REPTILES & AMPHIBIANS

Nesting and Parental Care by a Disabled Mugger Crocodile (*Crocodylus palustris*) and a Record of a Congenital Defect in a Hatchling from Junagadh, Gujarat, India

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The Mugger or Marsh Crocodile (*Crocodylus palustris*) has a wide distribution from Iran to the Indian Subcontinent, Bangladesh, and Sri Lanka (Bors et al. 2024). Legally protected in India, it is recognized as a Schedule I species under the Indian Wildlife Protection Act 1972, amendment 2023 (Government of India 2024), and is listed as Vulnerable (VU) on the IUCN Red List of Threatened Species (Choudhury and de Silva 2013). One of the most adaptable crocodilian species in southern Asia, Muggers are known to frequent areas altered by human activities (de Silva and Lenin 2010).

Crocodilian nesting ecology and breeding behaviors are subjects of scientific interest (Greer 1970; Murray et al. 2020). Multiple publications address aspects of nesting ecology (e.g., Brazaitis and Watanabe 2011; Grigg and Kirshner 2015), including information on the breeding ecology and biology of Muggers (Whitaker and Whitaker 1984) in captivity (Yadav 1969; Whitaker 1974; Reddy 1978; Lang et al. 1986, 1989; Desai et al. 2022) and in nature (Mobaraki et al. 2013; Vaghashiya et al. 2018, 2020). Other reports address crocodilian abnormalities and congenital anomalies (e.g., Webb and Messel 1977; Singh and Sagar 1992; Wu et al. 2000; Huchzermeyer 2003; Vyas 2018; Sierra Serrano et al. 2024). We herein present a report on congenital anomalies observed in freshly hatched Mugger Crocodiles.

Since 2016, Patel et al. (2019) have been studying the reptilian fauna of the Girnar Wildlife Sanctuary (GWS) in Gujarat, India, and regularly monitoring a small population of Mugger Crocodiles (Vaghashiya et al. 2018, 2020). The sanctuary comprises several permanent and ephemeral bodies of water of varying sizes that provide breeding habitat for the small Mugger population (Vyas et al. 2024). We herein present new information on the population in the Laldhori Wetland, Bhavnath, Junagadh, Gujarat, India (21.536767, 70.503650).

At 2345 h on 5 April 2023, we encountered a 2.5-m long Mugger as it emerged from a nearby forest rivulet and crossed a tar road in the direction of a dry channel at Laldhori, Bhavnath, Junagadh (Fig. 1). Obviously in search of a suitable nesting site it kept trying to dig a pit in the sandy patches on the banks of Laldhori Wetland, presumably a female intent on building a nest. We also noted that the animal lacked the right forelimb (Fig. 2). We subsequently encountered the same female returning to the same spot during late evenings on the three following nights, each time attempting

Figure 1. An adult Mugger Crocodile (*Crocodylus palustris*) crossing the road to enter the Laldhori Wetland in Bhavnath, Junagadh, Gujarat, India. Photograph by Pranav Vaghashiya.

Figure 2. A female Mugger Crocodile (*Crocodylus palustris*) without a right front limb searching for a suitable nesting site at the Laldhori Wetland, Bhavnath, Junagadh, Gujarat, India. Photograph by Pranav Vaghashiya.

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with some difficulty to dig a nest without a forelimb. We also noted other muggers leaving the wetlands and migrating to downstream areas during the day, but were able to confirm movements of this particular Mugger by tracing its footprints (verifiably the left forelimb) and tail marks between the wetlands and downstream pools.

On 12 June 2023, we encountered the same Mugger excavating fresh hatchlings from the nest (Fig. 3) located on a small rivulet almost a kilometer away from the Laldhori Wetlands (21.531103, 70.498422) (Fig. 4). This site is close to human habitation and also serves as a dumping ground for domestic garbage through which the female Mugger had to maneuver in order to uncover the hatchlings. She then transported them in her mouth to a nearby pool (Fig. 5), making eight trips to transport 14 hatchlings about 4 m from the nest pit to the closest pool of water, completing the entire task in 95 min. Most of the hatchlings were active and healthy, but one was missing a tail (Fig. 6). We were unable to determine clutch size or the percentage of eggs that successfully hatched. We also were unable to track the female's subsequent activity and whether the hatchlings dispersed from the nesting area by getting washed away from subsequent rains and flooding.

Parental care has been well documented in crocodilians (e.g., Cott 1971; Ferguson 1985; Grigg and Kirshner 2015), including Muggers (Whitaker and Whitaker 1984; Lang et al. 1986; Mobaraki et al. 2013). The present observation supports the earlier studies of Vaghashiya et al. (2018), as Muggers locate nests in response to vocalizations from hatchlings within the eggs, assist hatchlings in emerging from eggs, carry them to water, and guard them (Vaghashiya et al. 2020).

Inorganic matter like that found around the nest could help maintain the nest's temperature and retain moisture. Such environmental factors play a significant role in the growth of embryos and influence the sex of many oviparous reptilian species, including crocodiles (Ferguson and Joanen 1982; Lang et al. 1989).

Figure 4. Google Earth© map showing the path taken by a female Mugger Crocodile (*Crocodylus palustris*) without a right front limb between the Laldhori Wetland on the edge of Girnar Wildlife Sanctuary, Gujarat, India, and the nesting site in a garbage-dumping area about 1 km away.

The missing forelimb of the female also is noteworthy. Tetrapod vertebrates that lose an appendage find it hard to walk and even more challenging to excavate a nest, as noted in this instance. She might have selected a garbage-dumping area, available only near anthropogenic landscapes, as a relatively easier environment for nesting. This nesting site was an "intermediate" type, partly hole and partly mound (Stevenson 2019) correlated to habitat (Neill 1971; Campbell 1972), presumably selected by this female due to a physical disability.

Several factors (fights, predation, accidental injury, or congenital defects) can cause the loss of appendages in reptiles (Grossmann et al. 2024). Although we do not know the actual reason behind the loss of this female's limb, she obviously survived in nature without a right forelimb. Reports of road and railway incidents recorded in the study area (Vyas et al. 2023) suggest that this female might have been a victim of a vehicular encounter. Regardless, reports document handicapped Muggers surviving and functioning both in captivity (Vyas 2014) and in nature (Vyas 2019; this report).

The hatchling without a tail is almost certainly the result of a congenital abnormality known as anury or acaudia (i.e., the absence of a tail). Crocodilian embryos incubated under suboptimal conditions, particularly high temperatures, can hatch with severe deformities, including the lack of a tail

Figure 3. A female Mugger Crocodile (*Crocodylus palustris*) excavating a hatchling from a nest in a garbage-dumping site (left) and a hatchling near her right hindlimb (right). Photographs by Pranav Vaghashiya.

Figure 5. A female Mugger Crocodile (*Crocodylus palustris*) carrying a hatchling in her mouth. Photograph by Pranav Vaghashiya.

Figure 6. A hatchling Mugger Crocodile (*Crocodylus palustris*) without a tail (an example of congenital anury). Photograph by Pranav Vaghashiya.

(Huchzermeyer 2003). The intermediate-type nest might have resulted in the uppermost eggs being affected by high temperatures that resulted in a tailless hatchling. Healthy tailless Estuarine Crocodile (*C. porosus*) hatchlings have been produced in wild nests in India and Australia, suggesting a genetic basis for the deformity (Kar and Bustard 1982; Webb and Manolis 1989). Huchzermeyer (2003) reported tailless Nile Crocodile (*C. niloticus*) and Dwarf Crocodile (*Osteolaemus tetraspis*) hatchlings, and Vyas (2020) found an adult tailless Mugger in a wild population in the Vishwamitri River. Although the cause in this case is unknown, this appears to be the first record of hatchling anury in a Mugger.

Abnormalities and congenital anomalies have been recorded in captive (Singh and Sagar 1992) and wild populations (Vyas 2018) of Muggers, and a number of reports have documented similar defects in various species of crocodilians, including *Crocodylus niloticus*, *Gavialis gangeticus*, *Osteolaemus tetraspis*, *Alligator mississippiensis*, *C. porosus*, *C. johnsoni*, *C. moreletii*, and *C. acutus* (Webb and Messel 1977; Singh and Bustard 1982; Wu et al. 2000; Huchzermeyer 2003; Sierra Serrano et al. 2024), most in captive stocks. However, not all malformations are congenital, some can result from the exposure of embryos to environmental stressors (Seifer 2008).

Congenital anomalies have been reported in many groups of reptiles, including crocodilians (Ferguson 1985), turtles (Huchzermeyer 2003; Bell et al. 2006; Vyas 2012), and snakes (Huchzermeyer 2003; Sant'Anna et al. 2013). Congenital defects in reptiles have received little interest and largely have been considered mere curiosities rather than topics of ecological importance. However, in the context of an increasing number and intensity of threats to biodiversity, data on birth defects in wildlife could be important for evaluating the health of populations and pollution of ecosystems.

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Literature Cited

Bell, B., J.R. Spotila, and J. Congdon. 2006. High Incidence of deformity in aquatic turtles in the John Heinz National Wildlife Refuge. *Environmental Pollution* 142: 457–465. http://dx.doi.org/10.1016/j.envpol.2005.10.020.

Bors, M.S., P. Gowri Shankar, and J. Gruszczyńska. 2024. Current state of mugger populations. *Animals* 14: 691. https://doi.org/10.3390/ani14050691.

Brazaitis, P. and M.E. Watanabe. 2011. Crocodilian behaviour: a window to dinosaur behaviour? *Historical Biology* 23: 73–90. http://doi.org/10.1080/08912963.2011.560723.

Campbell, H.W. 1972. Ecological or phylogenetic interpretations of crocodilian nesting habits. *Nature* 238: 404–405. https://doi.org/10.1038/238404a0.

Choudhury, B.C. and A. de Silva. 2013. *Crocodylus palustris*. *The IUCN Red List of Threatened Species* 2013: e.T5667A3046723. https://dx.doi.org/10.2305/IUCN.UK.2013-2.RLTS.T5667A3046723.en.

Cott, H.B. 1971. Parental care in Crocodilia, with special reference to *Crocodylus niloticus*, pp.166–180 In: *Crocodiles. Proceedings of the 1st Working Meeting of the IUCN-SSC Crocodile Specialist Group*. IUCN, Gland, Switzerland.

Desai, B., S. Mukherjee, N. Whitaker, and R. Ghosal. 2022. Anecdotal observations of 'double clutching' behaviour in captive mugger crocodiles (*Crocodylus palustris*). *Behaviour* 159: 887–897. https://doi.org/10.1163/1568539X-bja10153.

de Silva, A. and J. Lenin. 2010. Mugger Crocodile. *Crocodylus palustris*, pp. 94–98. In: S.C. Manolis and C. Stevenson (eds.), *Crocodiles. Status Survey and Conservation Action Plan*. Third edition. Crocodile Specialist Group, Darwin, Northern Territory, Australia.

Ferguson, M.W.J. 1985. Reproductive biology and embryology of the crocodilians. pp. 329–491. In: G. Gans, F. Billet, and P.F.A. Maderson (eds.), *Biology of the Reptilia. Volume 14, Development A*. John Wiley & Sons, New York, New York, USA.

Ferguson, M.W.J. and T. Joanen. 1982. Temperature of egg incubation determines sex in *Alligator mississippiensis*. *Nature* 296: 850–853. https://doi.org/10.1038/296850a0.

Government of India. 2024. India Code. The Wild Life Protection Act, 1972. <https://www.indiacode.nic.in/bitstream/123456789/1726/1/a1972-53.pdf>.

Greer, A.E. 1970. Evolutionary and systematic significance of crocodilian nesting habits. *Nature* 227: 523–524. https://doi.org/10.1038/227523a0.

Grigg, G. and D. Kirshner. 2015. *Biology and Evolution of Crocodylians*. Cornell University Press, Ithaca, New York, USA.

Grossmann, W., B.M. Zwanzing, and T. Kowalski. 2024. Dreibeinige aus dem Gouvernement Dhofar. *Sauria* 46: 8–14.

Huchzermeyer, F.W. 2003. *Crocodiles. Biology. Husbandry and Diseases*. CABI Publishing, Cambridge, Massachusetts, USA.

Kar, S.K. and H.R. Bustard. 1982. Embryonic tail deformation in the saltwater crocodile (*Crocodylus porosus*, Schneider) in Orissa, India. *British Journal of Herpetology* 6: 221–222.

Lang, J.W., R. Whitaker, and H. Andrews. 1986. Male parental care in mugger crocodiles. *National Geographic Research* 2: 519–525.

Lang, J.W., H. Andrews, and R. Whitaker. 1989. Sex determination and sex ratios in *Crocodylus palustris*. *American Zoologist* 29: 935–952. https://doi.org/10.1093/icb/29.3.935.

Mobaraki, A., E. Abtin, H.G. 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.

Murray, C.M., B.I. Crother, and J.S. Doody. 2020. The evolution of crocodilian nesting ecology and behavior. *Ecology and Evolution* 10: 131–149. https://doi.org/10.1002/ece3.5859.

Neill, W.T. 1971. *The Last of the Ruling Reptiles*. Columbia University Press, New York, New York, USA.

Patel, H., R. Vyas, B. Dudhatra, V. Naik, A Chavda, D. Chauhan, A Vaghashiya, R. Vagadiya, and P. Vaghashiya. 2019. Preliminary report on Herpetofauna of Mt. Girnar, Gujarat, India. *Journal of Animal Diversity* 1: 9–35. https://doi.org/10.29252/JAD.2019.1.2.2.

Reddy, P.S. 1978. Crocodile breeding in Indira Gandhi Zoological Park. *Wildlife Club Newsletter* (*Dehra Dun*) 6: 68–69.

Sant'Anna, S.S., K.F. Grego, C.A.B. Lorigados, A.C.B.C. Fonseca-Pinto, W. Fernandes, L.C. Sá-Rocha, and J.L. Catão-Dias. 2013. Malformations in Neotropical viperids: Qualitative and quantitative analysis. *Journal of Comparative Pathology* 149: 503–508. https://doi.org/10.1016/j.jcpa.2013.06.001.

Seifer, R. 2008. Teratology, pp. 333–343. In: M.M. Haith and J.B. Benson (eds.), *Encyclopedia of Infant and Early Childhood Development*. Academic Press, San Diego, California, USA. https://doi.org/10.1016/B978-012370877-9.00162-6.

Sierra Serrano, O., A. Garcês, I. Pires, J.A. Calderón Mateus, J. Medina Olivera, and J.J. Dávila. 2024. Congenital anomalies in American Crocodile (*Crocodylus acutus*, Cuvier, 1807) embryos from a farm breeder in Colombia. *Veterinary Science* 11: 317. https://doi.org/10.3390/vetsci11070317.

Singh, L.A.K. and H.R. Bustard. 1982. Congenital defects in the gharial *Gavialis gangeticus* (Gmelin). *British Journal of Herpetology* 6: 215–219.

Singh, L.A.K. and S.R. Sagar. 1992. Prolonged egg incubation and congenital tail deformities in *Crocodylus palustris* (Reptilia: Crocodilia). *Journal of the Bombay Natural History Society* 89: 194–198.

Stevenson, C. 2019. *Crocodiles of the World*. New Holland Publishers, London, UK.

Vaghashiya, P.M., B. Dudhatra, and R. Vyas. 2018. Parental behaviour of mugger (*Crocodylus palustris*) at Lal Dhori, Junagadh, Gujarat, India. *CSG Newsletter* 37: 16–18.

Vaghashiya, P., D. Chauhan, and R. Vyas. 2020. Monitoring a breeding mugger (*Crocodylus palustris*) population at Girnar, Junagadh, Gujarat, India. *Reptiles & Amphibians* 26: 211–215. https://doi.org/10.17161/randa.v26i3.14407.

Vyas, R. 2012. Carapacial scute anomalies of star tortoise in Western India. *Taprobanica* 4: 105–107.

Vyas, R. 2014. Note on a seriously injured male mugger crocodile (*Crocodylus palustris*) surviving in captivity. *CSG Newsletter* 33: 8–10.

Vyas, R. 2018. Case of polydactyly limb in juvenile Mugger Crocodile (*Crocodylus palustris*). *Russian Journal of Herpetology* 25:139–142. 10.30906/1026-2296-2019-25-2-139-142.

Vyas, R. 2019. Chronicle of an injured mugger crocodile (*Crocodylus palustris*) surviving in the Vishwamitri River, India. *Herpetological Bulletin* 149: 44–45. https://doi.org/10.33256/hb149.4445.

Vyas, R. 2020. Tale of a tailless mugger (*Crocodylus palustris*) from the Vishwamitri River, Vadodara, Gujarat, India. *CSG Newsletter* 39: 18–19.

Vyas, R., V. Mistry, P. Vaghasiya, and D. Chauhan. 2023. Review of mugger *Crocodylus palustris* Lesson, 1831 mortality by vehicle collisions in Gujarat state, India. *Journal of Animal Diversity* 5: 80–91. http://doi.org/10.52547/JAD.2023.5.1.5.

Vyas, R., D. Chauhan, P. Vaghashiya, and H. Patel. 2024. Noteworthy observations on food and feeding behaviors of mugger crocodiles (*Crocodylus palustris* Lesson) at Lal Dhori, Girnar Wildlife Sanctuary, Gujarat, India. *Journal of Animal Diversity* 6: 1–11. http://doi.org/10.22034/JAD.2024.6.1.1.

Webb, G. and C. Manolis. 1989. *Crocodiles of Australia*. Reed Books, Frenchs Forest, New South Wales, Australia.

Webb, G. and H. Messel. 1977. Abnormalities and injuries in the estuarine crocodile *Crocodylus porosus*. *Australian Wildlife Research* 4: 312–319.

Whitaker, R. 1974. Notes on behaviour, ecology and present status of the marsh crocodile (*Crocodylus palustris*) in south India. The Madras Snake Park Trust, Madras, India.

Whitaker, R. and Z. Whitaker. 1984. Reproductive biology of the mugger (*Crocodylus palustris*). *Journal of the Bombay Natural History Society* 81: 297–317.

Wu, T.H., T.R. Rainwater, S.G. Platt, S.T. McMurry, and T.A. Anderson. 2000. Organochlorine contaminants in Morelet's Crocodile (*Crocodylus moreletii*) eggs from Belize. *Chemosphere* 40: 671–678. https://doi.org/10.1016/S0045-6535(99)00456-7.

Yadav, R.N. 1969. Breeding the mugger crocodile *Crocodylus palustris* at Jaipur Zoo. *International Zoo Yearbook* 9: 33. https://doi.org/10.1111/j.1748-1090.1969.tb02596.x.