STATUS OF MUGGER CROCODILES (*CROCODYLUS PALUSTRIS*) IN RIVER MOYAR, SOUTHERN INDIA

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Abstract

Status of Mugger crocodiles (*Crocodylus palustris*) was studied in the river Moyar between 2014 and 2016. In total, 98 positive sites (scat and basking sites) were observed in which 28 Muggers were encountered directly in the 102 km river stretch during entire study period. The relative abundance of muggers per kilometers was 0.44, 0.51and 0.41during post-monsoon, winter and summer period. The population abundance of the muggers was 46, 52 and 42 during post-monsoon, winter and summer period respectively. The distribution of mugger signs were positively correlated with width and depth of the river and negatively correlated with river substrate such as shallowness, mesquite invasion and steep-slopsites. In all, no burrows were observed along the river banks. No instances of human-crocodile conflicts and domestic animal causalities were observed. Perhaps, various types of threats to Mugger habitat were noticed including 'Mesquite' invasion, pesticide agriculture run-off mixing and dynamite fishing activities. Muggers in Moyar River are protected but, due to illegal fishing practice in some part of the river, fish abundance drastically declining and it could lead human-wildlife conflict in future. The present study suggest further ecological research to propose strategies to conserve the mugger population and the river Moyar ecosystem.

Key words: Mugger crocodiles; Status; river Moyar; Western Ghats; conservation

Introduction

The Marsh crocodile or Mugger (*Crocodylus palustris*) is one of the common, widely spread and most adaptable crocodilian species in India (De Silva & Lenin 2010). They areamphibious in nature, occupying a variety of habitats including hill streams, manmade reservoirs, seasonal tanks, large rivers, small pools, irrigation channels and also urban drainages & sewage puddles (Vyas, 2010, 2013). This species is a threatened reptile in India and legally protected under Schedule I in the India's 'Wildlife (Protection) Act 1972' and categorized as 'Vulnerable' under the assessment criteria of IUCN for threaten species (Choudhary & De Silva 2013). In the late 1970s, the mugger population was depleted from its entire distribution range due to illegal hunting, unrestricted fishing and habitat loss which brought muggers to the edge of extinction (Whitaker 1987, Bustard 1999). But now, the mugger population persisted due to the legal protection and the success of ex-situ programmes and release practices (De Silva & Lenin 2010). Mugger is known to inhabit many of the large fresh water bodies in India (Vijaykumar *et al.* 1999; Vyas, 2008; Vyas, 2010). However, river Moyar is one among the potential mugger habitat in southern part of the Western Ghats, which supports sizable mugger population.

Materials and Methods

Study area

Moyar is a well-known perennial river in the Western Ghats that flows through many protected areas viz., Mudumalai Tiger Reserve (MTR), Sathyamangalam Tiger Reserve (STR) and Nilgiri North & South Divisions (NND; NSD) (11.56 N' and 76.93 E' ~431m asl) (**Fig. 1**). Upper gorges of the river receives more than 5000mm rainfall and lower/down river area receives about 824 mm rainfall annually and average temperature in this region varies from 25 - 38˚C in the lower elevations and 14 - 30˚C in higher elevations. Further, the elevation of the river area varies from 250m asl (in downstream areas) to 2050 m asl (in upstream areas) (Puyravaud & Davidar 2013). The landscape supports one of the largest Tiger (*Panthera tigiris*), Leopard (*Panthera pardus*), Elephant (*Elephas maximus*), Otters (*Lutagale perspicillata*; *Anoyx cinerea*) and Gyps Vulture populations. Moyar is a key livelihood source for more than a million people and thousands of hectares of agricultural lands (Puyravaud & Davidar 2013). However, this river ecosystem

faces many threats such as agriculture runoff mixing, hydroelectric projects, fishing activities, pesticide and motor oil spilling in the river water (Puyravaud & Davidar 2013). Inspite of these threats, mesquite (*Prosopis juliflora*) continue to invade the river gorges catastrophically impacting native biodiversity.

Assessing distribution and status of muggers

The field survey was conducted by foot along the 102 km stretch of Moyar and its tributaries, using landmarks, the entire river was surveyed in three seasons post-monsoon, winter and summer, only inaccessible area were left-out to avoid accidents during the survey (Vyas 2008, 2009). The survey consist of two to three observers to assess the status and distribution pattern of muggers. Whenever we encountered the mugger (direct and indirect [scats, burrows/basking site]) its location marked using Geographical Positioning System (Garmin 80). Observations were made along the river from the eastern part (248 m asl) to western part (2054 m asl). The presence of crocodiles in each seasons was mapped based on sightings as well as indirect fecal evidence of mugger using QGIS software. Crocodiles were categorized into size classes- >1.5m as adults, <1.5m as sub adult (Vyas 2013). Direct sightings and photographic evidences (DSLR camera) were used for demographic classification (Vyas 2012).

Assessing the habitat correlation

We laid 1.2 km river transacts in which, 100 m X 15 m plots were laid at the distance of every 400m to assess habitat parameters). In each plot habitat parameters such as type of substrate (hard sand, loose sand, rock, stone and gravel, canopy cover, vegetation cover and leaf litter (measured as percentage cover of the plot) were assessed (Anoop and Hussain, 2004). 'Hard sand' are defined as fine-textured, tightly packed sand, while 'loose sand' as coarse and loosely packed. Any boulder are classified as rock, stones and gravels (small-sized stones roughly under 10mm in diameter) (Bonesi and Macdonald 2004). Pearson's correlation test was performed to understand the relationship between habitat traits with mugger signs distribution.

Results

The 102 km river Moyar was surveyed in three seasons yielded a total of 98 positive signs/scats were recorded and 28muggers were directly sighted. The relative abundance was not showing any significance either positive or negative in all three seasons (0.44 ± 0.18 individuals / km [post monsoon] and 0.51 ± 0.27

individuals / km [winter] and 0.41± 0.11 individuals / km [summer]) respectively (**Table. 1**). However, the habitat use by muggers were similar in all three seasons. Loose sand and rocky sites (51.72 ± 2.79 and 48.25 ± 1.89; p>0.825) were highly occupied by muggers where the canopy cover was less than 40% (**Table. 2**). Among different age groups adults (41%) followed by sub adults (29%), juveniles (5%), yearlings and those of unknown age group (25%) were observed respectively. The seasonal occurrence of mugger crocodiles in river Moyar was shown in **Figure. 1**. Mugger occupancy was positively correlated with rocky, loose soil and less canopy cover sites. However, it was negatively correlated with shallow river depth, narrow river width and Mesquite (*Prosopis*) invaded sites in river Moyar (**Table. 2**). Year-wise comparison of the relative abundance of crocodiles was shown in **Fig. 2.**

The survey results that the distribution of mugger crocodiles were high in downriver areas and low in the upriver areas. Perhaps, no cases of any human-crocodile conflicts and cattle predations were observed during the survey. However, the entire river was facing unrestricted fishing pressure mostly anglers, cast nets were used by fishermen. Sadly, fishermen infrequently using dynamites for fishing in river Moyar region. In addition, agricultural pesticide runoff and laundry waste water mixing into the river are polluting the river and its biodiversity.

Discussion

This study explored the population and distribution mapping of crocodiles, identified the habitat preference and threats associated in the Moyar River. The only crocodilian known to inhabit the river was *C. palustris*. In this study, the numbers of adults that were seen, is easily comparable to the sub-adults because the movement and other activities of the sub-adult muggers was not limited as most of the time they were basking on the rocks or sandy sites (Whitaker and Whitaker 1984). The highest numbers of mugger signs and direct sightings (fourteen) were found in the winter, which is the breeding season and hence peak activity period for this species in south India (Whitaker & Whitaker 1984). Crocodile preferred certain sites, along the river course with varying depth and fast moving meanders, similar to observations of Goit & Basnet (2011).

In winter and summer most sightings were in the sand bank, no grass cover and rock formations were found in middle of the river as compared to other habitats. Most of the muggers were found performing either basking or gaping. But, in Koshi River they preferred mainly sand bank, high grass cover and river channels as their habitat in winter and spring (Goit & Basnet 2011). According to Whitaker (1987),

gaping has significance in the thermoregulation. It may also perhaps be a way to get rid of oral infections, pathogens and parasites as small birds would come to pick off such animals from the mouth of crocodiles. Downstream movement of crocodiles during the monsoon and summer period has also been reported from the Koshi River to the Ganges River in India (Biswas 1970). However, similar movement pattern were observed in downriver areas during summer further, they moved towards upriver during the post-monsoon seasonin river Moyar.

However, anthropogenic pressures such as unrestricted fishing activities, pesticide agricultural runoff mixing into the mugger habitat were observed during the surveys. Inspite, in river Moyar muggers live in very close proximity to the humans with sizable populations in the region. It is difficult to ascertain that they would not pose any problem to local people, who regularly share the river habitat with the muggers. Although, the Moyar region has legal protection, one of the reasons for the low level of conflict may be that the local people here are indigenous tribes who have always lived with wildlife, including muggers. Their existence has been positively accepted by people mainly because of the fact that there have been no human casualties and cattle attacks in this region. But, incidence of a few attacks could possibly lead to the rise in negative attitudes about muggers in future.

Thus, most of the muggers were sighted sporadically during the census period. Initiation of systematic monitoring programme look into ecological parameters like movement patterns, territoriality, interspecific relationship with sympatric species, prey selection, breeding success and conflicts will be crucial to conserve the *Crocodylus palustris* in river Moyar ecosystem.

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Figure 1. Map showing the season-wise distribution of Muggers signs and sighting in the river Moyar, Western Ghats

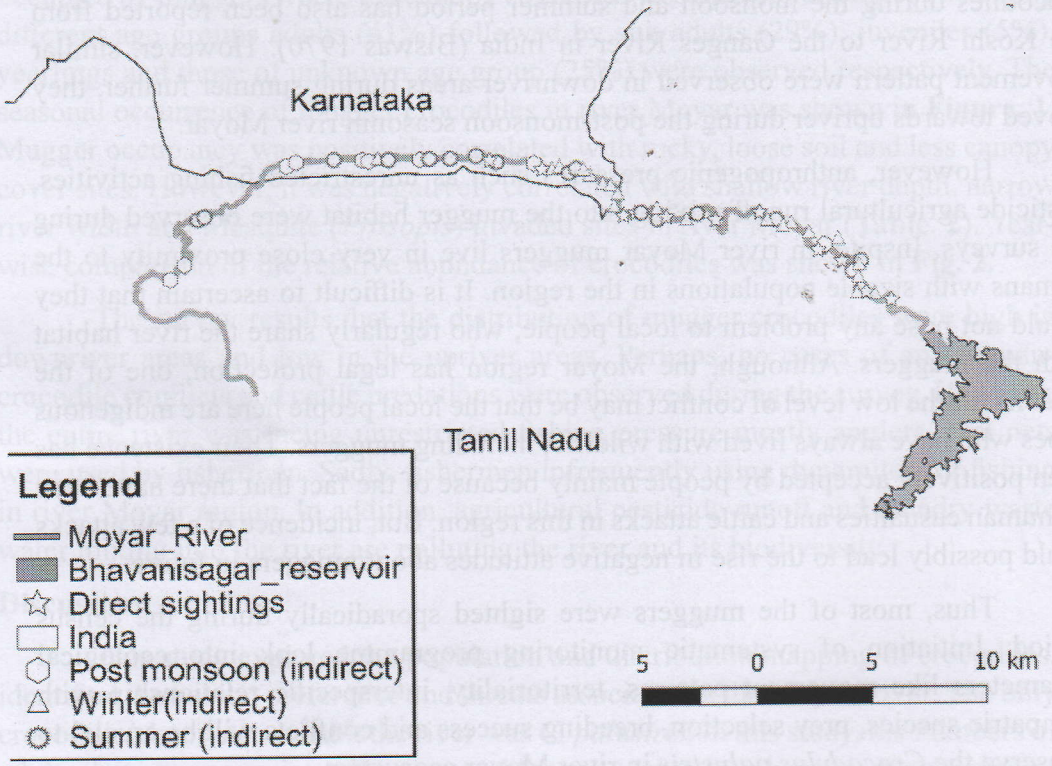

Table1. Relative abundance of Muggers/ kilometer in different seasons in river Moyar during 2014 - 2016.

	Post-monsoon	Winter	Summer
Relative abundance	0.44	0.51	0.41
Standard Error	0.08	0.27	0.11

Figure 2. Year-wise comparison of relative abundance/ kilometer of the muggers in river Moyar.

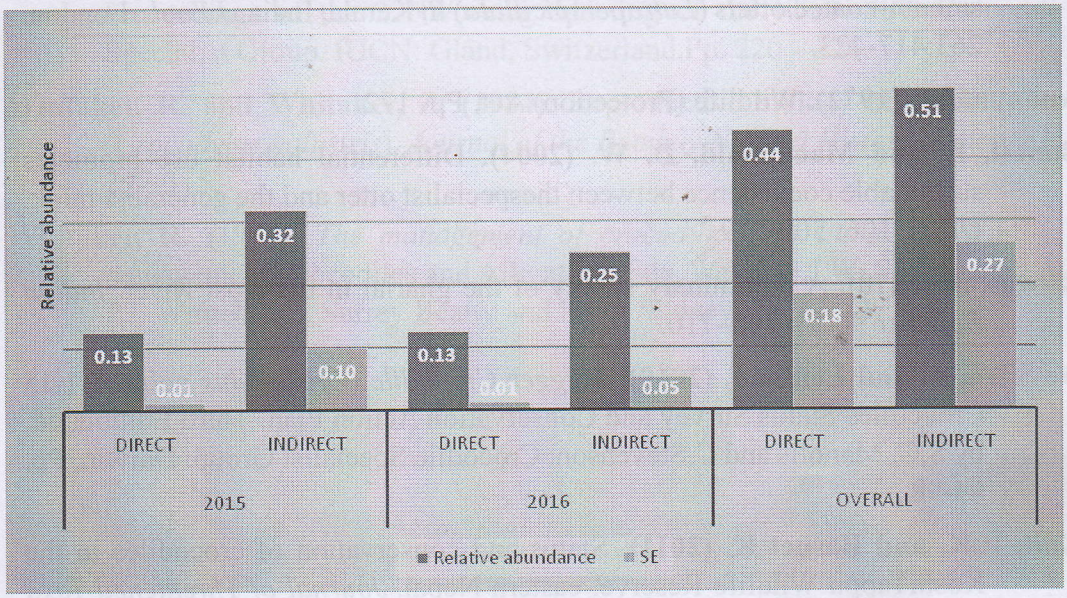

Table 2. Summary of the significant results of the $\chi 2$ analysis using cross-tabulation and Pearson's correlation tests for habitat relationship with mugger signs distribution in river Moyar.

Habitat type	Grid cell Neighborhood	$\chi 2$	Type of association	Significance (*P*)
Rocky	20 x 20	0.38	+	0.825
Loose sand	%	0.34	+	0.068
Mesquite sites	20 x 20	-0.37	-	0.075
Canopy cover	%	-0.53	-	0.038
River depth	Meters	0.43	+	0.671

A significant $\chi 2$ value indicates that there was a significant association between the presence or absence of signs and that habitat type. A positive association of mugger sign activity with a particular habitat types are indicated by a plus sign and a negative association by a minus sign in the table.

References

Anoop, K. R. and Hussain, S. A. (2004). Factors affecting habitat selection by smooth-coated otters (*Lutraperspicillata*) in Kerala, India. *J.Zool.*, London. 263:417-423.

Anonymous. (1972). Wildlife (Protection) Act. Pp- 172.

Bonesi, L. and Macdonald, D. W. (2004). Differential habitat use promotes sustainable coexistence between thespecialist otter and the generalist mink. *Oikos*. 106: 509-519.

Biswas, S. (1970). A preliminary survey of the gharial in the Kosi River. *Indian Forester* 96(9): 705–710.

De Silva, A. and Lenin, J. (2010). *Mugger Crocodile* (*Crocodylus palustris*). In Crocodiles Status Survey and Conservation Action Plan. Third Edition, ed. by S.C. Manolis and C.Stevenson. Crocodile Specialist Group: Darwin, Pp. 94-98.

Goit, R.K. and Basnet K. (2011). Status and conservation of crocodiles in the KoshiTappu Wildlife Reserve, eastern Nepal. *Journal of Threatened Taxa* 3(8): 2001–2010.

Puyravaud, J.P. and Davidar, P. (2013). The Nilgiri Biosphere Reserve: an unrealized vision for conservation. *Tropical Conservation Science*. 6: 468–476.

Vijaykumar, V.R., Vyas, R. and Choudhury, B.C. (1999). Status of mugger and its conservationproblems in Gujarat. ENVIS (Wildlife & Protected Area), 2(1): 69-76.

Vyas, R. (2008). Why muggers (*Crocodylus palustris*) are found at some of water bodies of Gujarat State? *CSG Newsletter*, 27(1), 14 – 16.

Vyas, R. (2010). Mugger (*Crocodylus palustris*) population in and around Vadodara City, Gujarat State, India. *Russian Journal of Herpetology*, 17(1): 43-50.

Vyas, R. (2012). Current status of Mugger Crocodiles *Crocodylus palustris* (Reptilia: Crocodylidae) in Vishwamitri River, Vadodara City, Gujarat, India. *Journal of Threatened Taxa* 4(14): 3333–3341.

Vyas, R. (2013). Recent scenario of mugger (*Crocodylus palustris*) population in three districts of Gujarat State, India. In World Crocodile Conference. Proceedings of the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.Pp. 220 – 226.

Whitaker, R. and Whitaker, Z. (1984). Reproductive biology of the Mugger (*Crocodylus palustris*). *Journal of the Bombay Natural History Society* 81: 297-315.

Whitaker, R. (1987). *The management of crocodilians in India*. In: Wildlife management: crocodiles and Alligators (Eds. Webb, G.J.W; S.C. Manoli & P.J. Whitehead). Surrey Beatty and Sons, Sydney. Pp. 63-72.