



# Results of the 2015 Mugger Crocodile (*Crocodylus palustris*) Count at Vadodara, Gujarat, India

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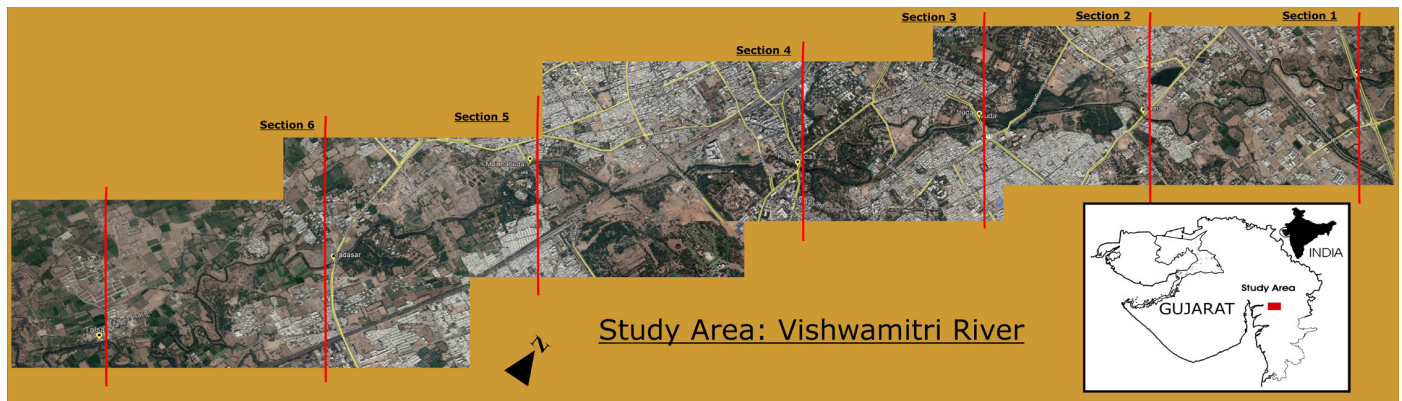
**Abstract.**—This report documents the Mugger Crocodile census conducted on 20–21 January 2015 at Vadodara City, Gujarat. This is a periodic procedure and part of an ongoing study designed to monitor this urban population with the help of public participation. The results show a gradual increase in the Mugger population within the demarcated stretch of the River Vishwamitri. The night-count numbers indicated the presence of 250 individuals of various sizes (< 1 m to > 4 m in total length). Mugger Crocodiles are wild, aquatic, carnivorous animals that have been flourishing in close proximity to humans, allowing for a noteworthy case study of the human-Mugger relationship. However, direct and indirect conflict data from the year 2014 are alarming – 24 documented Mugger attacks (12 of which were fatal) within the state, seven (three fatal) within the city limits, and 48 Muggers of various sizes rescued from the area. These numbers are indicative of a unique, complicated, and delicate relationship between humans and crocodiles as a balance is sought between Mugger conservation and a steadily rising urban population.

The Mugger or Marsh Crocodile (*Crocodylus palustris*) is a threatened species in India and legally protected under Schedule I of the Indian Wildlife (Protection) Act of 1972. During the late 1960s, this species dwindled across its entire distribution due to increasing threats, such as illegal hunting, fishing, and habitat loss (Whitaker and Andrews 2003).

Subsequently, the Mugger population grew due to legal protection and the success of an *ex situ* program launched by the Food & Agricultural Organization and the Indian Government, known as the Indian Crocodile Conservation Project. With the success of this program, all three Indian crocodilian species (the Mugger, the Gharial, and the



**Fig. 1.** The threatened Mugger or Marsh Crocodile (*Crocodylus palustris*) is legally protected under Schedule I of the Indian Wildlife (Protection) Act. Photograph by Raju Vyas.



**Fig. 2.** The study area along the River Vishwamitri in Vadodara City, Gujarat, India.

Saltwater Crocodile) recovered from the brink of extinction (Singh 1999). Nationally, the Mugger is now considered a ‘vulnerable’ species per IUCN criteria (Da Silva and Lenin 2010). Presently, this species can also be identified as conflict-prone and problematic throughout its entire range, including India (Pillai 1999; VijayaKumar et al. 1999a, 1999b; Jayson 2002; Whitaker 2007; CrocBITE 2017) as a result of increasing human-crocodile conflict, blurring the boundaries of the habitats of both humans and Muggers.

In the current scenario, Muggers (Fig. 1) are abundant in many bodies of water in Gujarat State thanks to legal protection and preservation measures taken by the State Forest Department and NGOs, as well as the development of an expansive network of irrigation canals (Vyas 2008). Muggers have entered into human settlements, creating conflicts throughout the state (Vyas 2007), including Vadodara City (Vyas 1993, 1994, 2005a, 2005b, 2010a, 2010b). The Mugger population found in and around Vadodara primarily occupies the River Vishwamitri (Vyas and Vyas 2002; Vyas 2012). Herein I present the results of the 2015 Mugger count in Vadodara, Gujarat, which was part of an ongoing study and regular monitoring of this population.

### Study Area

The Vishwamitri is a seasonal river, flowing east to west between two perennial river systems, the Mahi and Narmada. The Vishwamitri originates in the Pavagadh Hills, flows westward through the city of Vadodara, joins the River Dhadhar and the River Khanpur (two small tributaries near the village of Kothawada) and finally empties into the Gulf of Khambhat. As the river carves its way through the city of Vadodara, it becomes an open sewage system carrying enormous amounts of effluents. Despite the intense pollution, the Vishwamitri supports a sizeable population of Muggers. With each passing year, especially during the months of the rainy season, more and more crocodiles enter nearby human habitations through open drainages, canals, and the river itself, causing a state of panic and conflict across the city.

### Objectives

This census was conducted with the following objectives: (1) To assess the various sizes of Muggers found within the city limits, (2) to investigate the reasons behind indirect and direct conflict in order to find appropriate solutions, (3) to provide population numbers for the species-management program of the local forest department, (4) to use citizen science as a tool to create awareness of the species through public participation, and (5) to provide data for the ongoing study intended to monitor the urban Mugger population of Vadodara City.

### Methods

The crocodile survey was conducted on 20–21 January 2015 along a short stretch (25 km long and roughly 30 m wide) of the River Vishwamitri as it flows through the core of Vadodara. Methods were those of Vyas and Vyas (2002) with a slight modification (Vyas 2010a). This stretch of river was further divided into five parts: (1) NH8 to Sama Bridge, (2) Sama to VUDA Bridge, (3) VUDA to Kalaghoda Bridge, (4) Kalaghoda to Munjmahuda Bridge, (5) Munjmahuda to Vadsar Bridge, and (6) Vadsar to Talsat Bridge (Fig. 2), plus several reservoirs within the city. All river segments and reservoirs were surveyed with the help of the staff of the State Forest Department (range forest officers and foresters), along with 50 local wildlife enthusiasts. Participants were divided into seven groups; six surveyed the six segments of the river and the seventh surveyed the reservoirs.

Prior to the two-day procedure, all participants were trained on 19 January 2015 (Fig. 3). Training included briefings on how to approach animals for croc-counting in the field, how to document observations using the prescribed data-sheets, and detailed explanations of methods, especially the conduct and peculiarities of “day-basking” and “night-count” methods. Each group member was instructed to walk slowly along the riverbank with binoculars (8 x 40) during the day and a flashlight at night. The daytime “basking Mugger count” was conducted at 0900–1200 h on 20 January, including a brief reconnaissance session for participants to





Fig. 3. The training session prior to the crocodile count in Vadodara City, Gujarat, India. Photograph by Manoj Thaker.

familiarize themselves with the study area and terrain. The “night-count survey” was undertaken the next day at 2000–2400 h using powerful flashlights. All data were recorded, and data-sheets were then collected and compiled using Microsoft Excel to generate analytical data generated by the count.

**Results and Conclusion**

We counted 145 Muggers during the day and 228 at night along the urban stretch of the River Vishwamitri. Each of nine urban reservoirs contained one to six animals, with the highest number in the Lalbaug Tank. The croc-counts from each section and reservoir are provided in Table 1. The largest number of Muggers was from segment 4 (between the Kalaghoda and Munjmahuda bridges), which was in the geographical center of the city. The smallest number was in segment 1 (between NH8 and the Sama Bridge), which is farther upstream. The night-count result from this 25-km river stretch indicated a density of 9.1 Muggers/km within the city limits, but excluded the reservoir population. In 1993, only nine Muggers were counted. After 1995, regular monitoring was instituted and Muger counts were subsequently conducted every five years (Vyas 2010a, 2012) with the help of the forest department and local NGOs. The results of this count and seven previous surveys document a steady rise in the Muger population (Fig. 4).

The day- and nighttime counts differed by 83 Muggers (36%). Factors such as environmental conditions, water temperature, nature of the habitat, as well as observer skill and

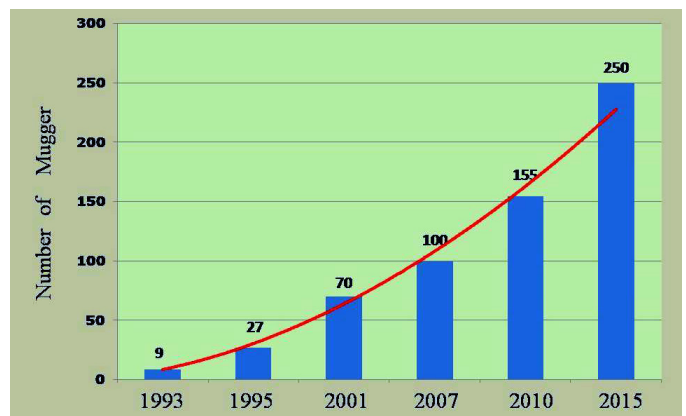


Fig. 4. The Muger (*Crocodylus palustris*) population in Vadodara City, Gujarat, India has risen steadily from 1993 to 2015.

experience, type of equipment, and familiarity with the surroundings might have contributed to the difference. However, crocs can be difficult to see during the day (e.g., Graham and Bell 1969; Magnusson et al. 1978; Bayliss 1987). Some remain submerged (out of wariness or for other reasons) and others likely were obscured by vegetation or other habitat features. Wariness of crocodilians can be estimated by the distance an observer can approach before submergence (Webb and Messel 1979; Pacheco 1996), but especially juveniles and subadults are quite stealthy and undetectable during the day. In sharp contrast, individuals of all sizes are noticeable

**Table 1.** Data from the Mugger (*Crocodylus palustris*) count along sections of the Vishwamitri River and in reservoirs in Vadodara City, Gujarat, India.

Section	Length (km)	Mugger size (daytime basking count)			Mugger count at night	
		< 1 m	1–2 m	> 2 m	Total	Total
1 NH-8 to Sama Bridge	4	0	00	1	1	05
2 Sama Bridge to VUDA Bridge	4	1	02	4	7	12
3 VUDA to Kalaghoda	4	5	18	17	40	53
4 Kalaghoda to Munjmauda	4	8	21	37	66	98
5 Munjmauda to Vadsar	4	2	05	09	16	24
6 Vadsar to Talsat Village	5	1	04	10	15	36
<b>Total</b>	<b>25</b>	<b>17</b>	<b>50</b>	<b>78</b>	<b>145</b>	<b>228</b>

Reservoir	Area (km <sup>2</sup> )	< 1 m	1–2 m	> 2 m	Total	Total
1 Vemali	0.5	1	0	0	1	1
2 Sama	1.5	0	1	0	1	1
3 Harni-1	2.1	0	1	1	2	2
4 Denha	1.0	0	0	1	1	1
5 Bhimnath	0.6	1	1	0	2	2
6 Lalbaug	0.7	0	4	2	6	6
7 Kalali-1	1.5	1	1	2	4	4
8 Vadsar	0.4	0	1	1	2	2
9 Talsat	0.7	1	1	1	3	3
<b>Grand Total</b>		<b>21</b>	<b>60</b>	<b>88</b>	<b>167</b>	<b>250</b>

at night due to reflection from the tapetum lucidum in their eyes (Fig. 5). Most crocodilian biologists prefer “eye-shine”

or “spotlight” methods for finding and counting crocodilians (e.g., Magnusson 1982; Woodward and Moore 1993).

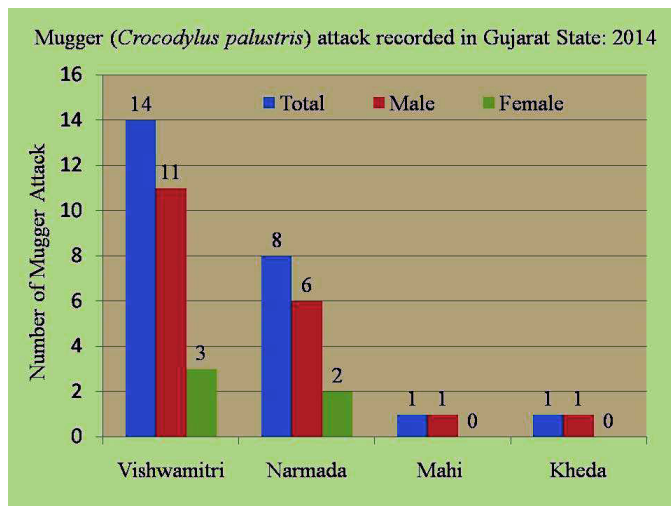


**Fig. 5.** Reflections from the tapetum lucidum of Mugger (*Crocodylus palustris*) eyes render them quite visible at night. Photograph by Manoj Thaker.

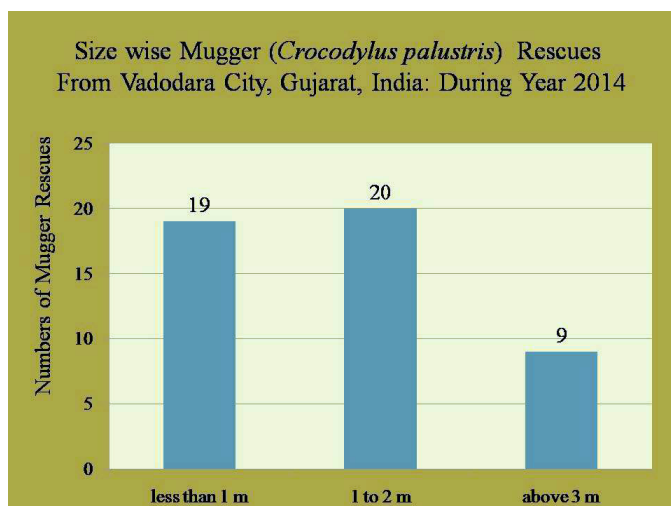


**Table 2.** Mugger (*Crocodylus palustris*) attacks during 2014 in Vadodara City, Gujarat, India. All victims were males.

Date	Outcome	Age	Location	Activity	Remarks
6 April	Nonfatal	40+	Dena	Fishing	Right leg/belly
20 April	Fatal	15	Maretha	River crossing	Body recovered
25 April	Fatal	55	Parshuram Bhaththa	Watching	Body recovered
29 April	Fatal	20	Canal Crossing	Fishing	Body recovered
16 July	Nonfatal	17	Dena	Swimming	Both feet
22 August	Nonfatal	22	Tarsali	Water collection	Left hand
28 October	Fatal	30	Bhimnath	River crossing	Body recovered



**Fig. 6.** Mugger (*Crocodylus palustris*) attacks in Gujarat during 2014.



**Fig. 7.** Sizes of Muggers (*Crocodylus palustris*) rescued in Vadodara City, Gujarat, India.

Nonetheless, results of the surveys confirm a high number of Muggers of various sizes flourishing in and around areas dominated by human habitation. The correlation between the concentration of crocs and densely urbanized environs is a unique and noteworthy example of human-Mugger coex-

istence. The presence of large Muggers in close proximity to human settlements poses a threat to both species. In 2014, 24 Mugger attacks were recorded in Gujarat State, 12 of which were fatal (Fig. 6). Of those, seven (four fatal) were recorded within the city limits of Vadodara (Table 2). Also, forest records from 2014 (Fig. 7) show rescue operations aided by local wildlife enthusiasts (Fig. 8) for 48 Muggers of various sizes from the city. Altogether, these data reflect a unique and evolving situation affecting not just the city and its human inhabitants, but also the future of crocodile conservation.

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**Fig. 8.** The translocation operation at the “Mugger Rescue Center”: Local forestry staff are caging a four-meter long Mugger (*Crocodylus palustris*). Photograph by Kartik Upadhyay.

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