Factors influencing human hostility to King Cobras (Ophiophagus hannah) in the Western Ghats of India

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Factors influencing human hostility to King Cobras (*Ophiophagus hannah*) in the Western Ghats of India.

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ABSTRACT.– **This paper investigates people's perceptions toward King Cobras in the tropical rainforests of the Western Ghats ecoregion of southern India. We built logistic regression models to test if people's perceptions (to kill/not to kill the snake) were influenced by factors such as the snake's size and defensiveness, whether the snake was found near human habitation, the time of encounter and season. The model correctly classified over 80% of instances when people expressed an inclination to kill the snake. Results support our expectation that the snake's defensiveness escalates the probability that the snake will be killed, but are contrary in that smaller snakes are more likely to be killed than larger ones, especially when encountered away from human habitation. Findings suggest a need for slight refocusing of King Cobra conservation outreach efforts towards smaller snakes, especially in regions where sizeable human habitations exist near fragmented King Cobra habitat.**

KEYWORDS.– **Agumbe, ARRS, King Cobra, logistic regression, mortality risk.**

Introduction

There is consensus that a variety of direct and indirect anthropogenic stressors may be linked to biodiversity loss worldwide (Ehrlich 1994; Pimm *et al*. 1995). Although direct persecution and habitat destruction contributes more to extinction risks in the majority of the species (Dodd 1987; Caughley & Sinclair 1994; Bonnet *et al*. 1999), intentional but non-exploitative killing of wildlife (i.e., retaliatory killing) could be an important but overlooked stressor (Mishra 1997; Kissui 2008; Liu *et al*. 2011). It is clear that formulating conservation strategies for species that are perceived as dangerous to humans can be difficult given the need to balance human and wildlife welfare. This is especially true for snakes, against which humans harbor deep-seated prejudices (Ohman & Mineka 2003; Prokop *et al*. 2009; Fita *et al*. 2010; Prokop & Fancovicova 2010).

From a biological standpoint, studies have identified combinations of behavioral and life-history traits and seasonal factors that affect mortality patterns in snakes. Reed & Shine (2002) found extinction risk in Australian elapid snakes to be related to foraging habit and combat behavior wherein ambush predators and snakes that do not engage in male-male combat were at a higher risk of extinction. Bonnet *et al*. (1999) found that snakes that dispersed over long distances were more at risk than their more sedentary conspecifics, and were more likely to be killed during the mating season. Although a number of studies have investigated patterns of

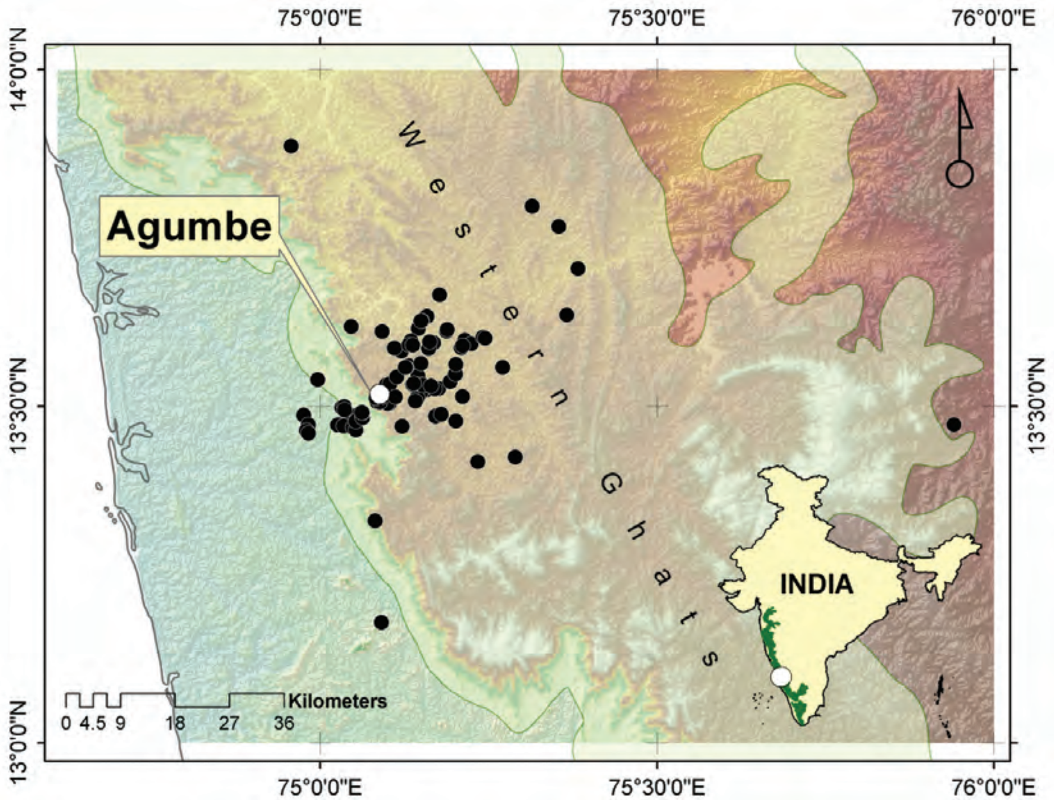

Figure 1. Location of Agumbe (○) in the Western Ghats of South India overlaid on a terrain-shaded map. Locations where encounters were reported from are shown as filled circles (●).

human-caused mortality in snakes (Bonnet *et al*. 1999; Lode 2000; Whitaker & Shine 2000; Akani *et al*. 2002; Ciesiolkiewicz *et al*. 2006), most have focused on factors influencing indirect or accidental mortality, such as via vehicular accidents. For example, Row *et al*. (2007) estimated road mortality to cause an increase in extinction probability from 7.3% to 99% over 500 years for black rattlesnakes in Ontario, Canada. Whereas estimates for intentional anthropogenic mortality are generally rare (Bonnet *et al*. 1999), Akani *et al*. (2002) could attribute ca. 50% of cases of snake mortality to intentional killing by humans in the Niger Delta. Akani *et al*. (2002) also found a significant seasonal pattern to snake encounters in human habitat wherein most events were related with rainfall events that forced snakes from their natural refuge to places inhabited by humans.

From the human standpoint, negative perceptions of snakes are believed to have evolutionary roots (Ohman & Mineka 2003) and have been observed as behavioral manifestations across countries and cultures (Prokop *et al*. 2009; Fita *et al*. 2010). As a result, conservation programs focused on snakes have to deal with two distinct issues: 1) patterns of snake behavior that put snakes in direct contact with humans and, 2) overcoming inherent human responses to encounters with snakes that make outreach and sensitization difficult. Sensitization is especially difficult when the species involved are venomous and easily identified as such. The issue is further compounded in developing countries where large human populations exist in close proximity to wildlife habitat and where the largest number of cases of envenomation occur (Harrison *et al*. 2009). Factors that affect the ability of snakes and humans to cohabitate are therefore important both from snake conservation and human welfare standpoints. This is especially important for a mega diverse country like India that reports a disproportionate number of snake envenomation cases globally (mortality estimates ranging widely from about 1300 to 50 000; Mohapatra *et al*. 2011)

The focus of this study, the King Cobra (*Ophiophagus hannah*, Cantor 1836) is the largest venomous snake in the world (Tin-Myint *et al*. 1991; Das 1996; Whitaker & Captain 2004; Inger *et al*. 2009). Largely diurnal, the snake can reach up to 5.5 m in length, feeds mainly on snakes, is oviparous, and is the only snake that builds a nest (Aagaard 1924; Smith 1943; Whitaker 1978; Daniel 2002; Whitaker & Captain 2004). Classified 'Vulnerable' by the IUCN (Inger *et al*. 2009), King Cobras are mostly found in and around the tropical rainforests of India, southern China and southeast Asia. They also inhabit a variety of microhabitats such as mangrove swamps, agricultural fields, and have been reported from degraded semi-evergreen and deciduous forest fragments in India. Although data on population trends of King Cobras in India are insufficient, it is thought that continuing habitat destruction and degradation may be negatively influencing their numbers (Inger *et al*. 2009).

Although many communities in India consider snakes (especially cobras, *Naja* spp.) sacred due to religious beliefs (Joshi & Joshi 2010), King Cobras are often killed when they come in contact with humans. Although the exact reasons are unknown, King Cobras in the region likely enter human habitations to seek other snakes (their major prey), which in turn, are probably attracted to a higher relative density of rodents around agricultural fields and household granaries. Human reactions to King Cobra encounters in India and elsewhere may be a complex combination of societal and situational factors. Such factors could include the behavior of the snake (i.e., level of defensiveness), the location where the snake is encountered (e.g., inside sleeping quarters of a dwelling), seasonal factors (such as during monsoons when burrows used as refuge by snakes are flooded, and during the mating season) or socio-cultural factors (religious beliefs, levels of formal education, prior exposure to sensitization).

This study investigates factors influencing people's perceptions (intention to kill, or leave a snake alone) in events of encounters with King Cobras in and around villages situated in tropical rainforests in southern India. We hypothesize that 1) people would be more hostile to highly defensive snakes, as a highly defensive snake may pose a greater immediate danger to people in the vicinity; 2) people would be more hostile to larger and healthier snakes, as a large (and healthy) snake could be perceived as more dangerous with respect to quickness, strength and perceived venom delivery than a smaller (or sicker) one; 3) people would be more inclined to kill a snake when encountered inside or near human habitation because of the perceived direct danger posed to humans and 4) people would be more inclined to kill a snake when encountered in the dark, as darkness could be perceived to confer an elevated opportunity to the snake to either escape or evade detection. Although societal and/or educational factors may strongly influence people's perceptions, we do not currently have data on socio-economic or cultural factors.

We believe that information on what shapes people's reactions to King Cobra encounters could be invaluable from both public welfare and management standpoints. Such information could aid King Cobra conservation by improving management of snake-human encounters, as well as for retooling conservation, education and first-response strategies. To the extent of our knowledge, this is the first study of its kind in the Indian subcontinent.

Material and Methods

Study area.– Agumbe is situated in a reserve forest in the Western Ghats Ecoregion of India (13°30'15" E, 75°5'25" N, Fig.1). The region harbors high levels of biodiversity, much of which is endemic. Not only is the Western Ghats ecoregion a global biodiversity hotspot (Mittermeier *et al*. 1998; Myers *et al*. 2000; Myers 2003) it was also recently designated a UNESCO World Heritage Site (UNESCO 2012). The physiography consists of forested hills, tropical evergreen rainforest (Champion & Seth 1968; Ramaswamy *et al*. 2001) and floodplains characterized by a mosaic of agriculture (paddy) and plantations (areca, coconut, plantain, acacia). The region is one of the wettest regions in southern India and receives an annual rainfall of ca. 8000 mm during the southwest monsoon (June–September). Terrain elevation ranges from 150 m to 800 m.

Data collection.– A research program initiated by the Agumbe Rainforest Research Station (hereafter ARRS) has been monitoring human-

Table 1. Number of total King Cobra rescue calls (2005–2009) received at ARRS, cross-tabulated by location where snake was encountered. Rescue calls in the breeding season are shown in bold typeface.

Month	Field	House	Forest	Plan-tation	Settle-ment	Total
Jan	4	7				11
Feb	3	6		1		10
Mar	12	9	3	3	2	29
Apr		3	2		1	6
May	1	6	1	1		9
Jun	1	3			1	5
Jul	1	5				6
Aug	2	1	4	1		8
Sep	1	4	1	2		8
Oct	2		1	1	1	5
Nov	3	3				6
Dec		1			2	3
Total	30	48	12	9	7	106

King Cobra encounters since 2005. Data for this study were collected over a five-year period from 2005–2009. The ARRS conducts long-term ecological research into the biology of the King Cobra as well as provides educational and outreach programs to village communities in the region. The outreach program at ARRS has ensured that most, if not all, King Cobra-human encounters are immediately reported and responded to. For each 'rescue' call received at the ARRS, a team comprised of a trained snake catcher and community outreach specialists were immediately dispatched. On arrival, the team evacuated all people from the immediate location and outreach specialists conducted a semi-structured interview of the first responders and the owners of the property. Outreach specialists also delivered a comprehensive "snake-talk" to people present at the location. In the meantime, the snake rescue specialist safely captured the snake using hooked sticks and cloth bags (Fig. 2, following the protocol by Whitaker 1970). The rescue specialist took length and weight measurements to the nearest centimeter and gram respectively, determined its gender, deposited it in custom-made bags, and prepared it to be safely released in a forested region at least a kilometer away from the capture locality. A brief health assessment of the snake was also carried out. We termed the health 'good' when the snake had a more or less circular body cross section and the vertebral column not visible through the skin, 'moderate' when the snake had a more or less round body with slightly evident vertebral column and 'poor' when the snake had a tented body with the vertebral column and rib bones easily visible. For each such call, details of the physical environment and the (pre-capture) opinion of the responders towards either killing or not killing the snake were also recorded.

The behavior of the snake was assessed by taking into consideration the objective opinion of the first responders, and by observations made by the team before the rescue commenced. The behavior was judged 'very defensive' when the snake reared up hooded, hissed and charged when first approached; 'defensive' when the snake reared up hooded, hissed and charged once disturbed during capture; 'moderate' when the snake showed moderate resistance to handling and 'docile' when the snake did not exhibit any signs of vigorous resistance during the course of rescue.

Statistical analysis.– As the response of responders (intention to kill/ not kill) was best modeled as a binary (1/0) choice, we built logistic regression models to model the response as a function of the variables: snake defensiveness (categorical: five levels: very defensive to very

Figure 2. An adult King Cobra being rescued from a well near Agumbe. Photo P. Gowri Shankar.

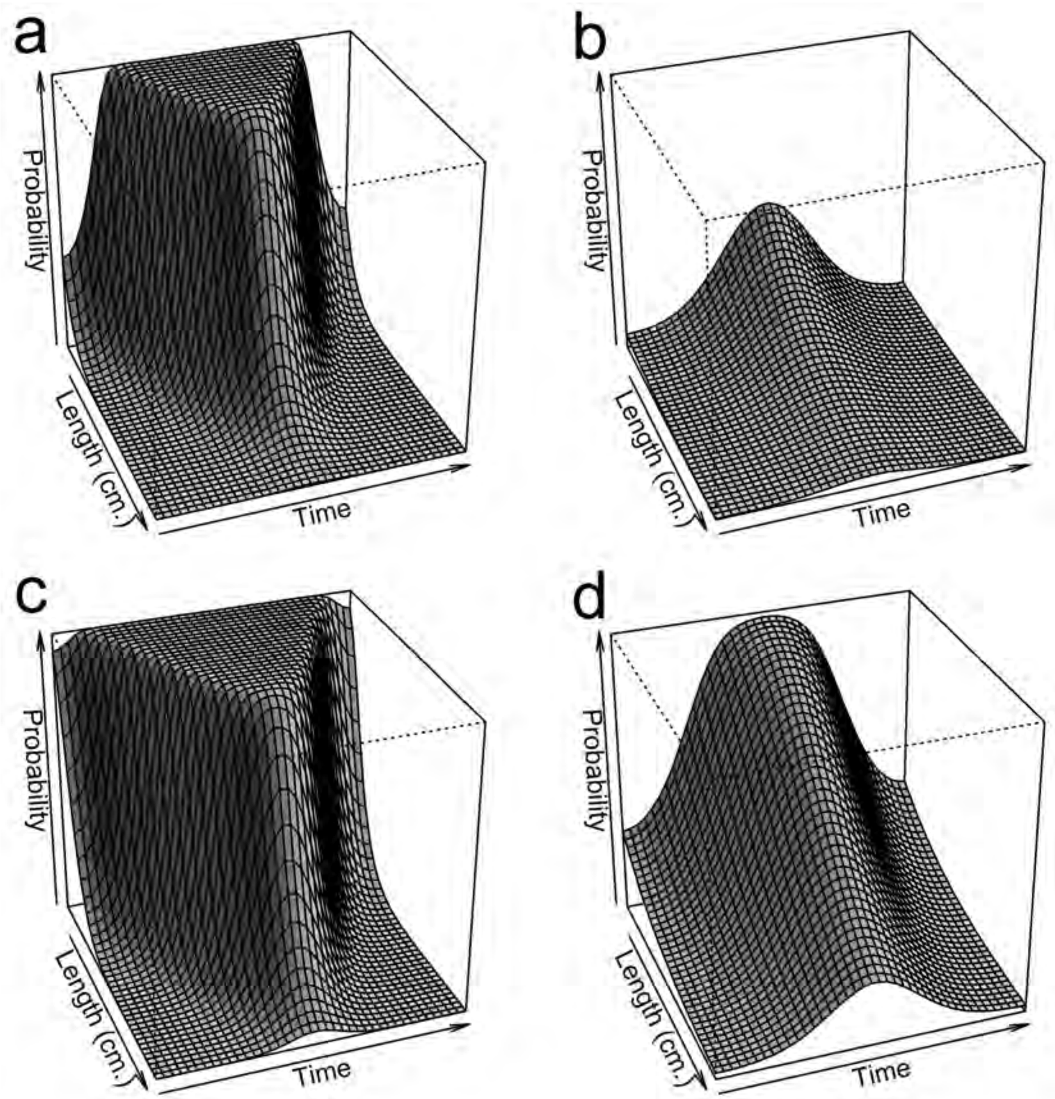

Figure 3. Surface plots showing the probability that a snake would be killed (on the *z*-axis) as a function of snake length (*y*-axis: min = 55cm, max = 400cm.) and time-of-day (*x*-axis; extremes denote midnight, axis midpoint denotes midday). Note: the *z*-axis is scaled from 0 to 1 in all subplots, probabilities are symmetric about the midpoint of the time (*x*) axis. Subplots grouped by combinations of whether a snake was defensive (subplot a, c) or docile (subplot b, d); if it was found in human habitation (subplot a, b) or in an open area (subplot c, d).

docile), health (categorical: three levels; bad, moderate, good), month (categorical), snake size (length in cm.), location (binary, near or inside house, well, shed or granary = 1, 0 elsewhere) and time of encounter (sine-transformed to scale midday to 1.0 and midnight to -1.0). We did not use the snake's mass as a proxy for size because 1) mass is highly correlated with length and 2) people would most likely find it easier to estimate length as opposed to mass as a proxy for size. Being a perception study, the gender of the snake was excluded as a predictor as none of the interviewees could give consistent guesses on the gender of the snake, and it likely did not influence their eventual perception. We sequentially tested all main and all possible two-way interaction effects between all variables for significance. We sequentially dropped all non-significant effects until only significant interaction effects and associated main effects remained. Preliminary analyses revealed that defensiveness was better modeled as a binary variable

Table 2. Results from a logistic regression model investigating factors affecting people's opinions (kill = 1, not kill = 0) on encounters with King Cobras in the Western Ghats of India (*n* = 106, Wald χ^2 = 19.28, df = 6, $P < 0.0037$). The model used a complementary log-log link function. The model correctly classified 83.8% of all cases where people wanted to kill Cobras (AUC = 0.839).

Parameter	df	*β*	S.E.	*P*
Intercept	1	0.607	1.670	0.7160
Defensive	1	6.129	2.056	0.0029
Length (cm)	1	-0.008	0.005	0.1672
Length*defensive	1	-0.026	0.007	0.0004
Habitation	1	-1.890	0.535	0.0004
Time	1	1.227	0.983	0.2122
Time*defensive	1	2.613	1.006	0.0094

and was thus recoded as such (very defensive or defensive = 1, moderate or docile = 0). Because the snake's defensiveness could be a major factor determining public perception, we separately modeled the snake's defensiveness as a function of size, month (or March = 1 as a binary variable denoting the end of breeding season), time of day and location. Finally, we used Moran's I (Moran 1950) to test for spatial autocorrelation in standardized residuals from the final model. All statistical analysis was conducted using SAS software, Version 9.2 (SAS System for Windows © 2002–2008, SAS Institute, Inc. Cary, North Carolina, USA).

Results

A total of 107 rescue calls were attended to between 2005 and 2009 (mean: 21 ± 7SD Year^{-1}). The maximum number of rescues were conducted in 2006 (N = 29) and 2009 (N = 28). Reporting patterns did not follow any predictable trend across years (P > 0.1). Across months however, rescue calls increased significantly in post-winter months (Jan–March mean: 16.66 ± 10.69 SD) in comparison to the rest of the year (Apr-Dec: mean: 6.33 ± 1.87 SD, P < 0.001). Rescue calls peaked in March, when there were approximately seven times as many rescues as the annual average (mean excluding March: 7.09 ± 2.3 SD). It should be noted that the breeding season for King Cobras starts around January, peaks in March, and culminates with hatching of the young near late July or early August. As expected, the majority of snakes were reported from around human habitation (88.68% in any human use area, 45.28% of total inside houses, Table 1). Although no trend was apparent for non-breeding months, a large majority of the calls during the early breeding season (Jan–Feb) involved snakes encountered in houses (>60%) and in agricultural fields or plantations in March (~40%). Around 80% of the snakes were found in good health, and on average measured 297.05 ± 6.38 cm in length (N = 107, range: 55.5–396.24 cm) and weighed 4464.54 ± 286.03 g (N = 63, range: 22–12 000 g). Responders expressed an inclination to kill the snake in only 14% of the cases.

We used a complementary log-log link function to fit the logistic regression model as response proportions were skewed (14% kill, 86% not kill). One observation did not have sufficient information on covariates and was dropped from all subsequent analyses. After removing all non-significant effects, the logistic regression model retained only four variables (Table 2), and correctly classified 83.8% of all instances where people wanted the snake killed. The main effect of the variable coding for human habitation was significant (P = 0.002) as were the interaction effects of length of snake and defensiveness (P = 0.001), and the time of day and defensiveness (P = 0.02). Tests for spatial autocorrelation in residuals were not significant (Moran's I, P > 0.1) indicating no significant spatial clustering in public perceptions and encounter reporting patterns. As independent examination of individual variables was difficult due to the presence of two interaction effects, we built 'kill-probability' response surfaces by segmenting the model by the categorical variables 'habitation' and 'de-

Table 3. Results from logistic regression investigating factors affecting King Cobra defensiveness (Wald χ^2 = 10.63, df = 1, $P < 0.01$). The model correctly classified only 37.7% of all cases where King Cobras displayed defensive behavior (AUC = 0.656).

Parameter	df	β	S.E.	*P*
Intercept	1	-0.715	0.255	0.005
Breeding season	1	1.757	0.539	0.001

fensiveness' and by varying continuous predictors (length of snake and time of day) across the range of the respective measurements.

Results indicate that defensive snakes (Fig 3a, 3c) are at a disproportionately higher risk of being killed than their relatively docile counterparts (Fig 3b, 3d) regardless of whether they are encountered around habitation or in open areas. Also, smaller snakes are more likely to be killed than larger ones regardless of the snake's level of defensiveness or the location where the snake is encountered. Results also indicate that the probability a snake will be killed is generally higher during the day than in the night (Fig 3). A logistic regression model built to explain snake defensiveness retained only 'month = March' as a significant explanatory variable but explained only 37.7% of all cases where the snake was found defensive (Table 3).

Discussion

Our intent was to investigate factors that influence people's opinions on harming King Cobras when encountered in and around human habitation. A logistic regression model relating situational factors with people's opinions successfully predicted over 80% of all cases where people wanted the snake killed rather than left alone. In spite of the apparent good fit of the model, it should be noted that this study is limited to situations when rescue calls are actually made, it may well be that a larger number of snakes are killed (often of the genus *Naja*) and never reported back to the conservation team.

While our expectation that defensive snakes would attract more hostile reactions was supported by the data we collected, none of the other hypotheses were supported. Specifically, when controlling for the size of the snake and the location of encounter, the model confirmed that defensive snakes were far more likely to be killed than ones that were relatively docile. In contrast, for the second hypothesis (larger snakes would be more at risk) the model suggested the opposite. We found that smaller snakes were far more likely to be killed than larger ones across all levels of defensiveness and location of the encounter. While this finding is counterintuitive, we suspect that elevated hostility of people towards smaller King Cobras may be related to the higher apparent likelihood of successfully subduing an 'aggressive' but smaller-sized and identifiably dangerous snake. We speculate that it is likely traditional knowledge in the region that the young of the King Cobra hatch with enough venom to cause mortality in humans. Elevated defensiveness in younger King Cobras has been observed in the field, and has also been widely reported for a number of other species (for example, see Brodie & Russell 1999; Shine *et al*. 2002). Our expectation that people would be more hostile towards snakes found in and around habitation was also not supported by the data. We found that snakes encountered in the open were significantly more likely to be killed than left alone. This finding indicates a potentially elevated mortality risk for King Cobras around forest edges and fragments. Whereas the model showed a significant time-of-day effect, in that people would likely want to have the snake killed when encountered during daytime, we suspect this may be an artifact of the confounding effects of the diurnal nature of the King Cobra coinciding with general activity patterns of humans. In combination, discounting time-of-day as a confounding factor, the model suggests the possibility of the 'ease of subduing' hypothesis to be the leading factor shaping people's perceptions in typical King Cobra encounters. It is likely that smaller snakes are more likely to be killed when encountered in areas where they can be tracked and pursued easily, especially when they display elevated defensive behavior.

The only factor that was a significant predictor for snake defensiveness was the binary variable coding for the month of March. This may indicate a seasonal pattern to snake defensiveness related to breeding and nesting phenology of King Cobras. In general, defensiveness in snakes has been related to antipredator behavior (in this case, likely a response to humans, also see: Bonnet *et al*. 2005; Aubret *et al*. 2011), seasonal weather patterns (Schieffelin & Dequeiroz 1991; Brodie & Russell 1999; Mori & Burghardt 2004), reproductive status (Brodie & Russell 1999; Brown & Shine 2004) and body condition (Shine *et al*. 2000; Shine *et al*. 2002). Although we currently do not have data to test these theories specifically for the King Cobra, they are a subject of ongoing research at ARRS.

From a conservation standpoint, the finding that smaller snakes are more likely to be killed could lead to the possibility of a population bottleneck occurring, especially if increasing habitat degradation and fragmentation drives more snakes into human habitation. Increased intentional anthropogenic mortality may pose an additional stressor to King Cobra populations when compounded with persecution from domesticated mesopredators (such as dogs, pigs) around forest edges. Further, such direct anthropogenic stressors may aggravate reproductive losses King Cobras suffer from nest-raiding mesopredators such as monitor lizards (*Varanus* spp.) and mongooses (*Herpestes* spp.).

From a human welfare and conservation standpoint, the findings point to a need for a slight retuning of outreach focus. Although the current outreach program has focused on educating people on the ecological importance of snakes in general, the focus on protecting smaller snakes could probably be emphasized. There is also the possibility of implementing sensitization programs and classes to train affected people in the safe handling of smaller snakes for removal from houses. Overall, these findings could be utilized to design better conservation and outreach strategies in India; and perhaps in other regions with extant King Cobra populations.

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