

King Cobra *Ophiophagus hannah* (Cantor, 1836) encounters in human-modified rainforests of the Western Ghats, India

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ABSTRACT.– We captured and relocated 106 King Cobras (*Ophiophagus hannah*) that were reported by villagers to the first author from human settlements. We report on their morphology, circumstances and possible reasons for their entering human settlements. Males were brownish to olive green with black tails, averaged 3.5 m (TBL) and 4.5 kg mass, whereas females were uniformly black or brown, 2.5 m (TBL) and 3.4 kg mass. King Cobras (*Ophiophagus hannah*) were usually seen as they were resting after a meal (as witnessed and reported by villagers) or foraging in paddy fields at 10.00–12.00 hrs, likely hunting for the ubiquitous Rat Snake (*Ptyas mucosa*) and Spectacled Cobra (*Naja naja*). We received most rescue calls between March and August, which coincides with their breeding season in southern India.

KEYWORDS.– King Cobra, spatio-temporal dynamics, sexual-dimorphism, removal, relocation, frequency, circumstances.

Introduction

Human encroachment on natural landscapes is a major cause of serious decline in global wildlife populations (McKee *et al.* 2003). Ever-changing land-use types cannot only eliminate fragile wildlife, but also force adaptive species to change their patterns of behavior (Brooks *et al.* 2002). Apex predators may be affected the most (Berger 1999).

Understanding the autecology of predators persisting in human-modified landscapes is the first step towards conserving these species (Elton 1927). Although anthropogenically-altered landscapes often do not support stable wildlife populations (Bender *et al.* 1998), some species may persist in certain human-dominated landscapes. Understanding the natural history of a species is essential to develop conservation

measures to protect the habitat and the species alike.

While large mammals, especially carnivores, have received much research attention in this respect (Bekoff *et al.* 1984; Weaver *et al.* 1996; Wickramanayake *et al.* 1998), other taxa, such as snakes, have rarely been studied in such detail (but see Shine & Fitzgerald 2000). Herein, we report on the spatio-temporal dynamics of King Cobras persisting in a human-modified agro-forest ecosystem.

Material and Methods

Study Species.– Capable of growing up to 5.5 m in length, the King Cobra (Reptilia: Serpentes: Elapidae: *Ophiophagus hannah* Cantor, 1836) is the largest venomous snake in the world. This largely diurnal, actively foraging snake inhabits

moist, forested tracts of southern Asia, where its diet consists primarily of other snakes. The King Cobra is oviparous, and it is the only snake that is known to build a nest (Aagaard 1924; Smith 1943; Whitaker 1978; Daniel 2002; Pfaff 2002; Whitaker & Captain 2004).

Study Area.—Agumbe ($13^{\circ}50.87'N, 075^{\circ}09.59'E$; 557 m a.s.l., Fig. 1) is an agricultural and Reserve Forest complex situated in the Malnad region of Karnataka, in the Western Ghats. The Western Ghats, identified by Myers *et al.* (2000) as a global biodiversity hotspot, was recently recognized as a World Heritage Site (UNESCO, 2012, Ref: 1342rev). In addition to agricultural land, Agumbe is covered mainly by tropical wet evergreen sub-montane and lowland rainforests. Agumbe is the wettest place in south India, receiving an average annual rainfall of over 8 m during the south-west monsoon season which occurs between the months of June and September (Champion & Seth 1968; Ramaswamy *et al.* 2001). Agumbe is a mosaic of land use types, containing human settlements, areca, coconut, acacia plantations and paddy fields, interspersed with stretches of forests in various stages of regeneration/degradation, depending on local human pressures and effectiveness of protection by the Forest Department.

Data Collection.— We obtained data on King Cobras from 2005 to 2009. Generally villagers here have high tolerance toward the King Cobra and seek help only after the snake is given ample time to move out on its own. We attended each King Cobra 'rescue' call and reassessed the situation and rescue operation was carried out only if it was close to their homes. We recorded complete details of the informant, locality of the house or other private holding into which the snake entered. We captured each snake using snake hooks and cloth bags (after Whitaker 1970) in the presence of local Forest Department authorities. We determined the sex

of all captured individuals by probing and obtained masses using a calibrated spring balance (Pesola). Because we were unable to obtain permission to anesthetize snakes for processing, we visually estimated the total body length (TBL) length of each snake, relying on our prior experience measuring captive, sedated, and dead King Cobras. We also documented the colouration of each snake. Early in the study, we relocated the snakes a considerable distance away from the site of capture according to the wishes of the local people and instructions of the authorities. However, when it was inferred from our ongoing radiotelemetry study that the King Cobra has a clearly defined home range, we generally released snakes within one kilometer of the site of capture (Whitaker *et al.* 2011). We could not permanently mark released snakes because we were unable to obtain permission from the Forest Department.

Results

In a five year period from 2005 to 2009, we captured and relocated a total of 106 King Cobras (Table 1). Table 1 reveals that most King Co-

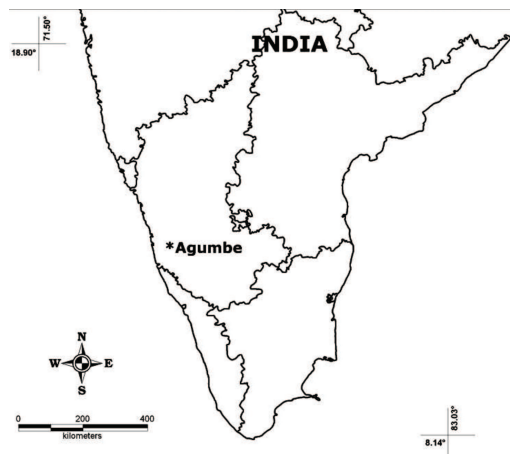


Figure 1. Location map of the study area, Agumbe, Karnataka, India.

Table 1. Monthly incidences of King Cobra captures by year. Bold numbers indicate the highest value in each year.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	—	1	9	1	1	1	—	1	2	2	1	1
2006	6	1	4	—	7	1	5	2	1	1	1	—
2007	3	2	5	1	—	—	—	1	—	—	—	—
2008	1	2	6	4	—	2	—	2	—	—	—	1
2009	1	3	4	1	2	1	2	5	2	1	4	1

bras were caught during the months of February, March (pre-monsoon season) and August (southwest monsoon season). King cobra encounters were on average lower during the months September through December. The lowest and highest frequencies per month ranged from 1–9 individuals. In 15 out of 60 months there were no King Cobra encounters reported.

In order to quantify sexual dimorphism, we compared the predominant dorsal fore-body color, length (m) and mass (kg) for males ($n = 79$) and females ($n = 27$) (Figs. 2, 3, 4).

We found that most snakes were reported in the late morning (10h00–12h00; Fig. 5), mainly from vegetation associated with paddy fields (Figs. 6, 7).

In an effort to understand why King Cobras enter human landscapes, we recorded behavioral observations on each snake we captured. After having been informed by villagers that the snake had been seen either foraging or feeding the previous evening or earlier that day we observed most King Cobras as they were resting after their meal or foraging in paddy fields typically from 10h00–12h00 (Fig. 8). Villagers confirmed that snakes commonly enter farms and settlements (Fig. 9) hunting for prey in paddy fields. These paddy fields contain high densities of rats, which presumably attract what appear to be unusually large numbers of Rat Snakes (*Ptyas mucosa*) and Spectacled Cobras (*Naja naja*) as compared to forest areas with a relative paucity of rodent prey. These are ideal prey

items for King Cobras as they are both large, common snakes which we have often observed being preyed upon by King Cobras (pers. obs.).

Discussion

Our study demonstrates that females were smaller and darker in colouration, while males were larger and paler (Fig. 10) which is consistent with the literature (Leakey 1969; Pfaff 1995, 2002; Whitaker & Captain 2004). We found this difference in colouration to be more pronounced in the breeding season. Additionally, we observed males to be darker during wet seasons, which we believe may be a thermoregulatory

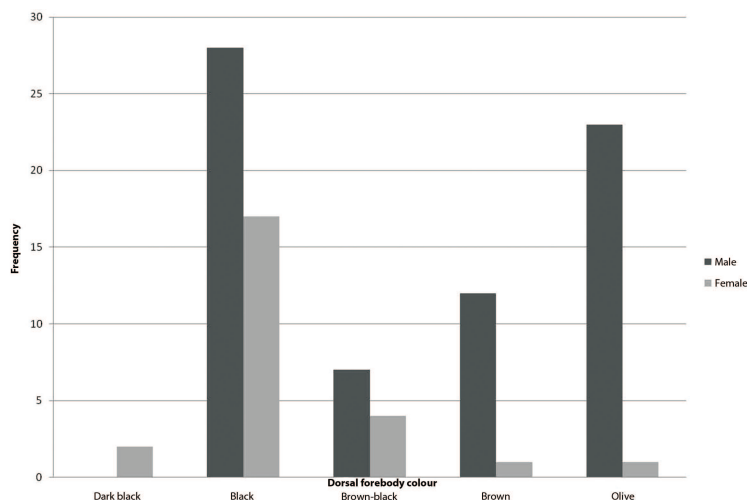


Figure 2. Dorsal fore-body colouration of male and female King Cobras.

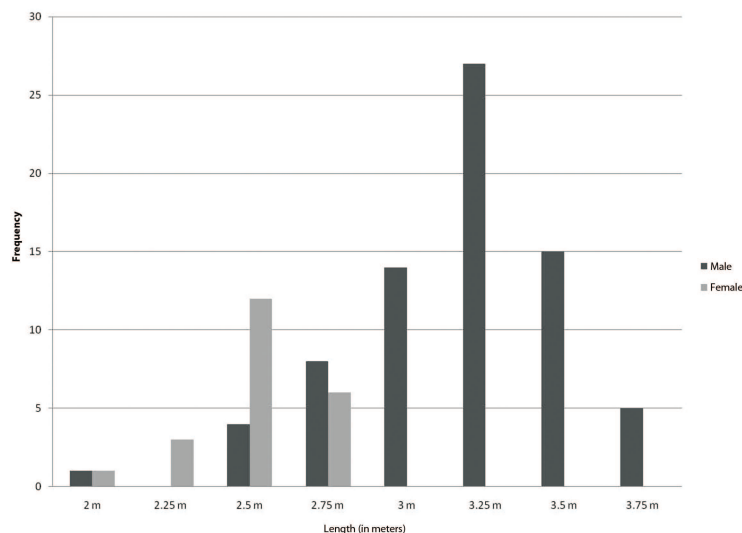


Figure 3. Length (m) of male and female King Cobras in the study.

adaptation (PGS & RW pers. obs.). In fact, sexual dimorphism in this species is so pronounced that Evans (1902) believed that males and females were two different species. In our work, males outnumbered females by nearly three to one, possibly because they have larger home ranges, require more prey and more actively search for mates during the breeding season (unpubl. data). Indeed, we received more King Cobra rescue calls during the breeding season.

We captured several snakes from riparian habitat, which the snake has an apparent affinity for (Leakey 1969; Pfaff 1995, 2002; Whitaker & Captain 2004). Our study indicated that this species is active year round, moves freely in paddy fields, open clearings and thinly forested tracts. This is contrary to Daniel (2002), who remarks that it inhabits dense jungles in the hills or their vicinity in peninsular India. Our work revealed that an average of 21 snakes (range = 12-29) are 'rescued' per year in the Agumbe area, although some snake rescuers who work in nearby districts have reportedly rescued hundreds of King Cobras per year. These snakes were often released in our study site, having been relocated from around ca. 40-60 km radius. Such

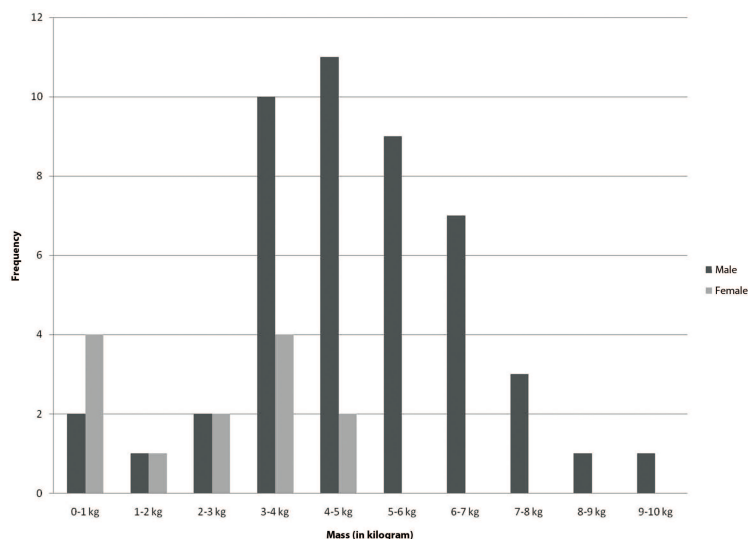


Figure 4. Mass (kg) of male and female King Cobras in the study.

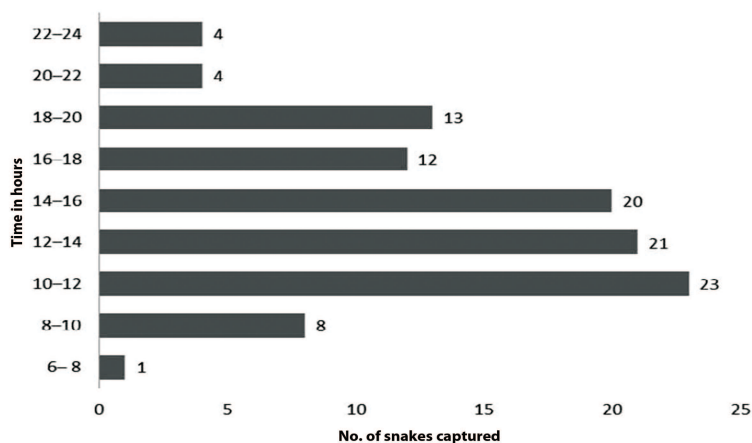


Figure 5. Time of day of captures of King Cobras from human habitations.

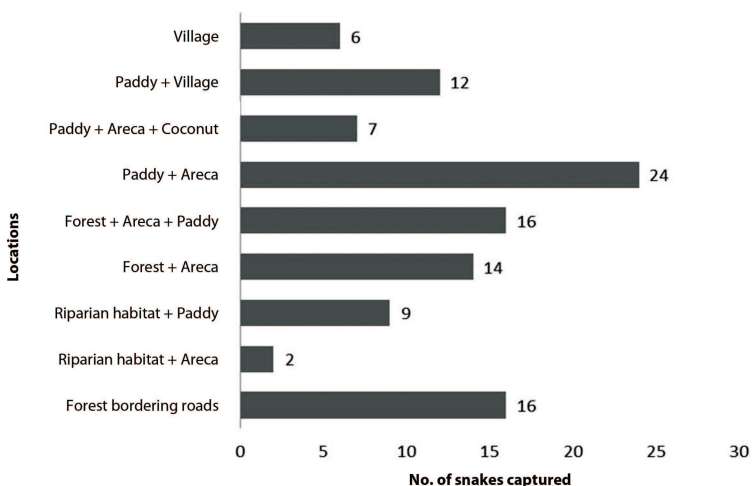


Figure 6. Habitats from which King Cobras were captured.

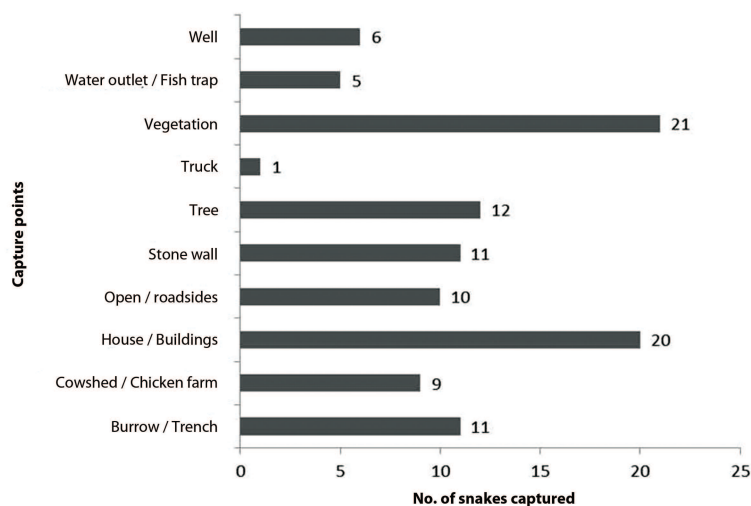


Figure 7. Location of King Cobra capture points.

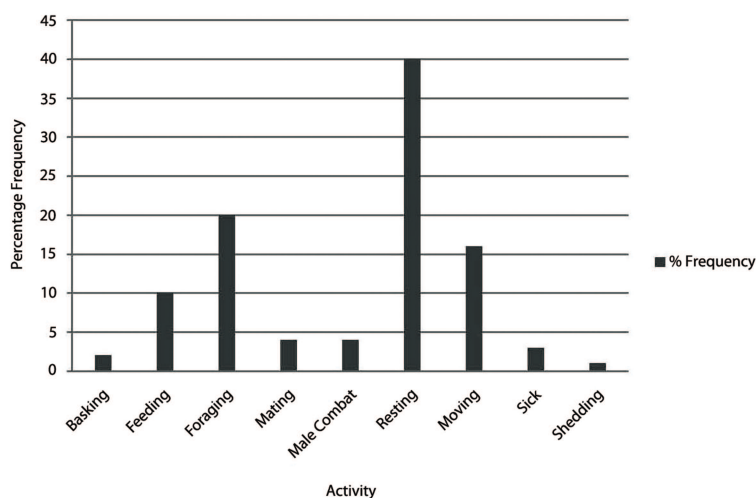


Figure 8. Activities and physical condition of King Cobras encountered around human settlements.

distantly relocated King Cobras could possibly be the ones noted by us to be 'sick' snakes, as our telemetry studies reveal that long-travelling snakes soon become evidently weak. Sick snakes

were clearly discerned by an evidently visible vertebral column and ribs, resulting from malnutrition (Fig. 11). It is noteworthy to mention here that a long-term study on King Cobras has never been done (Das & Whitaker 1996), despite the fact that it is a charismatic species with a very high public awareness profile and a wide distribution in several south Asian countries (Smith 1943; Whitaker 1978; Daniel 2002; Whitaker & Captain 2004). This highlights the necessity of continued research on this unique snake. Insight into its natural history is vital to the conservation of this species. Considering that the King Cobra is persecuted throughout much of the rest of its range, it appears that the Malnad people's remarkable tolerance and reverential attitude toward the King Cobra is crucial to driving conservation of this potentially dangerous snake in a predominantly human-altered landscape.

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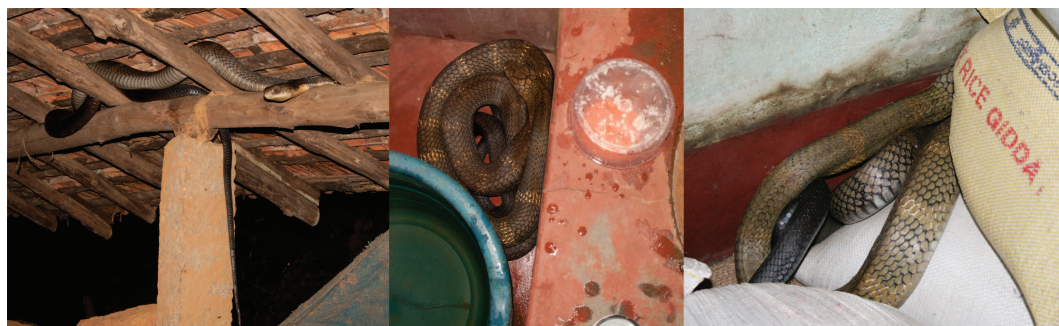


Figure 9. Various capture points of wild King Cobras in manmade structures in the Agumbe region.



Figure 10. Sexual dimorphism and dichromatism of Agumbe King Cobras showing a larger, paler (left) and a smaller, darker female (right).

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Figure 11. Emaciated King Cobra in poor health.

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