonging to 11 families (Table 1, Figure 1) frequenting the water and bank of this river for foraging and nesting were observed for their FID vis a vis the movement of the Mugger, the apex predator here. FID was calculated as a mean value in meters up to which the bird would approach the crocodile without hesitation, or distance at which any visible movement of the crocodile would trigger an escape flight in the bird being observed. Focused attention was given to the Mugger's active foraging activity through all seasons and also their passive hunting strategies. The affinity of these reptiles for 'floating objects' in the river such as flowers, was carefully documented. Photographs and videos were captured by digital and DSLR cameras.

Table 1. Flight initiation distance (FID) as a measure of wariness of birds that share habitat with Muggers of Savitri River, Mahad, Maharashtra.

	Family & common name of the bird	Scientific name	Nesting	Foraging	Feeding guild	Habit	Mean FID ± SE
I	Ardeidae						
1	Western Cattle Egret	<i>Bubulcus ibis</i> (Linnaeus, 1758)	Yes	Yes	IN	Invertebrates, mostly insects	1.12 ± 0.22
2	Little Egret	<i>Egretta garzetta</i> (Linnaeus, 1766)	No	Yes	PI/CV/IN	Fish, molluscs, crustaceans, insects	0.84 ± 0.15
3	Intermediate Egret	<i>Ardea intermedia</i> (Wagler, 1827)	No	Yes	PI/CV	Fish, crustaceans	2.2 ± 0.34
4	Great Egret	<i>Ardea alba</i> (Linnaeus, 1758)	No	Yes	PI	Fish	2.06 ± 0.17
5	Purple Heron	<i>Ardea purpurea</i> manilensis (Meyen, 1834)	No	Yes	PI	Fish	2.26 ± 0.10
6	Grey Heron	<i>Ardea cinerea</i> (Linnaeus, 1758)	No	Yes	PI/CV	Fish, crabs	2.66 ± 0.09
7	Indian Pond heron	<i>Ardeola grayii</i> (Sykes, 1832)	Yes	Yes	PI	Fish	0.36 ± 0.04
8	Black-crowned Night Heron	<i>Nycticorax nycticorax</i> (Linnaeus, 1758)	Yes	Yes	PI/IN	Fish, insects	0.44 ± 0.05
II	Threskiornithidae						
9	Red-naped Ibis	<i>Pseudibis papillosa</i> (Temminck, 1824)	No	Yes	IN/GR	Insects, grains	4.06 ± 0.04
10	Black-headed Ibis	<i>Threskiornis melanocephalus</i> (Latham, 1790)	No	Yes	PI/CV	Fish, snails	4.36 ± 0.08
11	Eurasian Spoonbill	<i>Platalea leucorodia</i> (Linnaeus, 1758)	No	Yes	CV/IN/PI	Crustaceans, insects, fish	0.9 ± 0.19
III	Ciconiidae						
12	Painted Stork	<i>Mycteria leucocephala</i> (Pennant, 1769)	No	Yes	PI/CV/IN	Fish, crustaceans, small reptiles, insects	7.7 ± 0.2
13	Asian Openbill	<i>Anastomus oscitans</i> (Boddaert, 1783)	No	Yes	CV/PI	Molluscs, crustaceans, fish, snakes, lizards	3.7 ± 0.2
14	Asian Woolly-necked Stork	<i>Ciconia episcopus</i> (Boddaert, 1783)	No	Yes	PI/CV	Fish, snakes, lizards, crustaceans and molluscs	2.02 ± 0.18
IV	Recurvirostridae						
15	Black-winged Stilt	<i>Himantopus himantopus</i> (Linnaeus, 1758)	No	Yes	IN/CV	Insects, molluscs, crustaceans	4.2 ± 0.12
V	Charadriidae						
16	Red-wattled Lapwing	<i>Vanellus indicus</i> (Boddaert, 1783)	Yes	Yes	IN/CV	Insects, molluscs	1.32 ± 0.07
VI	Phalacrocoracidae						
17	Indian Cormorant	<i>Phalacrocorax fuscicollis</i> (Stephens, 1826)	No	Yes	IN/CV	Insects, molluscs	0.74 ± 0.12
VII	Alcedinidae						
18	Common Kingfisher	<i>Alcedo atthis</i> (Linnaeus, 1758)	Yes	Yes	PI/IN	Fish, insects	5.5 ± 0.18
19	White-throated Kingfisher	<i>Halcyon smyrnensis</i> (Linnaeus, 1758)	Yes	Yes	PI/CV	Fish, crustaceans, snails, small reptiles	5.56 ± 0.18
20	Pied Kingfisher	<i>Ceryle rudis insignis</i> (Hartert, 1910)	Yes	Yes	PI	Fish	5.42 ± 0.18
VIII	Corvidae						
21	House Crow	<i>Corvus splendens</i> (Vieillot, 1817)	Yes	Yes	OM	Fish, fruit, crustaceans, scavenger	1.9 ± 0.1
IX	Motacillidae						
22	Grey Wagtail	<i>Motacilla cinerea</i> (Tunstall, 1771)	No	Yes	IN/CV	Insects, crustaceans and molluscs	5 ± 0.42
23	White Wagtail	<i>Motacilla alba</i> (Linnaeus, 1758)	No	Yes	IN	Insects and other invertebrates	4.5 ± 0.18
X	Scolopacidae						
24	Common Sandpiper	<i>Actitis hypoleucos</i> (Linnaeus, 1758)	No	Yes	IN/CV	Crustaceans, invertebrates	3.82 ± 0.19
XI	Accipitridae						
25	Black Kite	<i>Milvus migrans</i> (Boddaert, 1783)	Yes	Yes	CV/PI/OM	Fish, leftovers of chicken	3.2 ± 0.2
26	Brahminy Kite	<i>Haliastur indus</i> (Boddaert, 1783)	Yes	Yes	CV/PI/OM	Fish, leftovers of offal	4.62 ± 0.18

Feeding guild: IN—Insectivore (small arthropods) | CV—Carnivore (large arthropods and vertebrates) | PI—Piscivore (fish) | OM—Omnivore (plant and /or animal and scavenging on dead animals) | GR—Granivore (grains and seeds). Bird species have been put under feeding guilds according to their predominant diet after Gray et al. (2006). Inferences based on average values of minimum 90% observations between 2014 and May 2023.

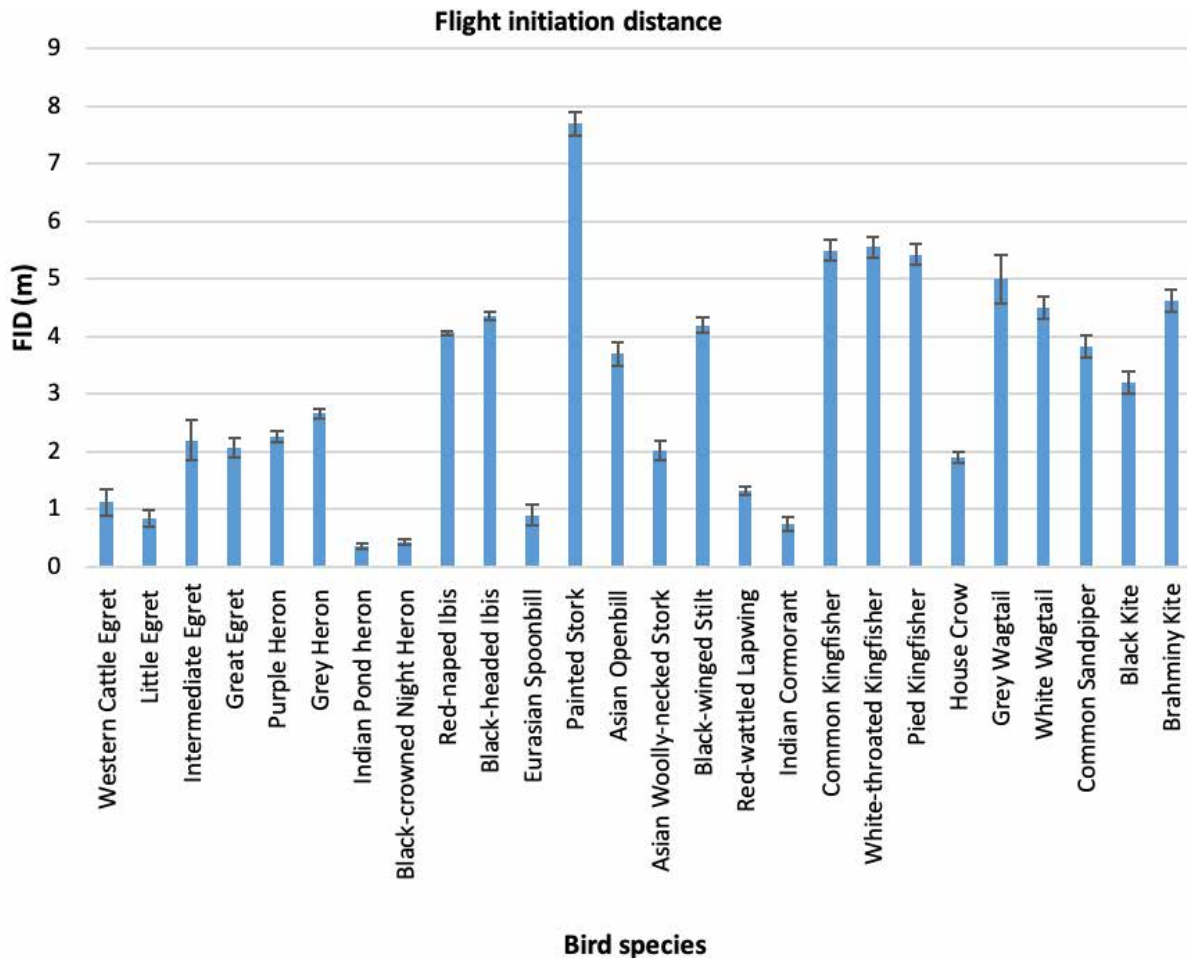


Figure 1. Flight initiation distance in meters (σ_m) of bird species that share crocodilian habitat in river Savitri, Mahad, Maharashtra.

OBSERVATIONS AND DISCUSSION

Foraging: Fishing and Hunting

At all the four stations we have been observing, Muggers of Savitri River were seen feeding on fish (80%) and birds (18%) of the times (Image 1). Bird prey species were egrets and herons predominantly. Also, on a few occasions they were seen scavenging on chicken offal thrown by the local poultry vendors. As this study was non-invasive, dietary composition could not be ascertained by analyzing stomach contents.

Muggers are generalist feeders whose diets comprise of a range of aquatic and terrestrial prey, juveniles mostly taking crustaceans, amphibians and fish; and adults going after larger vertebrates like fish, terrapins, tortoises, lizards, snakes, birds, monkeys, and dogs, besides carrion feeding (De Silva 2011, 2018; Chavan & Borkar 2022a). Research has shown that Muggers are opportunist predators that use available resources in and around the water in which they dwell, though fish

stocks determine their success (Mobaraki 2015; Chavan & Borkar 2022a) and in India their food reportedly includes beetles, rats and frogs (Whitaker & Whitaker 1984).

Muggers fish and hunt, either individually or collectively; though hunting is done by a single individual, but if the prey is large then other Muggers are known to join in to share the meal (Dinets 2014).

Among vertebrates, though coordinated and collaborative hunting is reported in several mammals (Gazda et al. 2005), there are a few studies of such social behaviour in wild reptiles (Dinets 2017). Little is known about crocodilian hunting behaviours barring a few anecdotal observations (Dinets 2011; Doody et al. 2013). However, cooperative hunting is now known to occur in some crocodilian species (King et al. 1998; Dinets 2010) like the Nile Crocodile *Crocodylus niloticus*, Yacare Caiman *Caiman yacare*, Spectacled Caiman *Caiman crocodilus*, American Alligator *Alligator mississippiensis*, and Cuban Crocodile *Crocodylus rhombifer*.

The behaviour of cooperative hunting has not been well described except in a few cases (Dinets 2010). Cooperative hunting where more than two individuals partake has been reported in at least four crocodylian species, sometimes involving 'role partitioning' to optimize efforts (Mikloukho-Maklay 1892; Dinets 2010), though the prevalence of such behaviour appears to be highly underrated, and many observations remain unpublished (Doody et al. 2013).

The earliest evidence of role partitioning is in form of diary noting of Russian herpetologist Mikloukho-Maklay (1892) who observed cooperative fishing by Estuarine Crocodiles *Crocodylus porosus*. Similar collaborative fishing behaviour was reported in Australian Freshwater crocodile *Crocodylus johnstoni* from Australia, Spectacled Caiman *Caiman crocodylus* from Venezuela, Nile Crocodile *Crocodylus niloticus* from Botswana, and Mugger Crocodile *Crocodylus palustris* in Yala National Park, Sri Lanka (Dinets 2014).

Cooperative Fishing

In our study we have observed ritualized sequence of cooperative fishing, where mostly three Muggers (four partaking individuals only on one occasion) swim at a moderate but constant speed in circles (visually approximated to be of mean diameter $24.2\text{m} \pm 1.7$) and create a whirlpool in water, in which the fish remain congregated (Image 2) as inferred from the emergence of crocodiles from this vortex, with fish in their mouth; since the turbid waters did not permit direct observations of crocodile behaviour under submergence. The surface ripples and turbulence of water was seen to get intense as the Muggers submerged in water to feed. Collective fishing was observed nearly always during early morning hours from 0800 h to 0900 h, almost on a regular basis in Smashaan until the last observation in May 2023, and in the late afternoon hours at Kemburli up to the year 2018; these episodes being too regular to be treated as stray incidents. In their observations, King et al. (1998) and Dinets (2014) have focused on efforts that several crocodylian species put in towards cooperative

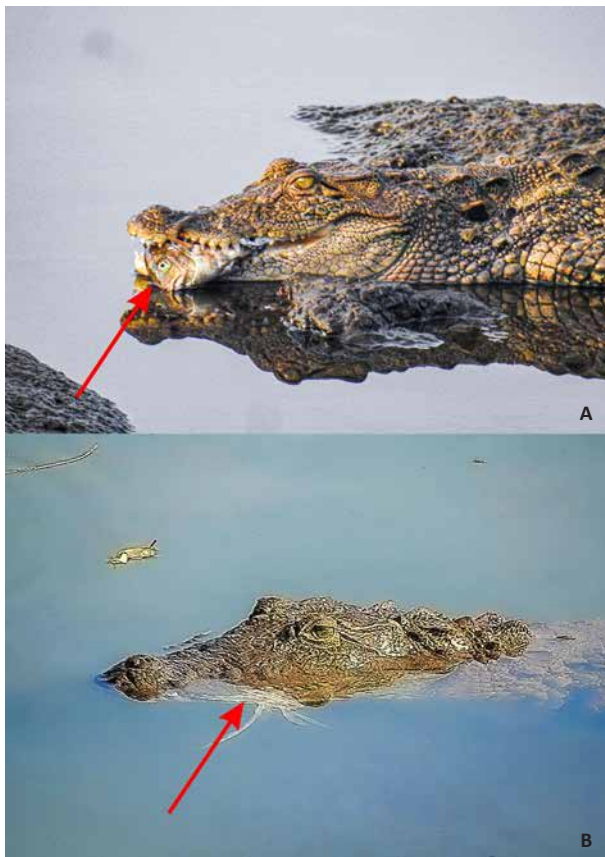


Image 1. Mugger *Crocodylus palustris* predominantly feeds on fish (A) but is also an ambush predator that takes birds as prey, as is the case with this Mugger(B) that has just successfully captured a Cattle Egret *Bubulcus ibis*. © Utkarsha Chavan & Sudhir Metkari.



Image 2. Cooperative fishing by Muggers in river Savitri, Mahad: A— three Muggers swimming in an equidistant circular formation | B— with whirlpools of ripples and turbulence. © Utkarsha Chavan.

strategies for optimal hunting. Cooperative fishing has been reported in American Alligators that demonstrate a stereotype sequence of circular swimming of more than two individuals with little vocalization, but intermittent jaw slapping to catch fish (Dinets 2010). These circular swimming episodes are different from those that are aimed at courtship and mating.

Dinets (2014) shares similar observations in Australian Freshwater Crocodiles, American Alligators and Nile Crocodiles. There are reports of Mugger feeding on Painted Stork flying close to water surface and chick of a Night Heron having fallen from its nest into the waters (Venugopal 2006), besides Teal (Battye 1945), Purple Moorhen, egrets and Common Coot (Vijaykumar et al. 1995). At our study site in Smashaan, Muggers calmly resting under the trees were observed ambushing Cattle Egrets sitting on the lower branches of trees.

Use of Bait for Hunting

Among the many facets of crocodilian behaviour, their use of baits to lure prey is an interesting premise of investigation. At Kemburli and Smashaan, Muggers were regularly seen lying still with short twigs on their snout, head, back, and even tail (Image 3). On one such occasion, it was observed that Cattle Egret came flying to pick up a stick, and the Mugger tried lunging at the bird; though the attempt was unsuccessful. Such deliberate trickery by placing twigs or rags (potential nesting material in bird roosting areas) seems strategic and deliberate, in that it can lure a nesting bird (potential prey) dangerously close and within striking distance of the Mugger. Prima fascia this behaviour hints strongly at the possibility of Mugger attempting to use a lure to attract the potential prey. It is interesting that such behaviour is increasingly witnessed during the nesting season of the common wading birds of this habitat. That crocodiles use tools for hunting has been meticulously established by Dinets et al. (2013), who report that the Muggers lay still in shallow waters with twigs positioned on their snouts to lure egrets that have rookeries around the crocodile occupied waters.

A few reports on the likely use of hunting baits or lures by crocodilians are anecdotal and lack robust empirical evidences (Shumaker et al. 2011). Dinets et al. (2013) has also recorded an unsuccessful attempt by a captive Mugger at MCBT Chennai in southern India to predate on an Intermediate Egret that got lured by a stick positioned on the Mugger's snout. However, he reports many individuals of crocodiles here that lay still balancing sticks, a potential nesting material for birds. It must also be noted that Dinets et al. (2013) have often

seen Muggers emerging from water from underneath the floating sticks. Despite a discrete threat from the reptile that can capture the lured birds by deceit and swallow their fledglings fallen in water, there is a clear advantage for birds roosting on trees in water bodies; in that the very presence of the crocodiles serve as a deterrent for predators like Indian Rat Snake, Indian Rock Python, Indian Cobra, and rats that can scale a tree from beneath in search of bird eggs and fledglings.

It is rather common for these birds to compete for space and nesting material which they do not hesitate to pilfer from their competing neighbours. As such, shortage of nesting material may compel them to switch off their innate wariness towards the reptile with sticks on their body. In a crocodile occupied river like Savitri, it is interesting to understand how the birds invest in anti-predatory behaviour. Various known as 'flight initiation distance' (FID), 'flush distance' (FD), and 'escape flight distance' (EFD); this important anti-predator behaviour has a species-specific consistency (Blumstein 2003, 2006). However, it is reasonable that individual experiences and perception of risk can influence FID between conspecifics and such a view has been corroborated by Bötsch et al. (2018).

Generally among the waders, species of Ardeidae had lesser FID. It is apparent that FID was lesser in the nesting season of birds indicating reduced wariness; making them vulnerable to crocodile ambushes while they get lured by nesting material. Such risk-taking decisions in nesting individuals have been reported (Dowling & Bonier 2018). 'Wariness' as used here refers to a 'level of fearful response' by the several bird species in response to potentially threatening presence of Crocodile manifesting in maintaining a 'safe distance' and flushing if that distance is violated (Images 4 & 5). Similar approach has been proposed earlier (Boissy 1995; Blumstein 2006).

Attraction towards marigold flowers

'Object play' has been frequently reported in captive crocodilians, and zoo keepers have often provided play objects as a part of zoo enrichment. However, Dinets (2015) submits that people observing such play behaviours do not consider these observations worth reporting and hence little is known about this curious behaviour. Various species of crocodiles are known to have been using floating debris in water as play-objects and show interest and attraction towards them. There are reports of captive Cuban Crocodiles and Western African Dwarf Crocodile *Osteolaemus cf. tetraspis* playing with pink Bougainvillea flowers over seven days



Image 3. Muggers of Savitri River use twigs as bait to lure nesting birds that forage as well as collect material for nidification from these shallow waters and basking zone. Note that the nesting material such as twigs and sticks are displayed prominently on snout (A, B & F), trunk (C, D & G), tail (D), and head (E). Also, the Mugger may position itself close to twigs within striking distances (H). © Utkarsha Chavan.



Image 4. Riverfront of Savitri offers congregation grounds for diverse bird species that wade and forage in the vicinity of Muggers. The bird species differ in their 'wariness' threshold, with some approaching the reptile dangerously close, while others keeping a safe distance. Egrets (A), Grey Heron (B) collecting twigs for nesting, Woolly-necked Stork (C), Black-headed Ibises (D & F), Back Kite (E), and Eurasian Spoonbill (F). © Utkarsha Chavan.

of observation, picking them up, pushing around, and carrying in the teeth or on the tip of the snout (Dinets 2015). Curiously, other coloured floating objects like the leaves, flowers and feathers were ignored. Also, many species are known to play with their prey carcasses. Of course, it is important to assess these behaviours against the criteria proposed by Burghardt (2005), before categorizing them as 'play'.

Though play behaviour of crocodiles was not the

focus of this investigation, it was regularly observed that the Muggers in Smashaan region floated, basked, and lay in the vicinity of yellow or orange coloured Marigold flowers *Tagetes erecta* (Image 6). These marigold flower garlands end up in this stretch of the river from offerings to the corpses brought here for cremation. Unlike 'play object' value of Bougainvillea (Dinets 2015), the Muggers here were not observed manipulating these marigold flowers, but just lay in the vicinity of these

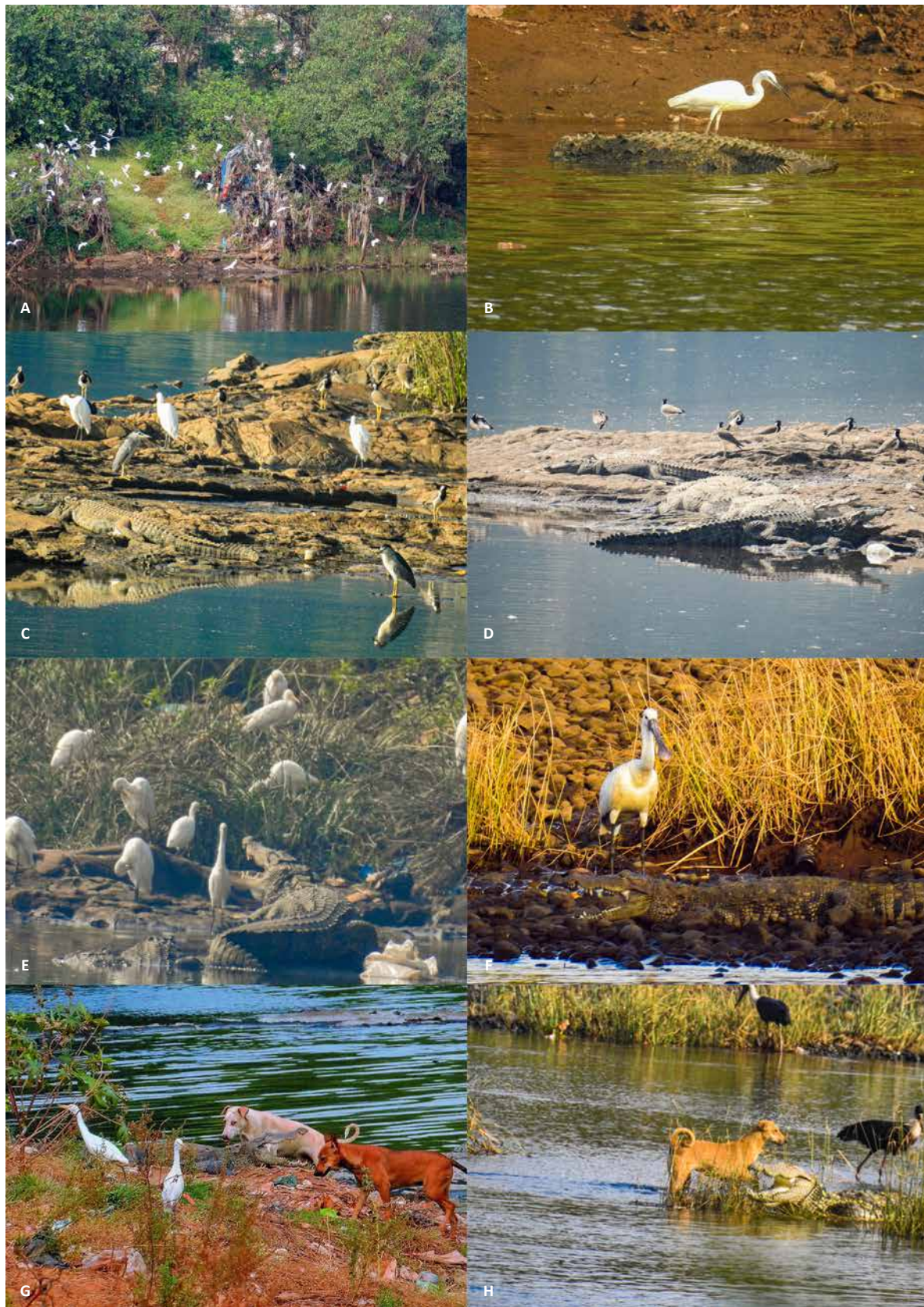


Image 5. Crocodiles under a rookery of egrets on the river bank (A), Median Egret (B & E), Median Egrets and Night Herons (C), Red-wattled Lapwings (D), Eurasian Spoonbill (F), Cattle Egrets and feral dogs (G), Woolly-necked Storks, and a dog (H) in the immediate proximity of crocodiles. © Utkarsha Chavan & Umesh Awadootha.



Image 6. The Muger Crocodiles of Savitri were invariably found to be floating or basking in proximity of marigold flowers, suggesting their propensity towards these brightly coloured flowers. © Utkarsha Chavan.

floating flowers often with a physical contact. Though it has been conclusively established by Nagloo et al. (2016), that crocodiles have sophisticated colour vision; this behaviour is novel and intriguing, requiring further experimental enquiry and validation using established criteria for play behaviour (Burghardt 2005); both in captive Muggers and in situ.

It is noteworthy that petals of marigold are known to have antimicrobial compounds with potent bacteriostatic properties against dermal pathogens; including fungi, gram-positive and gram-negative bacteria (Padalia & Chanda 2015; Latifian et al 2021). Given that stretches of Savitri have been contaminated with sewage (Chavan & Borkar 2022a), the Muggers here are susceptible to a host of opportunistic pathogens. It is surmised that their contact with the Marigold flowers could alleviate much of their topical bacterial load.

Mugger Sentience

Animal sentience is understudied but an emerging

area of research (Duncan 2006), and reptiles have received little attention (De Vere & Kuczaj 2016). Stray dogs were regularly seen to move amongst basking Muggers, without eliciting any hostility from the reptile (Image 5) suggesting reciprocal habituation. However, there were two incidences when these stray dogs were preyed upon by Muggers (Pers. comm. by residents staying near river).

On one occasion a young dog probably having strayed beyond its territory was chased by a pack of feral dogs after which the frightened individual inadvertently sought refuge by entering shallow water of the river Savitri. At this time three adult Muggers were clearly seen floating close by in the water and their attention was drawn to this dog and they moved closer towards the dog. What initially seemed to be a classical predatory instinct of the Mugger towards the hapless prey, soon turned out to be a more docile behaviour by two of the three crocodiles that guided the dog away from the site where it would have been vulnerable to



Image 7. Serial frames of a dog being given a 'safe passage' by three crocodiles, in a sentient behaviour suggestive of 'cross-species empathy'. © Utkarsha Chavan.

being attacked by the pack of feral dogs waiting on the river bank. These crocodiles were actually touching the dog with their snout and nudging it to move further for a safe ascent on the bank and eventually escape. The episode has been videographed and a few still frames have been presented here (Image 7). Reasons as to why

the three crocodiles chose not to attack the potential prey remain speculative. Given that the mugger was well within the striking range and could have easily devoured the dog, yet none of them attacked and instead chose to nudge it towards the bank, implies that the hunger drive was absent; and we propose this to be a case of sentient behaviour of the Mugger resulting in cross species 'emotional empathy', which is not a very extensively investigated behaviour, though capacity of one species to experience the emotional feelings of another species merits recognition (Panksepp & Panksepp 2013). This underpins the need to validate assumed sentience of animals using exploratory and experimental approaches (Proctor et al. 2013).

CONCLUSION

Reptiles have been underestimated as far as animal cognition is concerned, perhaps due to a skewed impression that they are lethargic and at the most reflex machines (Jerison 1973) due to the small size and simple structure of their brain (Robin 1973). All in all, research in reptilian cognition hasn't progressed much due to such biases. Paradoxically some of the behaviour like 'tool use' previously believed to be a mammalian prerogative is now being reported from reptiles (Dinets et al. 2013; De Meester & Baeckens 2021).

Crocodylians (Crocodiles, Alligators, Caimans, and Gharials) are arguably the most cognitively complex living non-avian reptiles. They display a rich behavioural repertoire in a variety of contexts; such as hunting, spatial orientation, and social interactions, including communication in several modalities (Grendeus & Reber 2020). In so far as deliberate use of vegetation as camouflage or bait by crocodylians is concerned, Schumaker et al. (2011) reported the first case of *Crocodylus porosus* using fish fragments as a bait to attract bird prey. Dinets (2011) has recorded empirical evidence of higher frequencies of stick display behaviour among the alligators that occupy waters with rookeries during the nesting season of the birds. Thus, this was the first report of a reptilian predator not only using hunting bait, but also optimizing its use with the nesting behaviour of the bird prey. Opportunistic observations of *A. mississippiensis* and *C. palustris* with sticks on their snouts has been interpreted as tool use for luring nesting waders to ambushing distances has been reported (Dinets et al. 2013).

That in both these cases the crocodylian species were in the vicinity of wading bird rookeries and the

birds did attempt to collect the sticks lend strength to the premise, that it was an attempt to improve hunting success. However, it is only through a study of controlled variables that more authentic evidence towards use of sticks as bait can be confirmed.

While use of flowers as 'play object' has been reported in captivity, this behaviour has not been firmly established in the wild. Hence play behaviour especially involving play objects such as flowers and other floating debris remains speculative, requiring detailed studies. Certainly, the water body under investigation where the crocodiles dwell receives a lot of vegetative material naturally and through human activity. Especially where the banks are used for cremation, a lot of flowers used in posthumous rituals end up floating in the river and remain there or get drifted until they decompose. Such conspicuous moving vegetative matter may elicit attack response from the crocodilians that may inadvertently end up ingesting it. Crocodiles are observed to have been attacking artificial objects that float or move passively on surface of water, particularly if these objects resemble large fruits (Somaweera et al. 2018).

Thus, it would be imprudent to draw a parallel between Dinets' observations (Dinets 2015) on Bougainvillea flower as play object of Cuban and West African Dwarf Crocodile and the propensity shown by Muggers of Savitri towards flowers of marigold. Perhaps more experimental evidence must be offered to propose such a behavioural analogy. However, given the antimicrobial property of marigold flowers, proximity to these flowers may offer some health benefits like bacteriostatic or bactericidal effects in a sewage contaminated environment.

The curious case of a dog 'rescued' by the group of crocodiles reported here seems more on lines of empathy than altruistic behaviour. However, there is little research done on such mental faculties of reptiles and this paper opens novel vistas of understanding behaviour of Muggers in general and that of Savitri River in particular.

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Mr. Jatishwor Singh Irungbam, Biology Centre CAS, Branišovská, Czech Republic.
Dr. Ian J. Kitching, Natural History Museum, Cromwell Road, UK
Dr. George Mathew, Kerala Forest Research Institute, Peechi, India
Dr. John Noyes, Natural History Museum, London, UK
Dr. Albert G. Orr, Griffith University, Nathan, Australia
Dr. Sameer Padhye, Katholieke Universiteit Leuven, Belgium
Dr. Nancy van der Poorten, Toronto, Canada
Dr. Kareen Schnabel, NIWA, Wellington, New Zealand
Dr. R.M. Sharma, (Retd.) Scientist, Zoological Survey of India, Pune, India
Dr. Manju Siliwal, WILD, Coimbatore, Tamil Nadu, India
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