REPTILES & AMPHIBIANS

# Behavior in a Captive Family Group of Siamese Crocodiles (*Crocodylus siamensis*) at the Madras Crocodile Bank Trust near Chennai, India

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Parental care in crocodilians is well documented (Lang 1987; Reynolds et al. 2002). Social interactions between young crocodilians and their parents have been documented at hatching and for a few subsequent days (Kushlan and Mazzotti 1989; Webb and Manolis 1998). Campos et al. (2012) observed groups of young Dwarf Caimans (*Paleosuchus palpebrosus*) in Brazil with an adult in attendance. Charruau and Hénaut (2012) observed ten recently hatched American Crododile (*Crocodylus acutus*) nests and found several instances of adults with their hatchlings but also cases of hatchlings without a parent present.

However, aggressive behavior by the parent(s) toward juveniles has been postulated as a means of indicating that the period of protection is over (Hunt and Watanabe 1982). At that time, juveniles should be able to effectively feed themselves and avoid larger crocodiles. "Learning" to avoid human hunting has been documented in crocodiles; examples include increased wariness in Saltwater Crocodiles (*Crocodylus porosus*) (Bustard 1967; Webb and Messel 1979) and reduced vocalization in *C. acutus* (Alderton 1998). Such learning might well be applicable to avoiding larger crocodiles.

The stability of the Siamese Crocodile (*Crocodylus siamensis*) family at the Madras Crocodile Bank Trust (MCBT) and the ease of observing them provided an opportunity to record the behavior of adults and interactions between adults and their offspring. We were interested primarily in the survivorship of juveniles and the development of juveniles' wariness and predator avoidance behavior.

## Materials and Methods

The MCBT, which was established in 1976 45 km south of Chennai in southern India (12°50'N, 80°10'E; WGS 1984), is a reptile conservation and research facility open to the public. Encompassing more than 3.4 ha, the collection of both Indian and exotic reptiles includes 15 species of crocodilians.

The MCBT acquired a captive-bred group of five Siamese Crocodiles in 1983 from the New York Zoological Park (now known as the Bronx Zoo). They were scute-clipped on arrival for identification. One female (F3) died within a year of arrival. One male (M2) became the alpha male when he matured in 1991; he subsequently killed both the subordinate male (M1) and a female (F7) in 1993.

Except for 1997 and 2003, the surviving pair (M2 and F5) have bred annually since 1991. At the time of their first successful reproduction, the male was nine years and ten months old and the female seven years and seven months old. This corresponds with previous reports of sexual maturity at 10–12 years of age in this species (Youngprapakorn et al. 1971). In 2002, M2 was 2.97 m in total length, 1.63 m SVL, and weighed 116 kg; F5 was 2.41 m in total length, 1.36 m SVL, and weighed 60 kg.

Adults are housed in a breeding pen with a perimeter wall of 45 m, a pond area of 49 $m^2$, and a land area of 87 $m^2$. The base of the wall has numerous cracks and crevices. The substrate consists of sand, leaf litter, and rock formations; vegetation includes shade grass at the edge of the pond, an Indian Mast Tree (*Pongamia glabra*), and a large Rain Tree (*Samanea saman*), against which the female constructs her nest (Fig. 1). Crocodiles were fed an average of 15 kg (5–25 kg) of buffalo meat and assorted offal each month, and have been observed feeding on free-ranging Indian Crows (*Corvus splendens*) and Cattle Egrets (*Bubulcus ibis*).

Following an incubation period of 71 days, seven juveniles hatched on 10 July 1999. Observation of their behavior relative to that of their parents began one year later in June 2000 and continued through May 2001. Except for one day off per week, the second author watched the adults and juveniles from 0800 to 1730 h for a total of approximately 312 days and 2,960 daylight hours. Most crocodilian foraging activity is known to occur at night or during crepuscular





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**Fig. 1.** An adult female Siamese Crocodile (*Crocodylus siamensis*) on her mound nest adjacent to a large Rain Tree (*Samanea saman*) at the Madras Crocodile Bank Trust (MCBT) south of Chennai, India. Juveniles frequently sought refuge in the crevices in the perimeter wall visible behind the nest. Photograph by Nikhil Whitaker.

hours (e.g., Marioni et al. 2008), and nocturnal observations are particularly important when monitoring maternal care, as in camera-trap studies of American Alligators (*Alligator mississipiensis*) (Hunt and Ogden 1991), American Crocodiles (*Crocodylus acutus*) (Charruau and Hénaut 2012), and Freshwater Crocodiles (*C. johnsoni*) (Somaweera and Shine 2012). Camera traps are invaluable non-invasive tools for recording nocturnal behavior of crocodilians. Unfortunately, lacking access to camera trips, we were limited to diurnal observations. We did attempt to monitor our Siamese Crocodiles at night with a flashlight but those attempts elicited charges by M2 in particular.

Previous studies on parental interactions of crocodilians involved catching and measuring hatchling or juvenile American Alligators (Kushlan 1973) and Yacare Caimans (*Caiman yacare*) (Cintra 1989). This would have been an ideal approach, as growth rates could have been associated with parental interactions from the time observations began. Unfortunately, capture by hand was not an option due to the danger to keepers, and the use of nets or nooses could have influenced parent-hatchling interactions.

Based on previous studies of other species and observations of these Siamese Crocodiles by the author and staff at the MCBT, we examined the following hypotheses: $H_1$: Attempts by the male to initiate courtship should peak 2–3 months before oviposition by the female (e.g., Guerrero et al. 2003); $H_2$: Attempts by parents to catch young will increase in frequency when hatchlings reach a critical size (or display or cease to display a specific behavior such as vocalization) related to terminating parental care (e.g., Hunt 1977; Hunt and Watanabe 1982); $H_3$: Assertive displays by parents (territorial behaviors such as "head slapping"; Lang 1987) will increase in frequency as hatchlings reach critical size; $H_4$: Juveniles will become more successful at foraging in water and land (Whitaker 2007); and $H_5$: Vocalizations by juveniles will reach maximum frequencies as parents increasingly attempt to catch juveniles.

For statistical analysis we used Microsoft Excel™ with XLSTAT™ on a Windows platform. We used Kendall correlations when Shapiro Wilk tests showed data were not normal; in one instance, we used a t-test when variables being compared were both parametric. Significance was established at $\alpha = 0.05$; means are presented ± on standard deviation.

## Results

The mean monthly temperature maximum during the study period was 31.77 ± 1.63 °C (29.4–34.4 °C), the mean monthly minimum temperature was 24.91 ± 1.77 °C (22.3–28.2 °C), and mean monthly rainfall was 72.3 ± 58.0 mm (0–164 mm).

Assertive displays by parents in the form of "head slaps" by M2 occurred in all months, with the maximum number in May 2001 (Fig. 2). F5 displayed this behavior in July and November 2000, once on each occasion. Courtship attempts were initiated by M2 moving over the female on the surface of the water, lining up with her, and extending one of his hindlimbs over her body. A total of 53 attempts by M2 to initiate courtship occurred during March 2001, with a minimum of one attempt each in November and December 2000. Courtship did not occur from July to October 2000. The

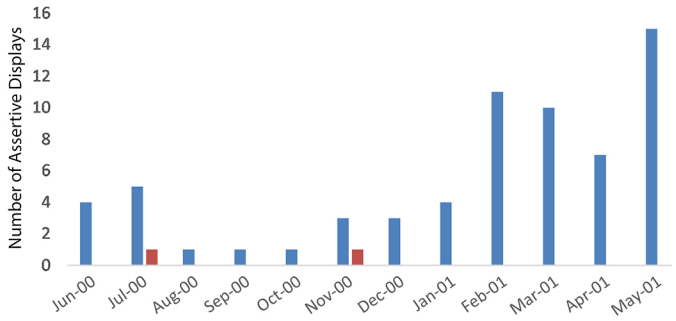


**Fig. 2.** The frequency of assertive displays (head- or jawslaps) by adult Siamese Crocodiles (*Crocodylus siamensis*) at the Madras Crocodile Bank Trust (MCBT) south of Chennai, India. Those of adult male M2 are in blue and those of adult female F5 are in red.

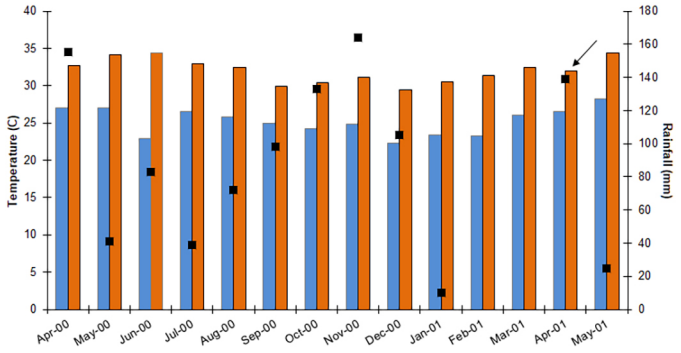


**Fig. 3.** Ambient mean monthly maximum (orange) and minimum temperatures (blue) and levels of precipitation (black squares) during the study period at the Madras Crocodile Bank Trust (MCBT) south of Chennai, India. The arrow indicates when oviposition occurred.

number of mating attempts was significantly correlated with the number of "head slaps" ($\tau = 0.70$; $P < 0.01$). The number of attempts to mate relative to oviposition increased from four in January to 22 in February, 53 in March, and 15 in April 2001. Oviposition (Fig. 3) occurred on 16 April 2001.

We observed M2 attempting to capture hatchlings only in August 2000, when he tried 17 times. F5 attempted to capture hatchlings once in August 2000 and again in May 2001. Capture attempts by both M2 and F5 were significantly correlated with one another ($\tau = 0.67$; $P = 0.04$).

Observations of juveniles foraging were greatest immediately after hatching and declined thereafter (Fig. 4). Juveniles foraged for food more frequently in water (monthly mean = 12.7 ± 14.1) than on land (4.3 ± 3. 7). Only in October 2000, January 2001, and February 2001 did observations of foraging on land exceed those of foraging in water. However, the time juveniles were observed in water versus on land did not differ significantly ($\tau = 2.0$; $P = 0.06$). The number of times juveniles foraged on land was negatively correlated to precipitation ($\tau = -0.51$; $P = 0.03$) and the number of juveniles foraging in water was negatively correlated to the number of times M2 attempted to mate ($\tau = -0.50$; $P = 0.02$).

The number of vocalizations peaked in December 2000 and no calls were heard from June through September 2000 (Fig. 5). The mean number of vocalizations/month was 9.3 ± 8.8. Vocalizations were negatively but not significantly correlated ($\tau = -0.55$; $P = 0.23$) with ambient temperature, but were significantly correlated with the number of times juveniles foraged on land ($\tau = 0.54$; $P = 0.02$).

## Discussion

The male initiated all observed cases of courtship and the female emitted periodic grunts as the male positioned himself, a sequence essentially identical to that described by Vliet (2001) for American Alligators. The number of "head-slaps" was positively related to the number of coupling attempts per month. Due to the cloudy water, we were unable to determine which mating attempts resulted in intromission. Both maximum number of attempts to mate, and the maximum number of "head slaps" (53, in March 2001) preceded oviposition by a month and increased mating attempts during that month might also have been related. Gestation in American Alligators is about three weeks (Joanen and McNease 1980) and four to eight weeks in Saltwater Crocodiles (Lang 1980).

Juveniles were two years old when the period of observation was concluded. The number of attempts by M2 trying to capture hatchlings was highest in August 2000 when new hatchlings would have emerged from the nest (after an incubation period of close to 90 days), even though the nest

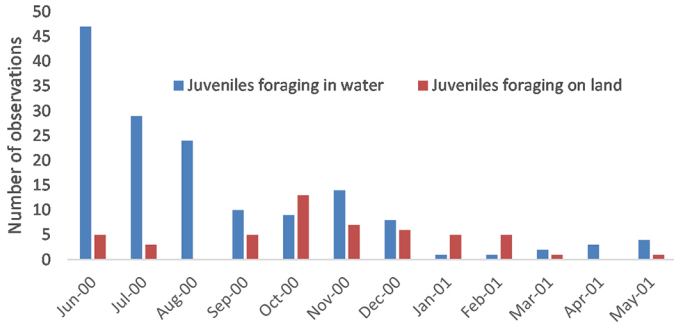


**Fig. 4.** The frequency of observations of juvenile Siamese Crocodiles (*Crocodylus siamensis*) foraging in water (blue) or on land (orange) at the Madras Crocodile Bank Trust (MCBT) south of Chennai, India.

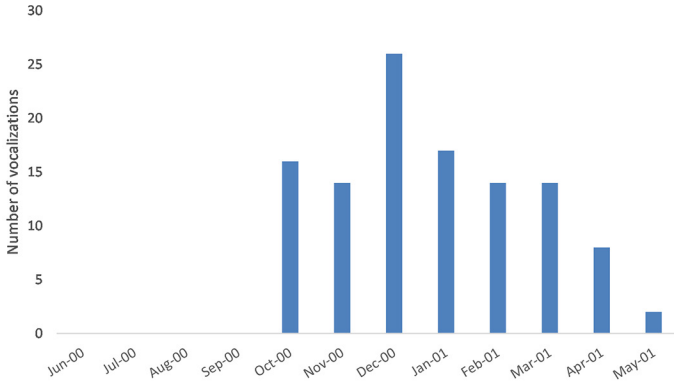


**Fig. 5.** The frequency of vocalizations by juvenile Siamese Crocodiles (*Crocodylus siamensis*) at the Madras Crocodile Bank Trust (MCBT) south of Chennai, India.

had been removed. This also coincided with the time when two-year-old juveniles were being displaced. Similarly, Hunt (1977) noted that juvenile Morelet's Crocodiles (*Crocodylus moreletii*) were most frequently attacked during egg incubation and hatching periods. Coinciding with the period of increased attacks, we noted that the juvenile Siamese Crocodiles at the MCBT frequently sought refuge in crevices in the perimeter wall (Fig. 1). The apparent displacement of two-year-old juveniles corresponds to observations by Campos et al. (2012), who found at least two generations of hatchling Dwarf Caimans as old as 21 months remaining with parents.

Juvenile Siamese Crocodiles became more efficient at prey capture as they grew, although we could not determine whether this was a function of increased experience or size. That foraging on land peaked in October, January, and February appeared to coincide with times when interactions by parents were at a minimum and juveniles had grown to a size at which they were no longer easy prey of birds or feral cats. Twenty two-year-old juveniles housed elsewhere measured 74.4 ± 4.3 cm (49.1–120.4 cm; n = 20) in total length.

Vocalizations by juveniles were highest in December 2000, a time when neither courtship nor attempts by parents to capture juveniles occurred. We did not attempt to categorize vocalizations as contact, threat, or annoyance, as reflected by a combined behavioral and spectrographic analyses (Britton 2000). Instead, the rise in the number of vocalizations might reflect increased levels of precipitation, which has been correlated with an abundance of aquatic and terrestrial prey (e.g., Wolda 1978). For example, we noticed a marked increase in the number of orthopterans (grasshoppers and crickets) and other terrestrial and aquatic invertebrates, and reproductive activity of the Common Indian Treefrog (*Polypedates maculatus*) is known to occur during periods of increased rainfall (Girish and Saidapur 1999).

Our observations suggest that the initiation of premating behavior (head slaps), an increase in hatchling foraging activity, and female nest construction and egg deposition occur in a sequence. Furthermore, this sequence appears to be associated with aggressive interactions (or predatory behavior) by adults toward hatchlings at a time when the latter, in turn, begin to avoid both parents and clutch mates and start to live a more solitary and independent existence. The apparent stimuli or cues that trigger these changes in the social behavior of both hatchlings and parents start with pre-mating male behavior (head slaps), which likely is prompted by seasonal changes in day length, temperature, and/or precipitation (Staton and Dixon 1977) and oviposition (Rhodes and Lang 1996). However, non-apparent modes of communication (e.g., secretions of the paracloacal glands; Rubio et al. 2002) might also play a role and warrant further study. Regardless, these changes, after a period when abatement of parental predatory impulses minimizes predation on their own young, apparently allow hatchlings to recognize and respond to the less benevolent behavior of their parents and employ more defensive behaviors.

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