A Preliminary Estimation of the Sambar Deer (*Rusa unicolor unicolor*) Abundance in Horton Plains National Park, Sri Lanka.

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Abstract

Grasslands are one of the tropics' most critically threatened habitats, while conservation attempts are rarely concentrated at these ecologically important landscapes. Sambar deer is a large wild ruminant found throughout Sri Lanka, in both grassland and forest ecosystems. Amidst their key position in the trophic web in '*wet patana*' grasslands of the Horton Plains National Park (HPNP), Sri Lanka, population of sambar deer has not been estimated during recent decades. In this research, field surveys were performed in the total grasssland area of 9.4 km^2 in HPNP to estimate the density of Sambar deer, for a period of six months, from 1st of January to 31st of June 2018. Sambar deer were sampled along line transects from 1600 hrs -1830 hrs for up to 300m of maximum distance from the line and the distance sampling technique was used to solve imperfect detection for the first time. Counting was carried out for three days per month along a 6.71 km road transect through grasslands. Collected data on sambar deer observations along the transect was analyzed by using the DISTANCE 7.2 computer application. The highest sambar deer density in HPNP was estimated as 113.45 ±11.79 individuals/km^2 with a detection probability of 28% in January with an estimated absolute abundance of 1066 ± 110.82 individuals. Our findings indicate consequences of imperfect detection of a statistically strong model. Sambar deer density estimates from this research lays the context for regular surveillance of their population, examining the effects of habitat alterations and assessing the long-term viability of '*wet patana*' grassland in HPNP, offering insight on the conservation of the fragile habitat of the resident sambar deer population.

Key words: Abundance, Density, Distance sampling, Sambar Deer, Population,

Introduction

Sambar (*Rusa unicolor unicolor)* is the most extensively spread deer species in Asia (McShea and Baker, 2011). The dietary pattern of sambar deer is ranging from grasses, forbes and tree fodder which is similar to other wild ruminants in the region (Rajapakse, 2003). Sambar deer can live in a variety of different types of environments which is why they have such a diverse distribution (Fritz and Loison, 2006) that range from Sri Lanka (Rajapakse, 2003), India (Joseph and Mani, 1980), Southern Nepal (Bhattarai and Kindlmann, 2012), Burma (Bhattarai and Kindlmann, 2012; Yen et al., 2014), throughout Southern China and in South-Eastern Asia to the Pacific Coast and the Islands of Borneo, Hainan and Taiwan (Leslie, 2011; McShea and Baker, 2011). It is found from sea level in South-Eastern Asia to about 3,000 m in the Indian Himalayas and Burma, and about 3,500 m in Taiwan (Joseph and Mani, 1980; Leslie, 2011).

Sambar deer is generally a non-social or solitary species, where a sambar group would usually number fewer than six individuals (Leslie, 2011). The characteristic of the social unit is one hind and one calf or one hind, a yearling, and a calf (Barry and Muir, 1993). During the breeding season, dominant stags are commonly seen with hinds and sometimes with other stags who may challenge the dominant stag for the breeding opportunity (Semiadi et al., 1994; see Weerasekera et al., 2018 for details on reproductive seasonality and the antler cycle of sambar stags in Horton Plains). Nevertheless, Sambar deer herds found within the Horton Plains National Park (HPNP) in the highland plateau of Sri Lanka deviates from this generality, where herds have been recorded to count as high as 10-40 individuals (Rajapakse, 2003).

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Few field studies have been conducted in the past to estimate the ecological density of sambar deer in HPNP by using direct and indirect methods more than 15 years ago (Rajapakse, 2003). We estimated the population density of Sambar Deer using the distance sampling approach (Horcajada-Sánchez and Barja, 2015). Accurate and reliable estimates of densities are difficult to achieve since they may be affected by environmental variation, behavior of the species, and/or improper detection/observation ability. Therefore, to obtain unbiased estimates of densities it is necessary to adopt sampling methods that quantify the probability to detect the target species. In this study, we introduce such a method for sampling sambar deer in HPNP for the first time, by emplying the distance sampling technique and estimating the population density using the computer application DISTANCE ver 7.2.

Methodology

Site selection

This research was conducted at an altitude of 2,100–2,300m in HPNP, located on the hill country montane landscape with '*wet patana*' type open grassland ecosystems covering an area of 9.4 km^2, with grass species like *Pennisetum glaburm, Pennisetum clandestinum,* and *Crysopogon zeylanicus* (Figure 1). However, the anthropogenic introduction of the exotic *Penisetum sp.* has altered the natural grasslands in this reserve. The mean annual rainfall in HPNP is higher than 2,000mm and the mean annual temperature is about 13°C with a significant variation during the day, reaching as high as 27°C during the mid day and dropping as low as 5°C at night (Chandrajith et al., 2012). The wind speed sometimes reaches gale force during the Southwestern Monsoon season, while the dry season spans from January–March, although some rain fall can usually be experienced throughout the year (Ranawana, 2015). The reserve harbors a wealthy grassland fauna, including mammalian apex predators like the Leopard (*Panthera paradus kotiya*), despite its small size (Rajapakse, 2003).

Sampling

Road strip transect counting was used to predict sambar deer population density and abundance in HPNP. Transect counts were carried out systematically, three days per month from the Pattipola entrance to the park to its Ohiya entrance (Figure 1) with a length of 6.71 km mostly through the grasslands. Biased outcomes were anticipated from animal counts in these regions due to the landscape heterogeneity (Rajapakse, 2003). Care was taken not to break the important assumptions of the road strip transect technique: 1. all the animals on the line were counted, 2. animals were identified and analyzed at their original localities prior to any behavioral reaction, and 3. measurements were taken properly without mistakes (Rajapakse, 2003; Bhattarai and Kindlmann, 2012; Muthamizh Selvan et al., 2014). Sampling was conducted from January to June 2018 by driving along the marked transect line between 1600h -1830h, three times per month. Transect line was marked using a GPS unit, (Garmin Montana 680t). Distance to the center of sambar deer individuals were determined using a Bushnell laser range finder and angles to the centers of individuals were measured using a Suunto prismatic compass (KB-14/360R G).

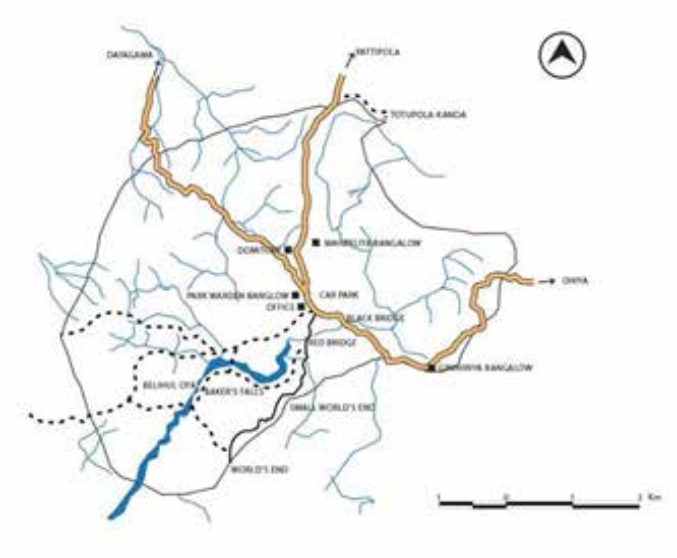

Figure 1: Location of Horton Plains National Park, Sri Lanka (2019).

Data Analysis

The computer application DISTANCE ver 7.2 was used to evaluate the probability of detection (p) in order to cator for imperfect identification (Li et al., 2010). We improved the detection function analysis by evaluating the main outliers and trimming them using the default truncation technique in th software. The best fit detection function model was chosen based on the Chi-square test (Hosmer et al., 1997). The detection probability estimated using the Canonical Estimator was used to estimate the absolute population density (Pollock et al., 2002). The density variance was estimated by the Delta method (Powell, 2007).

Result

Summary results for estimation of the population (N) and its density (D) for sambar deer in the 9.4km^2 of 'wet patana' grassland area in HPNP for the first six months of 2018 is tabulated in Table 1. Considering all three transects conducted per month an absolute population of 1066±110.82 sambar deer were estimated for January 2018. This was recorded as the highest population estimation for the period from January to June 2018 with a density of 113.45±11.795 individuals/km^2. The distances of viewing ranged from 0 to 150m in January with 224 individuals observed at a detection probability of only 28%. In February, the estimated sambar deer population in HPNP was 874± 48.143 individuals and the density was 93.014±5.1235 individuals/km^2. At a viewing range of 0-200m the number of observations was 228 in February with a detection probability of 92.4%. During March, the estimated abundance of sambar deer in HPNP was 835±39.633 individuals with a density of 88.788±4.2143individuals/km^2. The number of sambar observations was 233 in March with a detection probability of 99.2% within a 0-300m viewing range. When it comes to the April an abundance of 640±61.705 sambar deer were estimated with a density of 68.114±6.5671 individuals/km^2, based on 120 observations within a range of 0-178m at a detection probability of 97%. The minimum estimated sambar population in HPNP was for the month of May which was 469±45.193 individuals with a density of 49.929±4.8112 individuals/km^2. 176 sambar deer were observed during May within a range of 0-226m at a detection probability of 99.7%. A total of 204 sambar deer were observed during June within a range of 0-197m at a detection probability of 83% resulting in a population estimation of 676±50.214 individuals in HPNP at a density of 71.886±5.3398 individuals/km^2 (see Figure 2; Table 1).

Table 1: Population and density estimates for sambar deer in grasslands of Horton Plains National Park, Sri Lanka over the first six months of 2018 based on distance sampling observations.

Month	Parameter	Point estimate	Standard Error	Detection Probability	Encounter rate	Observations	Maximum Distance (m)
January	D	113.45	11.795	28.0	72.0	244	150
	N	1066.0	110.82				
February	D	93.014	5.1235	92.4	7.6	228	200
	N	874.00	48.143				
March	D	88.788	4.2143	99.2	0.8	233	300
	N	835.00	39.633				
April	D	68.114	6.5671	97.0	3.0	120	178
	N	640.00	61.705				
May	D	49.929	4.8112	99.7	0.3	176	226
	N	469.00	45.193				
June	D	71.886	5.3398	83.0	17.0	204	197
	N	676.00	50.214				

Effort : 20.13000
Number of samples : 3
Measurement Units

Density: Numbers/Sq. kilometers
ESW: meters

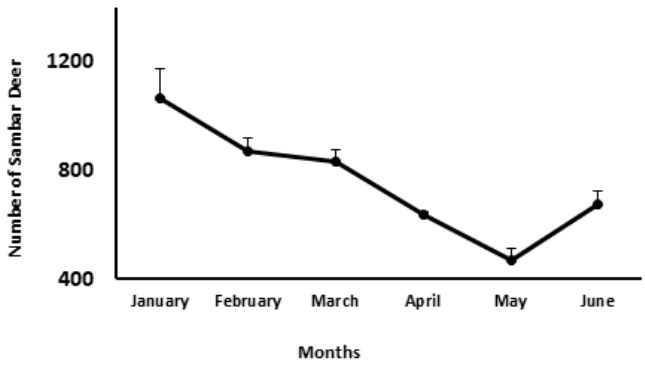

Figure 2: Sambar Deer Numbers (N) in Horton Plains National Park (HPNP) from January to June 2018.

Discussion

Our estimatinn of the sambar deer population density in HPNP over a range of 9.4 km^2 of grassland provides insight into the grazer population at HPNP, which is of much value for park management and

conservation decision making. The difficulties of estimating the density and distribution of sambar deer in HPNP have been repoted in pevious publications (see Rajapakse, 2003). However, there has not been any previous effort to count the sambar deer in HPNP considering the detection probability during each sampling session (Padmalal et al, 2003). The absolute count techniques were not clearly applicable in this study region, due to the landscape heterogeneity and the ground topography. The existence of invasive *Pennisetum glaburm* and *Pennisetum clandestinum* grasses have altered the landscape further, offering noval sources of enriched feeding for the sambar deer in HPNP (Padmalal et al,. 2003). The assessment showed that we could detect only about 28% of the absolute population of sambar in January (p hat is 0.28), followed by 92. 4% in February, 99.2 % in March, 97 % in April, 99.7 % in May, and 83 % in June indicating a fairly high degree of undetection of individuals, espercially in early months. Attempts of accuarte estimation of the absolute size of the sambar deer population is a significant ecological consideration for management of the HPNP (Padmalal et al,. 2003; Rajapakse, 2003). Such data on the sambar population density in HPNP would lead to further studies on the population such as the density dependence, predator prey reactions and population regulation (Rajapakse, 2003), while population demographic data helps to design and formulate conservation initiatives.

Acknowledgments

We thank the Department of Wildlife Conservation in Sri Lanka for permission to conduct our study in the Horton Plain National Park under the research permit number WL/3/2/10/18. Fieldwork support from Young Farmers' Club, Trinity College, Kandy, Sri Lanka is also acknowledged.

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