



Current status of Marsh Crocodiles *Crocodylus palustris* (Reptilia: Crocodylidae) in Vishwamitri River, Vadodara City, Gujarat, India

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Abstract: Data presented here is based on a three year study (2008–2010) on a population of Mugger *Crocodylus palustris* inhabiting Vishwamitri River near Vadodara City, Gujarat State, India. In total, 155 Muggers were counted in the 25km river stretch during 2010. In all, 40 burrows were observed along the river bank, and the same were clumped in certain sections of the river. Muggers fed eight species of birds, and domestic livestock in addition to scavenging. Eight instances of human-crocodile conflicts were observed including four human casualties. A total 90 Muggers were rescued from the urban areas and the same were relocated elsewhere in the river system. Various types of threats to Mugger were also noticed including habitat loss, alteration and soil erosion and mortality due to rail traffic. The present study suggests further research to propose strategies to conserve this population.

Keywords: Mugger-human conflicts, rescue, river system, translocation, urban area.

The Marsh Crocodile or Mugger *Crocodylus palustris* is one of the common and wide spread crocodylian species in India. This species is categorized as nationally ‘Vulnerable’ subsequent to an assessment following IUCN criteria for threatened species (Molur & Walker 1998) and has the highest legal protection in India as it is listed in Schedule I of the Indian Wildlife (Protection) Act 1972. During the early seventies, while the Mugger populations in India were reportedly declining (Whitaker & Andrews 2003), Oza (1975) reported over 50 individuals of this species in Sayaji Sarovar (Ajwa Village) in close vicinity to Vadodara City, Gujarat. This population has reportedly declined due to hunting and illegal fishing in the down-stream of River Vishwamitri (Vyas & Vyas 2002; Vyas 2010a). The present study was carried out between January 2008 and December 2010 to determine its current status and assess issues related to conservation.

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Materials and Methods

Study Area: The present study was conducted in a 25km long and 40–60 m wide stretch of Vishwamitri River (from Vemali Village to Vadsar Bridge Vadodara City). The river flows through Vadodara City from north to south (Image 1) and it carries a significant quantum of sewage from the city and effluents from the Gujarat Industrial Development Corporations of Kalali and Makarpura. The downstream of the river is highly polluted (Gujarat Pollution Board 2007–08) and the water color varied from dark green-black-pink to red with a putrefied smell. The river stretch was divided into four sections based on the development of the city (Appendix 1) and river bank for easy approach. The section-wise features of the river and general information are available in Vyas (2010b).

Mugger count: Muggers were counted (visually) during December 2008–January 2009 and night surveys

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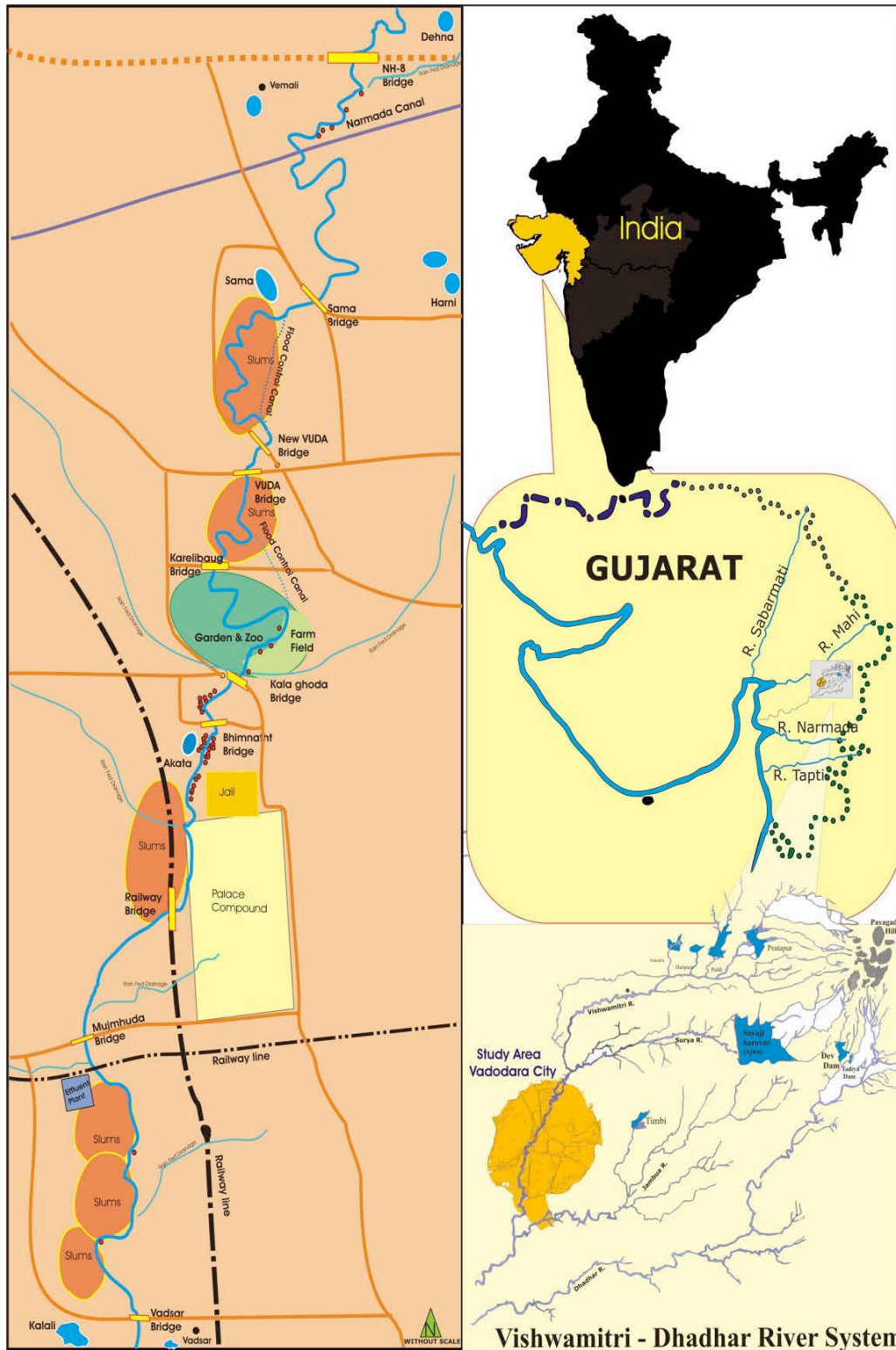


Image 1. Map of the study area: Vishwamitri River stretch and Vadodara City.

were done during January 2010 following Choudhary & Rao (1982) and De Vos (1982). Basking animals were counted from vantage points on the river bank

during mid-day using a pair of binoculars (8x40). Size class of the Muggers, shore and river bank features and river conditions were assessed visually. Mugger counts

during night were done using a search light. These counts were carried out in the last week of January 2010 involving the staff of Gujarat Forest Department and volunteers of a few local non governmental organizations (Appendix 2). Prior to initiating these counts, an orientation routine was conducted for all team members briefing them on methodology. Most of the Muggers were recorded following eye reflection. Data such as size, habitat type, water quality, river side features, and anthropogenic activities in the area were recorded visually and man-animal conflicts were recorded opportunistically.

Burrow count: Muger burrows were located manually during November 2008–January 2009. Burrows were categorised as active and inactive (abandoned) based on signs during repeated surveys.

Results

Mugger count 2008–09: Counts of Muggers during the day were carried out from the last week of December 2008 to January 2009. In total, 81 Muggers were counted within the 25km stretch of the river studied. This included 14 juveniles, 24 subadults and 43 adults (over two meters). Data on Muger counts at each section of the river and size class are given in Table 1. The highest of 36 Muggers was observed in river Section-2.

Mugger count 2010: During the night count, a total of 155 Muggers were observed, which included 78 adults. Section wise counts and size of Muggers are

given in Table 1.

Burrows count: In total, 40 burrows of Muggers were observed during November 2008–January 2009, including 25 on the left bank and the rest on the right bank of the river. Among them, 36 burrows were active (Table 2). The highest of 27 active burrows were observed in Section-3. Only two burrows were recorded in Section-4, the down-stream of the river.

A River Front Project was initiated during 2009 by the Vadodara Municipal Corporation. In the first phase, the river banks were cleared and widened to facilitate the flow of water. Due to this, about 25% of burrows got blocked with loose soil. However, it was observed that within a few weeks the Muggers had excavated new burrows nearby.

Food and feeding: It was found that Muggers actively foraged nocturnally (dusk to dawn). During the study, Muggers were observed feeding on eight

Table 2. Numbers of burrows observed in study area, River Vishwamitri.

Section no.	Number of Burrows		
	Right Bank	Left Bank	Total
	Used + Unused = Total	Used + Unused = Total	Used + Unused = Total
Section-I	0 + 0 = 00	3 + 2 = 05	3 + 2 = 05
Section- II	1 + 0 = 01	03 + 0 = 03	04 + 0 = 04
Section- III	13 + 1 = 14	14 + 1 = 15	27 + 2 = 29
Section- VI	0 + 0 = 00	02 + 0 = 02	02 + 0 = 02
Total	14 + 1 = 15	22 + 3 = 25	36 + 4 = 40

Table 1. The Vishwamitri River section and count of Muger *Crocodylus palustris*

	River length (km)	The river section	Numbers of Animals				Total	% Population	
			Juvenile <1>m	Sub-adult <1 to 2>	Adult <2 to 3>	Big-size <3m			
A - survey result December 2008–January 2009	8.5	Section-1	6	05	02	0	13	16.04	
	3.5	Section-2	6	15	11	4	36	44.44	
	7.0	Section-3	1	02	23	3	29	35.80	
	6.0	Section-4	1	02	00	0	03	03.70	
				14	24	36	7	81	
	25km	%		17.28	29.62	44.44	08.64		
B - survey result January 2010	8.5	Section-1	03	03	03	02	11	07.09	
	3.5	Section-2	10	14	20	05	49	31.61	
	7.0	Section-3	18	24	33	10	85	54.83	
	6.0	Section-4	01	04	02	03	10	06.45	
		Sub total	32	45	58	20	155		
	25km	%		20.64	29.03	37.41	12.90		

species of birds: Little Cormorant *Phalacrocorax niger*, Indian Pond Heron *Ardeola grayii*, Cattle Egret *Bubulcus ibis*, Night Heron *Nycticorax nycticorax*, Red-wattled Lapwing *Vanellus indicus*, Black-winged Stilt *Himantopus himantopus*, White-breasted Waterhen *Amaurionis phoenicurus* and Blue Rock Pigeon *Columba livia*. Juveniles fed on frogs (Indian Skipping Frog *Euphlyctis cyanophlyctis*, Indian Bull Frog *Hoplobatrachus tigerinus*) and invertebrates such as insects and dragon flies.

During this study, Muggers attacking domestic animals such as goats, dogs and poultry were reported on numerous occasions, which indicate dependency of this species on domestic livestock for food. Muggers also scavenged on materials dumped in the river and on its banks (Image 2). On two occasions, this species was found scavenging on human carcasses and human fetuses thrown in to the river, probably by hospitals indicating that the river is being used for dumping medical wastes as well.

Human-Mugger conflicts: Muggers attacking people were observed on eight occasions during 2008–2010; Five male victims, including a 12-year old boy and three females of age group of 20–40 years were victims. Two attacks were noted within the city limits and the rest (6) along the down stream of river Dhadhar-Vishwamitri. Six attacks happened while the victims were crossing the river and in the other two cases it was while washing clothes and operating a motor for pumping water. Barring one record during April, all the other conflicts were observed during



Image 2. A large Mugger crocodile feeding on an animal carcass

June–September.

Rescues: A total of 90 Muggers were rescued during this study including 25 juveniles, 25 sub-adults, 27 adults (13 muggers measured over three meter) (Fig. 1; Images 3 & 4). Monthly data showed that a higher number of Muggers were rescued during September, August and November (Fig. 2). The rescued crocodiles were sent to the Forest Department for release in suitable habitats. Prior to January 2009, the rescued crocodiles were released at Sayaji Sarovar, Ajwa Village and those rescued in subsequent years were released in the downstream of Vishwamitri River.

Nest and nesting success: Nine nests were recorded in Section-3 of the river from 2008–2010; of them, five nests were predated and hatchlings emerged successfully from the other four. However, hatchlings and juveniles contributed about 17% and 20% of the sampled population during 2009 and 2010, respectively. Of the three nests observed during 2009, 22 hatchlings emerged from two nests, found in Section-3 of the river (Image 5).

Threats: Threats to crocodiles include loss,



Image 3. A rescued Mugger with injury, inset close-up of injured foot.



Image 4. An injured juvenile Mugger rescued from the Vadodara City.

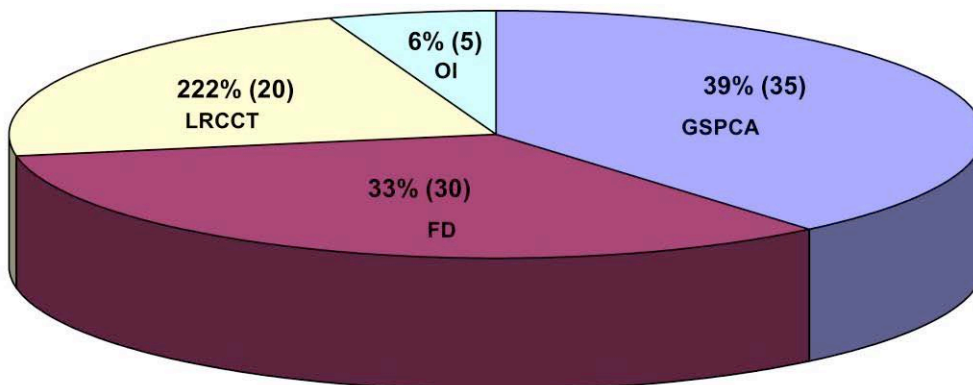
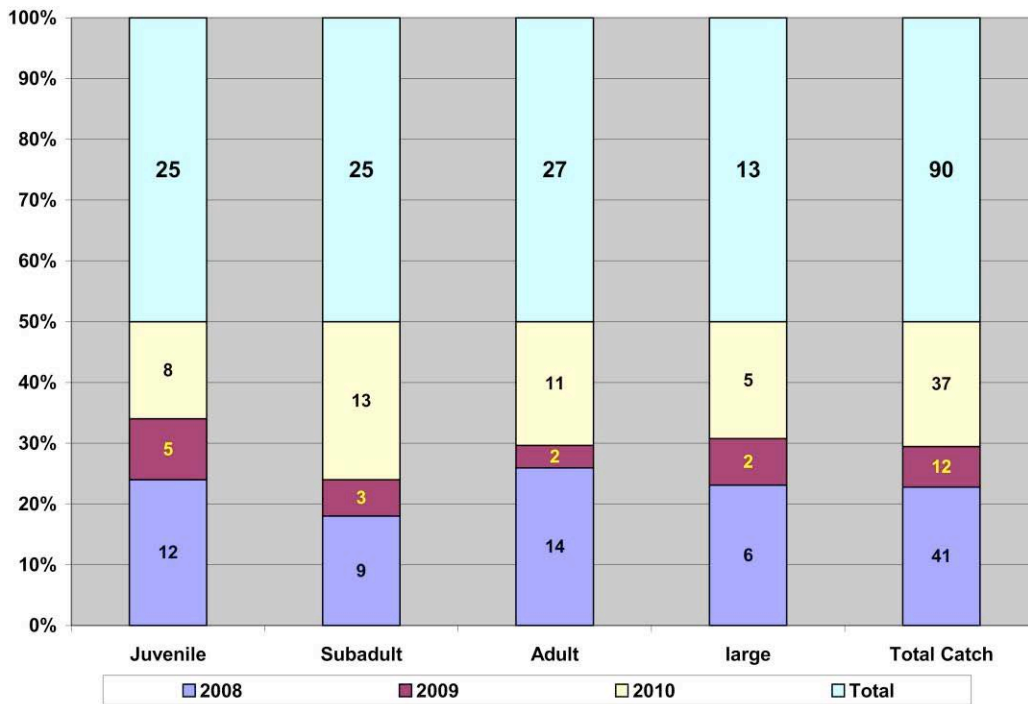


Figure 1. Size class of Muggers rescued from Vadodara City during 2008–2010 by Forest Department (FD) and Non Governmental Organizations.
 GSPCA - Gujarat Society for the Prevention of Cruelty to the Animals; LRCCT - Let. Rohan Crocodile Charitable Trust; OI - Others Individuals).



Image 5. Muger hatchlings.



Image 6. An adult Muger killed by rail traffic near Vishwamitri Railway Station, Vadodara

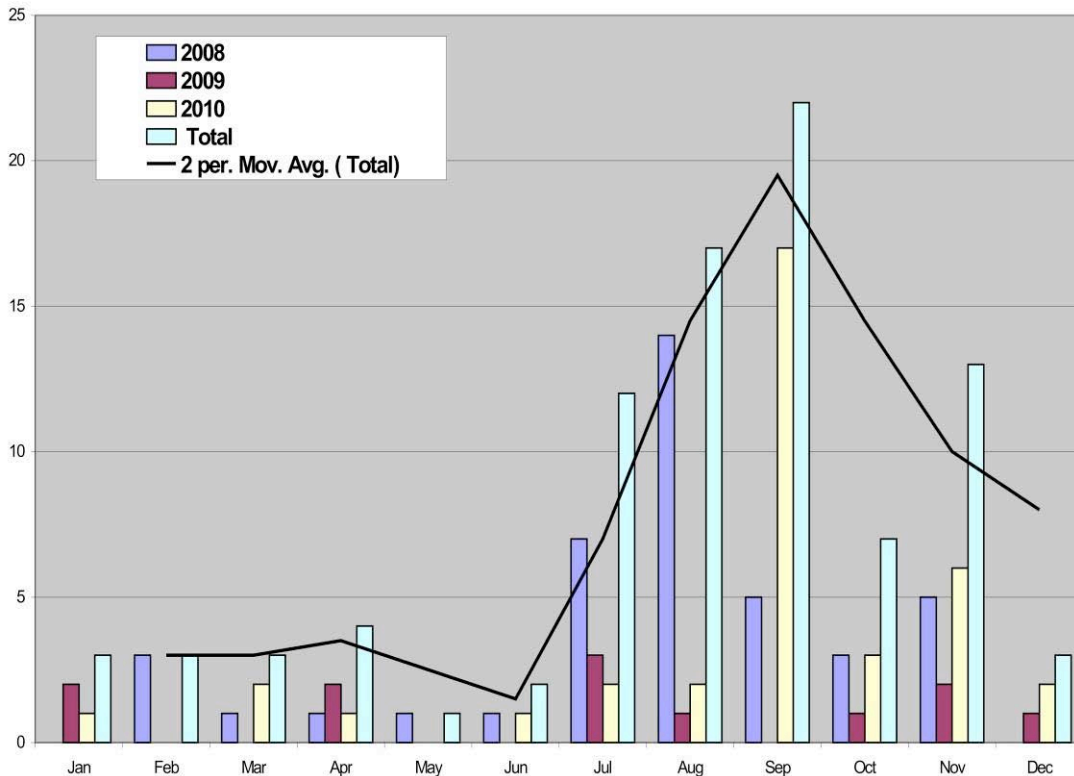


Figure 2. Muger rescue in different months from Vadodara City during 2008 to 2010.

alteration and erosion of habitats, along with new developments in the river and its close vicinity. Recently, a few Muggers were killed in road and rail traffic (Image 6).

Discussion

Muggers in river Vishwamitri is one unique example of man living in harmony with animals. The two decades of Muger count has shown an increasing trend in its population. Data on the status of Muggers of river Vishwamitri during January 1987 to December 2007 is summarized in Vyas (2010a). The 'night count' is relatively a better method to assess the population of Muger compared to surveys during day.

A total of 40 burrows were counted in 2009, of which 36 were active. Among them, the highest number of 29 burrows and 26 animals was observed in Section-3 of the river. The number of burrows positively corresponded with the number of animals counted in the same river section. This is similar to the report by Nathalie (2011) on *C. niloticus* in River Tapoa, Niger. Prior to 1995, there were only nine burrows along this river stretch (Vyas 2010b), which increased four fold during this study. During the riverfront project about

25% burrows were damaged, but new burrows within a few weeks shows the adaptability of Muggers with respect to a changing environment.

Nonperennial and polluted rivers in general do not support rich fish fauna round the year. Therefore, crocodiles were forced to feed on various species, both live and dead animals. Observations of crocodiles feeding on discarded medical wastes such as human body parts and foetuses are alarming and this should be stopped.

Most of the human-crocodile conflict was observed during June–September, which is the breeding season of the species (Vijaykumar 1997). Crocodiles are known to be aggressive during the breeding season and often attack the intruder. Including the present study, a total of 22 attacks have been reported from 1985 to 2010 (Vyas 1993, 2005, 2010a; Whitaker 2008). The trend in Muger attacking humans has increased over the years (Fig. 3), which requires attention of the concerned department, and further study is required to propose mitigation plans.

Muger counts during 2010 showed adult crocodiles over two meters contributed about 50%, which indicates a healthy population of this species

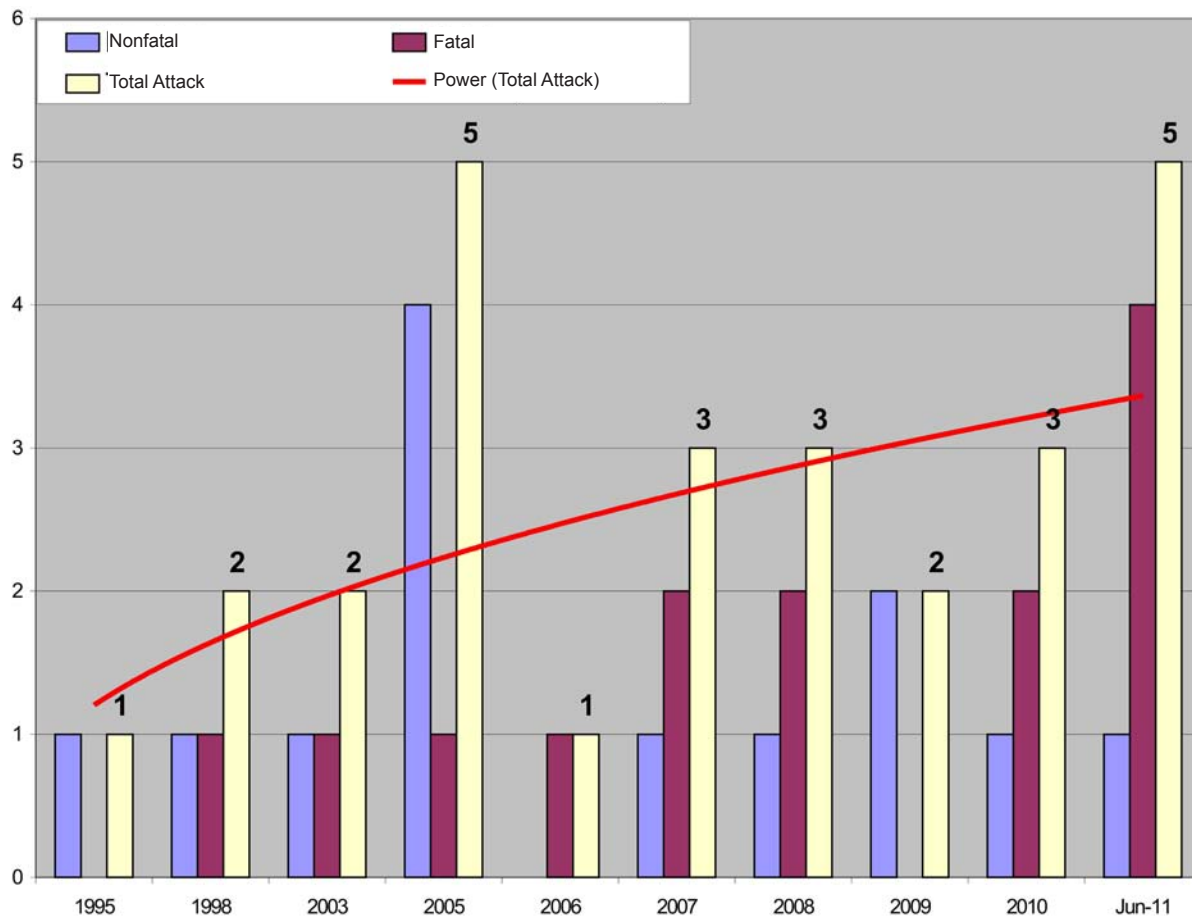


Figure 3. The trend in Mugging attacking humans has increased over the year, Vishvamitri River System, Gujarat, India.

in Vishwamitri River. However, continuous increase of a largely carnivorous species in close proximity to human habitation is a matter of concern. It is high time to design an action plan for this species at the state level and to evaluate the existing conservation strategy and reformulate the policies (Vyas 2010a), if required. Every year numerous Muggers are being rescued from urban areas of the city and translocated with the involvement of various NGOs and staff of the State Forest Department. While the interest of locals in crocodylian conservation is appreciable, lack of appropriate 'rescue and release' protocols is a matter of concern. A few translocated animals returned to the same river stretch from where they had been rescued earlier (Bhatt 2000; Vyas 2010b). Appropriate measures should be taken to protect Muggers from getting killed by vehicular traffic such as rail and road (Vyas & Bhavsar 2009; Vyas 2011), which are new threats faced by this species.

This small and dense population of Mugging survives

in the kernel of Vadodara, Gujarat, India is a notable example of crocodylian conservation and man-mugging concordance. The preservation of this population now lies in the hands of the residents of Vadodara City and various local government agencies, including the State Forest Department, Urban Development Authority and Municipal Corporation, Vadodara. Continuous monitoring of the population of this species is required as suggested by Vyas (2010a).

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Appendix 1. Segment studied in Vishwamitri River and description of the area and characteristics of river banks

River Segment	Boundary of the River Segment	Co-ordinates	Segment length	Features of the river Bank	Activities
Section-1	NH-No. 8 Bridge to VUDA Circle + Flood Control Canal	73°12'48.67"E 22°21'25.67"N 73°11'42.61"E 22°19'30.23"N	8.5km (+1.0km)	The river bank is undisturbed and covered with distant agricultural fields, and southwards near Sama Village and VUDA circle area are the recently developed urban residential societies, EME school and training campus and a few slums.	Fishing, washing and bathing. Also, river water is used by farmers for irrigation and a number of illegal liquor distilleries are operated on the banks
Section-2	VUDA Circle to Kalaghoda Circle + Flood Control Canal	73°11'42.61"E 22°19'30.23"N 73°11'20.18"E 22°18'29.66"N	3.5km (+1.0km)	The river banks are covered with slums, gardens and zoo and urban residential societies. One drainage (Bhukhi) empties on the left banks, which comes from the eastern side areas of Chhani and Nizampura and the second drainage drains on the right bank, from the north-western slopes of city.	Washing, bathing and some illegal distilleries are observed in this segment too. Most of the banks areas are used by the slum dwellers for defecation.
Section-3	Kalaghoda Circle to Munj Mahuda Bridge	73°11'20.18"E 22°18'29.66"N 73°11'16.70"E 22°17'08.03"N	7.0km	Both the banks are covered with slums, open scrub lands and a few residential societies. Left banks open scrub lands and society. One drainage pours into the right bank, which comes from Akota area of city and the second drainage empties into the left bank of the river, this drainage assembles rain water from the palace compound and city area.	Washing and a few illegal distilleries are operated on the banks
Section-4	Munj Mahuda Bridge to Vadsar Bridge	73°11'16.70"E 22°17'08.03"N 73°10'07.72"E 22°15'53.51"N	6.0km	The right river bank area is covered with slums, open scrub lands and few urban housing societies, whereas on the left banks; agricultural fields are found. A rain fed drainage merges into the river on the left banks, this collects rainwater from Sursagar, Dandiya Bajar and Manjalpur.	Washing and liquor distilleries (illegal). Also, river waters are pumped by local farmers for the irrigation purpose.

Appendix 2. List of government, non government organizations and individuals involved in rescuing wild animals in and around Vadodara, Gujarat.

	Name and address of organization	Name of the contact person	Contact number
1	Social Forestry, Forest Department, New Anexie Building, Kothi, Vadodara	Conservator of Forest	RFO-Sayajiaug (0265-27839542) RFO-Padra (02662-24196) RFO-Amod (02641-45359)
2	Wildlife Circle - Forest Department, Kothi Office, Vadodara	Conservator of Forest	RFO-Harni (0265-2484499)
3	Wildlife Circle- Bharuch, Forest Department	Conservator of Forest	RFO-Jambusar (02644-20294)
4	Sayaji Baug Zoo, Maha Nagar Seva Sadan Vadodara	Zoo Curator	0265-2784079
5	Fire Brigade, Maha Nagar Seva Sadan Vadodara.	Chief Fire Officer	0265-2562010; 0256-2432050
6	Vadodara Society for the Prevention of Cruelty to the Animals, Vadodara City	Secretary	0265-6555552
7	Gujarat Society for the Prevention of Cruelty to the Animals, 60-Kunj Society, Alkapuri, Vadodara	Secretary: Snehal R. Bhavsar Raj Bhavsar	91-9825011117
8	Let. Rohan Crocodile Charitable Trust, Raopura, Vadodara	President & Project Coordinator Mr. Ashok Pawar / Rakesh V.	91-9825317472 91-9925058137
9	Wildlife Reused Trust, Vadodara	President: Rajesh Kadam	91-9662039281
10	Canine Group, Vadodara City	President: Vishal Thakur	91-9825683960
11	Mr. Rohit Vyas and Group, Vadodara City	Mr. Rohit Vyas	91-9998954023
12	Mr. Kartik Upadhaya and Group, Vadodara.	Mr. Kartik Upadhaya	91-9426270077
13	Mr. Pravin Maharaj, Padra, Vadodara	Mr. Pravin Maharaj	91-9327960226

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