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ACKNOWLEDGEMENTS. We thank the Department of Science and Technology, New Delhi for financial support under the Himalayan Glaciology Programme. We thank Dr Navin Juyal, Physical Research Laboratory, Ahmedabad; Prof. G. S. Rawat, Head, Department of Geology, HNB Garhwal University, Srinagar Garhwal and the anonymous referees for their constructive comments and valuable suggestions that helped in improving the manuscript.

Received 18 June 2007; revised accepted 16 January 2008

Feeding and parturition of female annulated sea snake *Hydrophis cyanocinctus* in captivity

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The most abundant annulated sea snake (*Hydrophis cyanocinctus*) of the Coromandel coast was captured alive, unhurt using a gill-net deployed from a fibre boat at Kalpakkam and brought to Protonovo within 5 h after capture. Twenty-five snakes were maintained in sea water filled cement tanks (10,000 l) and water exchange (80%) was done everyday. The snakes lived

peacefully in captivity for a period of 5 months. Snakes located their prey by cutaneous mechano reception, after which they swam close to the prey, struck laterally and swallowed the prey from head to tail. For an increase of 1 cm in body length of the snake, the maximum prey size consumed increased by 0.08 cm. Parturition occurred in captivity during January–February 2004 when a single female released 3–5 neonates. Smaller mothers (116–131 cm) released three neonates and larger ones (>144 cm) released five neonates. The female neonates were larger than the males.

Keywords: Annulated sea snake, neonates, parturition, prey.

KNOWN for their venom¹ and valuable skin², sea snakes are protected by the Indian Wildlife Protection Act 1972. From the Indian waters, 29 species have so far been recorded³. Their neurotoxic venom⁴ and role in the marine food chain⁵ have attracted many investigations, especially to rear them in order to collect the venom as medicament⁴. However, there was no success as sea snakes do not survive in captivity.

The Indian hydrophiid annulated sea snake, *Hydrophis cyanocinctus* grows to a body length of 2.0 m and is black and yellow banded in colour⁶. A detailed investigation on their by-catch in commercial trawlers has established that the annulated snake is the most abundant sea snake in the Coromandel coast; for instance, among 957 sea snakes captured as by-catch during 2003–04, 520 were annulated sea snakes⁷. An attempt was made to rear the snake in captivity in our laboratory. This communication reports the captive rearing of a sea snake for a period more than 144 days.

With implementation of the Indian Wildlife Protection Act 1972, a readily permissible method of capturing live annulated snakes is to obtain them from the by-catches of research or commercial trawlers. Regular monthly survey was undertaken in the Coromandel coast during the period from April 2003 to March 2004 and as many as 520 annulated snakes were collected from the by-catch; among these, about 25% suffered mortality within the trawler and/or on-board. The efforts made to bring live annulated sea snakes were found to be difficult due to low speed of the trawler and the long distance away from the coast (21 km). Besides, the stress to the snakes as they were compressed in the trawl net.

With permission from the Chief Conservator of Forests, Tamil Nadu, we finally chose to use a gill-net (length 500 m; mesh size diameter 1 cm) operated from small fibre boat (5 m long) as a method to capture the annulated snake. Kalpakkam (12°33'N, 80°11'E) situated near Chennai was chosen as the study site and the Chennai–Portonovo National Highway was chosen for transportation (Figure 1). The fishermen operated the gill-net about 10 km away from the coast at about 10–15 m depth in the early morning (4–6 a.m.); after a period of 2–3 h fishes along with

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the sea snakes were captured. As many as 50 trappings were made within a week from 29 September 2003 to 5 October 2003. Among the trapped snakes, 25 live female annulated snakes were brought unhurt to the shore; only females were selected due to the Forest Department limitations on capture of sea snakes. Unlike in trawls, the sea snakes suffered neither mortality nor injury. As and when captured, the individual annulated snake was immediately released into a smooth-walled plastic can (capacity, 35 l; height, 80 cm, diameter, 40 cm) with perforated lid for aeration and transported to the laboratory within 5 h after capture.

In the laboratory, the snakes were randomly separated into two groups and stocked in separate concrete tanks, each with water-holding capacity of 10,000 l. The inner wall of the tank was repeatedly painted until the wall became smooth. The tanks measured 1.6 m in height and were filled with filtered and UV-treated sea water to a height of 1 m. The bottom of the tank was strewn with sand and stones to mimic the natural habitat. In addition, pieces of plastic pipes and broken, wavy cement sheets were provided as hideouts (Figure 2).

Fresh sea water was daily let into each tank to replace 80% water, especially to remove the unused feed, faeces inclusive of uric acid and other debris like peeled skin. Each snake had a volume of 500 l sea water, of which 400 l was replenished everyday. The other parameters included water temperature 25.5–28.5°C (80% water exchange daily), salinity 28–31 ppt, dissolved oxygen 5.67 mg/l, pH 7.9–8.2, total ammonia nitrogen 0.04–0.07 µmol/l, and nitrite nitrogen 0.09–0.11 µmol/l. Weekly measurements of these parameters were made⁸. Photoperiod was maintained at 10L : 14D.

From the stocking days 1 to 5, the snakes incessantly swam and refused to accept live or cut fish food. Then they became peaceful and began to accept food. Like all hydrophiid sea snakes⁹, the annulated snake also has small ventral scales compared to terrestrial snakes (Figure 3), which cannot aid the snake to move at the bottom or climb on the inner wall of the tank. When the snake settled at the bottom, it could only wriggle into the hideouts. On settling into a hideout, the snake swam to the surface for breathing once every 15 min. Being nocturnal, the snakes were active in the dark and accepted live or cut fish to satiation within 30 min of offering, when the food was offered regularly, once a day, at 7 p.m. Occasionally, when they were not fed for a couple of days, the snakes were not cannibalistic and did not bite each other.

The snakes were completely acclimatized to living in captivity, as evidenced by the fact that parturition occurred and neonates were released during January–February 2004. Following a week after parturition and according to the terms and conditions of the permission granted by the Chief Conservator of Forest, all the mother snakes were released into the sea off Parangipettai. As the snakes were captured between 29 September 2003 and

5 October 2003 and released between 30 January 2004 and 27 February 2004, each of them lived peacefully in captivity for a period of not less than 144 days, i.e. for nearly

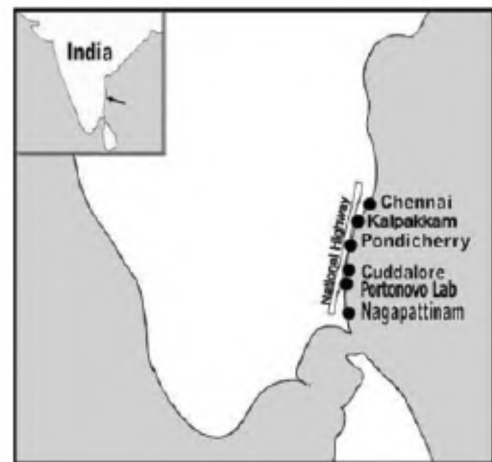


Figure 1. Map showing the national highway from Kalpakkam to Portonovo.



Figure 2. Apical view of a tank in which the annulated snakes were reared for a period of 5 months.

Sea snake (*H. cyanocinctus*) Terrestrial snake (*Naja naja*)



Figure 3. Arrangement of small scales in the annulated snake and large plate-like scales in a terrestrial snake.

5 months without suffering from any disease, injury or death.

Our observations for 5 months provided ample opportunities to understand their foraging and feeding behaviour. Everyday the sea snakes were offered live or cut pieces of fish. Live striped eel catfish, *Plotosus lineatus*, 9–16 cm was used as prey, and this grows up to 30 cm. Like the terrestrial snakes, the annulated snakes also occasionally flick their tongues but did not necessarily do so prior to striking the prey nor did they produce any hissing noise. The snake struck at the prey, only when it swam close to the bottom. Even during total darkness by visual orientation. When it accidentally dropped the bitten prey or was disturbed with a long rod, it repeatedly snapped for the prey in all directions, although the feed was just in its vicinity. Apparently, the snake senses the prey not visually but through its cutaneous mechanoreceptors and/or receptors in the inner ear, which are known to detect the weak water motion such as that generated by the live prey¹⁰.

Often the snake struck at the prey laterally. It held onto the prey in its original grip, irrespective of the position at which the prey was bitten. Then it began to position the prey for swallowing, when the prey remained still due to the effect of the venom injected into it during the first bite itself or rarely during the second bite. Sometimes it held the motionless prey against the wall of the tank with its body to re-position the prey for swallowing. Briefly opening its mouth, it moved to the head of the prey and then re-applied its grip at a slightly new position until the head of the prey was reached. Thus, it almost always swallowed the prey's head first (Figure 4). If a current was generated by releasing water into the tank to mimic the natural habitat, it kept its body curled in a J-shape, until the tail end of the prey was swallowed. This aided in easier passage of the prey into its mouth.

After swallowing the prey, the snake often swam rapidly and sometimes even tied itself into a knot, perhaps to aid the passage of the swollen prey into its stomach. The frequent yawning observed would be mainly for swallowing the prey.

To determine the relationship between the size of prey and predator, catfish of different sizes were offered individually one after another. When one of the snakes in the tank swallowed the prey, the snake was captured to measure its length. Such repeated observations allowed us to study the allometric relationship between the length of the prey and that of the snake. Figure 5 shows that for an increase of 1 cm body length of the snake, the prey length increased by 0.08 cm. The results confirm the previous observation made by Voris and Glodek¹¹ in wild collected snakes.

The palpation of maturing neonates in the uterus of the snakes was slightly visible, when they were captured during September–October 2003 (Figure 6a). Hence these snakes must have been impregnated prior to their capture

in September–October 2003. Palpation became progressively more pronounced, as the days of captivity advanced and by January 2004, it was distinctly visible (Figure 6b). Parturition occurred from 30 January to 27 February 2004.

In general, the neonates were delivered during night hours only. During the time of delivery, the mother snake rapidly swam around the tank; subsequently, it slowed down and rested in a chosen area. It then rapidly moved forward and backward and delivered the first neonate. After 5 min the remaining neonates were delivered one by one, repeating the same behavioural process. During delivery, the head of the neonate slowly appeared first and then the remaining body came out rapidly by the jerking action of the mother. The neonates were active

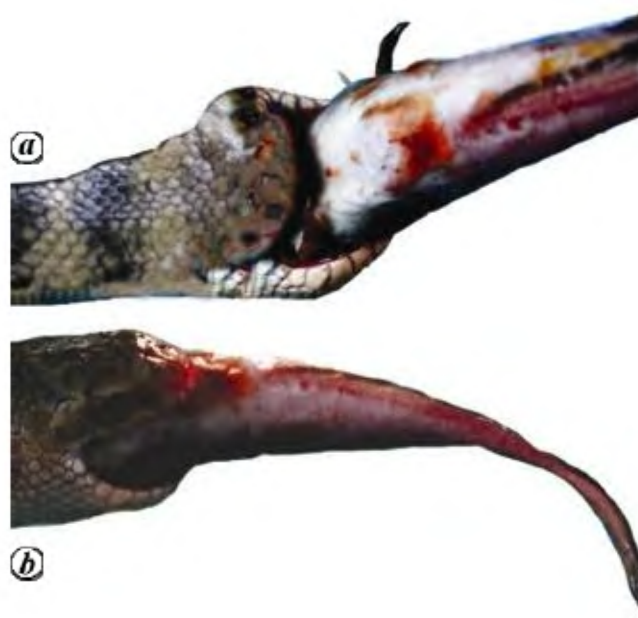


Figure 4. The process of swallowing the prey (*Plotosus lineatus*) by the annulated snake at night in the laboratory tank. For clarity, the surrounding water is not shown. **a**, Head of the prey being swallowed. **b**, Swallowing the tail end of the prey.

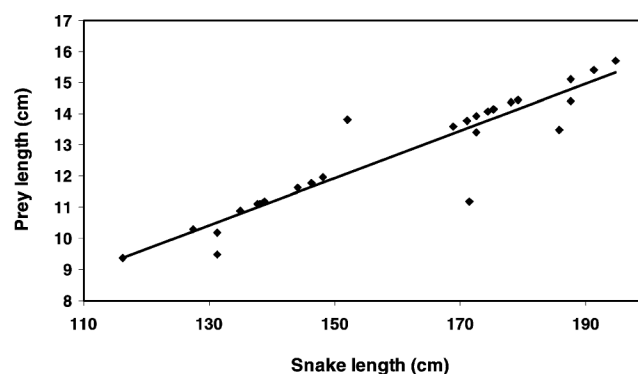


Figure 5. Prey and predator relationship (size) in *H. cyanocinctus*.



Figure 6. *a*, Developing and palpating embryos collected from the wild during September 2003; *b*, Fully developed neonates surgically removed from the mothers in captivity during January 2004; *c*, Healthy neonates first delivered by a mother snake in February 2004; *d*, Fully developed but dead neonates from dead mother snake after surgery.

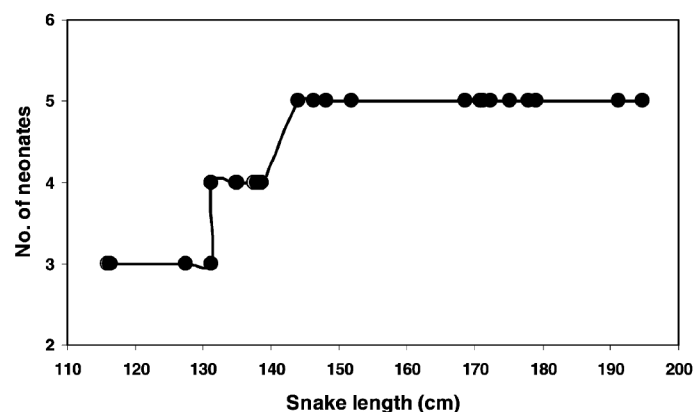


Figure 7. Number of neonates as a function of body length of the mother.

from the moment they were released. There were also occasions when two mother snakes within a tank undertook parturition on the same day in their respective chosen areas. Remarkably, none of these neonates were ever struck or injured by the other snakes, which shared the

same tank. However, the mother snakes did not show any signs of parental care. The neonates (Figure 5) measured 38–47 cm in body length and weighed 18–20 g (Table 1). They began to accept food from the first day of the birth.

Table 1. Morphological and sexual traits of new born neonates reared in captivity

Morphological and sexual traits	Male	Female
Weight (g)	18 ± 1	20 ± 1
Total length (mm)	382 ± 56	469 ± 37
Snout vent length (mm)	340 ± 50	417 ± 33
Tail length (mm)	52 ± 4	42 ± 6
Head width (mm)	9 ± 1	11 ± 4
Head length (mm)	19 ± 3	23 ± 2
Neck girth (mm)	21 ± 3	25 ± 2
Body girth (mm)	37 ± 5	46 ± 4
Sex ratio (male : female)	59	41

Among the 25 mother snakes, the delivery was normal in 21 of them. One mother struggled to deliver, but succumbed within 2 h after surgical release of five live neonates. The remaining three died during the parturition process; after surgery, it was found that these dead mother snakes had fully developed but dead neonates (Figure 6d). The causes for the death of fully developed foetus inside the embryonic sac and death of the mother snake are not known.

Figure 7 shows the number of neonates released by the snake as function of the body length of the mother in captivity. The minimum and maximum number of neonates given birth by the snake was 3 and 5 respectively (Figure 6c). Increase in body length of the mother from 130 to 140 cm resulted in increase in the number of neonates released. Smaller mothers (116–131 cm) released 3–4 neonates and larger ones (>144 cm) released five neonates. It appears that the snakes release a maximum of five neonates during one delivery.

All the 87 neonates were healthy. Their morphological traits were measured (Table 1). For every measured trait, except for that of the tail, the female, being viviparous, was longer/heavier than that of the male (see also Shine¹²). It is known that in almost all viviparous snakes, the females are larger than the males. For instance, females of the African file snake *Acrochordus arafura*¹³, olive sea snake *Aipysurus laevis*¹⁴, yellow-lipped sea snake *Laticauda colubrina*¹⁵ are larger than their respective males.

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ACKNOWLEDGEMENTS. We thank the authorities of Annamalai University, Parangipettai for the facilities provided and the Chief Conservator of Forests and Chief Wildlife Warden, Chennai for permission to the collection of sea snake. We also thank Prof. T. J. Pandian for suggestions to improve our method of study during 2002–04.

Received 30 July 2007; revised accepted 23 January 2008