throughout the evolutionary history. Even if it happens in the case of *Bt* genes, the possibility of the gene maintaining in the wild relatives will depend on the presence or absence of continuous selection pressure from the same pest[4]. If pollen flow occurs between *Bt* and non-*Bt* land races, the 'transformed' land races may thrive well to enhance the wild gene pool of the crops[5]. Development of resistance against Cry protein cannot be ruled out; scientists have to be ready with other strategies like *Cry* gene stacking[6]. At the end it must be pointed out that the products of technology are never 100% perfect. Let us have a healthy debate based on unbiased scientific data and make a consensus.

1. Shanmugam, G., *Curr. Sci*., 2011, **100**, 147.
2. Samuels, J., *Curr. Sci*., 2011, **100**, 603–604.
3. Prabhu, K. V., *Biotech. News*, 2010, **5**(2), 57–60.
4. Raven, P. H., *Biotech. News*, 2010, **5**(4), 162–165.
5. Uma Shaanker, R. and Ganeshaiah, K. N., *Biotech. News*., 2010, **5**(2), 75–77.
6. Padmanaban, G., *Biotech. News*, 2010, **5**(2), 64–67.

DEVAJYOTI BOKOLIAL

Department of Botany,
St Anthony's College,
Shillong 793 001, India
e-mail: devajitbk@gmail.com

Snake abundance: the limits of occupancy-based estimates

Field studies that have focused on estimation of animal species abundances have for long been confronted by the problem of not counting an individual that was actually present in the habitat or locality. More than 30 years ago, Preston[1] demonstrated how the detection probability of birds increased with enhanced effort wherein a team of field biologists working simultaneously in a site might detect more birds than a solitary observer would. That the problem of estimating the proportion of elusive individuals in a local population of animals continues to haunt field biologists is evident in the series of recent publications on the subject[2–4].

One suggestion common to all the authors who have discussed the subject is that the probability of detecting an animal increased with greater effort. Increased effort can be achieved by increasing the size of the team[1,2] (as appropriate) or by increasing the number of visits within a prescribed period[2,4]. Recent studies also lay emphasis on estimating 'occupancy'[2–4]. Occupancy is defined as the 'fraction of sampling units in a landscape where the target animal species is present'[2].

While it seems a simple task, ascertaining the absence of a shy and elusive species in a sampling unit is not by any means easy. Considering the limitations of time, manpower and funds, field biologists studying elusive and shy species have reiterated that it is 'profitable' to search for signs of their presence[4]. They also suggest that, under such circumstances, the detection probability can be treated as the average probability of detecting a sign (in replicated samples) that an elusive animal is present in a habitat or locality[4].

Snakes are some of the most elusive animals and assessing their abundance has been challenging. The presence of snakes in a habitat or sampling point is more often inferred by signs such as sloughs (molted skin), scats (excreta) or a track that leads to a frequently used hideout such as a burrow or a den than actually sighting one.

Between October 2008 and March 2009, I was involved in a short-term project commissioned by the Wildlife Wing of the Tamil Nadu Forest Department with the mandate of estimating the abundance of the Indian cobra, common krait, Russell's viper and saw-scaled viper in northeastern Tamil Nadu[5]. The project was commissioned in response to a demand by the Irula Snake Catchers' Industrial Cooperative Society (Irula Society) for an annual harvest of 15,000 snakes (including the four species) from Chennai, Kancheepuram and Tiruvallur districts that approximately covered an area of 4,000 sq. km in northeastern Tamil Nadu.

Harvesting the four species of common venomous snakes in northeastern Tamil Nadu began about 40 years ago. The harvested snakes are maintained for around a month in the Irula Society and milked for venom between 4 and 6 times before being released back into the wild. During the early years of this ingenious enterprise, 500–1000 snakes involving the four species were harvested annually. Nevertheless, the demand for snakes has since grown so much that during the year 2008 the annual harvest was around 8,000 snakes.

While it is presumed that the enterprise is sustainable, there has not been any data maintained by either the Irula Society or the Tamil Nadu Forest Department on the recapture of snakes that were caught once, marked and released. Further, there has not been any study to assess the annual recruitment in these four species within the landscape that has been intensely harvested during the past 40 years although it is evident that the landscape is now being intensely used by IT and automobile companies that extensive patches of fallow lands and cultivation have been urbanized.

Against this background, the task of designing a field study that would provide reasonably reliable data on the abundance of the four species of snakes and in just six months was the real challenge. Fellow ecologists brought to my attention the existence of considerable amount of literature on estimation of animal abundances using the occupancy model. I found the writings of Mackenzie[2] most practical and useful. Under the assumption that I have fully understood the model and its application, I went ahead and sampled the snakes.

Five competent snake hunters were engaged during the project and with the exception of one, all were Irulas. The field design allowed two snake hunters to search and find snakes, as they would do normally, and my role was to simply

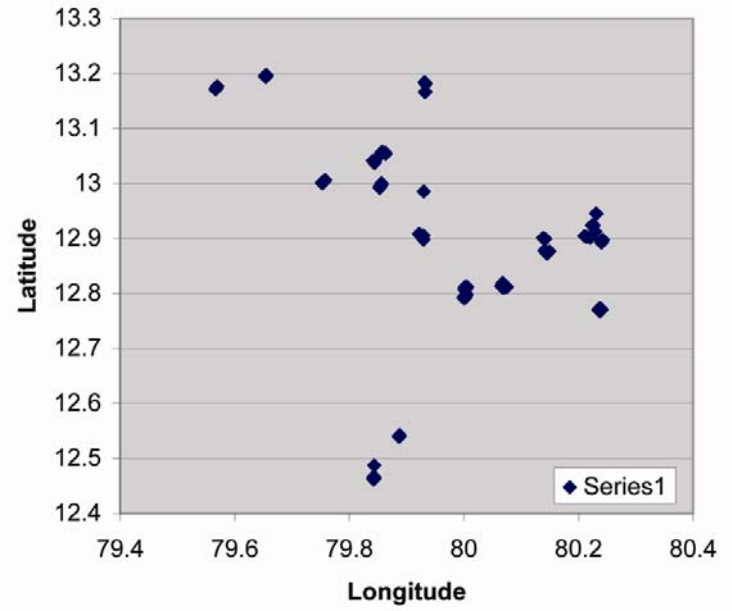

Figure 1. Distribution of snake points within the Chennai, Kancheepuram and Tiruvallur districts.

follow them. The hunters would thoroughly search around 100 snake points (preferred micro-habitats of the four species) in a day. Every time a snake or snake-sign was noted, the coordinates of the snake point were recorded using a GPS.

During the six months of field study, 2,305 snake points were sampled and these were distributed in 18 clusters (Figure 1). The sampling revealed the presence of 243 snakes belonging to 15 species including 34 cobras, 15 kraits, 10 Russell's vipers and 6 saw-scaled vipers. And of these, only 5 cobras, 4 Russell's vipers and 4 saw-scaled vipers were actually seen. No krait was seen during the sampling despite the fact that in a few clusters we worked during the night.

Repeated sampling within any cluster was not possible as the snakes that were seen were captured and taken away by the hunters. In case of the cobra, snakes were seen only after the hideout was excavated (and totally damaged) and the chances of the snake returning even if it were not seen during the sampling were bleak. Excavating a krait took as much as 6 hours and in a day's work it was not feasible. As a result, kraits were inferred only based on signs.

As 3–5 persons were simultaneously searching for snakes within a cluster, it was assumed that every inference of snake presence was an independent event. Occupancy, therefore, was estimated simply as the proportion of snake points wherein snakes were inferred. It emerged that the occupancy of venomous snakes was only 2.8% within the study area.

In my opinion, having personally recorded the observations in the field throughout the study, the apparent occupancy estimate is reliable. However, critiques of the report[5] were of the opinion that the occupancy was under-estimated and any extrapolation based on it can only be inconclusive, if not misleading.

In the absence of data on the home range of any of the four species of snakes and the fact that there has been no serious attempt made in the past to estimate the abundance of venomous snakes anywhere in India, the debate will continue. In the meantime, field biologists in India may well have to review the efficacy of the widely cited occupancy model in the population estimation of shy and elusive animals such as snakes.

1. Preston, F. W., *Ecology*, 1979, **60**, 451–454.
2. Mackenzie, D. I. and Royle, J. A., *J. Appl. Ecol.*, 2005, **42**, 1105–1114.
3. Sara, M., *Ibis*, 2008, **150**, 766–778.
4. Karanth, U. K. and Nichols, D. J., In *Tigers of the World* (eds Tilson, R. and Nyhus, P. J.), Elsevier, London, 2nd edn, 2010, pp. 241–261.
5. Daniels, R. J. R., Assessing the Distribution, Abundance and Food Availability of the Four Large and Common Venomous Nnakes in Chennai, Kanchipuram and Thiruvallur Districts of Tamil Nadu. Report submitted by Care Earth to the Tamil Nadu Forest Department, Chennai, 2009, p. 49.

ACKNOWLEDGEMENTS. The study was financially supported by the Wildlife Wing of the Tamil Nadu Forest Department. The comments and criticisms offered on the report by Jack Frazier, Richard Shine, Kimberly M. Andrews, Wolfgang Wuster, David Williams, Shreyas Krishnan, Indraneil Das, Karthik Shanker and Karthik Vasudevan have been the source of inspiration for this communication. The study would not have been possible without the participation of the snake hunters who chose to remain anonymous.

R. J. RANJIT DANIELS

Care Earth Trust,
No. 15 (old no 8), 2nd Main Road,
Thillaiganganagar,
Chennai 600 061, India
e-mail: ranjit.daniels@gmail.com