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Line Transact Method for Estimating Encounter Rate of Large Mammals in a Dry Deciduous Forest of Lakkavali Range of Bhadra Wildlife Sanctuary, Karnataka

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ABSTRACT

The encounter rate of large mammals were estimated using a line transect method in the Lakkavalli range of Bhadra Wildlife Sanctuary during April 2007 to March 2008 in the Lakkavali range for four species of large herbivorous mammals: chital (*Axis axis*), sambar (*Cervus unicolor*), barking deer (*Muntiacus muntjak*) and gaur (*Bos gaurus*). The range was divided into several zones based on location and habitat types. From 4 permanent vehicle transects of 6-10 km and from a total of 31 km in different habitat transects, the number of individuals was higher during pre- and post-monsoon seasons.

Keywords: dry deciduous forests, herbivores, mammals, tropical, vehicle, wildlife census

INTRODUCTION

Wildlife includes non-domestic plants and animals and holds the key for the well being of humans. In recent years, much interest has been shown towards protection and conservation of wildlife at various levels. The work on conservation and management of wildlife is often hampered due to non-availability of good quality data on species, habitats and suitability of the habitats for different species. The problem is more acute in the developing world, where wildlife and biodiversity conservation is often subordinated to more pressing demands like hunger and poverty (Kushwaha 2002).

Over recent years the job of a wildlife manager has become increasingly involved. The first, and most obvious, statistic he wishes to extract from a population is how many animals there are. By observing this over a given time frame one can look into trends in population numbers and if the population is stable or if there are areas for concern in their abundance.

Decisions about how to manage wildlife often rely on information whether populations are increasing or decreesing (James *et al*. 1996). Single species approach to conservation, management, and monitoring are in sufficient to combat the threat to overall biological diversity of the area. Multi species based monitoring approaches are needed to provide reliable, timely and informative measures of change in the status of population communities and biological diversity (Manely *et al.* 2005).

Ecologists have emphasized the important role that large herbivores (primates and ungulates weighing 5 kg or more) play in tropical ecosystems through their influence on forest structure, composition, productivity, nutrient cycling, soil structure and succession (McNaughton 1979; Crawley 1983). A major management challenge in conserving large herbivores is monitoring their populations, which is crucial both to assess the success of management and to formulate future management strategies. Monitoring herbivore population dynamics also helps us better understand various ecological processes at landscape and ecosystem levels. Estimating the population size, encounter rate of an animal species in an area is fundamental to understanding its status, demography and to plan for its management and conservation. In spite of the development of sophisticated statistical methods of sampling animal populations, their application to estimating densities in tropical forests is difficult mainly because of poor visibility and relatively low density of these populations resulting in inadequate sample size for statistically precise results, The practical difficulty of carrying to random sampling due to habitat topographic features is an additional constraint in sampling design Researchers are continuing to develop methods to tackle the problem of variance estimation of independent identically distributed (i.i.d.) sampling units (transects). For a review on variance problems with this method the reader is referred to Buckland *et al.* (2004). Even observation-based methods such as distance sampling (Buckland *et al.* 2001) and multiple observers (Nichols *et al.* 2000) are viewed by some as too consumptive of time and effort.

However, reliable estimates of herbivore densities and encounter rate in the forests of tropical Asia are rare. Counts of dung, trails, calls and direct observation along line transects are also widely used for richness and abundance estimates (Fashing and Cords 2000; Barnes 2001; McNeilage *et al.* 2001). Both direct and indirect methods of estimating mammal encounter rate in tropical forests have been used (Sale *et al.* 1990; Karanth and Sunquist 1992; Varman and sukumar 1995; Jathanna *et al.* 2003; Madhusudhan *et al.* 2003, 2004). Estimates based on indirect methods usually involve counting animal dropping, while direct methods use visual sightings of animals line transect sampling is practical, efficient and relatively inexpensive for many biological populations (Anderson *et al.* 1979; Burnham *et al.* 1980; Buckland *et al.* 1993). Although, it has been extensively used in temperate regions for estimating densities for a variety of vertebrate taxa, one of the first rigorous applications of the method in a tropical forest was by Karanth and Sunquist (1992) to estimate encounter rate of mammals.

Received: 28 April, 2008. Accepted: 18 June, 2009.

Research Note

STUDY AREA AND STUDY SPECIES

The study was carried out in Lakkavalli range of Bhadra Wildlife Sanctuary, consisting an area of 223.17 km^2 (13° 34' to 13° 46' N latitude and 75° 29' to 75° 45' E longitude) in the Karnataka state of Southern India. The altitude varies from 650-1875 m above sea level with a general elevation of 1200-1500 m. The sanctuary is located in the Malnad region of Karnataka about 50 km to the east of Western Ghats. The temperature in the valley ranges from 9-35°C. The region receives an annual rainfall of 1600 to 2000 mm during the southwest monsoon between June and September (Satisha 2007). A distinct rainfall gradient resulted in variation in vegetation type. The semi evergreen forest, moist deciduous forest, dry deciduous forest, shoals and grassland type forest were selected for this study during 2007-08. With its high rainfall numerous perennial streams and relatively low occurrence of invasive exotics, the habitat in Bhadra is ideally suited to support high densities of herbivores. In addition to these natural habitat features, Bhadra has, similar to other south Indian forests such as Nagarahole, numerous artificially maintained short grass clearings and swampy fallows, locally known as hadlus, both of which have been known to help maintain high densities of grazer species (Karanth and Sunquist 1992). Earlier studies, however, show that ungulate densities are low in Bhadra when compared to other, ecologically similar reserves in south India (Ahrestani 1999). Although there are laws that prohibit hunting, fishing, collection of forest products, agriculture and livestock grazing, and overexploitation of bamboos these practices are widespread in Bhadra (Madhusudan and Karanth 2000; Karanth 2002; Madhusudan 2004; Barve *et al.* 2005; Das *et al*. 2006; Karanth *et al*. 2006; Kumar and Shahabuddin 2006). However, the department of forestry has taken up the task more seriously by implementing new amendments to control these pressures.

Lakkavali range of Bhadra Wildlife Sanctuary supports a mammalian fauna typical of deciduous forests of peninsular India (Krishnan 1972; Raju 1999). Greater detail about the wildlife of Bhadra is available in Karanth (1982) and Kumar (2000). Of these, four species of large herbivorous mammals were selected for the present study: chital (*Axis axis*), sambar (*Cervus unicolor*), barking deer (*Muntiacus muntjak*) and gaur (*Bos gaurus*).

METHODS

Field method

Encounter rate estimation method

Based on vegetation types, the area was stratified into different habitat zones such as dry deciduous forest, semi evergreen forests, teak plantation, grassland type and sholas forests (Champion and Seith 1968). Transect lines were placed in these zones in a fashion that they sampled each zone in rough proportion to their areas.

Vehicles-based counts

During our census several game roads were traversed using a vehicle at a near constant speed of 20 km per hour. Four routes were identified so has to cover all the habitat types in rough proportion to their areas. Total distance covered by vehicle transect was 372 kms during the study period. The good network of roads inside the sanctuary made it possible to cover these regularly by vehicle.

Analytical method

The analysis were carried out separately for each species in monthly-wise separately general form of encounter rate is given by

$$\text{Encounter rate} = \frac{\text{Number of sightings}}{\text{Total km of distance traveled}}$$

Variance of the mean encounter rate was estimated as a composite of the variances of sample size, mean, standard deviation per km.

RESULTS

During our study from April 2007 to March 2008 we recorded the monthly data of animal census using transect method are shown in **Fig. 1**. The total distance covered by vehicle transect was 372 km. The study area consisted of mainly 4 zones of habitat strata to be utilized by the wild animals: dry, deciduous forest, semi-evergreen forest, teak plantations, grasslands and shoals.

During the current census operation, the proportion of area representing the forest type, forest range, total distance, weather condition, starting and ending time, GPS data of latitude and longitude at the beginning and end and the number of sightings were tabulated in a prescribed encounter rate data sheet (Nayak 2004). Details of the monthly analysis are given in **Table 1** and **Fig. 1**.

The sample size was generally very low in sambar deer (24), chital (309), barking deer (16), and gaur (67) (**Table 2**). Barking and sambar deer were well below the minimum of 40 recommended by Burnham *et al*. (1980).

In the case of sambar and barking deer, and gaur the estimate from the vehicle transect showed that the differences were particularly large in the case of sambar deer (0.07 ± 0.05). The result for the other mammals is shown in **Table 2** and **Fig. 2**.

DISCUSSION

Habitat suitability analysis is considered important for introduction, rehabilitation and *ex-situ* conservation of species and their habitats. Habitat models are based on the relationship between the animal and environment. Such models are

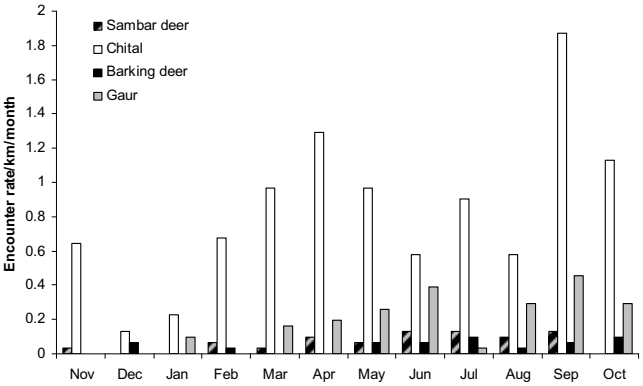

Fig. 1 Variation of encounter rate of each species in different months in vehicle transect.

Table 1 Month-wise variation of encounter rate of all species.

Months	Encounter rate (per km)
Apr – 07	1.58
May – 07	1.35
June – 07	1.16
July – 07	1.16
Aug – 07	1.00
Sep – 07	2.50
Oct – 07	1.50
Nov – 07	0.68
Dec – 07	0.19
Jan – 08	0.32
Feb – 08	0.77
Mar – 08	1.61

Table 2 Encounter rate estimation from vehicle based transects.

Species	Distance covered (km)	Sample size	Mean group size ± SD	Encounter rate (km^{-1}) ± SD
Sambar deer	372	24	2.00 ± 1.59	0.07 ± 0.05
Chital	372	309	25.75 ± 14.67	0.80 ± 0.47
Barking deer	372	16	1.33 ± 1.15	0.04 ± 0.04
Gaur	372	67	5.58 ± 4.88	0.18 ± 0.16

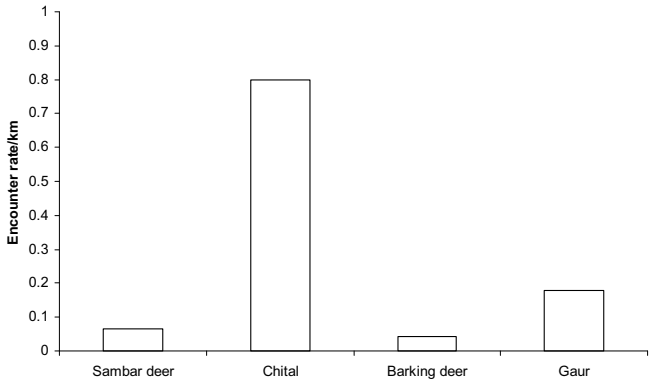

Fig. 2 Variation of encounter rate of different species in vehicle transect.

normally animal-centric and are usually consistent with the data needs for planning. In tropical forests line transect surveys have mainly been used to obtain the encounter rate of large mammals, and few studies have established monitoring programmes. It is often implied that subsequent surveys will show whether the population is changing but little thought is given to planning future surveys. If future surveys are to detect change then the results in this paper show that both surveys must be intensive. Where monitoring has occurred in Lakkavalli range it has provided useful data for conservation.

A high encounter rate was found in open ground areas from the forest edge, probably due to animals feeding on open ground at the forest edge. In habitats where the undergrowth is more open and has shorter grasses, a very high encounter rate of chital may be responsible for their similar abundances along road sides and the interior of the forest. It is well known that chital prefers the ecotones of forest-grassland and open habitats (Shankara Raman *et al*. 1996). It can thus be expected that the density of chital would be higher along roadsides, where artificial clearing is restored for increasing visibility for the benefits of tourists. In zones with relatively dense undergrowth of samplings or grass, chital was frequently observed at these salt licks, but it has never been reported feeding on aquatic vegetation (Dinerstein 1979b; Moe 1994).

As obvious from this and other studies (Surendra and Sukumar 1993; Jathanna *et al*. 2003) sambar prefers hilly areas with high tree density, while barking deer prefers plain areas, sambar prefers sites that score low in terms of direct human disturbance and similar conclusions can be drawn for barking deer.

The road we sampled includes game roads and as well as roads frequented by tourists; sampling was done in the morning with infrequent vehicular traffic. In both transect modes pre-monsoon (April-May) and post-monsoon months (October-November) marked the highest number of animals, but fewest were detected in winter (December-January), although barking deer showed a different pattern among the four mammals. Sambar and gaur do not prefer roadside probably because of disturbances from vehicular traffic in the sanctuary.

There may have been seasonal movement of animals from surrounding hills into valley habitats sampled by our transect which may have lead to the high chital and gaur encounter rate in earlier studies. Clearly, herbivores encounter rate are extremely low compared to other study sites where line transect estimates of herbivore density have been derived previously in the Bhadra Wild Life Sanctuary (Karanth 1982, 1988; Raju 1999). A possible reason for this could be the earlier study has been carried out in the whole range of Bhadra Wild Life Sanctuary whereas the present study is taken up in one range (Lakkavalli range).

REFERENCES

Ahrestani FS (1999) Population density estimates for mammalian herbivores in Bhadra Wildlife Sanctuary, South India. MSc thesis, Syracuse University, New York

Anderson DR, Laake JL, Crain BR, Burnham KP (1979) Guidelines for the line transect sampling of biological populations. *Journal of Wildlife Management* **43**, 70-78

Barnes RFW (2001) How reliable are dung counts for estimating elephant numbers? *African Journal of Ecology* **39**, 1-9

Barve N, Kiran, MC, Vanaraj G, Aravind NA, Rao D, Shaanker RU, Ganeshaiah KN, Poulsen JG (2005) Measuring and mapping threats to a wildlife sanctuary in southern India. *Conservation Biology* **19**, 122-130

Buckland ST, Anderson DR, Burnham KP, Laake JL, Borchers DL, Thomas L (2001) *Introduction to Distance Sampling: Estimating Abundance of Biological Populations*, Oxford University Press, Oxford, UK, 432 pp

Buckland ST, Anderson DR, Burnham KP, Laake JL, Borchers DL, Thomas L (2004) *Advanced Distance Sampling*, Oxford University Press, Oxford, pp 307-392

Buckland ST, Anderson DR, Burnham KP, Laake JL (1993) *Distance Sampling; Estimating Abundances of Biological Populations*, Chapman and Hall, London, 446 pp

Burnham KP, Anderson DR, Laake JL (1980) Estimation of density from line transect sampling of biological populations. *Wildlife Monographs*, The Wildlife Society, Washington, DC, **72**, 1-202

Champion HG, Seth SK (1968) *A Revised Survey of the Forest Types of India*, Government of India, New Delhi, 404 pp

Crawley MJ (1983) *Herbivory: The Dynamics of Animal-Plant Interactions*, University of California Press, Berkeley, 437 pp

Das A, Krishnaswamy J, Bawa KS, Kiran MC, Srinivas V, Kumar NS, Karanth KU (2006) Prioritization of conservation areas in the Western Ghats, India. *Biological Conservation* **133**, 16-31

Dinerstein E (1979b) An ecological survey of the Royal Karnali-Bardia wildlife Reserve, Nepal. Part II; Habitat/animal interactions. *Biological Conservation* **16**, 265-300

Fashing PJ, Cords M (2000) Diurnal primate densities and biomass in the Kakamega Forest: an evaluation of census methods and a comparison with other forests. *American Journal of Primatology* **50**, 139-152

James FC, McCulloch CE, Wiedenfeld DA (1996) New approaches to the analysis of population trends in land birds. *Ecology* **77**, 13-27

Jathanna D, Ullas Karanth K, Johnsingh AJT (2003) Density, biomass and habitat occupancy of ungulates in Bhadra Tiger Reserve, Karnataka. Final Report, Save the Tiger Fund, National Fish and Wildlife Foundation, Washington DC, pp 1-57

Karanth KK, Curran LM, Reuning-Scherer JD (2006) Village size and forest disturbance in Bhadra Wildlife Sanctuary, Western Ghats, India. *Biological Conservation* **128**, 147-157

Karanth KU (1982) BhadraWildife Sanctuary and its endangered ecosystem. *Journal of Bombay Natural History Society* **79**, 79-86

Karanth KU (2002) Nagarahole: limits and opportunities inwildlife conservation. In: Terborgh J, van Schaik C, Davenport L, Rao M (Eds) *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, Washington, DC, pp 189-202

Karanth KU, Sunquist ME (1992) Population structure, density and biomass of large herbivores in the tropical forests of Nagarahole, India. *Journal of Tropical Ecology* **8**, 21-35

Krishnan M (1972) An ecological survey of the large mammals of peninsular India. *Journal of Bombay Natural History Society* **67**, 496-501

Kumar DY (2000) Bhadra Wildlife Sanctuary: management plan for 2000–2005. Bhadra Wildlife Sanctuary. Karnataka: Karnataka Forest Department, India, unpublished report

Kumar R, Shahabuddin G (2006) Effects of biomass extraction on vegetation structure, diversity and composition pf an Indian dry tropical dry forest. *Environmental Conservation* **32**, 1-12

Kushwaha SPS (2002) Geoinformatics for wildlife habitat characterization. *Proceedings of the 5th Annual International Conference*, Map India 2002, New Delhi, pp 293-302

Madhusudan MD (2004) Recovery of wild large herbivores following livestock decline in a tropical Indian wildlife reserve. *Journal of Applied Ecology* **41**, 858-869

Madhusudan MD (2003) Living with large wildlife: livestock and crop depredation by large mammals in the interior villages of Bhadra Tiger Reserve, southern India. *Environmental Management* **31**, 466-475

Madhusudan MD, Karanth KU (2000) Hunting for an answer: is local hunting compatible with wildlife conservation in India? In: Robinson JG, Bennet EL (Eds) *Hunting for Sustainability in Tropical Forests*, Columbia University Press, New York, pp 339-355

Manley PN, Schlesinger MD, Roth JK, Horne BN (2005) A field based evaluation of presence-absence protocol for monitioring eco regional scale biodiversity. *Journal of Wild Life Management* **69**, 950-966

McNaughton SJ (1979) Grassland herbivore dynamics. In: Sinclair ARS, Norton-Griffiths M (Ed) *Serengeti: Dynamics of an Ecosystem*, Chicago University Press, Chicago, pp 46-81

McNeilage A, Plumptre AJ, Brock-Doyle A, Vedder A (2001) Bwindi Impenetrable National Park, Uganda: Gorilla Census 1997. *Oryx* **35**, 39-47

Moe SR (1994) The importance of aquatic vegetation for the management of the Barasingha (*Cervus duvauceli*) in Nepal. *Biological Conservation* **70**, 33-37

Nayak K (2004) *Workshop on National Tiger Habitat and Population Evaluation System*, Organized by Field Director, Kanha, Madhya Pradesh, pp 5-44

Nichols, JD, Hines JE, Sauer JR, Fallon FW, Fallon JE, Heglund PJ (2000) A double-observer approach for estimating detection probability and abundance from point counts. *Auk* **117**, 393-408

Raju R (1999) Studies on the impact of silvicultural and management practice on wildlife of Bhadra Wildlife Sanctuary with special reference to Gaurs. PhD thesis, Mysore University, pp 11-143

Sale JB, Johnsingh AJT, Dawson S (1990) Preliminary trials with an indirect method of estimating Asian elephant numbers. A report prepared for the IUCN/SSC. Asian Elephant Specialist Group, pp 331-339

Sathisha AM (2007) Survey and documentation of Bryophytes in Bhadra wildlife sanctuary, Karnataka. PhD thesis, Kuvempu University, 23 pp

Shankara Raman TR, Menon RKG, Sukumar R (1996) Ecology and management of chital and blackbuck in Guindy national park, Madras. *Journal of Bombay Natural History Society* **93**, 179-192

Surendra Varman K, Sukumar R (1993) Ecology of Sambar in Madhumalai Sanctuary, Southern India. In: *Deer of China Biology and Management – Proceedings of the International Symposium*, 21-23 November, 1992, Shanghai, China, pp 273-284

Varman KS, Sukumar R (1995) The line transect method for estimating densities of large mammals in a tropical deciduous forest: an evaluation of modes and field experiments. *Journal of Bioscience* **20 (2)**, 273-287