Proc. Indian Acad. Sci. (Anim. Sci.), Vol. 93, No. 2, March 1984, pp. 131–139.

Population of the Western Ghats squirrel, *Funambulus tristriatus* Waterhouse in South India

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MS received 23 July 1983; revised 7 December 1983

Abstract. A population of the Western Ghats squirrel, *Funambulus tristriatus* Waterhouse, was studied for some group attributes. The density ranged between 2 and 4 individuals/ha, the pattern being irregular. The rate of persistence was very low and nearly 83% of the squirrels marked and released disappeared from the population within 12 months. The sex ratio significantly favoured males. Males were heavier than females, but the difference was not statistically significant.

Keywords. *Funambulus tristriatus*; density; persistence; recapture; sex ratio; body weight.

1. Introduction

The Western Ghats squirrel, *Funambulus tristriatus* Waterhouse, is distributed along the west coast in the Indian peninsula (Moore and Tate 1965). It is a major rodent pest of cacao, *Theobroma cacao* L., an important commercial crop (Bhat *et al* 1981). A detailed study was taken up on its population structure, food habits and breeding biology at the Central Plantation Crops Research Institute, Regional Station, Vittal, Karnataka, from January 1976 to October 1979. This paper reports the observations made on population structure and rate of persistence.

2. Study area and climate

The population structure was studied in a 3·24 ha of cultivated tract of paddy (*Oryza sativa* L.) and arecanut (*Areca catechu* L.) near Vittal (12°30'N, 74°80'E) in the Dakshina Kannada District of Karnataka. The coconut palm (*Cocos nucifera* L.) is grown on the bunds of the paddy fields; and cacao, banana (*Musa paradisiaca* L.), pineapple (*Ananas sativus* Schult.) and pepper (*Piper nigrum* L.) as inter and mixed crops in the arecanut gardens. Hibiscus (*Hibiscus schizopetalus* Hooker f.) was common on the hedges. Other trees were mango (*Mangifera indica* L.), jack (*Artocarpus integrifolia* L.), cashew (*Anacardium occidentale* L.), black plum (*Eugenia jambolana* Lam.), strychnine (*Strychnos nux-vomica* L.) and kokra laurel (*Aporosa lindleyana* Baill.). Weeds such as *Caesalpinia mimosoides* Lam. and *Andropogon* sp. were very common.

The study area is bordered by a small river, *Vokkethur*, on the southern side, barren uncultivated dry land on the western and northern sides and a stretch of evergreen forest on the eastern side. It has an elevation of 5·3 m MSL and a tropical, hot and humid

climate with two well-defined seasons, *i.e.*, summer and rainy. The average annual rainfall during the study period was 4600 mm, about 70% of which occurred from June to August. A few showers occurred from September to November. Summer was from January to May when the maximum day temperature was 33·8°C. In June, July and August the day temperature was comparatively low (maximum 29·4°C) and the relative humidity was high (87–93%). Nights were cooler (maximum 21°C) from December to February.

3. Methods

The squirrels were trapped for 7–8 consecutive days in the latter half of each month from February 1978 to October 1979. Their movements were observed for one month before starting the experiment. Thirtyfive trapping points were then selected either on the branches of trees or on other spots frequented by these squirrels. Locally available single-catch wiremesh live traps (25 × 15 × 15 cm) were used for trapping and the location of each trap was marked on a map. The traps were set between 0800 and 0900 hr with ripe banana as the bait in the lever. A few grains of paddy were kept at the entrance of the trap to attract squirrels as whole grains of paddy was the favoured bait (Bhat 1979). Each morning the old baits (especially the banana) were replaced by fresh ones. Traps were inspected twice a day (0800–0900 hr and 1730–1830 hr). The trapped squirrels were marked by toe clipping (Melchior and Iwen 1965), examined superficially and released in the place of capture. The place of capture and the weight and general condition of each squirrel were recorded every time. Those squirrels which were trapped on the periphery of the study area were not considered in the estimation of population.

Density was calculated by two methods, *viz* direct enumeration technique or the minimum count method (Krebs *et al* 1979) and applying Seber's weighted mean formula (Seber in Begon 1979). For estimating population by enumeration technique, those marked squirrels, untrapped in one trapping period but trapped in a subsequent period, were assumed to have been present in the study area during the intervening periods and hence were included in the totals for those periods. The actual trapping areas were computed by adding a boundary strip equal to the average distance between successive captures of animals caught five times or more (Cheeseman and Delany 1979).

4. Results and discussion

4.1 *Density*

The population density for different months during 1978–1979 is presented in table 1. The Seber's formula could not be applied in some months because of lack of recaptures. In all months the density estimated by the minimum count method was slightly higher than that estimated by Seber's formula. Cheeseman and Delany (1979) pointed out that the figures obtained by direct enumeration fell within the confidence limits of the Jolly's highest estimate. However, the enumeration method is not without errors in that it estimates only the minimum number, as there will definitely be some animals in the population which are never caught and some trapped squirrels which probably survived one or more trapping periods without being retrapped.

Table 1. Density (no. per hectare) of *F. tristriatus* at Vittal.

	Density estimated by			
	Minimum count method		Seber's formula	
Month	1978	1979	1978	1979
January	—	2·22	—	*
February	4·44	2·53	4·09	2·47
March	3·80	2·85	3·71	1·39
April	3·48	3·17	*	1·27
May	3·48	3·17	1·43	2·31
June	3·17	3·48	1·65	3·71
July	3·17	3·80	1·87	3·68
August	2·85	4·12	*	3·17
September	2·85	3·17	*	2·50
October	2·22	3·48	*	3·23
November	2·85	—	2·22	—
December	2·53	—	1·27	—
Mean		3·18		2·50

* Formula could not be applied because of lack of recaptures.

The population density did not fluctuate much from the mean. This might be due to the fact that Vittal has a fairly stable climate during the periods of study. In Jodhpur where the climate reaches severe extremes, severe fluctuations in the populations of the northern palm squirrel, *F. pennanti*, were recorded (Prakash and Kametkar 1969).

4.2 *Recapture and persistence*

Out of the 41 squirrels marked and released, 36 (87·8 %) were recaptured 1–15 times; of these, about 68 % were recaptured 1–5 times, 14 % 6–10 times, and 17 % 11–15 times (figure 1). This shows that the squirrels were not trap-shy. A high degree of trappability was also reported in the northern palm squirrel (Prakash and Kametkar 1969); the Nelson's ground squirrel, *Citellus nelsoni* (Hawbecker 1958, 1975) and the striped ground squirrel, *C. tridecemlineatus* (Evans 1951).

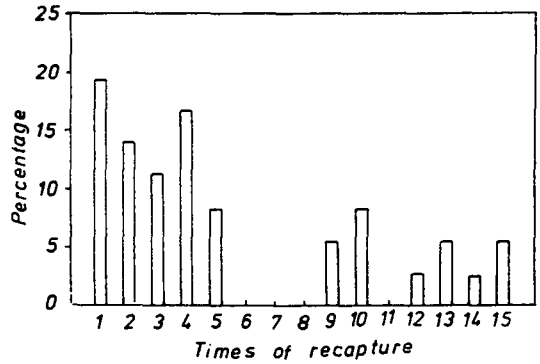

Figure 1. Number of *F. tristriatus* recaptured at different times. Expressed as percentage of the total recaptured animals. $N = 36$.

The failure to retrap a marked squirrel could be due to emigration or mortality. Even if a particular marked squirrel was not trapped in the very next trial of retrapping but was recaptured later on, it was considered to be persisting in the study area. Those squirrels which could not be retrapped in spite of repeated attempts were considered to have disappeared from the population. Persistence is referred to here as the duration of residence of the squirrel in the study area. It also meant the minimum known survival time. The actual survival period would be definitely longer as no allowance was made for dispersal and those first caught as adults.

The data showed that nearly 15% of the squirrels that entered the population each month disappeared in the succeeding month (figure 2). Further, less than 50% of the squirrels remained for more than 5 months in the population and less than 20% persisted for nearly 12 months. The annual persistence of the northern palm squirrel was less than 20% in Jodhpur (Prakash and Kametkar 1969). Similarly, very low rate of persistence was recorded for some other sciurids by Bradley (1967) and Hawbecker (1975).

4.3 *Sex ratio*

Specimens were collected from the areas around Vittal from November 1977 to October 1979. The sex and body weight of each squirrel were recorded. Out of 429 squirrels collected, 232 (55·24%) were males and 192 (44·76%) females. This preponderance of males was statistically significant ($x^2(1) = 4{\cdot}72$, $p < 0{\cdot}05$). The percentage of males was more than 50 in all the months except in January and February (figure 3). Both sexes were nearly equal in January, but females outnumbered males in February. However, the sex ratio did not deviate significantly from 1:1 in any month.

The preponderance of males was common in the populations of the northern palm squirrel both in Calcutta (Louch *et al* 1965–1966) and in Rajasthan (Agrawal 1965–1966, Purohit *et al* 1966; Prakash and Kametkar 1969) and in several other sciurids (Layne 1954; Packard 1956; Farentinos 1972; Brown and McGuire 1975; Rusch and Reeder 1978; Boag and Murie 1981). But male preponderance is not universal in sciurids (Allen 1943; Evans and Holdenried 1943; Rongstad 1965). Schmutz

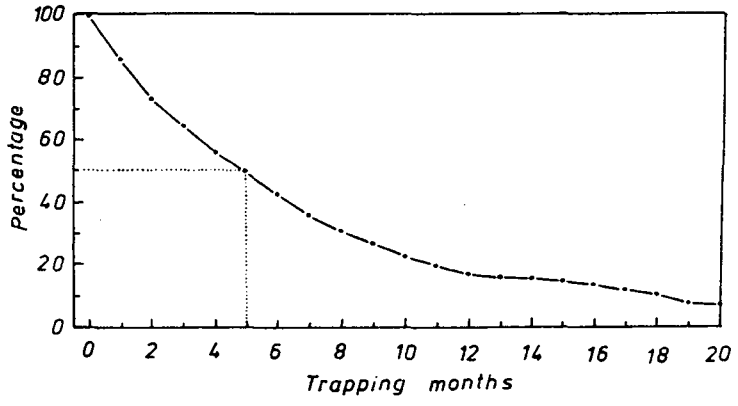

Figure 2. Percentage of marked *F. tristriatus* persisting in the study area since the month of first capture. $N = 14$.

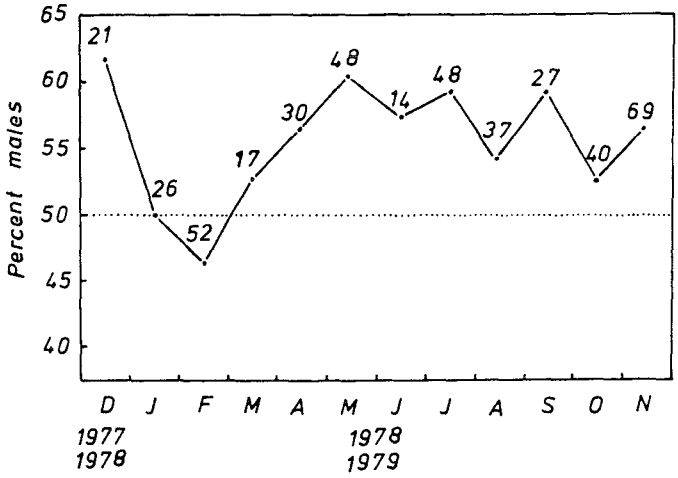

Figure 3. Monthwise sex ratios of *F. tristriatus*, expressed as percentage of males. Numbers on top denote sample size.

et al (1979) suggested that the difference in the rate of persistence, mortality, dispersal and predation pressure are the major factors responsible for the uneven sex ratio in squirrels.

4.4 *Body weights*

The squirrels trapped for the previous study were weighed to the nearest 0·5 g using a common counter balance. Males were slightly ($p > 0{\cdot}5$) heavier than females (table 2).

Table 2. Mean monthly body weight of *F. tristriatus* (pooled for two years) at Vittal.

Year and month	Males			Females		
	No.	Body weight (g) mean ± ISE	range	No.	Body weight (g) mean ± ISE	range
1977–1979						
Dec.	13	134·4 ± 7·4	75–159	8	122·4 ± 10·4	80–167
Jan.	13	128·9 ± 5·6	84–155	13	133·7 ± 4·9	105–174
Feb.	24	132·5 ± 3·3	83–149	28	132·9 ± 3·1	105–156
Mar.	9	134·9 ± 4·1	110–152	8	138·2 ± 4·9	121–165
Apr.	17	119·8 ± 6·5	58–148	13	125·8 ± 5·3	89–143
May	29	135·2 ± 4·4	76–176	19	127·1 ± 4·8	77–146
Jun.	8	119·0 ± 12·1	65–168	6	139·0 ± 2·7	130–147
Jul.	28	131·0 ± 5·0	79–164	20	121·1 ± 6·8	38–150
Aug.	20	124·7 ± 4·6	76–153	17	120·7 ± 5·6	62–142
Sep.	16	131·0 ± 3·8	102–160	11	134·9 ± 5·9	83–151
Oct.	21	127·9 ± 3·1	98–162	19	119·5 ± 3·7	83–144
Nov.	39	129·2 ± 3·5	81–165	30	125·6 ± 4·8	33–165
Total/ mean	237	129·6 ± 1·4	58–176	192	127·1 ± 1·6	33–174

Table 3. Monthly distribution of various weight classes of the male Western Ghats squirrel at Vittal: expressed as per cent of monthly collection during 1977–1979

Weight classes (g)	Months											
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
< 70·5	—	—	—	—	11·8	—	12·5	—	—	—	—	—
70·5–90	15·4	7·7	4·2	—	5·9	10·3	—	7·1	10·0	—	—	7·7
90·5–110	—	7·7	8·3	11·1	5·9	—	37·5	25·0	10·0	18·7	9·5	15·4
110·5–130	7·7	38·5	8·3	22·2	17·6	13·8	12·5	7·1	40·0	25·0	47·6	12·8
130·5–150	53·8	30·8	79·2	55·5	58·8	48·3	12·5	28·6	35·0	50·0	38·1	56·4
150·5–170	23·1	15·4	—	11·1	—	24·1	25·0	32·1	5·0	6·2	4·8	7·7
> 170	—	—	—	—	—	3·4	—	—	—	—	—	—
Sample size	13	13	24	9	17	29	8	28	20	16	21	39

Table 4. Monthly distribution of various weight classes of the female Western Ghats squirrel at Vittal: expressed as per cent of monthly collection during 1977–1979

Weight classes (g)	Months											
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
70·5	—	—	—	—	—	—	—	10·0	5·9	—	—	3·3
70·5–90	25·0	—	—	—	15·4	15·8	—	—	11·8	9·1	5·3	6·7
90·5–110	12·5	7·7	17·9	—	—	—	—	15·0	—	—	36·8	13·3
110·5–130	12·5	38·5	25·0	25·0	15·4	15·8	16·7	25·0	41·2	18·2	21·0	16·7
130·5–150	37·5	46·2	42·8	62·5	69·2	68·4	83·3	50·0	41·2	63·6	36·8	53·3
150·5–170	15·5	—	14·3	12·5	—	—	—	—	—	9·1	—	6·7
170	—	7·7	—	—	—	—	—	—	—	—	—	—
Sample size	8	13	28	8	13	19	6	20	17	11	19	30

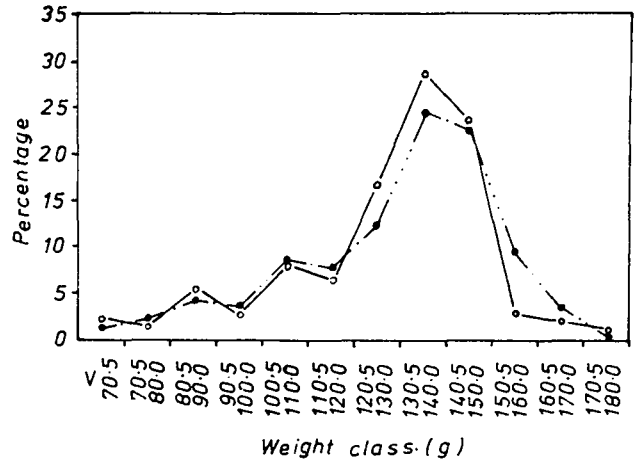

Figure 4. Percentage of occurrence of various weight classes of *F. tristriatus* (data accumulated over two years; $N = 429$. • Male; o female).

Males varied from 58 to 176 g and females from 33 to 174 g. But females were heavier than males during January–April, June and September; the presence of more pregnant squirrels (unpublished data) and young males in these months (tables 3, 4) was one of the reasons for this.

Most of the male (59·7%) and female (68·8%) squirrels weighed between 120·5 and 150·5 g (figure 4). However, in the heavier weight class (150·5–160 g) the males were significantly ($p < 0{\cdot}05$) more numerous than females. Occurrence of slightly heavier males was reported in the northern palm squirrel (Prakash and Kametkar 1969) and also in several other squirrels (Layne 1954; Packard 1956; Morton and Parmer 1975).

The body weight of adults showed little annual fluctuation. This could be attributed to the availability of food all the year round and the relatively stable weather conditions prevalent in the study area. In Jodhpur, where the climatic conditions were extreme, the body weight of the northern palm squirrel decreased considerably during summer months (Prakash and Kametkar 1969). Variation in the body weight was reported for fox squirrel, *Sciurus niger*, in different seasons (Goodrums 1972). Goodrums (1972) attributed this fluctuation to the reduced activity and food intake during extremes of temperatures.

Acknowledgements

The authors are grateful to Prof. K J Joseph of Calicut University, for facilities. They are also thankful to Dr N M Nayar, former Director, CPCRI, Kasaragod for providing research facilities. SKB is grateful to CSIR, New Delhi for the fellowship.

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