

## Food Preferences of 'Five-Striped' Squirrel, *Funambulus pennanti pennanti* Wroughton

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The 'five-striped' squirrel, *Funambulus pennanti pennanti* Wroughton, is distributed throughout north India. A pest of fruits and vegetable crops, its bait preferences are not accurately known.

In laboratory experiments, however, the squirrels are observed to select whole cereals in preference to other foods. The next choice is shown for pulses; while cereal flours are preferred the least. Boiled and moist foods, and similarly the foods mixed with groundnut oil (5% wt./wt.), are specially liked. Like oil, sugar at 10% concentration, increases preference; but not saccharine.

The feeding of squirrels appears similar to that of commensal rats, but distinctive features are also present.

**Key Words :** Sampling behaviour Food preference, Five-striped squirrel,

### Introduction

*Funambulus pennanti pennanti* Wroughton, is the common squirrel of north India. It is diurnal and arboreal; and often causes severe damage to fruits and vegetable crops in groves and gardens (Barnett & Prakash 1975). Bait preferences of the squirrel, important for our efforts to control it, are, however, not accurately known. Results of the laboratory experiments designed to study it, are discussed here.

### Materials and Methods

The squirrels, *F. pennanti*, were trapped from groves around Aligarh city. They were sexed, weighed and housed in wire-mesh cages, 1.2×1.0×0.3 m and 0.8×0.3×0.6 m. Wooden boxes and straw were given for nesting. Maintain-

ance rations given to them included bread, cabbage and occasionally some fruit.

Before the experiments started, the subjects were weighed again; and randomly grouped into bisexual (19), all male (6) or female colonies (3). Some were also housed individually. Number of squirrels in the colonies varied from 3 to 6. Of the total 28 colonies, minimum mean-body weight calculated was  $78.00 \pm 6.34$  g (range: 70-91 g) and maximum  $125.00 \pm 3.73$  g (range: 120-135 g). Breeding or death in the groups, was not observed.

Various kinds of foods—whole cereals, cereal flours, pulses, boiled foods, moist foods, sweet foods and oily mixtures; were compared on the colonies in

separate tests. Description of foods has been given earlier by Khan (1974); but reference can also be made to Aykryod (1963).

The choice usually consisted of two kinds of foods; offered in weighed amounts ( $\pm 1$  g) in separate metal containers. The residue, including the amounts spilled, was weighed the next day. Care was taken to avoid the presentation of the same foods in successive tests. Consumption of boiled or moist foods was determined on dry-wt. basis (Khan 1974). Consumption as calories was also found. Calorific value of foods was read from Aykryod's manual; and that of mixtures calculated according to Khan (1974).

Methods described by Bailey (1959) were followed for statistical analysis of the results.

## Results

The results obtained (tables 1 to 5) are summarised below:

### Cereals

Millet (*Pennisetum typhoides*) was always eaten by squirrels in copious amounts; and preferred to six other whole cereals tested (paired 't' tests,  $P < 0.05$ ; table 1). Wheat (*Triticum aestivum*) and jowar (*Sorghum vulgare*) were preferred next, followed by paddy (*Oryza sativa*), barley (*Hordeum vulgare*), rice and maize (*Zea mays*) (table 1). Equivocal choices were not shown.

### Cereal flours

Ground rice was preferentially eaten among five commercially available cereal flours tested in 15 combinations (table 2). The next choice was shown for wheat flour (whole meal), and then for semolina, maize flour and white flour, in this order.

Contamination of water dishes with foods was invariably noticed when the

choice consisted of cereal flours. The amounts could not be measured; but all the same accounted for higher intakes recorded on ground than whole cereals (tables 1, 2).

### Pulses

Eleven forms of pulses belonging to six species were cross-tested on squirrel colonies in 55 combinations. Whole Bengal gram (*Cicer arietinum*) was most preferred by them; others that followed, in order of decreasing choice, were cracked Bengal gram, whole green gram (*Phaseolus aureus*), cracked green gram, whole lentil (*Lens esculenta*), cracked lentil, whole red gram (*Cajanus cajan*), cracked red gram, whole black gram (*P. radiatus*), cracked black gram and cowpeas (*Vigna unguiculatus*) (table 3).

Whole form of pulses was more preferred by squirrels than their cracked and husked equivalents.

### Moist foods

In moist foods, moist whole Bengal gram and boiled rice were much preferred (table 4). Moist wheat, green gram and millet were, however, not generally favoured to dry alternatives. Equivocal choices were also shown, e.g. moist wheat was preferred to moist gram.

### Sweet foods

Boiled rice+sugar (10% wt./wt.) was preferred to plain boiled rice (table 5). The latter was, however, clearly selected when compared to boiled rice sweetened with saccharine.

### Oily foods

Millet and groundnut oil (*Arachis hypogea*) mixture was preferentially eaten by the squirrels as compared to plain millet (table 5).

**Table 1** Consumption of whole cereals by squirrels in two-choice tests. Relative intakes are expressed in ratios, calories equivalents are also given

Expt. No.	Length of tests in days	Colony No.	Foods offered	Ratio of mean daily intake	Calories/day	Total consumption g/100g body wt./day	Calories/100g body wt./day
1	7	3	Millet/Wheat	1:0.42	72.16/31.02	8.21	29.0
2	7	6	Millet/Jowar	1:0.48	70.18/32.62	7.32	26.0
3	8	1	Millet/Paddy	1:0.40	74.31/28.89	6.6	23.0
4	7	7	Millet/Barley	1:0.36	102.2/33.56	7.69	27.0
5	7	3	Millet/Rice	1:0.45	76.79/31.51	8.69	30.0
6	8	5	Millet/Maize	1:0.18	93.89/16.24	6.57	31.0
7	7	4	Wheat/Jowar	1:0.26	93.31/24.70	7.07	24.0
8	8	2	Wheat/Paddy	1:0.46	88.66/35.36	7.57	28.0
9	7	6	Wheat/Barley	1:0.14	88.95/11.51	7.04	25.0
10	8	5	Wheat/Rice	1:0.24	71.79/17.30	7.25	27.0
11	9	1	Wheat/Maize	1:0.26	98.78/25.36	8.10	28.0
12	7	3	Jowar/Paddy	1:0.36	76.60/26.6	8.37	29.0
13	7	8	Jowar/Barley	1:0.63	60.80/36.93	8.45	29.0
14	7	1	Jowar/Rice	1:0.35	59.80/20.88	5.26	18.2
15	7	7	Jowar/Maize	1:0.30	87.98/26.39	6.54	23.0
16	7	4	Paddy/Barley	1:0.58	89.70/50.40	8.45	29.0
17	7	6	Paddy/Rice	1:0.55	61.11/31.54	6.50	23.0
18	7	8	Paddy/Maize	1:0.13	58.65/ 7.33	5.66	20.0
19	7	2	Barley/Rice	1:0.23	82.56/19.71	6.39	21.0
20	8	3	Barley/Maize	1:0.15	105.84/15.96	10.07	33.0
21	8	4	Rice/Maize	1:0.30	87.54/26.08	6.6	23.0

**Table 2** Relative consumption ratios on choice of cereals in ground form

Expt. No.	Length of tests in days	Colony No.	Foods offered	Ratio of mean daily intake	Calories/day	Total consumption g/100g body wt./day	Calories/100g body wt./day
1	7	21	Rice fl./Millet fl.	1:0.56	71.18/51.94	7.72	27.9
2	6	12	Rice fl./Whole meal	1:0.29	105.53/30.69	11.35	39.1
3	6	1	Rice fl./Semolina	1:0.51	96.88/49.88	9.56	33.1
4	6	13	Rice fl./White fl.	1:0.52	96.88/51.04	10.48	36.2
5	6	1	Rice fl./Maize fl.	1:0.14	117.06/16.48	8.73	30.1
6	6	19	Millet fl./Whole meal	1:0.28	104.99/27.85	7.99	28.4
7	6	22	Millet fl./Semolina	1:0.58	96.6/54.52	10.71	38.3
8	6	23	Millet fl./White fl.	1:0.38	96.59/39.04	9.07	33.3
9	6	19	Millet fl./Maize fl.	1:0.13	121.80/15.35	8.22	29.3
10	6	1	Whole meal/Semolina	1:0.36	101.73/37.7	9.18	31.4
11	6	12	Whole meal/White fl.	1:0.24	98.89/23.78	10.3	35.2
12	6	21	Whole meal/Maize fl.	1:0.15	110.25/17.05	7.78	26.5
13	6	17	Semolina/White fl.	1:0.55	70.18/38.28	10.97	38.1
14	6	24	Semolina/Maize fl.	1:0.24	117.74/27.85	9.84	34.0
15	6	13	White fl./Maize fl.	1:0.37	87.17/31.82	8.54	29.1

**Table 3** *Pulses were cross-tested in 55 combinations. Ratios of mean daily intakes and consumption due to calories, shows that the choice for them was linear*

Expt. No.	Length of tests in days	Colony No.	Foods offered	Ratio of mean daily intake	Calories/day	consumption g/100g body wt./day	Calories/100g body wt./day
1	6	7	Bengal gram-w/ Bengal gram-c	1:0.50	97.47/53.31	8.45	29.7
2	6	6	Bengal gram-w/ Green gram-w	1:0.17	107.16/17.81	9.21	31.4
3	6	6	Bengal gram-w/ Green gram-c	1:0.30	79. 8/24.43	7.62	26.1
4	7	9	Bengal gram-w/ Lentil-w	1:0.14	77.67/10.64	7.22	25.0
5	7	6	Bengal gram-w/ Lentil-c	1:0.48	63.49/37.19	8.08	25.0
6	6	7	Bengal gram-w/ Red gram-w	1:0.11	143.64/17.94	9.2	31.8
7	6	3	Bengal gram-w/ Red gram-c	1:0.17	89.49/15.38	8.76	30.1
8	6	3	Bengal gram-w/ Black gram-w	1:0.04	74.10/ 2.76	6.25	21.3
9	6	13	Bengal gram-w/ Black gram-c	1:0.32	111.15/36.06	10.5	36.0
10	6	7	Bengal gram-w/ Cowpeas	1:0.01	143.91/ 1.73	8.74	29.90
11	6	7	Bengal gram-c/ Green gram-w	1:0.1	140.09/12.8	7.99	30.1
12	6	7	Bengal gram-c/ Green gram-c	1:0.31	117.78/33.74	8.15	29.8
13	7	10	Bengal gram-c/ lentil-w	1:0.27	89.28/21.97	7.67	27.6
14	7	11	Bengal gram-c/ lentil-c	1:0.30	82.36/61.64	7.34	30.9
15	6	7	Bengal gram-c/Red gram-w	1:0.11	156.24/17.94	9.03	34.3
16	6	19	Bengal gram-c/ Red gram-c	1:0.15	127.70/17.75	8.17	31.0
17	6	13	Bengal gram-c/ Black gram-w	1:0.02	132.66/ 2.66	8.94	33.1
18	6	15	Bengal gram-c/ Black gram-c	1:0.05	111. 6/ 5.24	10.03	37.2
19	6	12	Bengal gram-c/ Cowpeas	1:0.05	121. 5/ 5.74	9.86	36.5
20	7	13	Green gram-w/ Green gram-c	1:0.66	63.93/44.32	7.81	26.5
21	6	12	Green gram-w/ lentil-w	1:0.50	88.51/45.19	11.40	38.4
22	6	4	Green gram-w/ lentil-c	1:3.57	22.82/81.92	9.65	30.6
23	6	13	Green gram-w/Red gram-w	1:0.40	70.14/32.73	7.23	25.2
24	7	12	Green gram-w/Red gram-c	1:0.29	81.11/25.36	9.03	30.5
25	6	12	Green gram-w/ Black gram-w	1:0.26	75.15/19.14	8.00	27.0
26	6	12	Green gram-w/ Black gram-c	1:0.59	60.68/37.23	8.28	28.1

Expt. No.	Length of tests in days	Colony No.	Foods offered	Ratio of mean daily intake	Calories/day	Consumption g/100g body wt./day	Calories/100g body wt./day
27	6	12	Green gram-w/ Cowpeas	1:0.04	67.36/ 2.87	8.0	28.3
28	7	27	Green gram-c/ lentil-w	1:0.48	61.82/28.57	17.73	23.8
29	7	8	Green gram-c/ lentil-c	1:0.48	61.82/28.57	7.73	26.7
30	6	1	Green gram-c/Red gram-w	1:0.34	88.99/33.34	7.71	27.6
31	8	1	Green gram-c/Red gram-c	1:0.38	80.71/30.06	7.2	25.0
32	6	1	Green gram-c/ Black gram-w	1:0.29	97.72/25.52	8.13	27.8
33	6	17	Green gram-c/ Black gram-c	1:0.42	55.26/23.27	7.92	27.6
34	6	12	Green gram-c/ Cowpeas	1:0.04	65.73/2.87	6.92	24.1
35	10	1	Lentil-w/Lentil-c	1:0.66	68.81/46.15	7.58	25.8
36	7	7	Lentil-w/Red gram-w	1:0.12	106.05/14.28	6.90	23.7
37	7	1	Lentil-w/Red gram-c	1:0.20	83.05/106.5	6.66	42.6
38	6	11	Lentil-w/Black gram-w	1:0.04	105.57/3.64	6.96	23.4
39	7	7	Lentil-w/Black gram-c	1:0.04	121.55/4.98	6.36	24.9
40	6	12	Lentil-w/Cowpeas	1:0.20	80.21/16.72	8.19	27.8
41	6	1	Lentil-c/Red gram-w	1:0.34	77.50/30.14	6.81	24.3
42	6	11	Lentil-c/Red gram-c	1:0.31	64.84/24.85	7.23	20.2
43	6	11	Lentil-c/Black gram-w	1:0.15	90.22/12.76	6.45	23.2
44	6	4	Lentil-c/ Black gram-c	1:0.28	59.57/16.87	6.43	19.4
45	6	9	Lentil-c/Cowpeas	1:0.05	72.32/ 3.85	6.34	21.6
46	7	14	Red gram-w/Red gram-c	1:0.57	59.37/31.44	7.10	26.5
47	6	14	Red gram-w/Black gram-w	1:0.61	65.45/32.95	7.99	28.7
48	6	16	Red gram-w/Black gram-c	1:0.38	44.91/31.41	8.95	20.9
49	6	13	Red gram-w/ Cowpeas	1:0.07	125.13 /7.49	6.29	32.5
50	6	4	Red gram-c/Black gram-w	1:0.67	62.69/37.75	8.12	27.5
51	7	13	Red gram-c/Black gram-c	1:1.53	43.70/31.90	5.67	20.2
52	6	6	Red gram-c/ Cowpeas	1:0.30	49.70/14.71	4.59	15.1
53	6	16	Black gram-w/ Black gram-c	1:0.03	59.33/22.33	6.57	22.3
54	6	13	Black gram-w/ Cowpeas	1:0.11	84.55/ 9.79	6.94	23.1
55	6	18	Black gram-c/ Cowpeas	1:0.07	98.88/ 6.92	7.04	24.8

w, whole; c, cracked

**Table 4** The preference of squirrels for moist foods when compared to dry alternatives. The former are generally preferred

Expt. No.	Length of tests in days	Colony No.	Foods offered	Ratio of mean daily intake	Calories/day	Total consumption g/100g/body wt./day	Calories/100g/body wt./day
1	6	17	Moist bengal gram/ moist millet	1:0.54	51.92/28.6	8.32	21.38
2	7	13	Moist bengal gram/ Moist wheat	1:1.33	77.29/133.07	9.14	31.49
3	6	25	Moist bengal gram/ Moist green gram	1:0.56	71.07/49.52	9.5	27.22
4	6	16	Moist bengal gram/ Dry bengal gram	1:0.66	40.42/26.61	6.9	23.6
5	6	25	Moist bengal gram/ Dry green gram	1:0.17	56.67/31.65	8.96	31.44
6	6	1	Moist wheat/Dry millet	1:1.35	46.12/64.01	9.0	31.65
7	6	8	Moist wheat/Dry wheat	1:1.85	35.22/64.29	8.26	25.59
8	6	13	Moist wheat/Dry bengal gram	1:0.96	66.14/61.22	8.94	31.32
9	6	13	Moist wheat/Dry green gram	1:1.15	54.7/76.02	10.09	32.04
10	6	27	Moist wheat/Moist millet	1:0.95	59.86/58.49	7.61	26.72
11	6	1	Moist green gram/ Dry green gram	1:1.72	35.36/61.22	9.05	30.23
12	6	14	Moist millet/Dry green gram	1:1.72	35.50/61.23	9.05	30.23
13	6	1	Moist millet/Dry millet	1:1.06	50.35/53.33	6.58	23.41
14	6	1	Moist millet/Dry bengal gram	1:0.66	70.09/46.48	7.7	26.31
15	6	27	Boiled rice/Dry rice	1:0.67	112.62/76.40	8.18	28.29
16	6	28	Boiled rice/Rice flour	1:0.58	39.01/23.21	7.8	27.05
17	7	26	Boiled rice/Rice millet	1:0.32	82.27/27.08	10.29	35.61

**Table 5** Selection of sweet and oily foods by squirrels when compared to plain foods

Expt. No.	Length of tests in days	Colony No.	Foods offered	Ratio of mean daily intake	Calories/day	Total consumption g/100g/body wt./day	Calories/100g body wt./day
1	8	13	Boiled rice/Boiled rice + Sugar	1:1.5	56.89/90.24	10.42	36.05
2	12	20	Boiled rice/Boiled rice + saccharine	1:0.61	91.62/61.58	10.5	34.58
3	7	27	Millet/Millet + Groundnut oil	1:2.21	64.57/142.89	8.5	31.05

## Discussion

### *Preferential order for foods*

The squirrels, *F. pennanti*, select foods in linear order. Thus, among whole cereals—millet, wheat, sorghum, paddy, barley, rice and maize; and in cereal flours—rice flour, wheat flour, millet flour, semolina, maize flour and white flour; are preferred in the orders named (tables 1, 2). The choice for pulses follows in the sequence whole Bengal gram > cracked Bengal gram > whole green gram > cracked green gram > whole lentil > cracked lentil > whole red gram > cracked red gram > whole black gram > cracked black gram > cow peas (table 3).

Like squirrels, an orderly choice between foods is also shown by commensal rats, *Rattus rattus* L. and *R. norvegicus* Berkenhout (Barnett & Spencer 1953, Khan 1974). However, with the exception of Indian gerbil, *Tatera indica* (Hardwicke), simple preferential orders for foods have not been demonstrated for field rodents, *Bandicota bengalensis* Gray, or metads, *R. meltada* Ryley, etc. (Spillet 1968, Jain et al. 1974, Kamal & Khan 1977, Kumari & Khan 1978).

It appears that species living in close existence with man have stable preferences and aversions. Equivocal choices are not shown, and preference for foods is shown in linear order. In comparison, field rodents lack strong preferences or aversions; hence show contrary choices and fail to select foods in definite sequence. This difference has some adaptive significance, besides being important for classifying feeding patterns.

Obviously, squirrels resemble commensal rats, and not field rodents generally, in their feeding behaviour.

### *Characteristic food choices*

Although feeding patterns may show obvious similarities, the exact choice for

foods tends to vary; differences exist even between different populations (Jackson 1965, Barnett 1969, Khan 1974). Thus, while millet is most preferred among cereals, the squirrels, unlike wild rats, show less choice for sorghum and for cereals in ground form (tables 1, 2). No special liking is shown for lentil either, when it is much preferred by 'roof' rats and bandicoots (Spillet 1968, Khan 1974, Kamal & Khan 1977). Whole grains of pulses are similarly selected by squirrels, contrary to choice of most rats, in preference to cracked and husked grains (table 3, Khan 1974).

Cereal flours are also rejected by gerbils, because of textural similarities to substrates, as sand, used for bathing (Kumari & Khan 1978). No such confusion, however, arises in case of squirrels. They find finely divided food, or flours, difficult to swallow; and drink large amounts of water with it, contaminating the dishes as a result. Thus, although such foods may be eaten, they are not liked by squirrels.

### *Omnivory and sampling behaviour*

Of the foods offered, all were eaten by squirrels. However, the less preferred foods were eaten in considerable amounts in some tests; while in others, they were barely sampled (tables 1 to 5). This shows that both 'Omnivory', or tendency to vary the diet, and 'Sampling', or eating of foods of even little value, characterise the feeding behaviour of squirrels.

Undoubtedly, omnivory enables the squirrels, like other rodents, (i) to utilise diverse resources as food, (ii) and make rapid changes in diet when regular supplies, as with change of seasons, disappear (Barnett & Prakash 1975, Cole 1975, Kamal & Khan 1977). That it can lead to inclusion of even bizarre items in diet, has been observed in *Rattus* (Harison

1954, Lim 1966). Similar reports about squirrels are, however, as yet lacking.

Sampling has apparently important functions in testing of foods for their effects (Barnett 1969, Barnett et al. 1978). When each time only a small amount of food is eaten, feeding may continue for as long as the consequences are favourable, or at least not harmful. Alternatively, it would stop if the effects are toxic. Thus, sampling perhaps protects the squirrels, like other rodent pests, against toxic foods, and similarly against poisoned baits. For its role then in the formation of favourable feeding habits, sampling has, like omnivory, great survival value for squirrels.

#### *Factors affecting preference*

However, even the omnivorous species, including field rodents, show some specific choices (Barnett 1969, Kamal & Khan 1977). They like some foods more than others; though such differences in choice do not always reflect the superiority of one over the other (Barnett 1975). Thus, many species tend to favour foods that are usually eaten in the natural environment; though it hardly prevents them from switching over to superior choices when they become available (Barnett & Prakash 1975).

It is, however, noticed that most natural preferences are based on favourable physiological effects (Barnett 1975). Foods that contain easily digestible proteins, or high concentrations of lipid, starch or vitamins; are selected in comparison to alternatives which are inferior or devoid of these substances. Eating of various species of nuts by Grey and Fox squirrels, has thus been shown to depend on two main factors: (i) the speed with which they can ingest food, and (ii) digestibility of the matter eaten (Smith & Follmer 1972).

Some properties of foods are, however,

found attractive by rodent species without regard to physiological effects (Barnett 1975). Thus, texture, taste and energy value of foods greatly influence their choice (Barnett & Spencer 1953, Khan 1974). Similarly, the effects of social factors on feeding have also been found important (Galef & Clarke 1971). Preferences develop at an early age' with cues to foods transmitted with the mother's milk (Galef & Clarke 1972).

The interplay of these factors in determining feeding patterns is difficult to analyse, but the effects of some are more relevant, and clearly seen by the method of choice tests.

#### *Texture*

Normal food of squirrels consists of hard seeds of trees, e.g. shisham, *Dalbergia latifolia*; banyan, *Ficus bengalensis*, pipal, *F. religiosa*; neem, *Azadirachta indica* etc. (Barnett & Prakash 1975). Texture has, therefore, no great influence on their choice for foods. Thus, while millet is preferred, sorghum is rejected in comparison to harder wheat; whole grains of pulses are similarly eaten in preference over soft, husked grains (tables 1, 3).

#### *Water content*

Apparently, boiled foods may have been liked by squirrels for their extra water than soft texture (table 4). The need for water is also more important in case of tropical species (Barnett 1969).

#### *Taste*

That taste influences preference of squirrels is clear from selection of sweet foods (table 5). However, like 'roof' rats, bandicoots and gerbils; sweetness due to saccharine is not liked by squirrels (table 5, Khan 1974, Kamal & Khan 1977, Kumari & Khan 1978).

Selection of sweet foods has adaptive value (Garcia et al. 1974), but such



adaptability is perhaps one main factor which influences free feeding of squirrels in the natural state. Thus, fruits may become more susceptible to attacks as they ripen; unripe fruits may deter them. It is, however, generally understood that squirrels have some ability to eat bitter foods as unripe seeds of *Azardirachta*. Experimental confirmation of this is, however, presently required.

#### Energy Value

Selection of whole cereals and pulses reflects the influence of energy value of foods on choice of squirrels. Both kinds of foods have thus been preferred in order of their energy content (tables 1, 3, Aykryod 1963). Oily foods are favoured

similarly because of their high energy content (table 5).

#### Energy requirements

The daily food consumption of squirrels equalled 4.59% to 11.44% of the body-weight, corresponding to consumption of 15.1 to 42.6 cal./100 g body-weight/day. This is equal to daily energy requirement of other rodent species studied, e.g. 'roof' rat, bandicoots and gerbils (Khan 1974, Kamal & Khan 1977, Kumari & Khan 1978).

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