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Population distribution and conservation of the four-horned antelope (*Tetracerus quadricornis*) in the tropical forest of Southern India

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Abstract

Population density, distribution patterns and conservation problems of the four-horned antelope (*Tetracerus quadricornis*) were assessed in the Mudumalai Wild Life Sanctuary, Southern India. The antelopes were found to be restricted to dry deciduous and dry thorn forests in the northern and eastern areas of the sanctuary in an area of approximately 79 km^2. The ecological density of the antelope was 0.88 individual/km^2 and the crude density was ~0.22 individual/km^2. Within the dry deciduous forest, the antelopes were further restricted to flat short grass patches and hilly areas with open canopy patches of tall grass. The antelopes were relatively more abundant in the dry deciduous short grass habitat than in the dry deciduous tall grass and dry thorn forests. They also seemed to have higher preference for hill slopes with semi-open canopy (>70%). Antelopes and evidence of their presence have not been seen in recent years in some eastern areas of the sanctuary where antelopes were seen until 1990. We attribute the range decline to the overgrazing by cattle and the resultant weed invasion in the recent years.

Keywords : conservation, dry deciduous forest, dry thorn forest, four-horned antelope, Mudumalai, population density

INTRODUCTION

The four-horned antelope (*Tetracerus quadricornis*) is a small antelope, standing 65 cm at the shoulder. It is one of the tropical Indian antelopes and lives in undulating or hilly terrain (Prater, 1971). Unlike most other species of antelope, this species, like the deer, has adapted to live in wooded forests. It has been reported that the four-horned antelopes are distributed in all of the Indian States south from Uttar Pradesh except Kerala (Rice, 1990). Despite being widely distributed in India, this species has received very little scientific attention. A review of literature shows that the species is generally given only a brief treatment in accounts of multi-species studies (Krishnan, 1972; Sharatchandra and Gadgil, 1975; Schaller, 1987; Karanth and Sunquist, 1992). A community study on wild ruminants in the Gir forest ecosystem by Berwick (1974) was the first study that furnished information on population density, age structure, and food consumption of this species. Another significant report was by Rice (1990) on the status of four-horned antelope based on information collected through questionnaires from various sources. Information on population density, distribution, and habitat requirements are very essential for long-term conservation of a species. This paper describes the population density, distribution pattern in relation to major and microhabitats, and conservation problems of four-horned antelope *T. quadricornis* in Mudumalai Wildlife Sanctuary and National Park, Southern India based on extensive studies during September 1998 to February 1999.

STUDY AREA

Mudumalai Wildlife Sanctuary and National Park is located at the junction of the southern states of Tamil Nadu, Karnataka, and Kerala, and part of the Nilgiri Biosphere Reserve. It lies between 11° 32′ and 11° 45′ north latitude and 76° 20′and 76° 45′ east longitude. It is bound to the north by Bandipur National Park, to the west and northwest by Wayanad Wildlife Sanctuary, and to the south and east by Reserve Forests of Nilgiri North Division. The terrain is undulating with an average elevation of 900 to 1000m MSL. Only the Moyar River and a few bigger streams that drain into it are perennial. Additionally, there are several large man-made water holes that act as water sources during the dry season for wild animals. The study area has two wet seasons and a dry season, each lasting for four months. It receives rainfall from the southwest monsoon from May to August and from the northeast monsoon from September to December. The rainfall has a marked east-west gradient with eastern areas receiving 600 to 800 mm of precipitation annually and the western regions receiving 1800 to 2000 mm of precipitation. The vegetation follows a gradient in accordance with the rainfall, with dry thorn forests dominating the eastern side of the sanctuary followed by dry deciduous short

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grass and dry deciduous tall grass forests in the middle, and moist deciduous forests to the western side. There are also a few patches of semi-evergreen forest along the western side of the sanctuary.

METHODS

Identification of antelope distribution pattern

To identify the antelope distribution and the major habitat types used by the four-horned antelope, a preliminary systematic survey on foot was conducted to record the presence/absence of antelope in the three major habitat types: *viz*., moist deciduous, dry deciduous and dry thorn forest. In addition to this survey, all the forest roads were traversed by vehicle (driven at 20 km/hr). Poor visibility in tall grass areas coupled with low density of antelope made direct sighting a difficult task. Therefore, presence of antelope was recorded using both direct sighting and indirect evidence (pellets). The unique habit of antelope to defecate at specific sites (defecation sites) within their range made the determination of their presence (distribution) in a given area an easy task. During both the walking and vehicle surveys, whenever an antelope was sighted or its defecation site observed, the habitat (vegetation) type was noted and its specific location was marked on the sanctuary map (Survey of India Topographical Sheet 1:50,000) for the preparation of a distribution map.

Density estimation

Four-horned antelope population density was estimated using line transect and block count methods. For the line transect method (Burnham *et al*., 1980) transects of varying lengths (2 to 4 km) were laid in the forest and then walked to estimate densities. In addition, all forest roads in the antelope distribution area were also treated as transects and sampled. At every sighting, information such as sighting time, sighting angle, sighting distance, group size and group composition were recorded. Antelope density was estimated from the transect data with programme '*Transect*' (Burnham *et al*., 1980) by using the *Fourier series* density estimator model.

Two factors did not permit the density estimation to be based entirely on transects alone. First the species appeared to be very localized in its distribution in the Sanctuary, and this did not permit proper application of the line transect method. Second, the low visibility in forest transects due to the tall grass (that are taller than antelope) and presence of man-made microhabitats like clearings (firebreaks and view lines) along roadsides created a non-representative habitat. Therefore to overcome these constraints, the block count method was also used; however, this method too had its limitation, as manpower was insufficient to adequately sample an entire block in which antelope was distributed. Thus the numbers obtained by block count were considered as the minimum population size for the given area.

For block counts, the entire antelope distribution area within the sanctuary was divided into four sites/blocks: Site 1: Avarhalla and compartment 12, Site 2: Circular road area including compartments 7 and 8, Site 3: Ponnagiri area including compartments 9, 10 and 16, and Site 4: Honnaretti and Doddakatti area. These four sites were different in their vegetation physiognomy. The Moyar gorge, a natural topographical feature, separates Site1 and Site 2, and an interstate highway separates Site 2 and Site 3. There is no natural or anthropogenic barrier between Site 3 and Site 4. In each of these four sites, systematic surveys were done at different times of the day, and the highest number of sightings recorded during any particular visit was considered as the minimum number of individuals at the site. The density was calculated for each site using the area of the site and the maximum number of individuals sighted in a particular survey of a given site.

Identification and evaluation of microhabitats

To identify various types of microhabitats used by antelope, each major habitat (dry thorn, dry deciduous and moist deciduous forests) was further divided into four microhabitats based on topography: flat area, hilltop, hill slope, and nulla (dry stream) edge. At every antelope sighting, the microhabitat and canopy cover of the sighting location was noted. Evaluation of microhabitat use was arrived as a relative (per cent) occurrence of antelope in various microhabitats based on total number of sightings in a given microhabitat as well as in all microhabitats.

OBSERVATIONS AND RESULTS

Distribution patterns

A total of 81 direct sightings and 62 defecation sites were recorded during the systematic surveys in all the habitats. Both the direct sightings and indirect evidences show that antelopes are present in the northern and eastern areas of the Sanctuary (Figure 1). There was no sighting or indirect evidence on the western and northwestern areas of the Sanctuary. Both direct sighting and indirect evidence of antelope suggest that their distribution is restricted to dry deciduous and dry thorn forests, and they are not present in moist deciduous forests. Their distribution within these two habitats is further limited to an area approximately 79 km^2. In dry deciduous forest, the antelope seems to prefer short grass habitat such as the ones present in compartments 7, 8 (Circular road area) and part of compartment 12. But in the dry deciduous tall grass habitat, they are found in Ponnagiri, Imbarhalla, Honnaretti, and Doddakatti, mostly along the hilltops and hill slopes that are relatively open with semi-open canopy and sparse grass growth.

Population density

Line transect method

In total, four direct sightings of antelope were recorded from 20 line transects that were walked inside the forest, totaling 151.5 km length. Since a minimum sample size of forty sightings is needed for a reliable density estimate (Burnham *et al*., 1980), it is apparent that this method is not suitable for sampling the species distributed at low density, especially when species inhabits habitat having poor visibility. As compared to the walking transects, vehicular road transects proved to be a much more robust method for collecting data to estimate antelope population density as we were able to obtain a total of 47 sightings in 299.4 km of road transects. The antelope density, using this data was found to be 4 individuals/km^2 (Table 1).

Unfortunately, transects using forest roads may also be inappropriate for this species as we feel that such road transects tend to overestimate antelope densities due to two major reasons. First, due to relatively dense vegetation in their habitat (except of Jayadev, C12 and parts of Circular road) four-horned antelopes seem to prefer open areas. Under this condition, roads may offer a suitable microhabitat for this species as they have clearings on both sides (firebreaks or view lines). Secondly, artificial saltlicks present along forest roads may

Table 1. Density of four-horned antelope estimated using road side transect in Mudumalai Wildlife Sanctuary (total distance covered 299.4 km)

Sample Size	Mean group		Group density		Individual density		95% confidence interval	
	size	SE*	/km^2	SE*	/km^2	SE*	Lower	Upper
47	1.5	0.12	2.81	0.51	421	0.85	3.56	5.06

* Standard Error

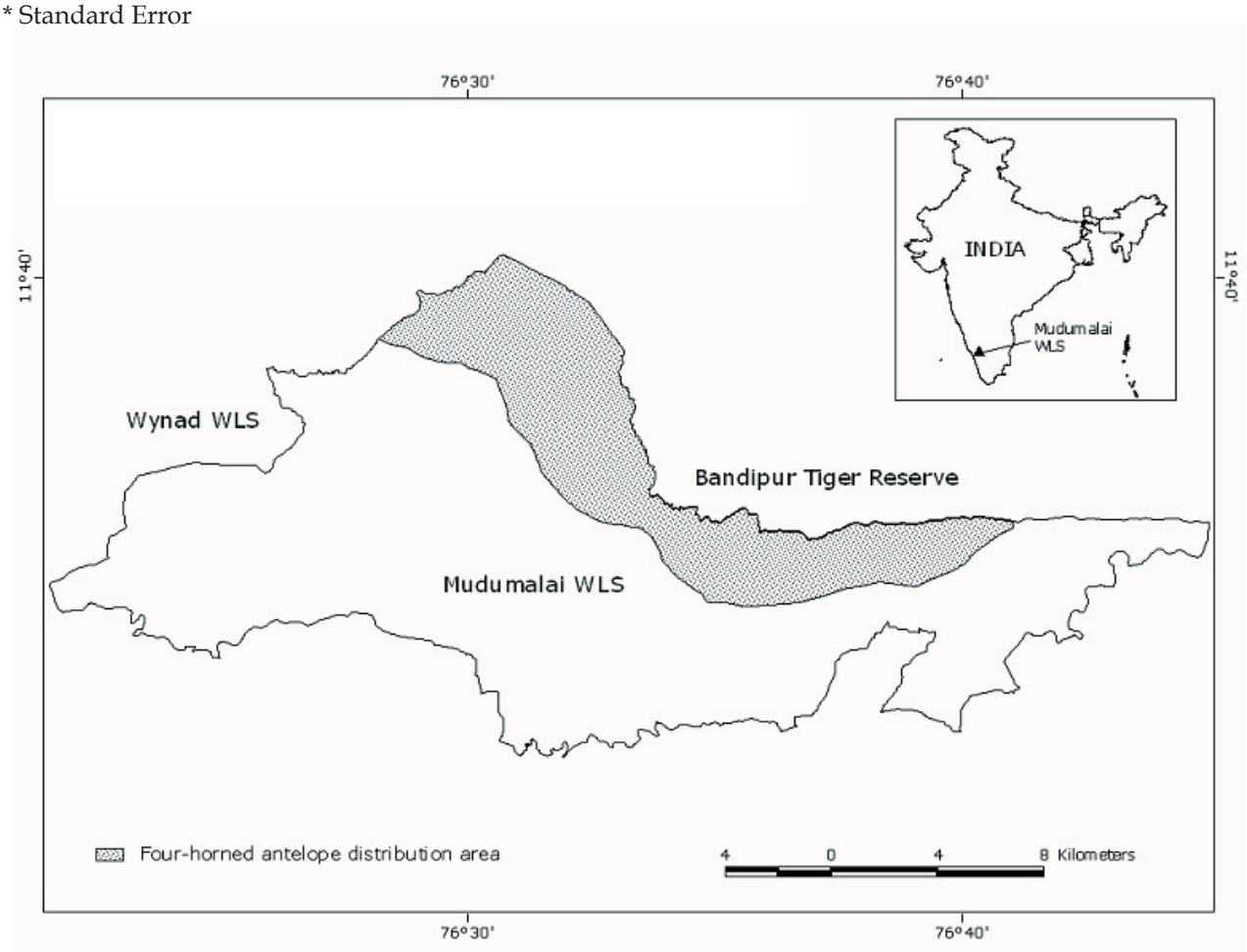

Figure 1. Map showing Four-horned antelope distribution in Mudumalai Wildlife Sanctuary

be another reason for the antelopes to concentrate along the forest roads, as ~ 9% of the sightings of antelope in the road transect were at these artificial salt licks.

Block count

Of the four sites/blocks defined in the antelope distribution area, two sites (2 and 3) were surveyed for block count. In total, eight individuals were sighted from an area of 9 km^2 of Site 2 and seven individuals from 8 km^2 area of Site 3. In these two sites together, 15 individuals were sighted within an area of 17 km^2. This gives an ecological density of 0.88 individual/km^2 and a crude density of 0.22 individual/km^2. Assuming that similar densities occur at the two sites (1 and 4), the population size for the entire distribution area (79 km^2) within the sanctuary was calculated to be approximately 70 antelopes. This figure should be treated as a minimum estimate considering the small body size of the species, the poor visibility of the habitat and the high sensitivity of this species to human activity.

Relative abundance of four-horned antelope at different sites

In order to compare the relative abundance of antelope between the four sites, the number of individuals sighted per km distance was calculated using total number of individuals sighted and total distance covered during the study period (Table 2). The highest number of individuals and groups sighted was in Site 2, followed by Site 3. In contrast, the number of individuals and groups recorded were much lower in Site 1 and Site 4 (Table 2).

Micro habitat preference

Microhabitats selected by antelopes was identified based on data gathered at 67 sighting locations (Table 3). Our data indicate that four-horned antelopes show very high preference to hill slopes (~ 70% of observations) and hill tops (~ 18% of observations), while they rarely use stream edges and flat areas (Table 3). In addition, with regard to canopy continuity we found that four-horned antelopes preferred areas with semi-open canopy (75% of sightings), followed by areas with open canopy (17% of sightings), as compared to closed canopy (8% of sightings).

DISCUSSION

The four-horned antelope distribution within the sanctuary is fairly restricted, and even in areas of suitable habitat their distribution is patchy. They were largely absent in areas adjoining human settlements. Similarly, their distribution in the dry deciduous forests is again influenced by the availability of suitable

Table 2. Frequency of sightings (encounter rate) recorded per km distance in different study sites at Mudumalai Wildlife Sanctuary

Site	Habitat	No. of individuals sighted/km	No. of groups sighted/km
1	Dry thorn forest - Jayadev & part of C12	0.095	0.095
2	Dry deciduous short grass - Circular road (C7 & C8)	0.286	0.21
3	Dry deciduous tall grass - Ponnagini (C9)	0.220	0.15
4	Dry deciduous tall grass* - Doddakatti & Cinnaretti	0.213	0.14

* Area dominated by *Shorea talura* regeneration

Table 3. Preferences to various microhabitats by four-horned antelopes at Mudumalai Wildlife Sanctuary

Micro habitat types	Number of sightings	Percentage
Hill slope	48	71.6
Hill top	12	17.9
Nulla (stream) edge	6	8.9
Flat area	1	1.5

microhabitat, either short grass areas or the open canopy patches of tall grass in hilly areas. In the eastern part of the sanctuary, areas around Karadibetta hillock and Nerillabetta (northern slopes in C14), direct sightings and defecation sites of antelope were found previously up to 1990 (Ajay Desai, and Baskaran pers. obs.). However, during the present study, no sighting of antelope or signs of defecation sites were recorded in these areas. Thus it appears that the range of this species in Mudumalai Wildlife Sanctuary is declining. Furthermore, though the dry thorn forest areas around U road and Chemmanatham appear to be an ideal habitat, for this species, no antelope or evidence of their presence were recorded during the present study. Both the above-mentioned areas are being subjected to high human disturbances and cattle grazing (Baskaran *et al*., 2004). On the other hand the four-horned antelopes are found still further east of Chemmanatham in tower line sides of Sigur Reserve Forest where biotic pressure was relatively less. They are also distributed in the western sides of Chemmanatham (close to the edges of Moyar gorge in Compartment 12), where again biotic pressure was less. So, it is possible that human disturbances adversely impact the distribution of this species.

The reason for the higher abundance of antelopes at Site 2 could be a function of availability of suitable habitat composed of short grass and more open canopy with stunted trees and less weed cover in this site compared to other three sites. Although, Site 1 could be the most suitable habitat for antelope with its short grass and more open canopy than all other sites, as seen in micro-habitat selection in the present study, the high biotic pressure in this site may still affect antelope abundance. The ground cover in Site 3 is dominated by tall grass, and canopy cover is also more closed compared to Site 1 and Site 2. Site 4 has more open canopy than Site 2 and Site 3; however, the thick understorey dominated by *Shorea* sp. regeneration and tall grass may not be ideal for the antelope in terms of visibility for detecting and escaping from predators or due to the non-availability of food species. Therefore, it could be that the availability of short grass and open canopy areas without biotic pressure support a higher abundance of antelope in Site 2 as compared to the other sites.

The present estimate of 0.22 antelope/km^2 is lower than the density estimates reported elsewhere in Gir forest (0.75/km^2) of Gujarat (Berwick, 1974), Pench Tiger Reserve (0.80/km^2), and Panna Wildlife Sanctuary (0.88/km^2) in Madhya Pradesh (Rice, 1990) and Nagarahole National Park (0.8/km^2) in Karnataka (Karanth and Sunquist, 1992). The reason for such low density of antelope in Mudumalai Wildlife Sanctuary could be the low availability of suitable major and microhabitats and higher biotic disturbances.

The habitat suitable for four-horned antelope is found largely on the eastern side of Mudumalai Sanctuary. This habitat continues eastward well beyond the sanctuary boundary and surveys of these areas are urgently needed to determine if they are indeed occupied by four-horned antelope. The population found in the northern part of sanctuary, however in all likelihood represents the occurrence of the species at the edge of its ecological range. The habitat beyond this point changes towards tall grass with dense ground cover or towards more moist conditions, and absence of antelope indicates that such habitat conditions are not suitable for survival. The low densities in the northern area would therefore be natural, considering that this area is largely a sub-optimum habitat for the species.

Though the population of four-horned antelope in the sanctuary is low, it is contiguous with other populations in the eastern side (Sigur RF and beyond) and also with the population in Bandipur National Park at the north. Despite this, the tendency of the species to be in low densities and its sensitivity to human disturbance might be an indication that there might not be a minimum viable population within the Nilgiri Biosphere Reserve (500 effective breeding individuals as suggested by Frankel and Soule, 1981) for long-term conservation. In addition, the species does not appear very mobile, the fixed defecation sites indicates that these antelope could be territorial and localized, therefore limiting or reducing the rate of flow of genetic material within the population. However, nothing is known about the dispersal patterns in this species and how that would affect gene flow within the population. Their sensitivity to human disturbances (through habitat degradation) would also indicate the possibility of further fragmentation even with the maintenance of forest contiguity. All the findings in this study indicate that even the small marginal or peripheral populations like those found in Mudumalai Wildlife Sanctuary are vitally important for the long-term conservation of the species, and management efforts should strive to ensure the survival of these populations.

Conservation problems and management recommendations

The distribution of four-horned antelope in the sanctuary is restricted to the northern and eastern parts. Although the habitat on the northern side has undergrowth that is much denser than the habitat in the eastern side, absence of human disturbances and presence of semi-open canopy are still favourable for the species to occupy this habitat. Considering that the major constraints imposed on the antelope populations are natural, no management action is recommended for these northern areas (Circular road, Ponnagiri and Doddakatti). However, there is one threat due to human activities, *i.e.* weed proliferation (*Lanatana* sp. and *Eupa-*

torium sp.); and this creates dense undergrowth that is unsuitable for this species. In a naturally marginal habitat, even small changes to vegetation physiognomy could potentially act to eliminate the species from the few open patches that currently exist.

The habitat in the eastern part of Mudumalai on the other hand, appears to be very suitable for the antelope. But even here, the population is low and the past range appears to have marginally decreased (in compartment 14). The likely reason for the low population and range decline in this region could be human disturbance, including cattle grazing. This problem has already been identified as a major issue in Mudumalai Sanctuary even for larger species like the Asian elephant *Elephas maximus* (Desai and Baskaran, 1996). The results of the present study would further support the need to address this problem of growing human pressure on the wildlife habitat in the eastern part of the Sanctuary. Unless these problems are addressed, there is little hope for the revival of antelope population in these areas. Human population growth, settlement expansions, new roads, etc. within and adjoining Protected Areas pose threats to wildlife. Further fragmentation of its range and degradation of habitat would adversely affect the long-term conservation prospects for this species.

Although the population of four-horned antelope is low in Mudumalai Sanctuary (it is also likely to be low in Bandipur Tiger Reserve and Nagarahole National Park), managers need to recognize that these Protected Areas (PAs) still play a significant role in the conservation of this species. In this part of its range most of its distribution lies outside the PA network (Sigur Range and beyond), and these PAs (Mudumalai, Bandipur and Nagarahole) offer significant protection for this species. The present study of the four-horned antelope however points to the need for including such dry thorn forest habitats in the existing PAs. These dry thorn forest habitats not only harbour the four-horned antelope but also many other endangered species like the Striped Hyaena (*Hyaena hyaena*) and Small Indian Civet (*Viverricula indica)*. The distribution of four-horned antelope outside the PAs further highlights the need to include the Sigur RF within the Mudumalai as Sigur RF has large tracts of habitat suitable for this species. The need to expand the PA network is justified as the four-horned antelope and other species, which depend on open forests, do not have adequate portions of their range protected under the present PA network. Further, their naturally (relative to some other species) low population densities require that large areas be protected to ensure a viable population for long-term conservation.

Although the present study was short term in nature, we have also made use of the data collected by the first two authors over a decade of their research on this sanctuary on Asian elephant, which provided essential information on the nature of distribution and the impact of biotic disturbances on antelope distribution that are essential to manage for the conservation of this species. However, detailed long-term studies on ranging behaviour, diet composition, dispersal pattern, molecular genetics etc., are still essential for better understanding and conserving the species.

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