



Basking Behavior of Marsh Crocodiles (*Crocodylus palustris*) in Pond Deva, Anand District, Gujarat, India

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Body temperatures of ectothermic reptiles in general and crocodylians in particular can be lowered by the loss of heat through radiation, convection, or evaporation of body fluids, can be either raised or lowered by conduction of heat to or from the substratum (thigmothermy) or air, or can be raised by the absorption of radiant heat (heliothermy) from the sun (Bogert 1949; Huey 1982; Pough 1983). Crocodylians have a “preferred” body temperature of around 30–33 °C, which they achieve by shuttling back and forth between warm and cool parts of their environment (Lang 1987; Grigg and Kirshner 2015; IUCN Crocodile Specialist Group 2019). Such behavior can be affected by climatic conditions, social interactions, circadian rhythms, and reproductive state (Lang 1987; Venugopal and Prasad 2003). Crocodylians gape by opening their mouth for long periods to help circulate air and permit cooling while basking (Spotila et al. 1977), although mouth gaping probably has other functions as well because it also occurs during rain and at night (Loveridge 1984).

Gujarat is home to one of the largest populations of Mugger Crocodiles (*Crocodylus palustris*) in India, with particularly large populations around Saurashtra and Kutch in central Gujarat and a smaller population in southern Gujarat (Vijaykumar 1999; Vyas 2010; Vasava et al. 2015). Most of the Mugger populations and habitat in Gujarat are considered secure and safe, although human-crocodile conflicts appear to be increasing along the Vishwamitri and Narmada Rivers, likely the result of human encroachment into Mugger habitat (Vyas 2010). The Vishwamitri River provides habitat for breeding and basking Muggers; along one 25-km stretch of river, Vyas (2012) counted 155 Muggers. Earlier studies showed only a small number of Muggers inhabiting the wetlands of Anand and Kheda Districts (Vijaykumar et al. 1999), but more recent surveys have revealed substantial Mugger populations in these districts (collectively known as Charotar), where crocodiles share various ecosystem services (water, fish, and space) with humans (Upadhyay et al. 2013;

Vyas 2013). Herein we provide information on the effects of water and ambient temperatures and anthropogenic activities on the basking behavior of crocodiles in the winter and post-winter seasons in Anand District, Gujarat.

We conducted this study from December 2018 to March 2019 at Pond Deva in central Gujarat, India (22°37'12.86"N, 72°44'6.14"E; Fig. 1). The climate is tropical semi-arid monsoon; monsoons last from June to September, peaking in July and August; and temperatures start rising from mid-April and peak in May (Vasava et al. 2015).

Using binoculars, we searched for basking crocodiles during five daily sessions (0800–1000 h, 1000–1300 h, 1300–1400 h, 1400–1600 h, 1600–1800 h) and recorded air and water temperatures and anthropogenic activities (washing clothes near the shore, cattle grazing, throwing stones at crocodiles, and fishing) during each session. We encountered 40 crocodiles that we assigned to either large (≥1.5 m) or small (<1.5 m) size classes, observed each for five minutes, and recorded the basking behavior and type of basking site.

Basking behavior was classified as: (1) Entire body on land (Fig. 2A); (2) entire body on land and gaping (Fig. 2B); (3) partially on land (Fig. 2C); (4) partially on land and gaping (Fig. 2D); (5) floating and not moving; (6) floating, not moving, and gaping; (7) floating and moving (Fig. 2E). Types

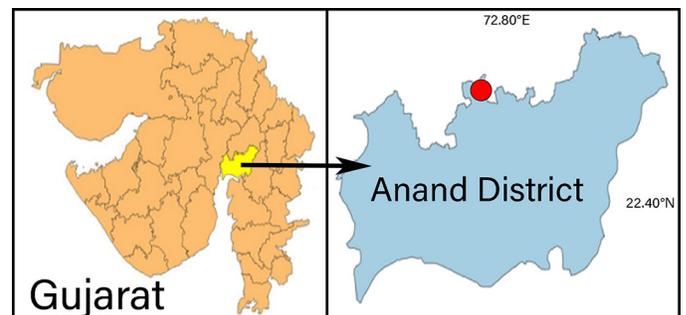


Fig. 1. Map showing the location of study area at Deva, Anand District, Gujarat, India (red dot).

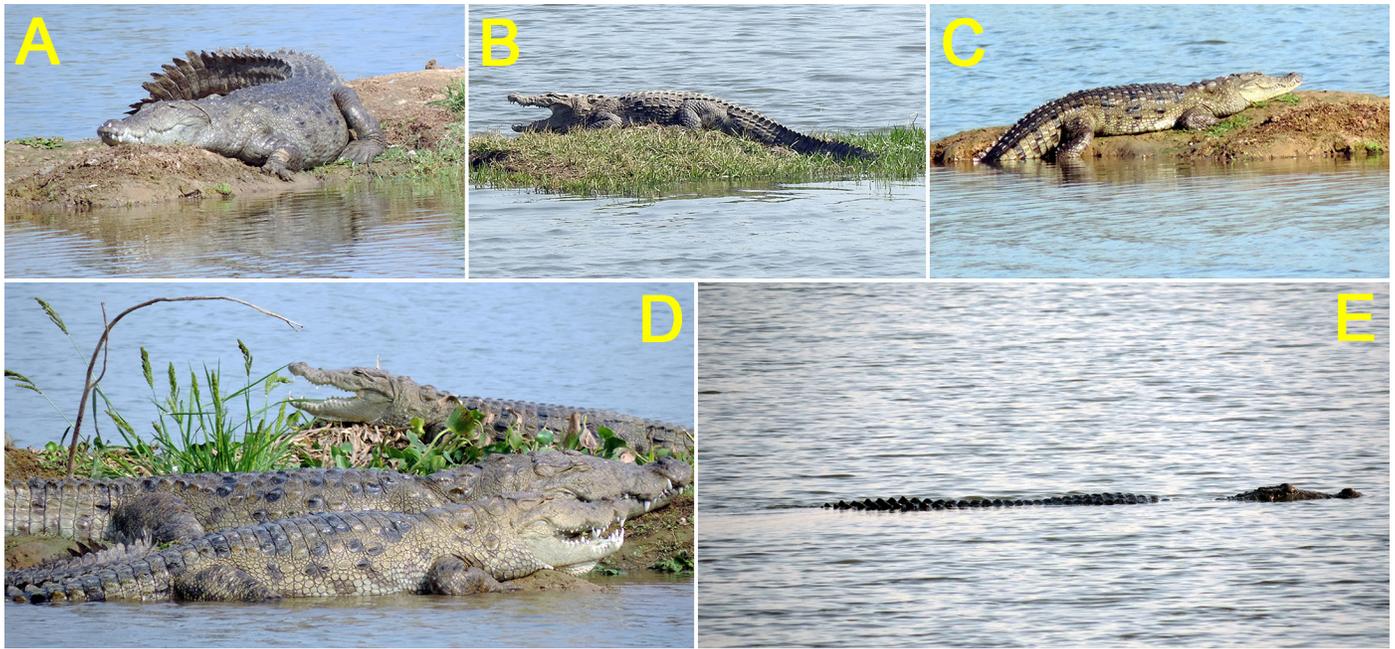


Fig. 2. Basking Muger Crocodiles (*Crocodylus palustris*) at Pond Deva, Anand District, Gujarat, India: entire body on land (A), entire body on land and gaping (B), partially on land (C), partially on land and gaping (D), and floating (E). Photographs by Urvi Dave.

of basking sites were classified as: (1) in vegetation, (2) on the shore, (3) on islands, and (4) in water.

In December and January, crocodiles started basking at 0800–0900 h when temperatures were 14–20 °C and peak winter basking was at 1300–1400 h, when temperatures were 24–35 °C (Fig. 3). However, crocodile sightings decreased slowly as weeks went by and temperatures began to rise. From 1000–1400 h when both air and water temperature were 19–24 °C, large crocodiles most frequently basked completely on land followed by partially on land, whereas small crocodiles basked most frequently while partially on land, followed by floating (Fig. 4). As temperatures increased to 30–35 °C in the afternoon, proportionately more crocodiles basked partially in water. Overall, numbers of basking croco-

diles declined later in the day. Both small and large crocodiles basked primarily on islands, although small individuals were in water more frequently than large crocodiles (Fig. 5). Although relatively few individuals basked in vegetation, that type of basking site was most frequently chosen at 1400–1600 h, when temperatures reach 30–35 °C.

During February and March, more crocodiles began basking at 0800 h when temperatures were about 20 °C and peak post-winter basking was at 1400 h when air and water temperatures were about 36 °C and 31 °C, respectively (Fig. 6). Sightings of basking crocodiles started declining in mid-February as temperatures continued to rise and decreased further in March, when temperatures sometimes exceeded 45 °C. Peak basking activity was seen at 1500 h when air

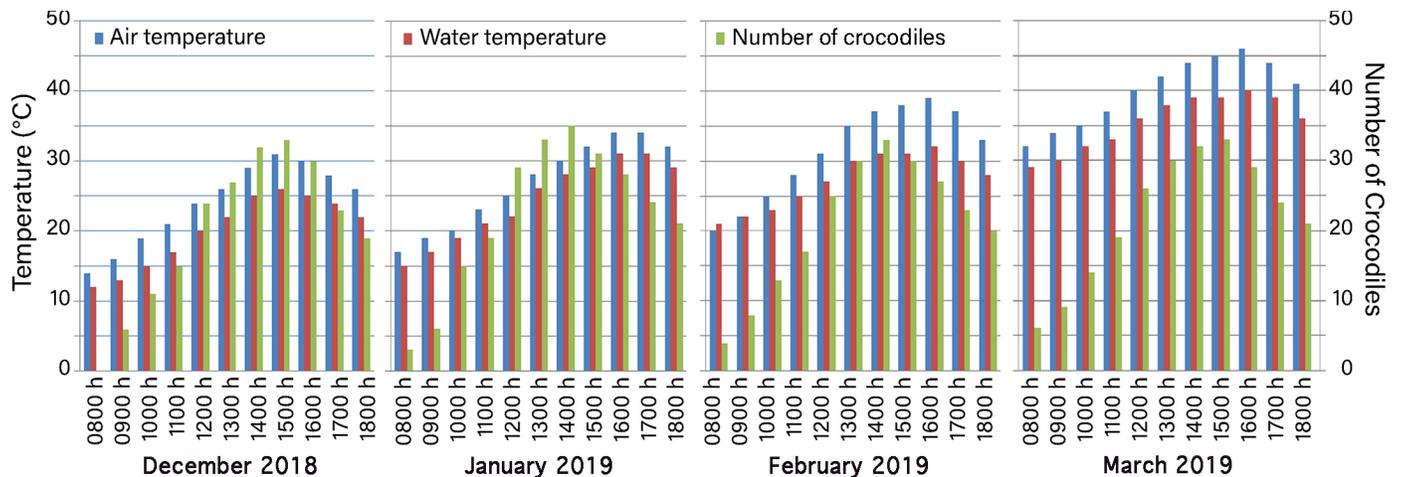


Fig. 3. Numbers of basking Muger Crocodiles (*Crocodylus palustris*) at Pond Deva, Anand District, Gujarat, India, relative to air and water temperatures on selected days during the study period.

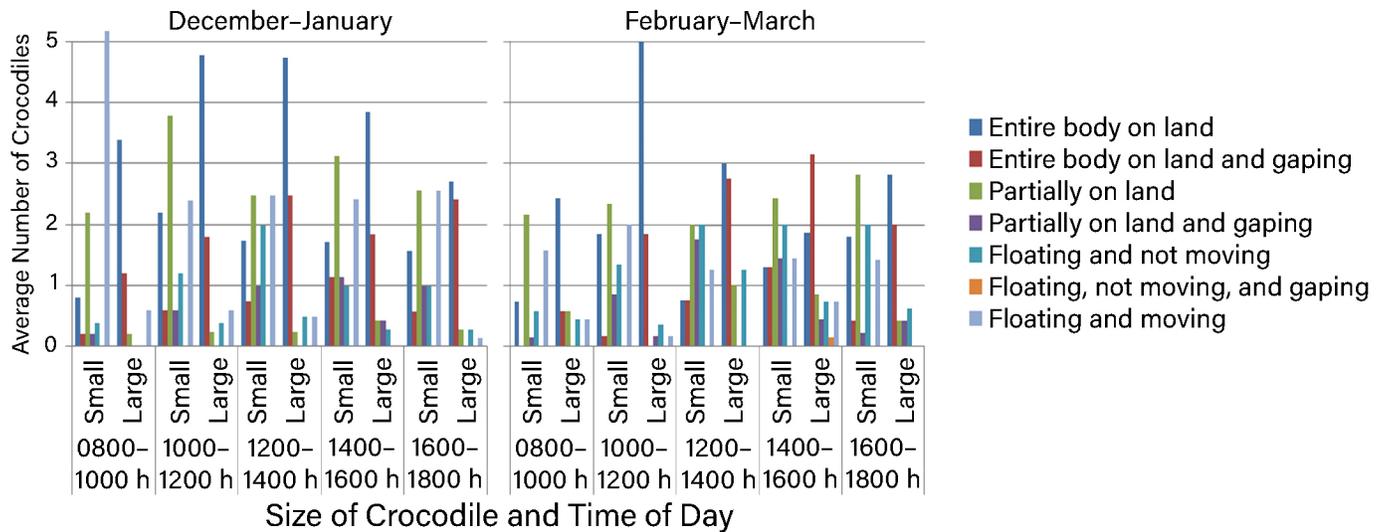


Fig. 4. Basking behavior of large and small Muggers (*Crocodylus palustris*) at Pond Deva, Anand District, Gujarat, India, in winter (December–January) and post-winter (February–March) seasons.

and water temperature were 45 °C and 39 °C, respectively. As temperatures increased, crocodiles started moving back into the water to cool down. Small crocodiles basked most frequently while partially submerged, followed by fully submerged in all five time periods (Fig. 4). Larger individuals usually were completely on land in the morning (0800–1300 h) when temperatures were around 25 °C but by afternoon (1400–1600 h), when temperatures peaked around 40 °C, most were basking while gaping, presumably to help circulate air and facilitate cooling. Islands were the most frequently used basking sites of both small and large Muggers, although small individuals basked in water more frequently than large crocodiles (Fig. 5). Sightings decreased from 1600–1800 h when the temperatures were falling below 40 °C.

In general, basking was most evident at lower temperatures. As temperatures increased, crocodiles were more likely to be in the water and more likely to gape. Islands, the largest of which could accommodate as many as 50 crocodiles, were the most frequently used basking sites, probably because they were far from human activities.

Small crocodiles were more frequently in water, especially if larger crocodiles were nearby. We repeatedly observed larger crocodiles chasing smaller individuals from the best basking sites. Some large crocodiles basked in the same locations day after day and actively discouraged interlopers.

Some anthropogenic activities, like washing clothes or cattle grazing along the shore (Fig. 6), appeared to have little effect on basking crocodiles. However, fishing and villagers throwing

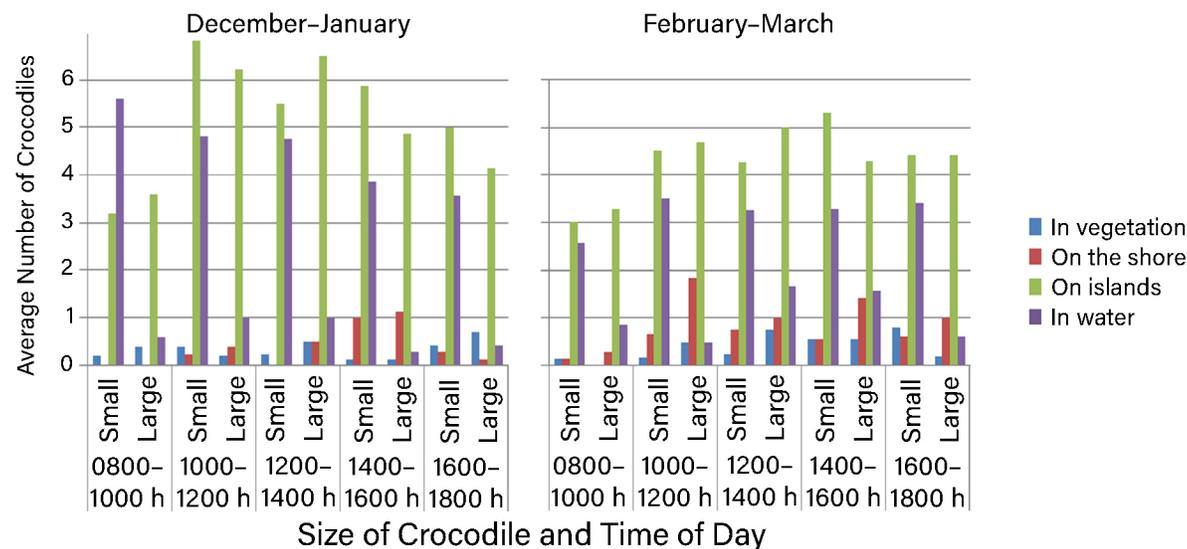


Fig. 5. Basking sites of large and small Muggers (*Crocodylus palustris*) at Pond Deva, Anand District, Gujarat, India, in winter (December–January) and post-winter (February–March) seasons.



Fig. 6. Anthropogenic activities at Deva Pond that had little or no effect on basking Mugger Crocodiles (*Crocodylus palustris*): Women washing clothes (left) and livestock (right) near the shore. Photographs by Urvi Dave.

stones at crocodiles did cause animals to move into water and out of the area. A fisherman reported that Muggers occasionally get caught in fishing nets and, if not released promptly, would drown. Smaller individuals, especially hatchlings and yearlings basking among water hyacinths in the canal, were particularly sensitive to human activities, reacting quickly to any approach. Studies conducted in Vadodara, Gujarat (Kaur 2015), documented a substantially greater negative impact on basking crocodiles, to the extent that crocodiles would not use available basking sites if humans were present on the same bank.

At this time, human-crocodile conflicts are relatively rare at Pond Deva (Lenin 2020). However, the future of Muggers in India is uncertain in light of the growing human population and the inevitable increase in human-crocodile encounters. However, the relative nonchalance of Pond Deva's crocodiles, possibly reflecting the villagers' tradition of generally leaving them alone (Lenin 2020), might serve as a model for the rest of the nation.

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