Aggressive interactions among male Cane Turtles *Vijayachelys silvatica* (HENDERSON, 1912)

Vijayachelys silvatica (HENDERSON, 1912) is a monotypic chelonian endemic to the Western Ghats (MOLL et al. 1986; PRASCHAG et al. 2006). It attains a maximum straight carapace length (SCL) of 170 mm (WHITAKER & JAGANATHAN 2009) and is thus one of the smallest terrestrial geoemydid turtles. The species is omnivorous, feeding on fruits, leaves, molluscs, beetles and millipedes (MOLL et al. 1986; DEEPAK et al. 2009; VASUDEVAN et al. 2010). Maximum straight carapace length is not significantly different between males and females (WHITAKER & JAGANATHAN 2009). However, the species exhibits a sexual shell shape dimorphism, with females attaining bigger carapace width, shell height, plastron length and weight than males (WHITAKER & JAGANATHAN 2009). In addition, the species is sexually dichromatic, with males showing different combinations of bright red, yellow, pink and black colors on the head, whereas females are clay to cinnamon rufous with or without a pink stripe on the head (MOLL et al. 1986; DEEPAK & VASUDEVAN 2009).

Mating in Cochin Forest Cane Turtles is reported to happen between June and November (APPUKUTTAN 1991; WHITAKER & JAGANATHAN 2009). Aggressive interaction among male Cane Turtles during this period is a known phenomenon (MOLL et al. 1986), but the potential consequence to the inferior rival of losing the nuchal scute is reported here for the first time and allows for inferences on the size at sexual maturity.

A field study on the Cane Turtle was carried out in the Anamalai and Parambikulam Tiger Reserves, in the Western Ghats of south India. This study was conducted in six different sites in the reserves. The precise localities are not being revealed in order to safeguard the populations from exploitation. These sites were spread over an area of 12 km^2 covered by southern tropical wet evergreen forest vegetation (CHAMPION & SETH 2005) with *Dipterocarpus indicus*, *D. bourdilloni*, and *Strombosia ceylanica* as the dominant tree species (PASCAL et al. 2004). The elevations in the study area

Fig. 1: Aggressive interaction in males of *Vijayachelys silvatica* (HENDERSON, 1912), can result in damage and loss of the nuchal scute. The broken nuchal scute is indicated by the pointer.

proper varied from 500 - 850 m a.s.l. There were four seasons in the study area: post monsoon from November to February, summer from March to May, southwest monsoon from June to August, and northeast monsoon from September to October. The annual rainfall for the years 2006, 2007, 2008 and 2009 were 1408, 2158, 1276 and 2000 mm, respectively. Rainfall was measured to the nearest mm using a rain gauge located in Topslip, Anamalai Tiger Reserve. There were two seasonal peaks in rainfall per year, one during the southwest monsoon (June-August) and the other during the northeast monsoon (September-November).

During the study sixty-five different individuals of the Cane Turtle were captured and marked of which, 57 turtles (32 males, 20 females, 5 juveniles) were measured. Straight carapace length (SCL), carapace width (CW), plastron length (PL), plastron width (PW), shell height (SH) and body mass (BM) for each turtle, were determined. The morphometric measurements were made using a dial caliper (Mitutoyo™) at 0.05 mm accuracy and weighing was done using a spring balance (Pesola™) at 0.1 g accuracy. The status of the nuchal scute was recorded as damaged or intact every time a turtle was measured. Extensive damages such as loss of first vertebral and first peripherals on both sides were considered to have been caused by accidental trampling by large hoofed mammals. These individuals were not included in the analysis of nuchal scute damage. The sex of individual turtles was determined based on the head coloration and the relative length of the tail. If the length of the tail proximal to the cloacal opening was short, it was classified as female, when it was long, it was classified as male (MOLL et al. 1986). Juveniles had a soft plastron and the sex in these individuals was not ascertained. Each turtle was marked individually by notching the marginal scutes following CAGLE (1939). In addition, six individuals (three males # 9, 10 & 11 and three females # 5, 6 & 10) were fitted with radio transmitters (G3-1V type, AVM Instruments Co. Ltd®) and were tracked on a daily basis using hand-held collapsible Yagi-Uda antenna. Ad-libitum behavioral observations were made by a single observer 8-10 m away, without disturbing

Table 1: Seven matings of *Vijayachelys silvatica* (HENDERSON, 1912) observed during the study, in chronological order. SCL - Straight Carapace Length; * - Individual not in the analysis (first anterior marginals on the right and the left, and the nuchal scutes were damaged).

No.	Date	Time (h)	Male #	SCL (mm)	Female #	SCL (mm)	Microhabitat
1	14.6.08	1107	11	126.9	5	133.0	under fallen log
2	17.6.08	1310	12	121.6	7	135.5	under fallen log
3	19.6.08	1310	14	120.5	9	128.5	under fallen log
4	25.8.08	1200	11	126.9	5	133.0	barren ground
5	03.7.09	1830	22	125.4	12	94.5	base of buttress
6	18.7.09	1500	22	125.4	12	94.5	base of buttress
7	16.9.09	1500	36*	112.2	20	108.8	barren ground

the turtle. Fisher's Exact test for count data was used to test whether the damage of the nuchal scute is related to size in males (SIEGEL & CASTELLAN 1988). Analyses were done using the software package R Version 2.12, (R DEVELOPMENT CORE TEAM 2007).

Sixty five individuals of Cane Turtles (38 males, 22 females and 5 juveniles) were captured and marked over four years (2006-2009). Direct observations were made on three (two male # 9 and # 11 and one female # 5) radio-tagged individuals after locating them on the forest floor. Out of seven mating events observed, five took place under fallen logs or in the base of tree buttresses (Table 1). On 25 July, 2008, at 12.22 h, we observed male # 18 clasped on top of radio-tagged male # 9. Another such event was observed when male # 17 clasped of top of male # 24.

Behavioral observations were also made on two males held together in captivity on 8 October, 2006. They hissed and opened their mouths wide, threatening one another. Male # 2 (122 mm SCL) bit male # 3 (124 mm SCL) into its nuchal scute (Fig. 1). Thereupon, male # 3 lowered the anterior end of its carapace, retreated, turned its back and moved away with its head retracted inside the carapace. Male # 2 chased and bit male # 3 on the nuchal scute until it buried under leaf litter. In 13 out of the 32 male turtles measured, the nuchal scute was either damaged or missing, whereas none out of the 20 females and five juveniles measured had a damaged nuchal scute (Table 2). The loss or damage of the nuchal scute was recorded only in males of SCL > 115 mm (Table 2). There was a significant difference in the absence (through damage) of the nuchal scute between males ≥ 115 mm SCL and males below this size (Fisher's Exact test $p = 0.02$, $df = 1$). All males with body size < 115 mm SCL had an undamaged nuchal scute. In the case of males with body size ≥ 115 mm SCL, 54.2 % ($n = 24$) of the individuals exhibited loss of the nuchal scute. Male-male combat resulting in loss of the nuchal scute in males of SCL > 115 mm suggests that the males of this species probably attain sexual maturity at this size. We found evidence supporting this in the mating pairs observed, where the SCL in five males ranged between 122-127 mm, and in five females between 95-136 mm (Table 1). Severe damage of the carapax was observed in three males (male # 4, male # 9 and male # 36). These damages might have been caused by a predator or accidental trampling by ungulates (e.g., *Bos gaurus*, *Sus scrofa*, *Rucervus unicolor* and *Axis axis*).

Mating in Cane Turtles was observed by the authors from 14 June to 16 September (Table 1) and reported in the literature from June, September and November (APPUKUTTAN 1991; WHITAKER & JAGANATHAN 2009). A week old hatchling was found in Kanyakumari, southern Western Ghats in December (DANIELS 2001). These reports along with our observations confirm that mating in the Cane Turtle coincides with the monsoon and post monsoon months (June to November) in the southern Western Ghats.

Damage of nuchal scutes by biting other males is known in the extinct Rodriguez Island Tortoise, *Cylindraspis vos-*

Table 2: Morphometric data of 57 *Vijayachelys silvatica* (Henderson, 1912) studied. Individuals sorted by sex and then by ascending straight carapace length (SCL). CW - carapace width; PL - plastron length; PW - plastron width; SH - shell height; BM - body mass; N - not measured; (+) - intact; (–) - damaged; * - data not used for analysis.

Ser. no	ID	Sex	SCL [mm]	CW [mm]	PL [mm]	PW [mm]	SH [mm]	BM [g]	Nuchal condition
1	26	male	99.4	78.0	88.5	65.0	45.0	110	(+)
2	8	male	100.1	83.5	87.7	68.0	36.9	125	(+)
3	31	male	108.7	82.3	95.8	69.0	41.3	150	(+)
4	7	male	110.5	88.0	97.0	72.5	38.5	150	(+)
5	36*	male	112.2	84.3	95.4	70.9	42.1	160	(–)
6	20	male	113.5	87.0	96.7	70.7	42.1	150	(+)
7	35	male	114.4	86.6	95.4	70.5	39.3	140	(+)
8	28	male	114.8	88.3	100.5	74.2	41.0	160	(+)
9	34	male	119.1	88.0	104.3	74.5	42.0	160	(–)
10	37	male	119.1	86.8	109.0	70.2	43.5	180	(+)
11	10	male	120.5	86.6	103.0	73.0	42.8	170	(–)
12	14	male	120.5	86.8	105.5	73.5	43.5	200	(+)
13	17	male	120.5	89.8	101.9	72.2	45.0	200	(–)
14	25	male	120.8	87.4	102.2	74.4	45.4	200	(–)
15	33	male	120.8	91.1	106.5	73.8	N	170	(+)
16	12	male	121.6	93.8	112.0	77.3	44.2	190	(+)
17	32	male	122.4	86.3	111.2	76.2	42.8	200	(–)
18	29	male	123.7	86.0	106.1	71.9	44.5	180	(+)
19	23	male	124.0	91.9	107.9	79.9	46.0	200	(–)
20	19	male	125.0	89.0	106.0	55.0	N	200	(+)
21	27	male	125.1	89.3	111.8	74.2	46.5	230	(–)
22	9	male	125.2	93.2	106.1	77.7	44.3	210	(+)
23	22	male	125.4	87.5	106.0	75.3	46.0	210	(–)
24	15	male	125.5	89.3	105.3	73.3	43.5	170	(+)
25	16	male	126.2	89.5	107.2	75.5	46.7	210	(+)
26	18	male	126.8	91.2	104.5	75.5	46.5	200	(–)
27	11	male	126.9	94.2	119.6	81.5	46.9	230	(–)
28	13	male	128.0	90.3	112.0	74.6	44.0	210	(+)
29	24	male	128.1	92.5	107.6	78.8	45.7	200	(–)
30	38	male	128.3	93.5	108.0	79.6	42.0	210	(–)
31	30	male	129.4	91.2	101.8	76.0	43.5	220	(+)
32	21	male	129.5	92.5	111.2	76.8	49.0	220	(–)
33	12	female	94.5	80.3	81.3	66.4	38.2	100	(+)
34	16	female	95.3	73.8	81.6	66.0	36.0	90	(+)
35	21	female	97.1	78.4	85.3	64.3	N	100	(+)
36	20	female	108.9	86.4	101.9	73.0	40.0	190	(+)
37	15	female	111.5	87.1	99.8	74.3	44.2	180	(+)
38	14	female	114.3	90.2	101.9	77.1	42.0	170	(+)
39	19	female	115.6	90.4	106.8	76.7	39.9	200	(+)
40	3	female	121.0	90.0	110.0	77.5	47.0	280	(+)
41	10	female	121.0	92.2	107.4	78.9	40.9	220	(+)
42	8	female	122.0	89.5	113.8	78.8	44.9	210	(+)
43	17	female	122.8	89.7	113.0	78.1	47.4	230	(+)
44	18	female	123.9	93.4	114.0	78.6	46.8	230	(+)
45	4	female	124.1	93.5	108.0	80.3	48.5	250	(+)
46	2	female	126.0	95.5	116.0	78.0	43.3	N	(+)
47	11	female	126.0	93.0	111.8	80.6	46.6	240	(+)
48	9	female	128.5	91.4	103.5	81.9	43.9	200	(+)
49	13	female	131.3	N	N	N	N	N	(+)
50	5	female	133.0	100.2	124.6	86.8	50.0	270	(+)
51	7	female	135.5	100.0	117.1	86.5	45.0	270	(+)
52	6	female	139.0	99.9	125.0	85.5	48.0	340	(+)
53	6	juvenile	58.25	49.8	49.55	39.15	23.25	23	(+)
54	1	juvenile	67.0	57.2	55.0	44.65	26.0	34	(+)
55	2	juvenile	70.7	59.4	58.8	47.5	27.2	30	(+)
56	5	juvenile	87.3	74.8	72.7	61.1	33.5	90	(+)
57	3	juvenile	90.0	73.0	76.4	61.6	31.7	80	(+)

maeri (SUCKOW, 1798) (PETER PRITCHARD pers. comm.). Male-male combat in *V. silvatica* involved biting and tipping of the anterior end of the carapace by the contestants (MOLL et al. 1986; APPUKUTTAN 1991). Our observations conform to these observations made earlier on this species in that we found that more than half of the adult male Cane Turtles had lost their nuchal scute. Obviously, the frequently observed damage to the nuchal scute was caused by biting action of combating males. If it was due to the protuberant position alone, one would expect small damages with the same probability among the 20 female and five juvenile turtle. But this was not the case, as is evident from Table 2. We always found individuals with damaged but healed nuchal scutes, which clearly had left behind the telltale sign of past injury. In the case of radio-tagged males # 10 & 11 had damaged their nuchals, but they showed no sign of growing back their nuchals during our monitoring. Male # 10 was tracked for 88 days and male # 11 was tracked for 264 days.

During aggressive interactions, some males avoided being bitten on the head by lowering their carapace, a behavior that is also present in some aquatic turtles. Other aggressive male-male interactions such as male-male mounting could be related to sexual maturity in males.

The onset of sexual behavior and aggressive encounters between males is considered as an indication of their sexual maturity in several vertebrate species (WINGFIELD et al. 1990). Based on our observations on the sexual behavior of male Cane Turtles, we infer that they attain sexual maturity at SCL > 115 mm. Sexual maturity of female turtles becomes obvious upon egglaying. SCL of five female Cane Turtles that laid eggs (WHITAKER & JAGANATHAN 2009) ranged from 112-121 mm (NIKHIL WHITAKER pers. comm.). In our study, the smallest female Cane Turtle involved in mating activities (however, maybe only in the form of molestation through a male) was 95 mm in SCL (Table 1). Thus, size at sexual maturity in females needs further investigation.

ACKNOWLEDGMENTS: This study is supported by Grants-in-aid for research from the Wildlife Institute of India. The Tamil Nadu and Kerala forest Departments are thanked for supporting this study with permissions and logistic help. Silamban, Ganeshan, Rajamani, Utpal Smart and Rajan are thanked for their assistance in the field and painstaking searches in difficult terrain. Special thanks to Peter PRITCHARD and Nikhil WHITAKER for sharing valuable information.

REFERENCES: APPUKUTTAN, K. S. (1991): A survey report of cane turtle and Travancore tortoise. Kerala, India (Kerala Forest Department), pp. 1-21. CAGLE, F. (1939): A system for marking turtles for future identification.- Copeia, Washington; 1939: 170-172. CHAMPION, H. G. & SETH, S. K. (2005): A revised survey of the forest types of India. Nasik, India (Government of India Press), pp. 65. DANIELS, R. J. R. (2001): The Cochin forest cane turtle (*Geoemyda silvatica*) in Kanyakumari District, Tamil Nadu.- Cobra, Chennai; 43: 18-20. DEEPAK, V. & VASUDEVAN, K. (2009): Endemic turtles of India. Chapter 3; pp. 25-42. In: VASUDEVAN, K. (Ed): Freshwater turtles and tortoises of India, ENVIS Bulletin, Vol. 12 (1). Dehradun, India (Wildlife Institute of India). DEEPAK, V. & VASUDEVAN, K. & PANDAV, B. (2009): Preliminary observation on the diet of cane turtle (*Vijayachelys silvatica*).- Hamadryad, Madras; 34: 167-169. MOLL, E. O. & GROOMBRIDGE, B. & VIJAYA, J. (1986): Redescription of the cane turtle with notes on its natural history and classification.- Journal of the Bombay Natural History Society, Mumbai; 83: 112-126. PASCAL, J. P. & RAMESH, B. R. & DE FRANCESCHI, D. (2004): Wet evergreen forest types of the Southern Western Ghats, India.- Tropical Ecology, Varanasi; 45: 281-292. PRASCHAG, P. & SCHMIDT, C. & FRITZSCH, G. & MÜLLER, A. & GEMEL, R. & FRITZ, U. (2006): *Geoemyda silvatica*, an enigmatic turtle of the Geoemydidae (Reptilia: Testudines), represents a distinct genus.- Organism Diversity and Evolution, Berlin, Heidelberg; 6: 151-162. R DEVELOPMENT CORE TEAM (2007): A language and environment for statistical computing. Vienna (R Foundation for Statistical Computing). Software package and documentation available at < http://www.R-project.org >. SIEGEL, S. & CASTELLAN, N. J. Jr. (1988): Nonparametric statistics for the behavioural sciences. New York (McGraw-Hill), pp. 399. VASUDEVAN, K. & PANDAV, B. & DEEPAK, V. (2010): Ecology of two endemic turtles in the Western Ghats. Final Technical Report, Wildlife Institute of India, Dehradun, pp. 74. WHITAKER, N. & JAGANATHAN, V. (2009): Biology of the forest cane turtle, *Vijayachelys silvatica*, in South India.- Chelonian Conservation and Biology, Lunenburg; 8: 109-115. WINGFIELD, J. C. & HEGNER, R. E. & DUFTY, A. M. Jr. & BALL, G. F. (1990): The "challenge hypothesis": theoretical implications for patterns of testosterone secretion, mating systems, and breeding strategies.- American Naturalist, Chicago; 136 (6): 829-846.

KEY WORDS: Reptilia: Testudines: Geoemydidae, *Vijayachelys silvatica*, mating behavior, aggressive behavior, sexual maturity, male combat, nuchal scute damage, terrestrial chelonians, Western Ghats, India

SUBMITTED: January 31, 2012

AUTHORS: Veerappan DEEPAK, Wildlife Institute of India, P.O. Box 18, Dehradun 248001, India < deepaksalea@gmail.com >; Karthikeyan VASUDEVAN, Department of animal ecology and conservation biology, Wildlife Institute of India, P.O. Box 18, Dehradun 248001, India < karthik@wii.gov.in >