ECOLOGY OF SNAKES IN AN URBAN ENVIRONMENT: AN ANALYSIS OF THE DATA ON SNAKES COLLECTED BY SUNDARVAN NATURE DISCOVERY CENTRE, AHMEDABAD[1]

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The Sundarvan Nature Discovery Centre in Ahmedabad (Gujarat), collected data on the frequency of occurrence of snakes and other reptiles during the period June 1996 to July 1998. Twelve species of snakes were encountered/released, Cobra (*Naja naja*) being the most frequently encountered species, closely followed by Checkered Keelback (*Xenochrophis piscator*) and Rat Snake (*Ptyas mucosa*). Studies on the seasonal abundance of snakes suggested that their peak occurrences, corresponding to the monsoon rains, are due to additions to the populations. Predictably, there is some evidence that snake abundance is positively correlated with ambient temperatures during the non-breeding season. An analysis of the habitat preferences of various snake species suggests that the occurrence of a species inside or outside residential premises is roughly correlated with its food preferences.

Key words: Snakes, Gujarat, wildlife rescue, Sundarvan, urban ecology

INTRODUCTION

Sundarvan Nature Discovery Centre (henceforth referred to as Sundarvan), a facility of the Centre for Environment Education (CEE)-Ahmedabad, has been active in nature education using live snakes as a medium, since its inception in 1978. The staff also helps local people to cope with snakes that may appear in residential premises or cause panic among the public (Urfi 1999a). This activity complements the wildlife rescue programmes undertaken by governmental agencies and has received wide appreciation and support from the public. In recent years, Sundarvan has also taken a number of initiatives in herpetological research (Urfi *et al.* 1999) such as breeding and release of endangered species of snakes (Urfi 1999b).

Although Gujarat is rich in herpetofauna, which is well documented (Gayen 1999; Vyas 1998), there are still lacunae in our knowledge on snake populations and patterns of their seasonal abundance. It is well known that reptiles are difficult to census (Daniel 1983). Therefore data on their abundance and distribution obtained through rescue programmes, such as Sundarvan's, can be invaluable for studying ecological patterns of reptilian populations.

As the coordinator of Sundarvan, I made an attempt to systematically record biological information about snakes handled during the period 1996-98. A preliminary analysis of the data (for 1996) with a view to discussing the conservation aspects of Sundarvan's snake programme has been reported earlier (Urfi 1999a). In this paper, a larger data set is used to evaluate the ecological aspects of snake abundance and distribution in Ahmedabad.

METHODS

To collect data about snakes in Ahmedabad, a 'snake form' was put into use by the author in June 1996. The information was collected in two categories:

A. People's perceptions about snakes, and information to evaluate the educational programmes of Sundarvan involving snakes. The results of this exercise have been reported in Urfi (1999a).

B. Data of ecological interest and snake biology, including 1. date, 2. location of the reptile when caught, 3. species, 4. size/length, 5. health condition and 6. colour.

All requests for removal of snakes/ reptiles were documented, irrespective of whether they were followed up or not. The usual procedure was that on receiving a call to deal with a snake, the park supervisor informed two of the specially trained ground level staff to attend to it. Once collected, the snake was either trans-located immediately to an area far from human habitation or temporarily kept in Sundarvan before relocation. On location, the Sundarvan staff was also required to distribute an educational booklet on snakes prepared by CEE (in English and the local language). The booklet contains information about snakes, common myths associated with them, their economic importance, what to do in case of a snake bite, etc.

Standard methods, such as the hooked aluminium stick, were used to handle snakes, which were immediately put into a cloth bag on being caught (Whitaker 1970). In most cases, the snakes could be identified accurately up to the species in the field by the Sundarvan attendants, but in case of doubt, they were brought for examination to the Park Supervisor and the Sundarvan Coordinator. To estimate length, the snake

was held by its tail and suspended against a graduated scale, fixed on a wall or temporarily fixed on a vertical object in the field, and the length was read to the nearest centimetre. However, since this procedure often had to be performed rapidly, the estimation of lengths was not always accurate. Moreover, the lengths of only a few species such as Cobra (*Naja naja*), Rat Snake (*Ptyas mucosa*) and Checkered Keelback (*Xenochrophis piscator*) could be ascertained in this way.

The data collected from June 1, 1996 to July 31, 1998 was later transcribed into a Minitab worksheet (Version 10) for statistical analysis. Meteorological data of the city of Ahmedabad for the corresponding period was purchased from the Indian Meteorological Department, Ahmedabad. The data was analyzed with a view to answering the following questions.

1. Which species are reported from Ahmedabad and with what frequency?
2. What are the temporal patterns of snake abundance and what biotic and abiotic factors influence these patterns?
3. What kinds of habitat within urban areas are frequented by different species of snakes?

RESULTS

Snakes handled by Sundarvan

During the study period, a total of 2,311 calls for help with problem snakes (and other reptiles) were received by Sundarvan, of which 1,142 resulted in reptiles being handled. The reptiles handled included 12 species of snakes and one species of lizard (the Common Indian Monitor, *Varanus bengalensis*). Besides these, some other species were also brought to Sundarvan or sometimes handled by Sundarvan staff. These species included the Indian Star Tortoise (*Geochelone elegans*) and Indian Mud Turtle (*Lissemys punctata*), but such cases were few (< 10 of the entire sample) and sporadic. Whereas 'snake calls' came from virtually all parts of Ahmedabad and also from areas lying outside the city limits, the majority (approximately 90%) were from a radius of about 8 km around Sundarvan (Fig. 1).

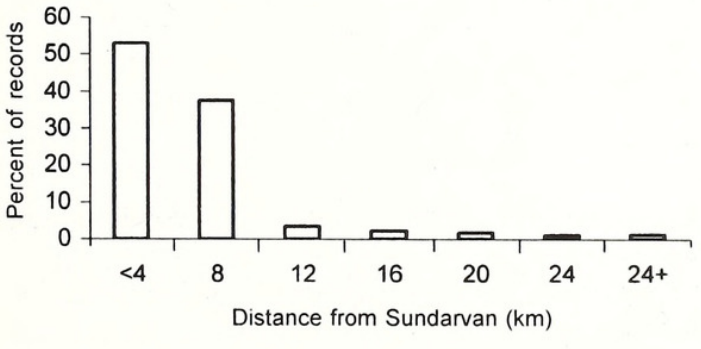

Fig. 1: Number of calls (% age) to deal with reptiles received by Sundarvan during 1996-98 in relation to the distance

Before we can start examining the Sundarvan data for any pattern, it is necessary to ascertain that it is free from bias brought about by human factors. For instance, the staff who went out on reptile handling missions could be reporting more or less calls than there actually were, and this could introduce some bias in the data. However, a bias if any would reflect itself in a number of ways, for instance as discrepancies in the number of snakes handled on different days of the week or as a discrepancy in the number of blank calls (i.e., no snake handled) and realized calls (i.e., those which resulted in a snake being handled). The number of calls on any given day was not influenced by the day of the week (Fig. 2). A goodness of fit test for the percentage of snakes being different from a uniform percentage of snakes being handled on each day of the week, yielded a non-significant result ($\chi^2 = 3.598$, d.f. = 6, NS). In addition, there was a high correlation between blank calls and realized calls (Fig. 3, $r^2 = 91.4\%$, d.f. = 23, $p < 0.001$). Further, if there were indeed any discrepancies in attending to calls then it would also be reflected as a poor correlation in the number of calls per month across the two seasons. We analyzed our data for any differences for the two years separately and discovered that the correlation (r^2) between calls attended per month for the seasons 1996-97 and 1997-98 was 84.3 % ($p = 0.001$).

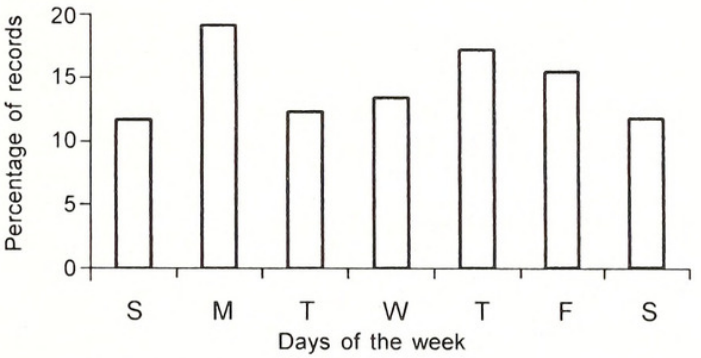

Fig. 2: Number of records for snakes handled by Sundarvan on each day of the week expressed as a percentage (Data for only a few randomly chosen months has been used)

In Ahmedabad, snake charmers are a regular, though not common, feature of the cultural landscape. Sometimes they let loose their snakes in housing localities and then on request from panic stricken people, catch them, extracting a small fee in the process (Whitaker and Whitaker 1986). The snakes used by snake charmers are easily recognized by their poor body condition and in the case of venomous snakes such as Cobra, by their fangs having been pulled out. In our sample, we came across some instances where the snake

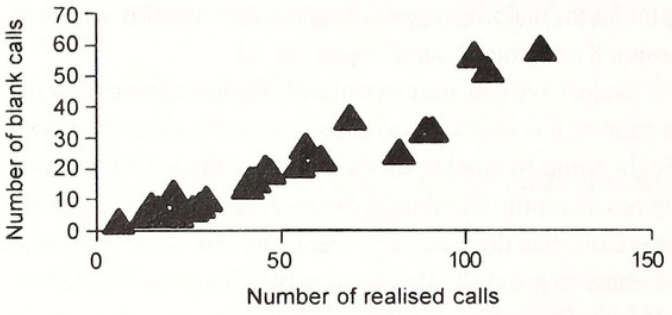

Fig. 3: Relationship between the number of realised calls and blank calls (per month) received by Sundarvan during the study period

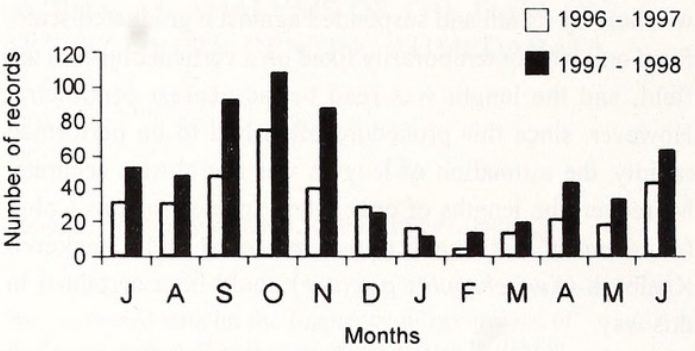

Fig. 4: Monthly distributions of the number of snakes for 1996-97 and 1997-98 recorded by Sundarvan

recovered was suspected to be one let loose by snake charmers, but such cases were few (<5).

From the data on the abundance of snakes during the study period (Table 1), it emerges that the Cobra is most abundant (35%), followed by Checkered Keelback (24%) and Rat Snake (20%). Incidentally, Cobras have also been reported from other cities in Gujarat (Snehal Patel, *pers. comm.*) as the most common species in snake rescue data.

Temporal patterns in snake abundance

Fig. 4 shows the seasonal abundance of snakes and reptiles for each of the two years of study. The monthly distribution for snakes differed significantly from that expected under the null hypothesis of equal numbers per month (GOF test $\chi^2 = 126.81$, 11 d.f., $P < 0.01$ for the season 1996-97 and $\chi^2 = 232.50$, 11 d.f., $P < 0.01$ for the season 1997-98.).The majority of the snakes handled by Sundarvan (approximately 75%) were from June to November during each of the two seasons. These results indicate a highly clumped distribution of snakes in the yearly cycle. As these months of reptilian abundance correspond to the monsoon, which stretches from June to September in western India, these seasonal peaks could be a result of the physical effects of the rains. It is possible that rain drives the reptiles out of their burrows, which get filled with water. While this idea is difficult to test, an alternative and perhaps more likely explanation could be that these seasonal peaks reflect recruitments to the population.

To test this idea, we segregated the data into two categories, young and adult, based on size. Since we had information on snake lengths for only a few species, this analysis could be done only for the Rat Snake, Cobra and

Table 1: Snakes rescued by Sundarvan during the period June 1996 to July 1998

Species	1996	1997	1998	Total
Typhlopidae				
Common Worm Snake *Ramphotyphlops braminus* (Daudin 1803)	1	0	0	1
Boidae				
Common Sand Boa *Eryx conicus* (Schneider 1801)	9	9	13	30
Red Sand Boa *Eryx johnii* (Russell 1801)	3	4	0	7
Colubridae				
Trinket Snake *Elaphe helena* (Daudin 1803)	1	0	0	1
Common Rat Snake *Ptyas mucosus* (Linnaeus 1758)	39	105	50	194
Banded Kukri *Oligodon arnensis* (Shaw 1802)	3	3	3	9
Common Wolf Snake *Lycodon aulicus* (Linnaeus 1758)	0	10	7	17
Striped Keelback *Amphiesma stolatum* (Linnaeus 1758)	2	17	4	23
Checkered Keelback *Xenochrophis piscator* (Schneider 1799)	69	129	31	229
Elapidae				
Common Krait *Bungarus caeruleus* (Schneider 1801)	30	56	18	104
Indian Cobra *Naja naja* (Linnaeus 1758)	96	190	55	341
Viperidae				
Saw-scaled Viper *Echis carinatus* (Schneider 1801)	1	3	0	4

Checkered Keelback for which individuals smaller than 60 cm, 45 cm and 45 cm, respectively were classified as juvenile (Daniel 1983; Whitaker 1978). When the combined data for the monthly abundance of the three species of snakes was plotted against the number of juveniles, a correlation was observed ($r^2 = 67.8\%$ $P < 0.001$), suggesting that the peaks of seasonal abundance could be due to the recruitment effort (Fig. 5).

To test the idea that weather conditions influence the number of calls received by Sundarvan, we explored the influence of temperature and rainfall using a subset of our data including only the winter months from November to February. Data for only four species, the Rat Snake, Checkered Keelback, Common Krait and Indian Cobra was used, as only these were recorded in large numbers (exceeding 100). As the results show (Fig. 6), the number of snakes handled was positively correlated with maximum temperature ($r^2 = 8.1\%$, d.f. = 238, $p < 0.001$) and minimum temperature ($r^2 = 15.5\%$, d.f = 238, $p < 0.001$). However, with respect to rainfall, no clear pattern emerged, due to the small sample size.

Habitat associations of snakes

As Table 2 shows, snakes are ubiquitous, to be found in every conceivable place, and indeed sometimes in quite unusual places too. We did not attempt to analyze habitat selection for each species individually because more information, especially on environmental factors at the local level, would be required for each of the habitats where snakes were found. However, from the available data it is still possible to study the extent to which each species had a propensity to be indoors or outdoors. From our analysis (Table 3), it appears that some snakes such as Common Wolf Snake (*Lycodon aulicus*) and Indian Cobra were mostly recorded indoors, while

Table 2: Habitats in Ahmedabad city from where snakes were rescued by Sundarvan during the study area

Indoors	Outdoors
Including residential houses, *godown*, water pump room in farm houses etc.	Heaps, Garbage Rubble/stone/bricks Woodpile
Bathroom Near water tap Near commode	*Others* Kitchen garden/nursery Trees in garden/orchard/farm Water tank, Parking lot Roads (in urban areas and on the periphery of the city, close to the country) Well
Kitchen Near gas cylinder	
Bedroom Beneath the bed	
Others Inside false ceiling Inside air-conditioner Inside fuse box Near window On door grills In cracks on the wall and on roofs tiles	

Rare and unusual sites: Motorcycle seat, Motor car engine, Swimming pool

Table 3: The frequency (%) with which different species of snakes were encountered in indoor or outdoor locations by Sundarvan along with information on their diets and foraging methods

Species	Indoor	Outdoor	Known diet & foraging method*
Common Sand Boa	14	86	Predominantly rats, occasionally frogs. Hatchlings feed on insects, mice, small lizards and later on birds and rodents. Prey caught by constriction
Red Sand Boa	16	84	Mainly rats (rodents). Prey caught by constriction.
Trinket Snake	50	50	Mainly rodents, occasionally birds and their eggs. Young consume insects and small lizards. Prey apparently caught by constriction.
Rat Snake	38	62	Very eclectic diet, includes rats, frogs, toads and also birds, geckos, bats and snakes. Capture of prey by stealth and power.
Banded Kukri	50	50	Geckos, skinks, small mice, bird & reptile eggs. Young feed on insects, their larvae and spiders. Prey caught by swift movements in which the strong teeth are useful.
Wolf Snake	84	16	Geckos, skinks, mice and frogs. Prey caught by swift movements in which the strong teeth are useful.
Striped Keelback	46	54	Mainly frogs but also toads, small lizards and rodents. Young known to feed on insects, tadpoles etc. Prey capture by stealth and swift strikes.
Checkered Keelback	36	64	Mainly fish, frogs and aquatic creatures. Prey captured by swift strikes.
Common Krait	47	53	Mainly snakes, lizards and rodents. Prey immobilized by poison.
Indian Cobra	57	43	Mainly rats. Prey immobilized by poison.

*from Daniel (1983) and Whitaker (1978)

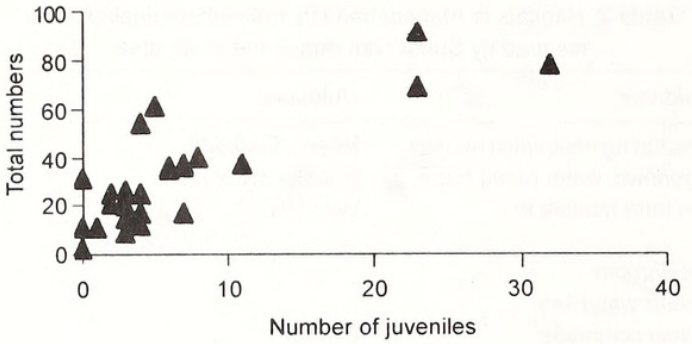

Fig. 5: The relationship between the number of juvenile snakes per month and the number of snakes of all age groups in that month, recorded by Sundarvan during the study period (Note this analysis includes data for only three species, Cobra, Checkered Keelback and Rat Snake)

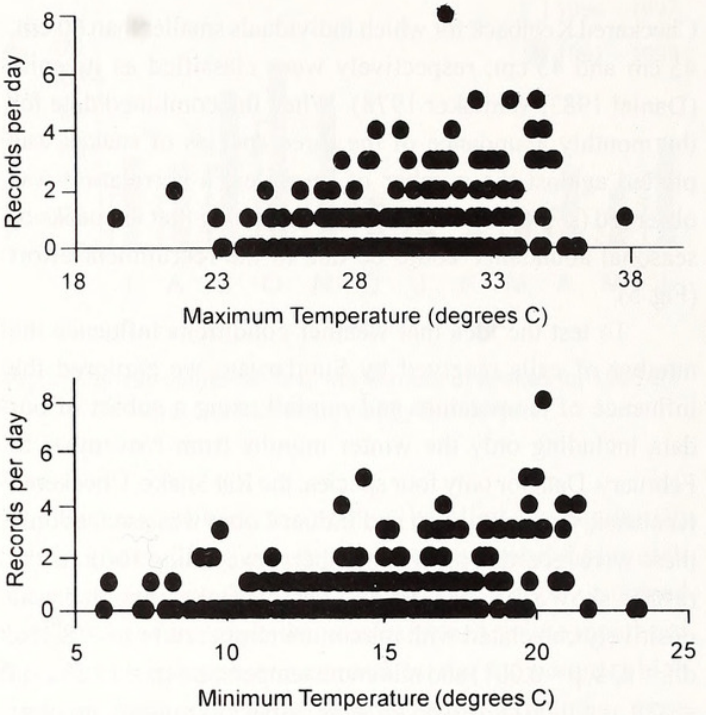

Fig. 6: The number of snakes handled by Sundarvan per day in winter (from November to February, data for the two seasons 1996-97 and 1997-98 combined) compared with daily maximum air temperature (upper graph) and daily minimum air temperature (lower graph) for the city of Ahmedabad. Each point represents a day

others such as Common Sand Boa (*Eryx conicus*), Red Sand Boa (*Eryx johnii*), Rat Snake, Striped Keelback (*Amphiesma stolatum*), Checkered Keelback and Common Krait (*Bungarus caeruleus*) were recorded outdoors on the majority of occasions (>50%). The rest of the species were recorded indoors and outdoors in equal proportions.

DISCUSSION

Excluding the Family Hydrophiidae (sea snakes), our sample has representatives of five out of the eight families of Serpentes recorded in Gujarat. The species missing in our sample could be those which are partial to undisturbed environment free of humans, in the less populated parts of the state, or those which are less cosmopolitan in distribution. Of course, the absence of some species in our sample could also mean that they were overlooked, but this is a remote possibility. Also, since our data emerges from reptiles as and when they are noticed by humans, it is not comparable to data from a census or inventory.

Our analysis of seasonal peaks of snake abundance strongly suggests that they are due to the higher proportion of juveniles in certain months. For cobra, egg laying is recorded in April and May, and can continue up to August according to Daniel (1983), with eggs hatching after a period of *c.* 60 days. Also, according to Whitaker (1978), the cobra may breed more than once per year. As for the Checkered Keelback, the egg laying period is reported to be November to May according to Daniel (1983) and March according to Whitaker (1978) with an incubation period of about 60-70 days. In the case of Rat Snake, egg laying is in August-September, the young being born during September and January.

The influence of environmental factors on the activity of reptiles is well known (Cloudsley-Thompson 1971). In this regard, our results indicating a positive relationship between ambient temperature and number of reptiles recorded are along predictable lines (Shine and Koenig 2001). However, the correlation is not strong, which could be due to the fact that individual species may have a different relationship with ambient environmental factors and this aspect needs to be probed further. One would also expect close relationships to emerge in the abundance patterns of snake numbers with rainfall. While rainfall would be negatively correlated with temperature, it will influence the behaviour of reptiles in novel ways (Auffenberg 1994).

It is reasonable to assume that the site where a snake is found would have something to do with its habitat preference, of which one of the crucial factors is food availability. Factors such as safety from predators, micro-climate (including temperature, humidity) could also play a role. While we have no information of the habitat characteristics with respect to micro-climate, it is possible to compare the known food preferences of various species and their occurrence outdoors or indoors, and the availability of food in these two broad categories. As the information on ten species of snakes (Table 3) suggests, among the outdoor type of snakes such as the two Boas and the Rat Snake, their food is also of the type which one would expect to find mostly outdoors. Contrary to

what its name suggests, the Rat Snake's diet is eclectic and does not consist entirely of rats (Daniel 1983). The Checkered Keelback's prey is mainly fish, frogs and other aquatic creatures that would be found in ponds and wetlands, and this is why it is reported mostly outdoors (64%). However, on 36% of the occasions it was encountered indoors, perhaps while it is in transit from one habitat patch, which is often isolated and fragmented, to another.

Among the snakes found indoors, the Wolf Snake is at the top of the list. Its main prey is recorded to be geckos and inside Indian homes the Asian House Gecko (*Hemidactylus flaviviridis*) is a common and abundant prey. In our study, the Cobra was also largely an indoor species, with 57% cases reported from indoors. This may be because its principal food is the rat, which is a common pest in all types of human premises. Studies have also shown a high correlation between the number of cobras and the build up of rat populations at the time of paddy crop harvesting in certain rural areas of India (Whitaker 1978). Generally speaking, wherever there are rats, cobras are likely to follow.

Snakes are usually seen and reported when they are on the move in search of food, or while prospecting new habitats as their original habitat gets destroyed due to land modification. Given that in our sample the majority of the reptiles were recovered from an area of 8 km around Sundarvan, it would be useful to examine the development in this area. The information on the population growth and built up area, as revealed by satellite imagery data and ground surveys indicates that the area around Sundarvan is undergoing massive modification, with numerous housing and commercial complexes coming up (Bhowmick *et al.* 1997). From the viewpoint of both conservationists and town planners, this merits serious discussion.

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