



# The Mysterious Deaths of Mugger Crocodiles (*Crocodylus palustris*) near Vadodara, Gujarat, India

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The current global situation could lead to population depletion or even the extinction of many freshwater-inhabiting species, including reptilian fauna (Stanford et al. 2020). The present status of the freshwater ecosystems in India is dire and much of the fauna has been gradually depleted (Sandilyan 2016; Chandra et al. 2017), largely due to the establishment of invasive species and water pollution. Recently, Vasava et al. (2021) emphasized the unexplained deaths of aquatic reptiles, especially the mass deaths of a species of freshwater turtles from Gujarat State, India.

The mysterious deaths have been documented in three species of Indian reptiles, including one crocodylian - the Gharial *Gavialis gangeticus* (Whitaker et al. 2008), two Chelonians – the Ganges Softshelled Turtle, *Nilssonina gangetica* (Vyas 2015), and the Flap-shelled Turtle, *Lissemys punctata* (Vasava et al. 2021). However, the same phenomenon has been occurring with the Mugger Crocodile (also known as the Marsh Crocodile) (*Crocodylus palustris*). These three aquatic reptiles are highly protected species under the Indian Wildlife Protection Act. I herein present new information on the mysterious deaths of Mugger Crocodiles reported during the last five years (from 2017 to 2021) from the Vishwamitri River System, Gujarat, India.

The Vishwamitri River basin area encompasses 3,422 km<sup>2</sup>. Geographically, this river system lies between two large perennial rivers, the Mahi and Narmada Rivers Systems. This river system contains three major tributaries: Vishwamitri, Dhadhar, and Jambuva. All three branches originate from the Pavagadh Hills and Jambughoda forests. The Vishwamitri River flows westward through Vadodara City and links with two other tributaries (the Dhadhar and Jambuva near Kothawada Village). Finally, it reaches the Gulf of Khambhat near Khanpur Village (Bhatt et al. 2018). The Vishwamitri River flows through the urban metro city Vadodara (an approximately 25 km stretch), so the sewage of the entire city and other industrial effluents are drained into the river, causing immense pollution. The water of the river turns reddish-black as it passes through the city. This river system contains several small to larger water bod-

ies, including two larger man-made reservoirs; Sayaji Sarovar near Ajwa village on Vishwamitri River and Dev Dam on the Dhadhar tributary (Fig. 1), both of these reservoirs are sources of drinking water and water for irrigation, and support small Mugger populations (Vyas 2012).

## Methods

All the information was collected from various sources, including personal observations, non-governmental organizations (NGOs), the offices of the Gujarat Forest Department, Animal Husbandry and Health Department (Vadodara), wildlife rescuers, and print and electronic media. Moreover, we took photographs and collected information on dead animals by visiting the sites to note specifics of the Muggers and the circumstances around the water bodies. These death records include size, sex, date, incident, location, month, season, and the animals injured or killed. Finally, the dead body was recovered from the site whenever possible. The dead animals were then transported to veterinary facilities for a post-mortem at

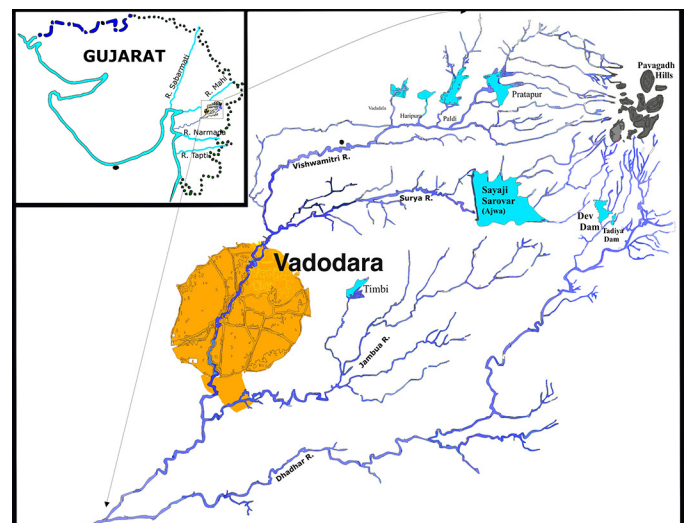


Fig. 1. Map of the Vishwamitri River System and locations of various reservoirs and Vadodara, Gujarat, India.

the local state Animal Health and Husbandry Department, Gujarat, to determine the cause of death. Tissues from various interior body parts/organs (viscera), were taken for histopathology, and gut contents were examined. We classified dead Muggers as juveniles and subadults (< 180 cm total length; TL) or adults (> 180 cm TL) based on published literature on Mugger growth and sizes (Whitaker and Whitaker 1984; Mobaraki et al. 2013). Total length was measured dor-

sally from the tip of the snout to the end of the tail. Sex was determined by examining the cloacal passage for the presence or absence of a penis (Whitaker et al. 1980).

**Results**

In the last five years, 20 different sizes of Muggers (45–374 cm in total length) were found dead in the river system (Table 1; Figs. 2–4). Most (n = 14) were found when their decaying



**Fig. 2.** A large male Mugger (*Crocodylus palustris*) found dead in the Jambuya River at Dhanayavi on the post-mortem table at the Veterinary Polyclinic, Vadodara (A); a 3.3-meter-long male Mugger found dead at the Kalaghoda Bridge, Vadodara, on the post-mortem table at the Veterinary Clinic, Vadodara (B); a large size Mugger found at the Zulto Pool of the Vishwamitri River in Vadodara (note that most decomposed carcasses could not be collected (C)); and a large male Mugger recovered from the Vishwamitri River at Kalaghoda, Vadodara (D). Photographs by R. Vyas (A and B) and Hemant Vadhavana (C and D).



**Fig. 3.** The sizeable dead Mugger retrieved from polluted waters of Vishwamitri River (B) the dead Mugger’s body is brought out for further inspection at Kalaghoda Bridge, Vadodara City, Gujarat, India. (Photo Credit: Pratik Lakadawala).

Table 1. Dead Mugger Crocodiles (*Crocodylus palustris*) found in the Vishwamitri River System, Gujarat, India. M = male, F = female, ND = not determined.

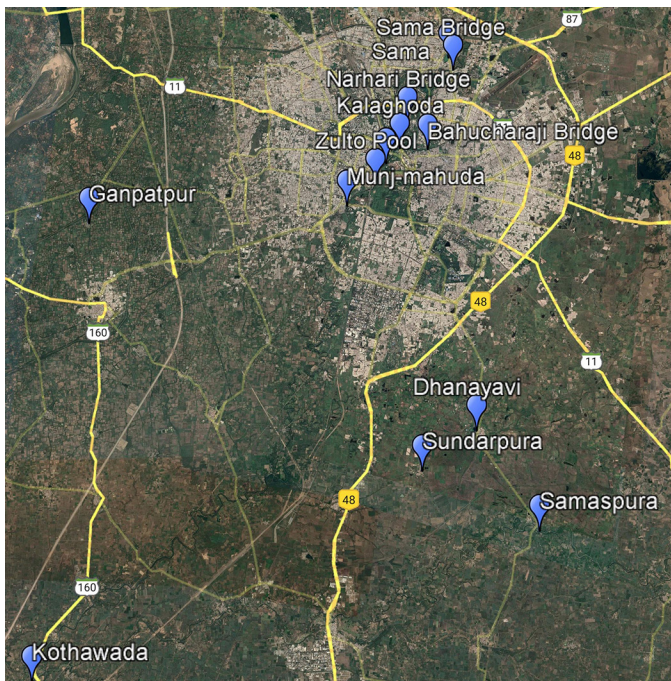
No	Date	Size in cm	Age Group	Sex	Location	Latitude	Longitude	Remarks
1	10 Jul 2017	300	Adult	M	Dhanayavi, Jambuva R.	22°13'9.91"N	73°13'53.58"E	Rope entangled around neck. Post Mortem Conducted (Fig. 2)
2	25 Jan 2018	330	Adult	M	Kalaghoda, Vishwamitri	22°18'28.10"N	73°11'17.29"E	An injury on the head Post Mortem Conducted (Fig. 3)
3	2 Dec 2018	374	Adult	M	Samaspura, Dev River	22°10'53.99"N	73°15'24.93"E	Post Mortem Conducted
4	8 Aug 2019	240	Adult	F	Sama Bridge Vishwamitri	22°19'37.87"N	73°11'50.85"E	Decomposed dead body
5	25 Dec 2019	360	Adult	ND	Zulto Pool, Vishwamitri	22°17'38.79"N	73°10'51.00"E	Dead body not recovered (Fig. 4)
6	2 Mar 2020	165	Subadult	F	Kalaghoda, Vishwamitri	22°18'28.10"N	73°11'17.29"E	Decomposed dead body
7	5 Aug 2020	120	Subadult	F	Dhaniyavi, Jambuva R.	22°12'46.05"N	73°13'45.36"E	Decomposed dead body
8	20 Aug 2020	150	Subadult	F	Village Tank, Sundarpura,	22°11'49.68"N	73°12'40.39"E	Decomposed dead body
9	7 Oct 2020	360	Adult	M	Kalaghoda, Vishwamitri	22°18'28.10"N	73°11'17.29"E	Decomposed dead body (Fig. 5)
10	27 Dec 2020	240	Adult	ND	Kalaghoda, Vishwamitri	22°18'28.10"N	73°11'17.29"E	Decomposed dead body
11	3 Jan 2021	244	Adult	F	Bahucharaji, Vishwamitri	22°18'30.92"N	73°11'56.26"E	Decomposed dead body
12	14 May 2021	250	Adult	M	Kalaghoda, Vishwamitri	22°18'28.10"N	73°11'17.29"E	Decomposed dead body
13	26 Jun 2021	360	Adult	M	Kalaghoda, Vishwamitri	22°18'28.10"N	73°11'17.29"E	Decomposed dead body
14	28 Jun 2021	330	Adult	M	Darsham Flate Vishwamitri	22°18'6.58"N	73°11'1.83"E	Decomposed dead body
15	28 Jun 2021	120	Subadult	F	Pond, Ganpatpur, Vadodara	22°16'4.47"N	73°4'31.74"E	Post Mortem Conducted
16	10 Aug 2021	300	Adult	M	Kalaghoda, Vishwamitri	22°18'27.06"N	73°11'15.83"E	Decomposed dead body (Fig. 6)
17	30 Aug 2021	290	Adult	M	Kothawada, Vishwamitri R	22°6'44.69"N	73°4'50.19"E	Decomposed dead body
18	19 Sep 2021	45	Subadult	ND	Munj-mahuda, Vshawamitri	22°17'5.42"N	73°10'16.05"E	Post Mortem Conducted
19	1 Oct 2021	60	Subadult	ND	Narhari Bridge, Vishwamitri	22°19'3.81"N	73°11'24.41"E	Post Mortem Conducted
20	26 Oct 2021	133	Subadult	F	Pond, Sama, Vadodara	22°20'31.00"N	73°12'9.46"E	Decomposed dead body

and foul-smelling bodies floated to the surface of the water (Fig. 2–3) and were no longer in any state for necropsy. Carcasses often would float in the current and pile up in shallow pools, some near river bridges (n = 12), although the animals might have died in more remote locations. Of the 12, five were in the river course and three subadults were in stagnant waters at village ponds (Fig. 3). The greatest number (n = 10) of dead Muggers were found in 2021, and the least number (n = 1) in 2017 (Fig. 5).

The recovered carcasses consisted of seven subadult and adult females and nine adult males, plus four individuals for which the gender could not be determined. However, six dead animals were sufficiently intact for proper post-mortems to be conducted with the help of local veterinarians. Unfortunately, they could not determine any cause of death. The remaining 14 dead bodies were handled according to routine procedures as per the wildlife protection act.

### Discussion

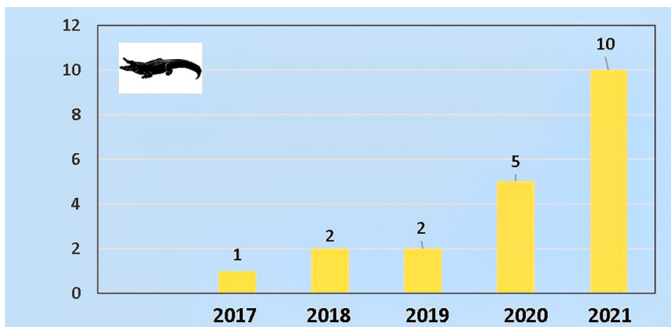
The present study indicates that for some unknown reason or reasons, 20 Mugger deaths occurred within five years, an average of four deaths per year. Although the causes of death could not be determined, they could have resulted from the substantial use of toxic chemicals such as insecticides, other pesticides, and herbicides in urban areas. A nominal death rate, which is more significant than crocodile-vehicle collisions (Vyas and Vasava 2019), is lower than other wildlife deaths in the state (Kaushik 2020; Kukreti 2020; Vasava et al. 2021). Recently, a



**Fig. 4.** Sites of various unexplained Muger Crocodile (*Crocodylus palustris*) deaths in the Vishwamitri River System in Gujarat, India.

report of eight mysterious mugger deaths (160–300 cm total length) from eight locations in Bharuch (1 site), Kheda (4 sites), and Vadodara (3 sites) in central Gujarat, including the Vishwamitri River (Vyas et al. 2020), indicated that a forensic investigation facility is needed to identify the causes of these mysterious deaths of prestigious wildlife.

Similar observations have been recorded in other states. Recently, the media reported fifty Muggers found dead at Kala Talab, Kota, Rajasthan (Jha 2022). The Kala Talab (25°12'33.10"N; 75°53'36.32"E) is an urban water body encompassing a 2.2 km<sup>2</sup> area linked via a canal to the Chambal River that supports a diverse aquatic fauna, including a natural population of Muggers. The preliminary investigation indicated that these deaths resulted from an influx of fly ash and soils associated with land reclamation under the upcoming housing and wetland beautification development project of the Urban Improvement Trust, Kota, Rajasthan.



**Fig. 5.** Annual records of dead Muger Crocodiles (*Crocodylus palustris*) found in the Vishwamitri River System in Gujarat, India.

However, the actual causes of large numbers of unnatural crocodile deaths remain a mystery, and judicial inquiries are pending with local administrators and the National Green Tribunals (NGT) in Delhi, India (Jha 2022).

During 2007–2008, over 113 critically endangered Indian Gharials (*Gavialis gangeticus*) (1.6–3.5 m total length) were found dead along a 25-km stretch of the Chambal and Yamuna River confluence area of the National Chambal Sanctuary (Whitaker et al. 2008). It was the worst misfortune in the history of conserving aquatic reptiles (Webb 2008).

In addition, published reports have documented large numbers of sudden mysterious deaths of Ganges Soft-shell Turtles (*Nilssonina gangetica*) and Flap-shell Turtles (*Lissemys punctata*) in Gujarat (Vyas 2015; Vasava et al. 2021), and a press report documented the deaths of 57 Flap-shelled Turtles in a small body of water in Kalyan, Maharashtra (Anonymous 2022).

These reports collectively raise questions whether any of these cases were investigated appropriately and whether any actions should have been taken. Possible causes include: (1) Some unknown disease or contaminated food; (2) illegal release of some toxic effluent; or (3) animals killed illegally for the collection of body parts considered to be aphrodisiacs or magical potions (see Vyas 2010, 2017); all of which are indicative of harmful anthropogenic activities in ecosystems and reinforce the previously stated need for a state or national veterinary freshwater and forensic investigative laboratory to identify the mysterious deaths of these aquatic species.

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### Literature Cited

Anonymous. 2022. Deliberate poisoning likely cause behind death of 57 turtles at lake near Mumbai. <<https://www.news18.com/news/india/mumbai-lake-death-turtles-deliberate-poisoning-cause-4689578.html>>.

Bhatt, B, S. Sharma, J.P Joshi, S. Patel, and T. Lohar. 2018. The hydrological response of Vishwamitri River watershed: A spatio-temporal analysis of the impact of land use change on planform. *International Journal of Geology, Earth & Environmental Sciences* 8(2): 44–53.

Chandra, K.C., K.C. Gopi, D.V. Rao, K. Valarmathi, and J.R.B. Alfred (eds.). 2017. *Current Status of Freshwater Faunal Diversity in India*. Director, Zoological Survey of India, Kolkata, India.

Jha, S. 2022. 50 Muggers crocodiles die in a month. Down To Earth, 11 March 2022. [https://www.downtoearth.org.in/news/wildlife-biodiversity/50-mugger-crocodiles-die-in-kota-in-a-month-81914?fbclid=IwAR0NK7JMIInLYC ySgR\\_Bdh2EsQ4Kd2uKsx1ORjDSvq XtNdnHi-yqSjgMba](https://www.downtoearth.org.in/news/wildlife-biodiversity/50-mugger-crocodiles-die-in-kota-in-a-month-81914?fbclid=IwAR0NK7JMIInLYC ySgR_Bdh2EsQ4Kd2uKsx1ORjDSvq XtNdnHi-yqSjgMba).

Kaushik, H. 2020. 261 lions, 340 leopards die in 2 years in Gujarat. TNN, March, 5,

2020. <[http://timesofindia.indiatimes.com/articleshow/74497745.cms?utm\\_source=contentofinterest&utm\\_medium=text&utm\\_campaign=cppst](http://timesofindia.indiatimes.com/articleshow/74497745.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst)>.
- Kukreti, I. 2020. 92 lions already dead in Gir this year, report flags. DTE, 12 June 2020. <<https://www.downtoearth.org.in/news/wildlife-biodiversity/92-lions-already-dead-in-gir-this-year-report-flags-71721>>.
- Sandilyan, S. 2016. Occurrence of ornamental fishes: a looming danger for Inland fish diversity of India. *Current Science* 110: 2099–2104. <https://doi.org/10.18520/cs/v110/i11/2099-2104>.
- Mobaraki, A., E. Abtin, H. Kami, and B.H. Kiabi. 2013. Reproductive biology of the Mugger Crocodile, *Crocodylus palustris*, in Iran (Reptilia: Crocodylidae). *Zoology in the Middle East* 59: 207–213. <https://doi.org/10.1080/09397140.2013.841423>.
- Stanford, C.B., J.B. Iverson, A.G.J. Rhodin, P.P. van Dijk, R.A. Mittermeier, G. Kuchling, K.H. Berry, A. Bertolero, K.A. Bjorndal, T.E.G. Blanck, K.A. Buhmann, R.L. Burke, J.D. Congdon, T. Diagne, T. Edwards, C.C. Eiseberg, J.R. Ennen, G. Forero-Medina, M. Frankel, U. Fritz, N. Gallego-García, A. Georges, J.W. Gibbons, S. Gong, E.V. Goode, H.T. Shi, H. Hoang, M.D. Hofmeyr, B.D. Horne, R. Hudson, J.O. Juvik, R.A. Kiestler, P. Koval, M. Le, P.V. Lindeman, J.E. Lovich, L. Luiselli, T.E.M. McCormack, G.A. Meyer, V.P. Páez, K. Platt, S.G. Platt, P.C.H. Pritchard, H.R. Quinn, W.M. Roosenburg, J.A. Seminoff, H.B. Shaffer, R. Spencer, J.U. Van Dyke, R.C. Vogt, and A.D. Walde. 2020. Turtles and tortoises are in trouble. *Current Biology* 30: R721–R735. <https://doi.org/10.1016/j.cub.2020.04.088>.
- Vasava, A., R. Vyas, V. Mistry, and P. Sindha. 2021. Mysterious deaths of aquatic reptiles, with special emphasis on the Indian Flap-shelled turtle *Lissemys punctata* (Bonnaterre, 1789) from Gujarat State, India. *Journal of Animal Diversity* 3: 20–27. <http://doi.org/10.52547/JAD.2021.3.4.3>
- Vyas R. 2010. An Incidence of fresh water turtle poaching at Vadodara City, Gujarat State, India. *Sauria* 32(3): 52–56.
- Vyas, R. 2012. Current status of Marsh Crocodiles *Crocodylus palustris* (Reptilia: Crocodylidae) in Vishwamitri River, Vadodara City, Gujarat, India. *Journal of Threatened Taxa* 4: 3333–3341. <https://doi.org/10.11609/JOTT.o2977.3333-41>.
- Vyas, R. 2015. Status of Ganges Soft-shell Turtle *Nilssonina gangetica* amidst deplorable scenarios in urban wetlands of Central Gujarat State, India. *Reptile Rap* 17: 3–12.
- Vyas, R. 2017. Emergence of a new potential threat to the mugger (*Crocodylus palustris*) population of Gujarat state, India. *CSG Newsletter* 36(4): 16–17.
- Vyas, R. and A. Vasava. 2019. Mugger crocodile (*Crocodylus palustris*) mortality due to roads and railways in Gujarat, India. *Herpetological Conservation and Biology* 14: 615–626.
- Vyas, R., A. Vasava, and V. Mistry. 2020. Mugger crocodile (*Crocodylus palustris*) interactions with discarded rubbish in Central Gujarat, India. *CSG Newsletter* 39(2): 5–11.
- Webb, G. 2008. Editorial. *Crocodyle Specialist Group Newsletter* 27(1): 3.
- Whitaker, R., D. Basu, and F. Huchzermeyer. 2008. Update on gharial mass mortality in National Chambal Sanctuary. *Crocodyle Specialist Group Newsletter* 27(1): 4–8.
- Whitaker, R. and Z. Whitaker. 1984. Reproductive biology of Mugger. *Journal of the Bombay Natural History Society* 81: 119–127.
- Whitaker, R., Z. Whitaker, and A. Vaughan. 1980. Notes on sexing crocodilians. *Journal of Bombay Natural History Society* 77: 341–343.