

Vijayachelys silvatica (Henderson 1912) – Cochin Forest Cane Turtle

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SUMMARY. – The Cochin Forest Cane Turtle, *Vijayachelys silvatica* (Family Geoemydidae), is a cryptic species in a monotypic genus endemic to the semi-evergreen and evergreen forests of the Western Ghats in southwestern India. It is the smallest turtle species in India, with carapace length (CL) in females up to 139 mm and males up to 126 mm. The species occurs at densities at 0.8 individuals per hectare and the home range varies from 3.5 to 12 ha. *Vijayachelys silvatica* is omnivorous, with the diet including insects, molluscs, earthworms, millipedes, and fruits. Most mating behavior occurs during the rainy season between June and November. One to two clutches are produced; the clutch size ranges from 1 to 4 eggs, and hatchlings measure 37–40 mm in CL. The major threats to this species are habitat loss and subsistence hunting. Conservation measures should focus on identification of crucial turtle habitats and creating awareness among wildlife protection staff and local people about the conservation status of the species.

DISTRIBUTION. – India. Endemic to the Western Ghats of southwestern coastal India, in the states of Kerala, Karnataka, and Tamil Nadu.

SYNONYMY. – *Geoemyda silvatica* Henderson 1912, *Heosemys silvatica*, *Vijayachelys silvatica*.

SUBSPECIES. – None recognized.

STATUS. – IUCN 2014 Red List: Endangered (EN B1+2c, assessed 2000); TFTSG Draft Red List: Endangered (EN, assessed 2011); CITES: Appendix II; India: Indian Wildlife (Protection) Act (1972): Schedule I.

Taxonomy. – Henderson (1912) described the Cochin Forest Cane Turtle as *Geoemyda silvatica* based on two specimens collected from Chalakudy forest in Kerala and assigned them to the genus *Geoemyda* Gray 1834.

At that time the genus *Geoemyda* included a variety of semi-terrestrial and terrestrial turtles from the Oriental and Neotropical regions. McDowell (1964) reorganized the Emydidae largely on the basis of cranial anatomy



Figure 1. Adult male *Vijayachelys silvatica* from the rainforests of Anamalais. Photo by V. Deepak.



Figure 2. *Vijayachelys silvatica*, male (left) and female (right) plastra. Photos by Peter Praschag.

and partitioned the genus *Geoemyda* into *Heosemys*, *Melanochelys*, *Rhinoclemmys*, and *Geoemyda*, and the Cane Turtle was assigned subjectively to the genus *Heosemys* Stejneger 1902. Moll et al. (1986), based on osteological characters, compared *Geoemyda spengleri*, *Heosemys grandis*, and *H. spinosa* and proposed that *H. silvatica* be transferred back to its original generic position under *Geoemyda*. However, this decision was rejected by some authors, for example, Ernst and Barbour (1989) and Ernst et al. (2000), and the use of *Heosemys silvatica* remained prevalent. Praschag et al. (2006) used both phylogenetic and morphological evidence to show the distinctness of *G. silvatica* and erected a new monotypic genus *Vijayachelys* to include *V. silvatica*. The name recognizes the late Jaganathan Vijaya (1959–1987), turtle biologist from the Madras Snake Park Trust and the Madras Crocodile Bank Trust who spent several months living in a cave to study this species. Praschag et al. (2006) also inferred that *V. silvatica*

was more closely related to *Melanochelys trijuga* than to the genera *Geoemyda*, *Heosemys*, and *Leucocephalon* as proposed by previous taxonomists.

Description. — Adult *V. silvatica* have a low carapace with three prominent keels (Fig. 1). The keels on the carapace are prominent in all but the oldest individuals but the central one is widest and most pronounced. The carapace color in females varies from cinnamon to tawny or raw umber with a dark brown stripe along the central keel; males have a much darker carapace than females, varying from burnt umber to dusky brown. The plastron color varies from buff to buff yellow in females and straw to sulfur yellow in males (Moll et al. 1986). The maxillae form a distinct median upper jaw hook, the labial ridge is slightly serrated irregularly. The nuchal scute is well developed. The forelimbs are heavily armored anteriorly, with enlarged, imbricate, and squarish to pentagonal-shaped scales extending on to the toes and soles of the feet. On the hind limbs enlarged scales are confined to the posterior medial surface except for the feet where they cover the entire surface. A large pointed scale is present on each heel (Henderson 1912; Smith 1931; Moll et al. 1986; Praschag et al. 2006).



Figure 3. Different male *Vijayachelys silvatica* found in the Anamalais, Tamil Nadu, showing variation in head color. Photos by V. Deepak.



Figure 4. Female *Vijayachelys silvatica* showing variation in head color. All individuals are from Anamalais except second row center image from Karnataka. Photos by V. Deepak.

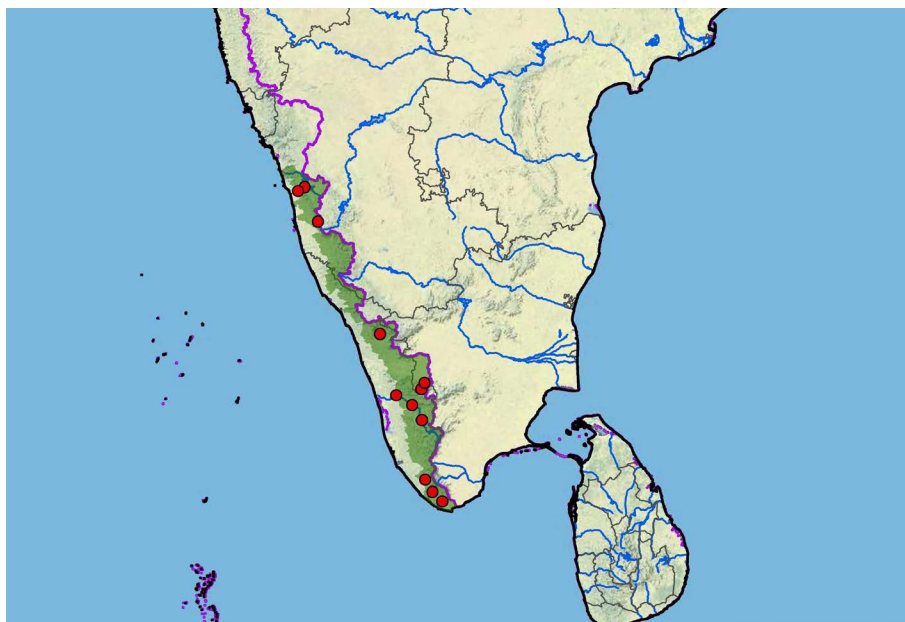


Figure 5. Distribution of *Vijayachelys silvatica* in the Western Ghats of southwestern peninsular India, south Asia. Purple lines = boundaries delimiting major watersheds (level 3 hydrologic unit compartments – HUCs); red dots = museum and literature occurrence records of native populations based on Iverson (1992) plus more recent and authors' data; green shading = projected native distribution based on GIS-defined HUCs constructed around verified localities and then adding HUCs that connect known point localities in the same watershed or physiographic region, and similar habitats and elevations as verified HUCs (Buhlmann et al. 2009; TTWG 2014), and adjusted based on authors' subsequent data.

Vijayachelys silvatica is a sexually dichromatic species, with males (Fig. 2) having darker and brighter pink or scarlet markings on the head as compared to females (Fig. 3), and the male iris is usually flame scarlet or white surrounded a scarlet sclera. The mandible is yellow to orange yellow and considerably brighter in males than in females. Typically the head color of females ranges from clay to cinnamon rufous; some large females also have light brick-red head coloration, and the iris is amber to chrome orange and is surrounded by a scarlet to flame scarlet sclera. Some females possess a dull geranium pink colored post-ocular stripe, but it is not common. The mandibles are a dull buff which may be washed with red.

In addition to the striking dichromatism, *V. silvatica* is also sexually dimorphic. Males have a concave plastron, and

in females it is flat. The tail is more elongated and thicker at the base in males than in females. The length of the tail proximal to the cloacal opening exceeds the portion distal to it in the case of males; in females the proximal pre-cloacal portion is shorter than the distal portion.

Females are generally heavier and wider than males; the carapace width and shell height of females are significantly larger compared to males (Whitaker and Vijaya, 2009). Males measured between 100–126 mm ($n = 24$) in straight carapace length (CL) and females measured 114–139 mm in CL ($n = 18$); males weighed 84–275 g ($n = 47$) and females weighed 76.5–340 gm ($n = 60$) (Whitaker and Vijaya 2009; Deepak et al., unpubl. data).

Hatchlings have a CL of 37–40 mm and a carapace width of 26–31.5 mm. Hatchling color is mainly light



Figure 6. Hatchling *Vijayachelys silvatica*. Photos by Peter Praschag.



Figure 7. *Vijayachelys silvatica* hill forest habitat in the Western Ghats. Photo by V. Deepak.

brown. Carapace color varies from cinnamon to clay with dark mottling, especially on the marginal scutes. The three carapacial keels are dirty yellow initially, but their color fades after a few months. Some hatchlings show the same dirty yellow coloration on the edge of the marginals. The head and neck are similar to that of the shell, but with orange markings on the occipital region. The iris is clay colored and surrounded by an orange sclera and eyelid (Fig. 4). The plastron varies from buff yellow to cream with a small dark central figure reaching from the humerals to the femorals, sometimes including the anals (Moll et al. 1986; Praschag, pers. comm.).

Distribution. — The Cane Turtle is endemic to the Western Ghats in southwestern peninsular India (Fig. 5). The species has been reported from Kerala, Karnataka, and Tamil Nadu states (Vijaya 1982; Sharath 1990; Appukkuttan 1991; Das 1995; Daniels 2001; Easa and Ramachandran 2004; Jose et al. 2007; Jaffer Palot, pers. comm.; T.V. Ramachandran, pers. comm.; K.V. Gururaja, pers. comm.; S. Bhupathy, pers. comm.).

Habitat and Ecology. — *Vijayachelys silvatica* is found in evergreen and semi-evergreen forests of the Western Ghats (Vijaya 1982; Moll et al. 1986; Vasudevan et al. 2010). The observations by J. Vijaya on Cane Turtles suggest that they do not show affinity towards water bodies (Moll et al. 1986); even during the dry months of the year, the turtles never ventured into streams (Vasudevan et al. 2010). The extensive algal growth on the carapace suggests their close association to wet areas on the forest floor (Whitaker and Vijaya 2009).

Vijaya (in Moll et al. 1986) reported that she found more Cane Turtles in areas with considerable undergrowth of herbaceous plants that were one to two feet tall; they were either concealed beneath the plants or amidst the leaf litter. In a survey of local ecological knowledge (Kanagavel and Raghavan 2012), *V. silvatica* was reported as being



Figure 8. *Vijayachelys silvatica* habitat in the Western Ghats. Photo by Karthikeyan Vasudevan.

encountered more often during the fruiting season of specific plants, and in areas where temperatures were relatively low. In a study by Vasudevan et al. (2010) turtles were radiotracked for 620 days between July 2006 and March 2009; six turtles (3 males, 3 females) were found 61% of the time buried under leaf litter, 14% under lianas, roots, tree buttresses, or fallen logs, 13% in the open, 6% walking or mating or feeding, and 5% inside tree holes or termite hill burrows. They are active predators that search for prey under leaf litter and use vantage points (fallen logs) to scan for food (Smart 2008, Smart et al. 2014).

Home Range and Behavior. — Vasudevan et al. (2010) documented that radiotagged turtles were more active on rainy days (47%) than on dry days (23%, $n = 1351$ tracking days); they suspended their activity and remained buried under leaf litter during the cold-dry months between December and February and during the hot-dry months between March and May, and a female spent 46 days from December to May in the same location under leaf litter. Home range of this species ranged between 5–9 ha (Vasudevan et al. 2010).

Smart (2008) and Smart et al. (2014) made a total of 54 hrs of observations on wild turtles that yielded seven behavioral states (alert, sleeping, walking, scanning, staring, feeding, and inactive) and ten behavioral events (yawning, wiping face, blinking, nosing, stretching limbs, penetrating litter, biting, head jerk, climbing, and positioning of the head). Moll et al. (1986) described two forms of defensive behavior in the Cane Turtle. In the first form, during male-to-male combat, one male moved towards a second male with its neck extended and mouth open. The second male defended itself by retracting its head and tipped the anterior portion of its carapace downward, towards the aggressor (Deepak and Vasudevan 2013). This kind of defensive behavior may be intraspecific in nature. A second form of defensive behavior was observed in both the sexes, where Cane Turtles defecated when picked up from the ground, and males extruded their

penis. These defensive behaviors deter predators. A third form of defensive behavior in the species was in the form of release of a pale yellow-colored, offensive smelling secretion squirted from the Rathke's gland, located at the junction of the infra-marginal and the seventh marginal scute (Deepak and Vasudevan, 2010).

Diet. — *Vijayachelys silvatica* is omnivorous and has been reported to feed on fruits, leaves, molluscs, beetles, and millipedes (Moll et al. 1986; Deepak et al. 2009). Vasudevan et al. (2010) documented 55 fecal samples collected from 50 individuals (30 males, 16 females, 4 juveniles); 85% had insects and molluscs, 82% had plant matter, 76% had sand, and 31% had millipede remains and seeds. *Vijayachelys silvatica* were observed feeding on the endemic snail *Indrella ampula* on four different occasions (Deepak et al. 2009). Fifteen out of the 55 samples had seeds, of which seven were *Glycosmis arborea*, six *Diospyros buxifolia*, and one *Ficus* sp. and an unidentified climber species (Deepak et al. 2009).

Courtship and Nesting. — Males have aggressive encounters during the breeding season, which results in biting and scarring of the nuchal scute; a significant proportion of males ≥ 115 mm CL had damaged nuchal scutes indicating inter-male aggression at the size when males attain sexual maturity (Deepak and Vasudevan 2013). Mating occurs during the commencement of the southwest monsoon, between June and September in the Anamalais, Western Ghats, and mating was reported during November in Chalakudy (Whitaker and Vijaya 2009). Seven direct observations of mounting and copulation were made *in-situ*, where the males extended their head and eyes forward and looked at the female from above while mounting (Deepak and Vasudevan 2013). Mating was usually observed during late evening hours and night by Whitaker and Vijaya (2009) and especially during rains in captivity. Seven *in-situ* mating observations were made between 1100 and 1830 hrs by Deepak and Vasudevan (2013).

In captivity, a Cane Turtle was observed laying eggs in December; the eggs were oviposited in a small depression on the ground and covered with leaf litter (Moll et al. 1986). According to Whitaker and Vijaya (2009), females produce one to two clutches in a year; a clutch consists of 1–4 eggs, but usually 2 eggs; females deposit the first clutch between October to December and can nest a second time in February to April. Females lay eggs in narrow crevices under logs or big pieces of bark; they neither dig an egg chamber, nor cover them with substrate or leaves. A clutch at the Madras Crocodile Bank Trust had two eggs that measured 44 x 22.5 and 45 x 23.5 mm; eggs from other clutches measured between 40 x 21.5 to 41 x 24 mm; hormone-induced oviposition using oxytocin during January and February was successful, and an incubation temperature of 27°C resulted in hatchlings emerging after 91 to 96 days (Whitaker and Vijaya 2009). A week-old hatchling was found in Kanyakumari Forest Division during December (Daniels 2001).

Population Status. — The Cane Turtle was considered rare by Henderson (1912), Groombridge et al. (1983), and Vijaya (1983). The species is cryptic, and therefore detections were infrequent, prompting previous researchers to consider the species as ecologically rare. Intensive studies by J. Vijaya in Chalakudi district in Kerala and more recently by V. Deepak and others have revealed that they are probably patchily distributed, but in sites where they are found, they occur in relatively high densities. A total of 317 man-hours spent in searches between February 2006 and October 2007 in six different localities in the Anamalai hills yielded 49 turtles; within an intensively monitored area of 42 ha in the same area, 35 turtles (23 males, 9 females, 3 juveniles) were found between January 2007 and October 2009 (Vasudevan et al. 2010). In Chalakudy, Kerala (also in the Anamalai hills), 135 turtles were reported from an area of 1390 ha, approximating 0.1 turtles per hectare (Whitaker and Vijaya 2009). In a recent study, 0.83 turtles per hectare were found, suggesting that they can occur at relatively high densities on the forest floor (Vasudevan et al. 2010).

The remnant habitats suitable for the species are constrained in the mountains by the upper limit in its elevational distribution (up to 800 m asl), and by the complete decimation of low elevation evergreen forests (below 400 m asl). Therefore, the Cane Turtle appears to occur in relatively high densities in small scattered patches throughout its limited geographic range in the Western Ghats.

Threats to Survival. — Hunting of Cane Turtles for bush meat using dogs by native people of the Kadar tribe was reported from Chalakudy, Kerala (Vijaya 1982). Deforestation and alteration of habitat is rampant and ongoing in the Western Ghats (Jha et al. 2000; Anand et al. 2010) and the consequences for *V. silvatica* populations is of concern. There are 24 operational and 12 proposed hydroelectric projects to be implemented in the state of Kerala alone (Sreekumar and Balakrishnan 1998; Nikhil Raj et al. 2009); such projects if implemented could submerge habitats for the species. The species is exploited in illegal wildlife trade; however, the level of exploitation and the nature of utilization of the species is not known. Forest fires and human consumption were reported as the greatest threats to the species in a survey of local ecological knowledge (Kanagavel and Raghavan 2012).

Conservation Measures Taken. — *Vijayachelys silvatica* is protected under Schedule I of Indian Wildlife (Protection) Act of 1972. It has been listed on the IUCN Red List as Endangered since 2000; the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group provisionally re-assessed it as Endangered in 2011. It has recently (2013) been listed on CITES Appendix II.

Any form of exploitation of the species can result in imprisonment for a term of not less than three years and up to seven years; further penalties not less than 25,000 Indian

Rupees could be imposed. A total of 53 protected areas covering an area of 11,222 km² have been gazetted in the Western Ghats, covering 17% of the entire biogeographic region (Source: PA network, Wildlife Institute of India); however, *V. silvatica* is known to occur in only ten of these, which have an area of 2458 km² (Deepak and Vasudevan 2009; Vasudevan et al. 2010). And since *V. silvatica* is a habitat specialist, it would occupy only a fragmented fraction of the total area under protection.

The species has been reported to occur in the following protected areas (Deepak and Vasudevan 2009): Peechi-Vazhani, Neyyar, Peppara, Idukki, and Aralam Wildlife Sanctuaries and Parambikulam Tiger Reserve in Kerala, Anamalai Tiger Reserve (Indira Gandhi Wildlife Sanctuary) and Karian Shola National Park in Tamil Nadu, and Mookambika Wildlife Sanctuary in Karnataka.

Conservation Measures Proposed. — We agree that the current IUCN Red List status of Endangered be retained for *V. silvatica* because it is an endemic species experiencing hunting pressure and survives in small declining fragmented populations. Recurrent attempts to establish new hydroelectric projects in this region will result in rapid, extensive, and irreversible habitat loss. The conservation concerns of the Cane Turtle should be taken into consideration before such projects are initiated. Conservation efforts focusing on increasing the Protected Areas coverage by identifying small community-owned or state-owned areas and improving connectivity between populations will be one of the priorities for the survival of the species. Creating awareness among wildlife protection staff and local people about the conservation status of the species should help improve protection and reduce exploitation of the species. Removal of domestic dogs from Protected Areas will also considerably reduce the threat of exploitation of the species. Primary evergreen forests at elevations between 400–800 m asl provide suitable habitat for the Cane Turtle. The forests in this narrow elevation zone are also severely fragmented; therefore, a targeted management strategy is required to ensure protection of this critical habitat. Reproductive ecology of the species *in-situ* and breeding in captivity are poorly understood. Studies focusing on conservation breeding need to be initiated in zoological parks.

Captive Husbandry. — The Centre for Herpetology at Madras Crocodile Bank Trust had a few captive individuals of this species, and some observations on this group have been published (Vijaya 1983; Moll et al. 1986). At present there are no captive populations in the country.

Current Research. — Several recently completed research projects by Wildlife Institute of India on the ecology of *V. silvatica* in the wild in the Anamalai hills have published their preliminary results (Vasudevan and Deepak 2008, 2010; Deepak et al. 2009; Deepak and Vasudevan 2010; Vasudevan et al. 2010).

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