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A preliminary study on translocation of "rescued" King Cobras (*Ophiophagus hannah*)

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ABSTRACT.– Translocation of "nuisance" snakes is a common practice in India. We investigated effects of translocation on movement patterns and home range characteristics of King Cobras (*Ophiophagus hannah* Cantor, 1836) living in the rainforests of the Western Ghats, Karnataka, India. We radiotracked one translocated snake and two non-translocated snakes. The translocated snake exhibited significantly greater movement frequency, distance moved per day, and total distance moved, and its home range was significantly larger than non-translocated snakes. We present our findings on the potentially deleterious effects of long-distance translocation on King Cobras, and we provide information on the scale of the snake translocation problem in India based on information obtained from snake "rescuers."

KEYWORDS.– King Cobra, *Ophiophagus hannah,* translocation, movement patterns, spatial ecology, snake rescue, radiotelemetry

Introduction

Rapidly expanding human populations, and associated acceleration of habitat destruction and degradation, have led to a dramatic increase in human-wildlife conflicts worldwide (Conover 2002). These conflicts can be classified into four broad categories: 1) competition for space; 2) destruction of crops, gardens or landscaping; 3) depredation of livestock, and; 4) injury or death of humans (Smith 2007). Human-snake conflicts are especially important, because they may result in the deaths of both humans and snakes. In India, an estimated 800 000 snake bites cause as many as 50 000 human deaths and tens-of-thousands of amputations every year (Mohapatra *et al.* 2010). The widespread nature of human-snake conflicts in India is largely due to encroachment on snake habitats by humans, and persistence of snakes in human-dominated environments that provide suitable habitat for snakes (e.g., agricultural developments that attract rodent prey).

The last decade has seen a considerable increase in the number of "snake enthusiasts" or "sarpa-mitra" across India. These "activists" have been successful in safely removing thousands of snakes from houses, where they otherwise would have been killed. The number of "rescue" calls has undoubtedly risen steadily across the country, but reliable data documenting this increase are scant. One NGO in the Delhi region, Wildlife SOS, has received more than 300 rescue calls per month for reptiles, most of which were snakes (http://www.wildlifesos.com/rprotect/repthome.html). The Gujarat Society for Prevention of Cruelty to Animals has rescued up to 1000 snakes per year from the Vadodra region alone (Athreya 2006). Approximately 320 people, who were officially recognized by the Maharashtra State Forest Department, have rescued more than 2000 snakes per year from in and around Mumbai, and many more snake rescues remain undocumented (Nandvikar 2010). Interviews with snake rescu-

Table 1. Estimated number of snakes "rescued" and distances translocated based on interviews of four prominent snake rescuers at four sites in Karnataka, India.

Rescuer	Time Period	No. Snakes	Location	Distance Translocated (km)
Mohan	1997–2010	8000	Bangalore	20–50
Snake Shyam	1997–2010	23000	Mysore	15–60
Kiran	2005–2010	2500	Shimoga	20–30
Naresh	2006–2010	7000	Chikmaglur	15–20

ers in Karnataka have also produced startling figures (Table 1). Although largely anecdotal, we believe that the above estimates provide a fair indication of the scale and frequency of the snake-human conflict problem in India. The sheer magnitude of snake-human confrontations is undoubtedly due to human encroachment on relatively natural areas; however, the dramatic increase in well-intentioned people who "rescue" snakes may be a positive sign of increased awareness of snakes and their plight. After capture, it is normal practice in India to release rescued snakes into the nearest forested area away from human habitation, and release sites are often designated by local forestry department officials. However, there is usually very little thought given to the suitability of release sites or to the fate of translocated snakes. Therefore, translocation is primarily used as a "quick fix" to mitigate "nuisance" snakes, and other wildlife species (Athreya 2006); this is true not only in India, but throughout the world as well. The effect of translocation on snakes has been studied in other countries like Australia, the United States, and England (Germano & Bishop 2008), but not in India, where the number of translocated snakes is undoubtedly much higher than the above-mentioned countries. Many snake species are known to have fixed home ranges, and snakes inhabiting temperate areas are known to use the same hibernacula throughout their lives. However, translocated individuals tend to exhibit aberrant movement patterns, often exhibiting long-distance, fixed-angle movements, in an apparent effort to find their original home range. In some cases, individuals may fail to locate suitable hibernacula, cease reproductive activities and feeding, and even die (Reinert & Rupert 1999). We present a case study on the effects of translocation on King Cobras (*Ophiophagus hannah* Cantor, 1836) by comparing radiotelemetry data from one translocated and two non-translocated snakes in the Western Ghats of southern India.

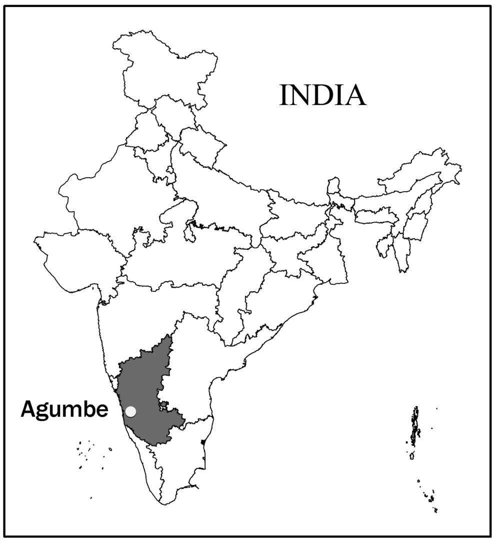

Figure 1. Location of study site in the Agumbe region of the Western Ghats, Karnataka, India.

Material and Methods

The study area was located in the Malnad region of Karnataka in the vicinity of the Agumbe Rainforest Research Station (ARRS), from where our operations were based. The area was characterized by a large tract of wet evergreen upland forest situated on the edge of the Western Ghats plateau. The rainforest has become increasingly fragmented due to anthropogenic impacts, including rice (*Oryza* spp.) paddies, areca nut (*Areca catechu*) and *Acacia* spp. plantations, and towns and villages interspersed with small forest fragments and sacred groves. The region receives heavy rainfall (8000–10 000 mm annually) during the monsoon season (June–September), followed by an eight-month long dry season.

Table 2. Minimum convex polygon (MCP) and 95%, 50% active kernel (AK) home range estimates and total distance traveled (in 6 months) of one translocated (M1) and two non-translocated (M2, M4) King Cobras from the Agumbe region of the Western Ghats, Karnataka, India.

Snake ID	MCP (km^2)	95% AK (km^2)	50% AK (km^2)	Total distance traveled (km)
M1	91.3	83.9	8.4	83
M2	14.8	15.3	2.2	45.5
M4	30.0	15.0	6.5	30.5

Tolerance of, and even reverence for, snakes, especially King Cobras, is an important aspect of local beliefs and culture. People seldom kill King Cobras, even if they are found in homes. Respect for King Cobras in the region has been crucial to the success of the project, because local inhabitants inform our research team immediately when a snake is encountered, which led to 143 rescues from 2005–2010 (G. Shankar *et al.*, unpubl. data).

We surgically implanted radio transmitters (model AI-2T, Holohil Ltd., Ontario, Canada) into the coelomic cavities of three King Cobras. We obtained all three snakes from houses or private property. We translocated one male snake (M1) approximately 40 km from his original capture site and released him in the vicinity of ARRS. We released two other male snakes (M2 and M4) at their original capture sites, also near ARRS. We tracked M1 from March–December 2008, M2 from July 2009 to July 2010 and M4 from December 2009–September 2011. Initially, we tracked each snake daily, following it around the clock, until we determined that they were primarily diurnal; subsequently, we tracked each snake throughout its entire diurnal activity period from dawn to dusk, which averaged 10.6 hrs/day. Although we observed snakes continuously when possible, we only recorded exact locations if the snake moved more than 100 m from its last recorded location. We always maintained a minimum distance of 10 m (usually much greater) from snakes to minimize disturbance. We also collected data on a suite of environmental variables, including temperature, humidity, and a variety of habitat parameters.

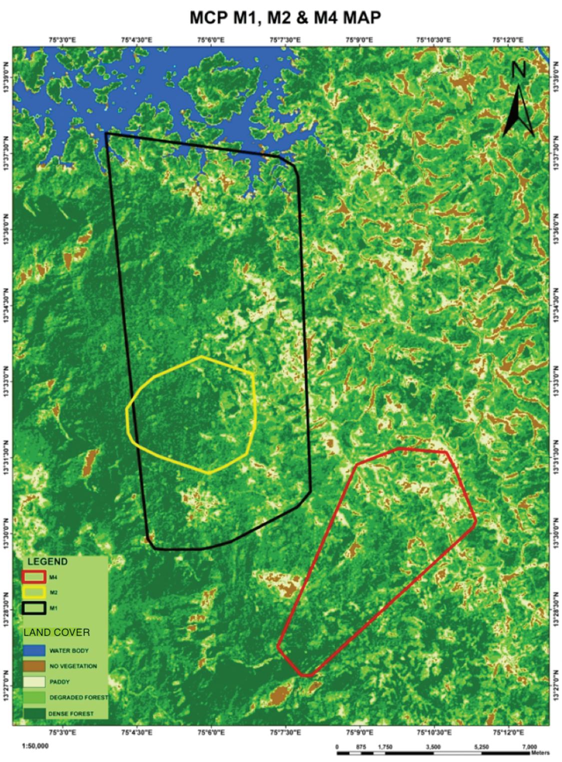

Figure 2. Minimum convex polygon home ranges for one translocated (M1) and two non-translocated King Cobras (M2, M4) from the Agumbe region of the Western Ghats, Karnataka, India.

We analyzed home range and movement patterns using the Animal Movement Analysis extension (Hooge *et al.* 1999) for ArcView 3.2 (ESRI, Inc.). We carried out 5% outlier removal, an in-built function in the program that removes the most disparate points to increase the precision of the calculated home range before analyses. We compared total movement over a six-month period (month 2–month 7) and average daily movement distances among snakes. Total distance was calculated by summing the aerial distance between successive points recorded for each snake. Because data were not normally distributed, we used a non-parametric Mann-Whitney U test to examine differences

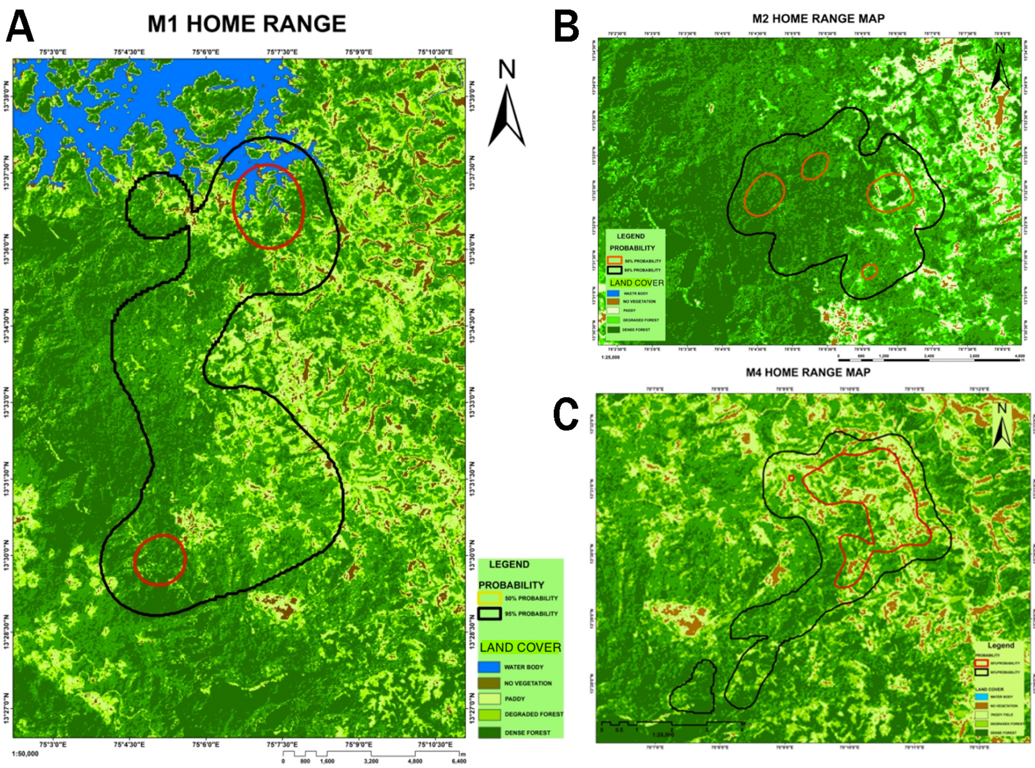

Figure 3. (A) Map depicting home range of translocated King Cobra, M1, red polygons enclose intensively used areas making up 50% of locations, from the Agumbe region of the Western Ghats, Karnataka, India. (B) Map depicting home range of nontranslocated King Cobra, M2, orange polygons enclose intensively used areas making up 50% of locations, from the Agumbe region of the Western Ghats in Karnataka, India. (C) Map depicting home range of nontranslocated King Cobra, M4, red polygon encloses intensively used areas making up 50% of locations, from the Agumbe region of the Western Ghats in Karnataka, India.

in average daily movement. We also compared 95% and 50% active kernel (AK) and minimum convex polygon (MCP) home range estimates to examine potential differences in space use between the translocated snake and the two non-translocated snakes.

Results

Total distance traveled varied greatly between M1, the translocated snake and the two non-translocated snakes, M2 and M4. Over the course of one six-month period, M1 moved a total of 83 km, compared to 45.5 km and 30.5 km for M2 and M4, respectively. A Mann-Whitney U test revealed that average daily movement of M1 (330 m ± 536 m, N = 205) was significantly greater than M2 (201 m ± 307 m, N = 364) (Z = 5.58, P = 0.001) and M4 (194 m ± 144 m, N = 427) (Z = 7.07, P = 0.001). The average daily movement distances between M2 and M4 were not statistically significant (Z = 1.11, P = 0.26).

Home range analyses revealed striking differences in home range size and use between M1 and the two non-translocated snakes. The MCP of M1, the translocated snake, was approximately three times larger than the MCPs of the two non-translocated snakes (Fig. 2). The 95% AK home range of M1 was more than five times greater than that of the other two snakes (Table 2, Fig. 3A–C). Although the 50% AK core use area of M1 was greater than the two translocated snakes, the differences were not as great as the 95% AK (Table 2, Fig. 3A–C).

Discussion

Analyses of King Cobra movement patterns revealed important individual differences in habitat use between translocated and non-translocated snakes. M2 utilized primarily forested and forest-fringe habitat (Fig. 3B), moving greater total distance than M4, whose home range was comprised largely by human-dominated landscape with very little forest cover (Fig. 3C). However, M2's core home range (50% AK) was only about one third that of M4, even though estimated home ranges of the two snakes were almost identical. Habitat type may have affected prey consumed, which in turn, may have affected movement distances. For example, M2 often fed almost exclusively on small Malabar pit vipers (*Trimeresurus malabaricus*; Bhaisare *et al.* 2010), which are encountered more often in dense forests, while M4 fed primarily on much larger spectacled cobras (*Naja naja*) and Indian rat snakes (*Ptyas mucosa*), which are found more often in edge habitats and associated with human disturbance. Perhaps M2 moved farther to obtain the greater number of smaller snakes needed to meet its energy requirements.

We also found a striking difference in use of shelter sites between the translocated snake and the two snakes that were not translocated. For example, M4 reused six burrows 17 times, and M2 reused 8 burrows 19 times, with up to 11 months between visits of the same burrow. We never observed M1 reusing burrows. Clearly, the two snakes that were not translocated had established home ranges, and were able to home back to particular sites that apparently provided them with a secure, thermally suitable site, often during vulnerable periods, such as ecdysis. Detailed knowledge of home ranges and homing behavior, likely mediated by chemosensory reception has been documented in other snake species (e.g., Reinert & Rupert 1999; Goode *et al.* 2008).

Despite small sample sizes, our results are congruent with other studies on snake translocation. Significant increases in home range size, and average daily and total distance travelled are widespread effects seen in the relatively small number of species that have been studied (Nowak *et al.*1999; Butler *et al.* 2005). The translocated King Cobra (M1) also showed other anomalous behavior typical of translocated snakes such as ceasing reproductive activities and even feeding. Because King Cobras are often apex predators in the ecosystems within which they occur, it is possible that translocation may not only affect individual snakes, but may also have unknown trophic cascade effects (Estes *et al.* 2011). Although the focus of our study was the King Cobra, we speculate that the magnitude of the translocation problem may be greater in species commonly found near human habitation, such as the rat snake (*P. mucosa*) and spectacled cobra (*N. naja*), both of which are regularly rescued and translocated, often large distances. Although snakes that are translocated short distances (i.e., within their established home ranges) appear to fare better than when moved long distances (e.g., Reinert & Rupert 1999), this does not necessarily solve the problem, because individuals often remain in the area of conflict (Brown *et al.* 2009). Considering the magnitude of snake translocation in India, there is an urgent need to educate "snake rescuers," not only about the likelihood of direct negative impacts on individuals, but also the potential for population-level effects.

Animal translocation has been a tool used for management of "nuisance" or "problem" animals for decades, often in the absence of any scientific evidence to support its use. However, there is a growing volume of scientific literature documenting the complexity of translocation, including studies on a large diversity of taxa (e.g., mammals, Linnel *et al.* 1997; birds, Richardson *et al.* 2006; tortoises, Field *et al.* 2007). The complexity of translocation is compounded by the fact that "success" or "failure" may be difficult to define (Wolf *et al.* 1998). The importance of combining information on survival and reproduction with behavior and physiology of translocated animals in comparison to animals that have not been translocated is gradually being realized (Wollman *et al.* 2009).

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