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RESEARCH ARTICLE

Indian Giant Squirrel (*Ratufa indica*) Distribution pattern, Habitat Structure and Characteristics in the Grizzled Giant Squirrel Wildlife Sanctuary, Srivilliputhur, Tamil Nadu, India

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Study Area: Srivilliputhur, Tamil Nadu, India

Coordinates: 9° 21' to 9° 48' N and 77° 21' to 77° 46' E

Key words: Tree density, Habitat assessment,
Relative abundance, Western Ghats

Abstract

An attempt has been made to study the distribution pattern and habitat characteristics of the Indian Giant Squirrel (*Ratufa indica*) at Grizzled Giant Squirrel Wildlife Sanctuary, which is a part of the Periyar-Agasthyamalai landscape of Southern Western Ghats, Tamil Nadu, Southern India. The study results revealed that the *R.indica* is widely distributed in moist deciduous forest followed by evergreen forest and not located in dry thorn forest habitat. Among the 17 habitat variables studied, 14 variables were significantly higher in *R. indica* distribution area than those in the non-distribution area. Tree species density and GBH were significantly higher in *R.indica* distribution area (density: 442±13.12, GBH = 81±1.56) than that of non-distribution area (density: 318±6.3, GBH: 57±0.68) (density: t-test, df = 153, P < 0.05 and GBH: t = -7.27, df = 169, p < 0.05). The present distribution pattern and habitat characteristics of *R. indica* in the area provides baseline data for future studies. The study is also addressed the issue of an urgent need of survey the status, distribution, abundance and habitat utilization patterns of *R.indica* in the studied area.

Introduction:

The *Ratufa indica* is a large sized squirrel with a long tail and tufted ears, adapted for arboreal life and their dependence on forests has resulted in numerous co-evolutionary relationships with forest plants (Steele & Koprowski, 2001). As a result, they are excellent indicators of forest health (Smith & Nichols, 2005). Tree species composition and structural attributes of the forest have an important role in *R.indica* habitat selection and utilization pattern (Borges, 1989; Lemos de Sa & Strier, 1992; Datta, & Goyal, 1996). The species that are highly dependent on the spatial structure of the forest for their habitat requirements and dispersal are the ones to be most affected by fragmentation of canopy (Gurnell, 1987; Nandini & Parthasarathy, 2008; Verbeylen *et al.*, 2009). It is widely recognised that habitat loss is one of the leading causes of local and global species extirpation and extinction (Ceballos & Ehrlich, 2002). The direct consequences of human activities on habitat and landscapes are increasingly well recognised. However, the combined effects of natural and human disturbances on

landscape dynamics have received less attention (Linderman *et al.*, 2006).

The distribution of the *R.indica* has been reduced to isolated forest patches due to the forestry operations and tree felling (Borges *et al.*, 1992). Therefore, data on distribution and the influence of tree species (composition, density, diversity and their characteristics) on the habitat selection by *R.indica* are out most important for long-term conservation plans. Though the species is known to exist widely in Southern India, very few studies (Datta, & Goyal, 1996; Baskaran *et al.*, 2011) have documented the influence of the tree species on the occurrence *R.indica* in different habitats. The present study was carried out to provide baseline information on population distribution and its influence on tree species and their characteristics for the long-term sustainability of the species in the study area.

Materials and methods:

Study area: the Grizzled Giant Squirrel Wildlife Sanctuary is a part of the Periyar-Agasthyamalai

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landscape (Fig. 1), one among the four landscapes of the Western Ghats. The area declared as a Wildlife sanctuary in 1989 and it extended over 480 km². The altitude varies widely from 200m in the plains to 2019m (Kottaimalai). It receives a mean annual rainfall of 849 mm but varies from 700 to 3000 mm, from both southwest and north-east monsoons with major share from the latter one. Madurai Forest Division is bordering its northern side, the Theni Forest Division and Periyar Tiger Reserve are on the western side and Thirunalveli Forest Division is on the southern side. It consists of four ranges namely Rajapalayam, Srivilliputhur, Watrap and Saptur (Fig. 1).

Figure-1: The distribution of *R.indica* in the studied area

Distribution Pattern: it was studied by following line transect method (Burnham *et al.*, 1980). The line transect sampling location was identified through systematic random sampling: i.e. by overlaying a 4 km² grid on 1:50,000 topographic maps of the sanctuary. All the grids were numbered resulting in an overall of 128 grids. The sampling was carried out in alternative grids at 64 grids. In total, the 64 transects (each varying from 1–2 km length), covering 121 km total length was laid systematically covering all the habitats and microhabitats across the sanctuary. Transects were walked during morning (06:00–10:00 h) or evening (16:00–18:00 h).

Habitat assessment (Quadrat Method): as the Indian Giant Squirrel is a canopy dwelling species, the tree species composition and tree characteristics were known to influence its distribution (Baskaran *et al.*, 2011). To assess the tree species composition, density, and diversity, a quadrat (20 x 20 m) was laid using 20m tape at every 250m interval of the line transect (Fig. 2). In total 484 such quadrats were laid. In these quadrats, all the tree species >20cm, GBH, canopy cover percentage, cattle grazing and the human disturbance sign on the quadrat were recorded. In addition, we collected tree species characteristics for four individuals from each quadrat, sampling trees were selected by selecting the one individual at each corner of the quadrat (Fig. 2). In total 1915 trees were sampled and recorded the following variables: (i) Tree height (m) (ocular measurements), (ii) Tree GBH (cm) measured

using a tape measure, (iii) Total number of branches, (iv) Canopy contiguity to neighbouring trees on four major directions, as well as up to 10m distance (by rating method: presence rated as 25% / direction or absence: rated as 0%), (v) Canopy height (m) (ocular measurements), (vi) Canopy length (m) (ocular measurements) (vii) Canopy width (m): (in meter by ocular measurements) (viii) canopy shape (circular, oval and irregular).

Figure-2: Diagrammatic representation of quadrat established for habitat assessment sampling along the line transect within the sampling grid.

Data Analysis: distribution areas are those where population estimate yielded either direct or indirect evidence (nest) or both. Non-distribution areas those where population estimate yielded neither direct nor indirect evidence (nest). Computing the number of species and their total individuals from each quadrat, estimated the individual and overall tree species density, tree species diversity (Shannon-Weiner index) separately for the *R. indica* presence and absence areas. Similarly, tree species characters were computed to arrive at the mean value of each parameter in distribution and non-distribution areas. The observed difference in all the parameters studied between distribution and non-distribution areas was tested for statistical significance using Two-sample "t" Test. In addition, binary logistic regression was performed taking into account all the variables (tree density, diversity, richness, % canopy cover and other tree species characters) assessed between *R.indica* distribution and non-distribution areas.

Results and Discussion:

Distribution and relative abundance of Indian Giant Squirrel in the study area: data on a direct sighting of giant squirrel and its nesting location collected across all the major habitats in four ranges showed its distribution to be discontinuous or patchy in the sanctuary. The species is distributed contiguously, relatively over a larger area in the southern side (Rajapalayam Range) as compared to the northern side of the sanctuary (Watrap and Saptur Ranges) (Fig. 1). Relative abundance estimated using

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encounter rate of direct sightings and nest/km walk in different habitat showed that moist deciduous forest had the highest abundance followed by evergreen and dry deciduous forest (Fig. 3). The species or its nest was not encountered in dry thorn and high altitude grassland habitats. Similarly, abundance estimated in four forest ranges: Rajapalayam (0.7/ km), Srivilliputhur (0.2/km) and Watrap (0.1) while the lowest encounter rate (0.02/km) was recorded in Saptur range (Fig. 4).

Figure-3: Abundance of *R.indica* recorded in different habitat types

Figure-4: Abundance of *R.indica* recorded in different forest ranges

Table-1: Tree species density, diversity and characters in Indian Giant Squirrels distribution and non-distribution areas

S. Parameter	Distribution area	Non-distribution area	't'	'p'	DF
1 Tree density /ha	442±13.12	318±6.3	-8.51	0	153
2 Tree GBH / tree	81±1.56	57±0.68	-7.27	0	169
3 Diversity Shannon/pl.	3.26±0.02	3.88±0.01	25.12	0	173
4 Species Richness/pl.	17.70±5.36	12.74±4.91	-8.51	0	153
5 Canopy cover %	67±0.57	38±0.33	-11.1	0	146
6 Canopy breaking by human %	41	76.24	10.06	0	374
7 Main stem cut by human %	8.47	14.54	0.39	0.7	151
8 Tree height(m)/tree	16.89±0.35	10.74±0.12	-9.91	0	133
9 Total branches/tree	15.97±0.48	10.48±0.17	-7.06	0	124
10 Canopy ht.(m)/tree	10.05±0.22	7.12±0.09	-7.73	0	145
11 Canopy lt.(m)/tree	10.03±0.22	7.13±0.10	-7.63	0	147
12 Canopy width (m)	7.6 ±0.16	5.74±0.08	-7.04	0	173
13 Canopy shape circular %	8.4	10.05	0.96	0.34	173
14 Canopy shape irregular %	80.3	74.1	-2.72	0.007	175
15 Canopy shape oval%	15.7	11.13	2.76	0.006	205
16 Canopy continuity% in 4 directions	58.57±1.69	48.45±0.71	-3.19	0.002	137
17 Canopy continuity 10m (%) in four directions	85.5 ±1.37	58.21±0.98	-9.23	0	217

Tree species composition and characteristics in the study area: tree species composition and characters assessed in *R.indica* distribution and non-distribution areas of the Sanctuary are given in Table 1. Among the 17 variables studied, 14 variables were significantly higher in distribution area than those in a non-distribution area. Tree species density and GBH were significantly higher in *R.indica* distribution area (density: 442±13.12, GBH = 81±1.56) than that of non-distribution area (density: 318±6.3, GBH: 57±0.68) (density: t-test, df = 153, p < 0.05 and GBH: t = -7.27, df = 169, p < 0.05). Though the diversity of trees was lower in animal distribution area (3.2617±0.02161) than the non-distribution area (3.8843 ± 0.0121), distribution area had significantly higher species richness (17.70±5.36) and canopy cover (67±0.57). Tree height(m), a number of branches, canopy height(m), canopy length(m) and canopy width(m) were also significantly higher in the distribution area than that of the non-distribution area (Table-1). There was no significant difference in canopy shape circular (t-test, df = 173, p > 0.05). Canopy breaking and main stem cutting by the human were significantly higher in non-distribution areas (Table-1). These results indicate that human activity has negative influence on the distribution of *R.indica* and therefore they are avoiding certain places in the sanctuary.

Further, Binary logistic regression was used taking the *R.indica* distribution dependent variable and tree species attributes (density, diversity, richness), tree characters (canopy cover, tree height, number of branches, canopy, height, length, and width, canopy shape and its contiguity in four major directions as well as up to 10m and human disturbances: (lopping and main stem cut) to understand the collective effect of each variable on the distribution of *R.indica* (Table-2). The analysis showed five (tree species diversity, main stem cut by human, mean number of branches, canopy width mean, canopy cover % up to 10m in four major directions) out of 17 variables tested had either positive (i.e. number of branches, canopy cover up to 10m distance) or negative relationship (tree diversity, main stem cut by human and canopy width) with the distribution of *R.indica*. The remaining 12 variables (density, richness, canopy cover (%) and contiguity, tree height, canopy height, and length, canopy shape: circular, oval and irregular, and lopping by human) turned out insignificant indicating no impact of these variables on the distribution of the *R.indica*. These results indicate the importance of maintaining canopy contiguity and decreasing the human disturbances in *R.indica* habitats to retain the species in its natural habitats. The results of the present study show that the *R.indica* distribution is discontinuous in the study area. The reason for such patchy distribution could be due to tree species composition or discontinuous canopy contiguity. Data on squirrel abundance in different habitat from the present

Table 2. Binary logistic regression tested for tree species attributes and characteristics in distribution and non-distribution area of *R. indica*

Predictor	Coefficient	SE	Z	P	Odds Ratio	95% Confidence limit Lower	Upper
Constant	34.7598	4.36911	7.96	0.000			
Tree diversity	-11.4073	1.31014	-8.71	0.000	0.00	0.00	0.00
Main stem cut by human (%)	-0.0314938	0.0098734	-3.19	0.001	0.97	0.95	0.99
Mean no. branches (n)	0.126054	0.0449659	2.80	0.005	1.13	1.04	1.24
Canopy width mean (m)	-0.516658	0.131827	-3.92	0.000	0.60	0.46	0.77
Mean Canopy cover (%) 10 m	0.0895805	0.0147596	6.07	0.000	1.09	1.06	1.13

study show that *R.indica* abundance was higher in the moist deciduous and evergreen forests, lower in dry deciduous and completely absent in dry thorn and grass land habitats. Among the five habitats, canopy contiguity is expected to be higher in habitat with high rainfall i.e. evergreen and moist forests than in dry deciduous and dry thorn forests and could be very scanty or virtually nil in the grassland due to very low density or absence of tree cover in this habitat. The observed abundance results of *R.indica* in different habitats go in support of the above statements that canopy cover positively influences the distribution of *R.indica*. Some studies reported an absence or patchy distribution of *R.indica* only along the riverine habitats in dry thorn forests due to poor canopy contiguity (Desai *et al.*, 1999; Baskaran *et al.*, 2011). These studies (Desai *et al.*, 1999; Baskaran *et al.*, 2011) have also pointed the effect of selection felling of mature trees prevailed in the past on the distribution of *R.indica* and highlighted the need for maintaining the canopy contiguity. Further, the abundance data in relation to forest ranges i.e. highest in the Rajapalayam Range followed by Srivilliputhur and lowest in northern side forest ranges like Watrap and Saptur could be a function of canopy contiguity and tree species composition. As shown in vegetation and land use map (Fig. 5), the majority of areas on the northern side of the sanctuary (Watrap and Saptur Ranges) are occupied by dry thorn forests and high altitude grassland habitats, which is known to have poor canopy contiguity. Therefore, *R.indica* patchy distribution and absence in dry thorn and grass land habitats as well as on the northern parts of the sanctuary could be a function of canopy contiguity and tree species composition as reported elsewhere (Borges, 1989; Datta & Goyal, 1996; Baskaran *et al.*, 2011; Ramachandran, 1992; Rout & Swain, 2005).

The present study compared tree species attributes and their character: 17 different variables with the distribution pattern of *R. indica* (presence/absence area). Of which, tree species density, GBH, richness, canopy cover, tree height (m), the number of branches, canopy height (m), canopy length (m) and canopy width were significantly higher in *R. indica* distribution area than that of the non-distribution area. While on the other hand canopy breaking and main stem cutting by a human were significantly higher in non-distribution areas indicating

Figure 5. Land use and vegetation map of the Grizzled Giant Squirrel Wildlife Sanctuary

that positive effect of tree density, diversity, richness and their characteristics and the negative effect of human disturbances on the distribution of *R.indica*. *R.indica*, being a canopy-dwelling species, occasionally comes to the ground (Ramachandran, 1988), mostly to overcome breaks in canopy continuity. Further, the species mostly feeds on seeds, leaves, flowers and bark from trees and constructs globular nests or dreys with leaves and twigs (Thorington & Cifelli, 1989; Ramachandran, 1992). Considering its arboreal nature and dependence on trees for food, shelter, and movement, it is apparent that the composition of tree species and structural attributes of the forests play a major role in the use of the habitat by the giant squirrel (Ramachandran, 1992; Borges, 1989; Datta & Goyal, 1996). The Binary logistic regression showed that positive correlation of *R.indica* distribution with a number of branches, canopy cover and negative correlation with tree diversity, main stem cut by human and canopy width further revealed the importance of maintaining canopy contiguity and decreasing the human disturbances in *R.indica* habitats to retain the species in its natural habitats.

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