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Population density of Indian Giant Squirrel (*Ratufa indica*) in Srivilliputhur Grizzled Giant Squirrel Wildlife Sanctuary, Tamil Nadu

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Abstract
The Indian Giant Squirrel *Ratufa indica*, an endemic species to India, is widely distributed from the evergreen to moist and dry deciduous forests of Western and Eastern Ghats and the central Indian hills. Although several studies were conducted on the ecology of this species all over India, little is known on the density and distribution of this species from this region. In the present study an attempt has been made to study the population density and distribution of the Indian Giant Squirrel at Sivilliputhur Grizzled giant squirrel Wildlife Sanctuary which is a part of the Periyar-Agasthyamalai landscape of Southern Western Ghats, Tamil Nadu, southern India, during 2011-12. The study results revealed that the present mean population density of Indian giant squirrel 6.9 ± 2.9 individuals / Sq Km in Srivilliputtur Wildlife Sanctuary and this density estimates from this area will provide baseline data for future study. Present study is also addressed the issue of urgent need of survey the status, distribution and abundance of Indian giant squirrel in Srivilliputtur Wildlife Sanctuary.

Keywords: Giant squirrel, Population density, Srivilliputhur

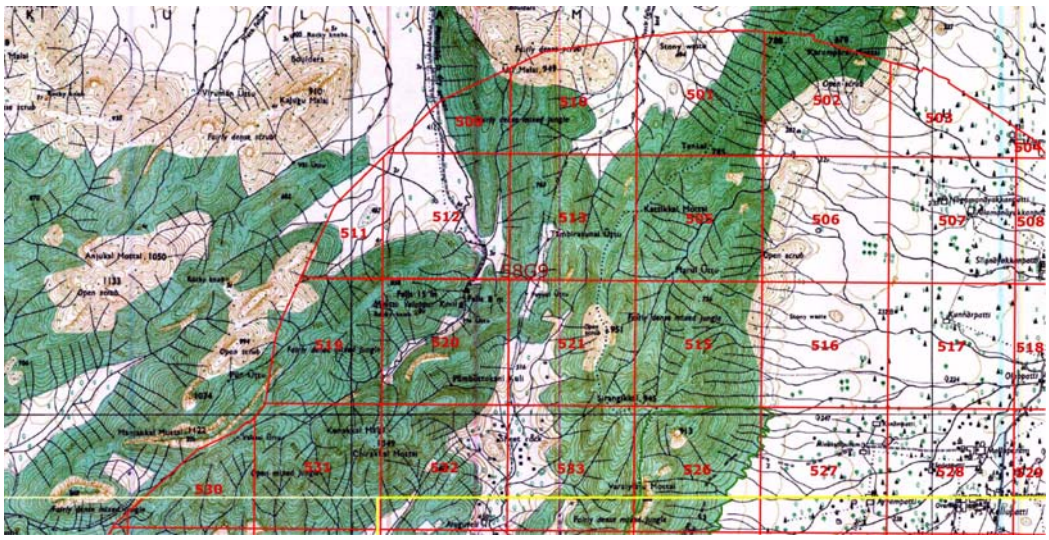
1. Introduction
Tree squirrels constitute an important component of the animal biomass of tropical rainforests (Eisenberg 1980) [1], and play an important role in seed dispersal and predation of several plants (Vandermeer *et al*. 1987, Smythe 1989) [2,3]. The tropical forests of Asia, Africa, Central and South America are the current centres of tree and flying squirrel diversity and endemism. Species richness exceeds 50 in Southeast Asia and is typically 6–10 species with substantial endemism in most tropical forests (Koprowski and Nandhini 2008) [4]. There are four species of the giant squirrels found in the world which belong to the genus *Ratufa*. Among them, the Pale Giant squirrel (*Ratufa affinis)* found in rain forests of Southeast Asia, other three species were found in India. Malayan giant squirrel (*Ratufa bicolor*) found in northeast India, Indian Giant Squirrel (*Ratufa indica)* in peninsular India and Grizzled giant squirrel (*Ratufa macroura)* endemic to Southern India and Sri Lanka (Ipsitha 2010) [5].
The *R. indica* is endemic to India and widely distributed in peninsular India (Abdulali and Daniel 1952, Corbett and Hill 1992) [6,7], form the evergreen to moist and dry deciduous forest of Western Ghats (Ramachandran 1998, 1992, Rout and Swain 2005, Molur *et. al*. 2005) [8,9,10,11], Eastern Ghats (Molur *et. al*. 2005, Kumara and Singh 2006)[11,12] and central Indian hills (Agarwal and Chakraborty 1979) [13]. It is a large arboreal species with most of the time spent on tree and moving from tree to tree. *R. indica* uses large trees of 16–20 m height in the wet and dry forests (Kumara and Singh 2006) [12] and can leap 6 m or more. The species is like many other squirrel of its genus, is a top canopy dweller, which occasionally come to the ground (Ramachandran 1988, Nowak 1999) [8, 14]. The species is listed as least concern in the Red List of IUCN (Rajamani *et al.*, 2010) [15] and is included in Scheduled I (Part I) of the Indian Wildlife Act (1972).
R. indica are typically solitary animals being pairs rarely only during the breeding. These are omnivores; feed on fruits, flowers, nuts, bark, bird eggs, and insects. They feed by standing on the hind legs and using their hands to handle food, they also use their large tail as a counter-weight, improving their balance (Nowak 1999) [14]. It constructs globular nests with leaves and twigs (Borges 1989, Thorington and Cifelli 1989, Ramachandran 1992) [16, 17, 9].

A few studies estimated the population status of the species in southern India (Ramachandran 1988, Desai *et al.*, 1999, Srinivas *et al*., 2008, Baskaran *et al*. 2011) [8, 18, 19, 20]. Recent studies speculate a population decline of 20-30% due to habitat fragmentation and hunting (Srinivas *et al*. 2008) [19].

2. Materials and Methods

2.1 Study area: The study carried out in Srivilliputtur Wildlife Sanctuary, Tamil Nadu, which is located in southern Western Ghats between 9° 21' to 9° 48' N and 77°21' to 77°46' E. The Sanctuary is a part of the Periyar-Agasthyamalai landscape (Fig. 2), one among the four landscapes of the Ghats. The area declared as a Wildlife sanctuary in 1989 and it extent over 480 km^2. 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 followed by Rajapalayam, Srivilliputtur, Watrap, and Saptur.

Fig 1: A part of Sampling grid (2 X 2 km block) established on 1:50,000 topographic map of the sanctuary to identify the transect location for population estimate



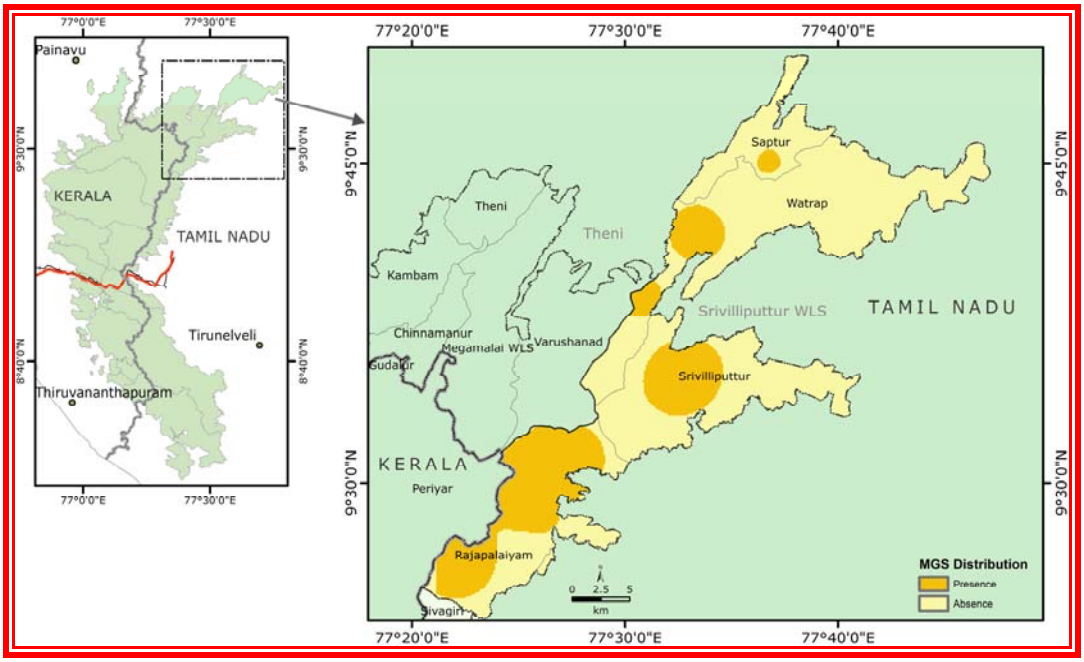


Fig 2: Map showing the Study area and distribution of Indian Giant Squirrel.

2.2 Population density

Estimation of population density was carried out following line transect method (Burnham *et al*. 1980) [21]. The line transect sampling location was identified following systematic random sampling method: i.e., by overlaying a 4 km^2 (2 X 2 km block) grid on 1:50,000 topographic maps of the sanctuary (Fig. 1). All the grids were numbered resulting in an overall of 128 grids (blocks). 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. The transects were walked during morning (06:00–10:00 h) or evening (16:00–18:00 h) and at every sighting of squirrel besides noting the group size, sighting angle and sighting distance were recorded respectively using field compass and range finders. In total, 17 sightings were recorded from 121 km line transect walk. Population density was estimated using distance-sampling techniques following the software DISTANCE (version 6.0, Buckland *et al*. 2004, Thomas *et al*. 2005) [22, 23]. The squirrel cluster and individual density and their SE was estimated by evaluating different models of detection probability, viz. uniform, half-normal and hazard-rate with three series adjustment terms and used the minimum *Akaike Information Criteria* (AIC) as the standard model selection procedure to select the best model for estimating density.

3. Results and Discussion

In total, survey of using 64 line transects (covering 121 km of walking) has yielded 17 direct sightings of *Ratufa indica* (Table 1). Analysis of these data using Distance software showed 4.8 ± 1.99 groups (clusters) per km^2 or 6.9 squirrels (individuals) per km^2. The Confidence Interval of individual density varied from 3-15 squirrels/km, indicating the need for increasing the sample size to narrow down the CI (Table 2).

Table 1: Showing the location, habitat type and number of individuals recorded during the study period

S.no	Area name	lat	long	Forest type	No.ind
1.	Ayyanar kovil	9.51577	77.44924	seg	1
2.	Ayyanar kovil	9.51726	77.44697	seg	1
3.	Ariviattukal	9.50309	77.44748	mdf	2
4.	Ariviattukal	9.54118	77.56007	mdf	2
5.	Kattumayttu mottai	9.52353	77.42786	mdf	1
6.	Kattumayttu mottai	9.52354	77.42826	mdf	1
7.	Kattumayttu mottai	9.52669	77.42473	mdf	1
8.	Pacchayar Estate	9.43739	77.37772	mdf	2
9.	Pacchayar Estate	9.44128	77.37304	mdf	1
10.	Pacchayar Estate	9.442	77.3734	mdf	2
11.	Nagayar Estate	9.44005	77.36452	seg	2
12.	Nagayar Estate	9.43706	77.36207	seg	2
13.	Ayyanar kovil	9.47458	77.42857	ddf	1
14.	Kottamalai Estate	9.50001	77.40697	mdf	1
15.	Kottamalai Estate	9.50001	77.40697	mdf	1
16.	Kovilar dam	9.69583	77.55974	mdf	2
17.	Kottamalai	9.4647	77.38216	seg	1

*seg-Semi evergreen, ddf- Dry deciduous and mdf-Moist deciduous

Table 2: Density estimation of Indian Giant Squirrels in Srivilliputhur Wildlife Sanctuary region using for Distance sampling program

Parameter	Details
No. of transects	64
Total line length of sample(km)	121
No.of cluster size (Mean ± SE)	1.4 ± 0.12
Key Function model	Uniform
Key adjustment	Cosine
Detection probability (Mean ± SE)	0.42 ± 0.08
Effective strip width (m) (Mean ± SE)	14.73 ± 3.01
Encounter rate / km2	0.1404
Encounter rate % CV	36.59
Cluster density , number / km2 (Mean ± SE)	4.76 ± 1.99
Cluster density % CV	41.94
Cluster density 95 % CI	2.13 - 10.62
Individual density/ km2 (Mean ± SE)	6.68 ± 2.86
Individual density % CV	42.81
Individual density 95 % CI	2.95 - 15.11
Minimum AIC	112.8

The present study estimated a mean density of 6.9 squirrels (individuals) per km^2 with CI varying from 3-15 squirrels/km. The wider confidence interval and high % Coefficient of variation (42.8) and lower sample size (n = 17) than the suggested (*n* = 40 minimum) (Burnnham *et al*. 1980) [21], indicate the need for increasing the effort to obtain sufficient the sample size for estimating the more reliable density. Nevertheless, the density estimated in Srivilliputhur Wildlife Sanctuary is lower than those estimated for the parts of Bhadra Tiger Reserve (Muthodi: 10.2 squirrels/km^2 and Lakkavalli: 12.3 squirrels/km^2) (Jathana *et al*. 2008) [24] with deciduous habitats dominating the sampling areas, Borges *et al*. (1998) [16] (12–66/ km², respectively, in the semi-evergreen and evergreen habitats) in Bimashankar Wildlife Sanctuary, Maharashtra. On the other hand, the present estimate is higher than the density of giant squirrel estimated (2.9 squirrels/km^2) in Mudumalai sanctuary (Baskaran *et al*. 2011) [20], and in Bandipur Tiger Reserve (2.4 giant squirrels/km^2) (Jathana *et al*. 2008) [24]. Such variation density among different forest areas could be a function of availability of various forest types and its tree species composition. The findings of the present study and the earlier studies (Baskaran *et al*. 2011, Borges *et al*. 1998) [25,16] suggest that habitat with primary forests (evergreen) or with moist deciduous habitats with better canopy cover and more tree species density and diversity is likely to support higher density of giant squirrels than secondary forests (deciduous and dry thorn). Strict measures like habitat protection, disturbances, un noticed poaching and other anthropogenic activities should be minimised for better survival and sustenance of the IGS in the region.

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