

Rodent Ecology in Sugarcane in Lower Sind, Pakistan

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Rodents were trapped from sugarcane fields bimonthly for 16 months and data on seasonal variation in abundance, diet and reproduction were gathered. *Millardia meltada* was the most abundant species and maintained year around resident populations in cane fields. Changes in *Millardia* abundance corresponded to changes in reproductive activity, except in September when abundance was too low, presumably due to emigration to the ripening rice fields, and in November when abundance was too high, presumably due to immigration from harvested rice fields. About half the diet of *Millardia* was sugarcane in November, December and January, but otherwise little cane was eaten. Mice populations (*Mus* sp.) resembled *Millardia* as to seasonal changes in abundance and reproduction, but differed as to diet: mice ate less cane and more insects. *Bandicota bengalensis* ate cane more frequently than *Millardia* did, i.e., 50% or more of its total diet for half of the year, but was less abundant and accounted for only 24% of the crop damage. *Bandicota* populations in cane were the most transitory; and changes in abundance seemed to be independent of reproduction. *Nesokia indica* probably maintained stable resident populations, but this fossorial rodent was inadequately sampled. These observations are compared with a similar study in Sind rice fields and the difference in utilization of these crops by rodents is discussed. It is suggested that sugarcane serves as a source of rodent infestation to other crops.

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INTRODUCTION

Sugarcane has a long growing season and is especially vulnerable to rodent attack. Rodents damage cane wherever it is grown and, in some parts of the world, this problem has been studied: Hawaii (K a m i, 1966; Hood *et al.*, 1971), Jamaica (M e t c a l f e & T h o m a s, 1966), Mexico (C o l l a d o & R u a n o, 1962) and India (B i n d r a & S a g a r, 1977). In most of these countries the rodent pests are species of *Rattus*. In Pakistan and India, however, the sugarcane rodent community is complex, including representatives of at least 4 genera: *Bandicota*, *Millardia*, *Nesokia* and *Tatera*. Although this rodent community has been observed and studied in other agricultural habitats (B i n d r a & S a g a r, 1977; F u l k, L a t h i y a & K h o k h a r, 1979), it, nevertheless,

remains poorly understood compared to other groups of rodent pests.

Agriculture in Pakistan is labor intensive and cropping is usually mixed. Sugarcane fields are small and adjacent to other crops. In contrast, cane production in many other countries is highly mechanized and done in large monocultures.

Herein we report on a 16-month study of the ecology of rodent pests to sugarcane in lower Sind, Pakistan. We have used methods which enabled us to suggest a general picture of the ecology of these pests and to compare results with our earlier study in the same area (Fulk *et al.*, 1979a).

STUDY AREA

Rodent population were sampled in the vicinity of the Khoski Sugar Mill, Badin District (24°41'N — 69°08'E), situated near the Indus Delta about 250 km east of Karachi.

The main crop in Badin District is rice grown in large tracts from June to October. However, sugarcane is the predominant crop (20,000 ha) in the area near the mill, where rice is of secondary importance. Wheat is grown from November

Table 1

Mean temperature and rainfall data at Badin Weather Station based on 30 years (1947 through 1976).

Month	Mean Maximum Temperature, °C	Mean Minimum Temperature, °C	Mean Rainfall, mm
January	25.5	7.9	1.14
February	27.7	10.3	1.90
March	35.3	15.9	4.01
April	39.3	20.0	2.57
May	39.5	21.4	0.00
June	35.9	23.0	5.76
July	36.0	24.0	72.29
August	34.2	20.8	50.70
September	34.9	22.0	54.70
October	34.2	20.3	4.24
November	32.9	14.2	0.00
December	26.7	9.5	0.53
Total			197.84

till March in few small fields scattered between the sugarcane fields. About half of the sugarcane crop is from seed, while the other half is a »ratoon« crop (resprouting of the first crop). The average yield for the Khoski area in 1977—1978 was estimated to be 23 tons per hectare, which was about half the mean productivity for all of Pakistan and about one-sixth that achieved by major sugarcane producing countries, such as Cuba and Brazil.

Typically, the sugarcane harvest starts in November and continues until April. The harvested fields (about 0.25 ha in size) are prepared either for another sugarcane crop, for a wheat crop, or left fallow and planted with rice in June.

The young cane will be harvested the next winter and hence the crop cycle is 10–12 months.

Salinity is one of the major problems in this area, and salty patches of uncultivated land occur between cane fields. Swamps, situated in dead river arms, are another common feature of the landscape. Common plants, both in cultivated and uncultivated land are *Tamarix* sp., *Cyperus glomeralis*, *Desmostachya bipinnata*, *Paspalidium geminatum*, *Chenopodium album*, *Scirpus maritimus* and *Brassica campestris*.

Weather data for Badin town 35 km west of Khoski, are shown in Table 1. The years of 1976 and 1977 were atypical; only 7 out of the last 30 years had more rainfall.

METHODS

Starting in November, 1976, snap-trapping was carried out bimonthly through March, 1978. Two snap traps were set every 10 meters in a line of 50 traps along the edge of sugarcane fields, about 1–2 meters into the crop. Before July, 1977, two farms were visited and different fields in these farms were sampled. From July, 1977, and onwards three farms were visited on each trip, two being the same as before and the third different each time. Precautions were taken so that individual fields were not sampled more than once. One trip was made every two months until July, 1977. Thereafter, two trips were made every two months: a major one on a bimonthly basis and one usually 3 weeks after the major one. This sampling schedule was also part of a rodent control scheme that will be reported elsewhere. To represent a bimonthly sample, data from the two trips were combined.

The percent trap success of the sampling programme described above was used as the measure of rodent abundance. However, data on reproduction and diet also included animals from two additional sources: trapping in fields baited with rodenticide and trapping by an animal hunter in December, 1976.

Animals were autopsied; sex, weight and length were recorded. Females were categorized as lactating, with perforate or imperforate vagina, estrus, parus (embryos and/or placental scars) or nulliparus. The visibility of the tubules in the *cauda epidymys* was recorded for males.

An index of the production of young (P) was calculated for each bimonthly sample for each species according to the formula:

$$P = (\% \text{ trap success} \times \% \text{ pregnant} \times \text{litter size}) : 100$$

Lower jaws from the larger species were collected, cleaned in the laboratory and the height of the first molar was measured on the median side from the bottom of the first groove to the crown.

Stomachs were preserved in the field in 10% formalin and their contents examined in the laboratory following the procedure in Fulk *et al.* (1979a). A crop damage index was calculated for each species for each month. This index was based on the abundance of the pest species and on the proportion of sugarcane in the diet as in Fulk *et al.* (1979a).

The number of young per female per year produced by the population was calculated for each species from the pregnancy rate, according to Southwick (1966). In addition, the average number of young produced by each female collected

was estimated by the procedure in Fulk *et al.* (1979a), which considers counts of placental scars and embryos. The average age (AA) of adult females collected was then estimated by

$$AA \text{ in months} = \frac{\text{number of young per female collected}}{\text{number of young per female per year}} \times 12 + X.$$

Where X is the age in months to reach sexual maturity, taken to be 2.5 for *Bandicota*, 2 for *Millardia* and 1 for *Mus*. Only data from February, 1977, through January, 1978, were used in these calculations.

Differences in frequencies were tested in a 2×2 table using the G-statistic (Sokal & Rohlf, 1969, p. 591).

We have not assigned a species name to the mice, since little is known about the systematics of *Mus* in this area. All the animals we refer to as *Mus* sp. seemed to be morphologically identical to *Mus musculus*.

Voucher specimens of *Mus* as well as of the other small mammal species collected are housed at the British Museum for Natural History (London) and in the Vertebrate Pest Control Centre (Karachi).

RESULTS

Over the whole study period, an effort of 4291 trapnights was expended and 979 animals were examined.

Millardia meltada (Gray, 1837)

A total of 570 *Millardia* was examined. Data on abundance, reproduction and diet are summarized in Fig. 1. Abundance was relatively stable

Table 2

Seasonal variation in pregnancy rates; number of adult females examined shown in parentheses.

	<i>Millardia</i>	<i>Bandicota</i>	<i>Tatera</i>	<i>Mus</i>	<i>Nesokia</i>
November 1976	0 (11)	—	—	—	—
December 1976	0 (48)	0 (17)	0 (14)	—	0 (3)
February 1977	40 (25)	66.7 (3)	25 (4)	50 (4)	—
May 1977	52.4 (21)	—	—	40 (10)	0 (1)
July 1977	45.7 (35)	12.5 (8)	0 (1)	46.7 (15)	0 (4)
September 1977	64.7 (34)	50 (2)	0 (3)	40 (5)	100 (1)
November 1977	8.2 (49)	0 (1)	—	9.1 (11)	0 (2)
January 1978	0 (23)	50 (2)	—	0 (4)	—
March 1978	64.7 (17)	100 (3)	80 (5)	75 (4)	—

over most of the year and reached a peak in the winter months (December, 1976; November, 1977). Reproductive activity occurred throughout the year, except in the cool months of December and January, when pregnancy rates were zero (Table 2).

Generally the abundance depended on the production of young. However, in September abundance was low in spite of a peak in production of young two months earlier and in November abundance increased to 31.8% in spite of decreasing production of young. Clearly, emigration and immigration, respectively, influenced the abundance in these months. Seasonal changes in the age structure of the population can be implied

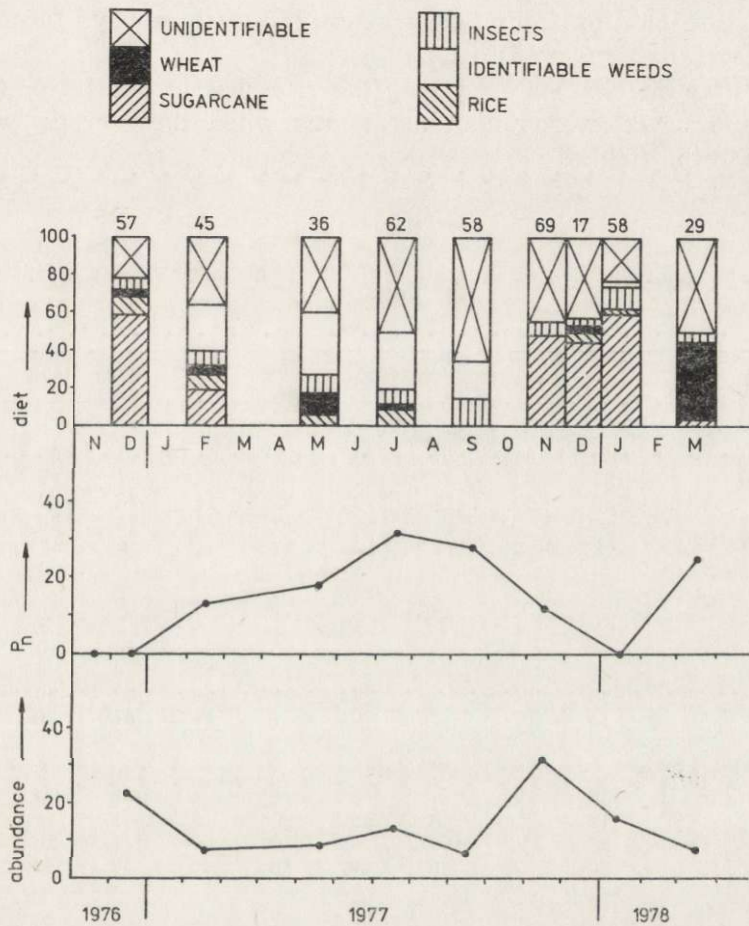


Fig. 1. Abundance, production of young and diet of *Millardia meltada*; numbers above the bars indicate sample size.

from tooth height data (Table 3). In January and February, following the period of reproductive inactivity, the proportion of old animals (tooth height ≤ 2) was high (42 and 65%) and no young animals were caught (tooth height ≥ 7). Otherwise, young animals accounted for 12 to 33% of each sample and the percentage of old animals never exceeded 25.

The diet changed considerably over the year. Sugarcane formed a large (>49%) proportion of the diet only in November, December and January. In these months, the cane was sweet. Although the cane was still sweet in February and March, other food seemed to be preferred. In March, 43% of the diet consisted of wheat. The seeds of *Chenopodium album* and *Paspalidium geminatum* accounted for most of the identifiable weeds in the months from February-July. Insects always formed part of the diet, ranging from 5 to 13%.

Very little rice was eaten during the rice season, but traces (<10%) of rice and wheat were found in months when these crops were not standing in the field.

Table 3

Age structure: percentages of animals with small or larger tooth height for each sample.

Tooth Height	Dec. 1976	Feb. 1977	May 1977	July 1977	Sept. 1977	Nov. 1977	Jan. 1978	Mar. 1978	Total
<i>Millardia</i>									
Sample size	60	34	35	50	46	97	43	30	395
0-2	25	65	17	20	15	14	42	3	24
3-4	35	32	14	20	35	14	33	44	26
5-6	28	3	52	38	20	40	25	20	30
≥7	12	0	17	22	30	32	0	33	20
<i>Bandicota</i>									
Sample size	21	1	—	15	8	8	3	5	61
0-5	14	0	—	60	25	25	0	0	26
6-10	34	100	—	13	13	12	0	0	20
11-15	38	0	—	27	25	50	33	80	38
≥16	14	0	—	0	37	13	67	20	16
<i>Tatera</i>									
Sample size	6	6	1	2	5	4	1	5	30
0-5	17	83	0	50	0	0	100	40	33
6-10	33	17	100	0	20	0	0	20	20
≥11	50	0	0	50	80	100	0	40	47
<i>Nesokia</i>									
Sample size	1	—	2	4	2	7	2	—	18
0-5	100	—	0	50	100	0	0	—	28
6-10	0	—	50	25	0	14	0	—	17
≥11	0	—	50	25	0	86	100	—	55

The average litter size was 5.1 (S.D.=1.6; n=74). An increase in litter size was observed from 4.4 in February (n=10) to 5.9 in September (n=21). The difference between February and September is significant, while the difference between other months is not (Duncan's New Multiple Range Test; 5% level). There appeared to be no relationship

between the age of the female, as measured by tooth height, and litter size ($r=0.31$; $n=47$).

The reproductive potential of the whole population, as measured by the Southwick procedure, was 39.8 young per female per year (Table 4). The average age of adult females was 2.9 months.

Bandicota bengalensis (Gray & Hardwicke, 1833)

A total of 100 *Bandicota* was examined. Data on abundance, reproduction and diet are summarized in Fig. 2. Abundance was generally much lower, compared to *Millardia*, and fluctuated considerably, being zero in one month (May) and reaching a peak two months later (July).

Production of young also fluctuated greatly, but did not correspond to changes in abundance. For example, no *Bandicota* was caught in

Table 4

Various population parameters for comparison of rodent populations in rice and sugarcane.

F=Incidence of pregnancy, AA=Average age of adult females.

Crop/Authors	Species	Percent Trap Success	No. Young	No. Young	F	AA	Avg. Litter Size
			per Female Collected	per Female per Year			
Sugarcane Present study	<i>Bandicota</i>	1.8	8.9	43.6	6.7	5.0	6.5
	<i>Millardia</i>	14.5	3.0	39.8	7.7	2.9	5.1
	<i>Mus</i>	3.5	4.2	43.5	7.9	2.2	5.5
Rice	<i>Bandicota</i>	2.8	7.0	28.2	1.6	5.5	10.2 ¹ 6.7 ²
Fulk <i>et al.</i> , 1979a	<i>Millardia</i>	2.7	5.4	34.5	3.1	3.9	5.6
	<i>Mus</i>	1.1	—	—	—	—	5.9

¹ Near harvest, ² Other seasons.

May in spite of the high production of young in February. *Bandicota* were abundant in July, but most of the animals were old (Table 3; tooth height ≤ 5). Apparently, the abundance of *Bandicota* was always largely determined by immigration and emigration and not by the production of young in the cane fields.

Bandicota seemed to reproduce at a low rate over most of the year. Pregnancy rates were low in the only two months with a reasonable sample size (December and July; Table 2). A few young animals were collected every month except in July (tooth height ≥ 16 ; Table 3).

Sugarcane was eaten in every month. More than 75% of the diet in November, December and January was cane. The least amounts of cane were consumed in March and July. Wheat was eaten in February and

March, but rice was never part of the diet. Insects were always eaten, proportions in the diet ranging from 1 to 13%.

Average litter size was 6.5 ($n=8$; S.D.=3.7). The number of young produced per female per year for the entire population was 43.6, slightly higher than for *Millardia*. The average age of adult females was 5 months, higher than *Millardia* (Table 4).

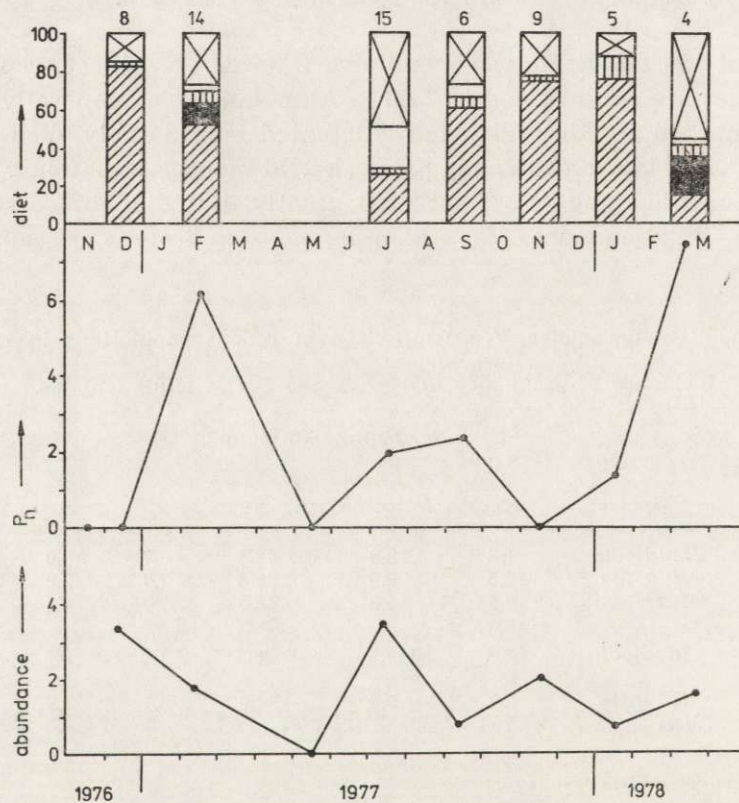


Fig. 2. Abundance, production of young and diet of *Bandicota bengalensis*; numbers and symbols for diet as in Fig. 1.

Mus species

A total of 136 mice were examined. Abundance, reproduction and diet are summarized in Figure 3. Abundance was low at the start of the study, increased to a peak in July and declined thereafter. Reproduction showed seasonal changes similar to those for *Millardia*: a fairly high proportion of females were pregnant in all months except the coldest months, when none or few were pregnant (Table 2).

Generally, abundance depended on the production of young in the preceding months, except in September, when abundance was low in

spite of peak production of young in the preceding months, and in November, when abundance was high in spite of the previous low reproduction. Apparently, as in the case of *Millardia*, emigration decreased abundance in September and immigration increased abundance in November.

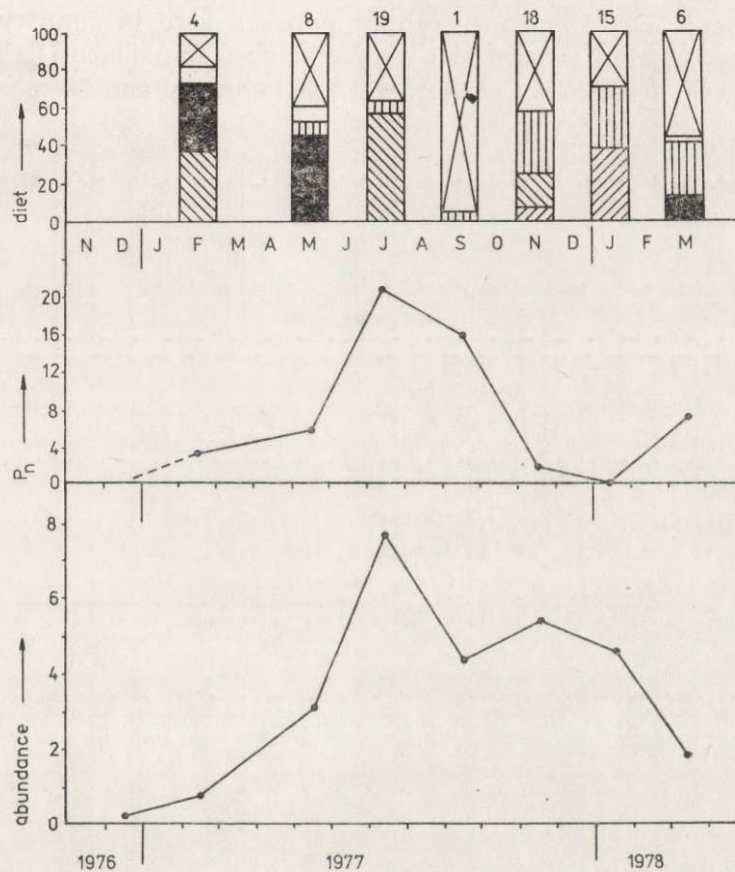


Fig. 3. Abundance, production of young and diet of *Mus* sp.; numbers and symbols for diet as in Fig. 1.

Significant amounts of sugarcane were only eaten in January (38%). Rice was eaten in February, July and November (18–59%). Wheat was eaten in February, March and especially May (47%). Insects were an important part of the diet (>25%) in the cooler months of November, January and March, but were otherwise eaten in lower amounts. Often a large proportion of the diet could not be identified (20–94%).

The litter size averaged 5.5 (S.D. = 2.1; $n = 19$). The population produced 43.5 young per female per year, more than *Millardia* and the same as

Bandicota. The average age for females was 2.2 months, less than the 2.9 months for *Millardia* and the 5 months for *Bandicota* (Table 4).

Tatera indica (Hardwicke, 1807)

A total of 74 animals was examined, of which 40 were brought in by a local animal hunter in December, 1976. Sample sizes for the other months were low. Abundance ranged between zero in January to 1.8 in February. March showed the second highest abundance (1.4%). The only pregnant females we caught, were in February and March.

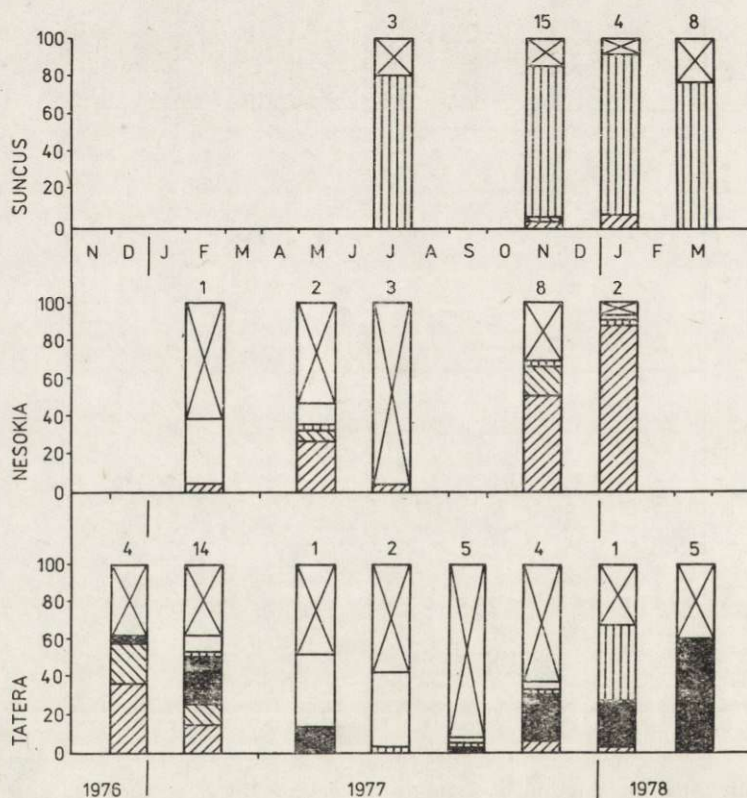


Fig. 4. Diet of *Tatera indica*, *Nesokia indica* and *Suncus stoliczkanus*; numbers and symbols as in Fig. 1.

Litter size averaged 6.6 ($n=5$). Toothwear data (Table 3) showed that young animals (tooth height ≥ 11) were present throughout the year, except in January and February. To achieve this, breeding must have taken place in all months, except December and January. No breeding in December was confirmed by the lack of pregnant females in the sample of 14 adult females taken in this month (Table 2).

Tatera seemed to be similar to *Mus* in diet: both seldom ate cane, but frequently ate cereals or seeds of *Chenopodium album*. In the case of *Tatera*, the cereal eaten was mostly wheat. *Tatera* ate fewer insects than *Mus* (Fig. 4a).

Nesokia indica (Gray & Hardwicke, 1832)

A total of only 31 animals was examined. *Nesokia indica*, a highly fossorial animal, was not frequently caught in our surface traps. Fulk *et al.* (1979a) found that trappability increased when *Nesokia* fed on rice close to the harvest. Apparently, *Nesokia* was seldom active on the surface in sugarcane fields; since only a few individuals were caught, in spite of the many burrows observed. The only pregnant female caught, was taken in September and had four embryos (Table 2). Young animals (tooth height ≥ 11) were collected in May, July, November and January (Table 3). Together with the pregnant female in September, this suggested that at least some breeding took place during all seasons.

Sugarcane was eaten mostly in November and January (53 and 89%; Fig. 4b). Most of the other food items were unidentifiable fibers, probably from roots. The proportion of insects in the diet was very low (0–2%).

Suncus stoliczkanus (Anderson, 1877)

We examined 68 of these small insectivores. Their abundance was lowest in May (trap success 0.4%), before the monsoon began, and highest in November (3.2%), after the monsoon. Shrew abundance was probably affected by rainfall, presumably indirectly through insect abundance.

Only 4 females were pregnant, 3 in March and 1 in July. Embryo counts were 4, 4, 4 and 5. Most (50 of 68) animals caught were males.

The proportion of insects in the diet was always more than 75% (Fig. 4c). Traces (<10%) of rice and sugarcane were occasionally found.

Rodent Damage to Sugarcane

Most damage (87.3%) occurred in November, December and January (Table 5). Damage in other months was much lower, ranging between 0.3% and 6.4% of the total damage. The large increase in damage between September (1.6%) and November (34.4%) was due not only to a higher percentage of cane in the rodent diet, but also a higher rodent abundance in November.

Millardia caused 68.9% of the damage and *Bandicota* 24%. A single *Bandicota* on an average consumed 2.8 times more cane than a single *Millardia*, but *Bandicota* was much less abundant and this reduced its contribution to the damage index. Other species contributed about 7% to the overall damage index.

Table 5

Damage index to sugarcane for each sampling month and each species.

	<i>Millardia</i>	<i>Bandicota</i>	<i>Tatera</i>	<i>Nesokia</i>	<i>Mus</i>	Total	%
Dec. 1976	61.9	22.4	3.5	—	—	87.8	32.6
Febr. 1977	6.8	8.0	2.2	0.1	0	17.1	6.4
May 1977	0	—	0	0.7	0	0.7	0.3
July 1977	0.1	8.3	0	0.2	0	8.6	3.2
Sept. 1977	0	4.2	0	0	0	4.2	1.6
Nov. 1977	71.1	13.1	0.5	7.8	0.4	92.9	34.4
Jan. 1978	44.9	5.9	0	2.2	1.6	54.6	20.3
March 1978	0.7	2.6	0	—	0	3.3	1.2
Total	185.5	64.5	6.2	11.0	2.0	269.2	—
%	68.9	24.0	2.3	4.1	0.7	—	100

Effect of Cane Height

Trapping was carried out simultaneously in tall cane (4 meters high) and in short cane (1—1.5 m high) in February. The tall cane was awaiting harvest, while the short cane had been newly planted in fields harvested in November. Results are summarized in Table 6.

Table 6

Effect of cane height on rodent abundance; number of animals caught is shown in parentheses.

	Percent Trap Success	
	Short Cane	Tall Cane
Number of trap nights	252	370
<i>Millardia</i>	7.5% (19)	7.3% (27)
<i>Bandicota</i>	0.4% (1)	2.4% (9)
<i>Tatera</i>	3.2% (8)	0.8% (3)
<i>Mus</i>	2.0% (5)	0.3% (1)
Total	13.1% (33)	10.8% (40)

Rodents were slightly more abundant in short cane, but not significantly so ($G=0.74$). *Millardia* was equally abundant in short and tall cane ($G=0.02$). *Bandicota*, however, was more abundant in tall cane ($G=4.7$; $p<0.05$) and *Tatera* and *Mus* were more abundant in short cane ($G=4.8$ and 4.7 , respectively; $p<0.05$).

The *Millardia* trapped in short cane had diets different from those trapped in tall cane. While samples of 23 stomachs from tall cane contained 671 fragments of sugarcane, samples of the 17 stomachs from short cane contained only 21 fragments ($G=56$; $p<0.005$). The 9 *Bandicota* stomachs from tall cane contained 78.2% sugarcane, while 1 animal trapped in short cane had no cane in its stomach. The stomachs of *Tatera* and *Mus* contained very little sugarcane at all.

DISCUSSION

Our previous study (Fulk *et al.*, 1979a) showed a fundamental difference between the dynamics of *Millardia* and *Bandicota* populations in rice fields. *Bandicota* responded markedly to the sudden abundance of energy-rich food as the rice crop matured. At this time the *Bandicota* population tripled its pregnancy rate and doubled its litter size. Moreover, *Bandicota* stored large amounts of rice underground. *Millardia*, on the other hand, managed to find energy-rich food (insects and seeds) even when the rice crop was not mature. Consequently, *Millardia* maintained more stable pregnancy rates throughout the year and responded less markedly to the ripening of rice.

Sugarcane differs in two important aspects from rice fields as a rodent habitat. First, sugarcane fields provide cover over a longer period. Second, sugarcane is not an energy-rich food. On the contrary, a study of the digestion of cane by *Rattus exulans* showed that sugarcane alone is not sufficiently nutritious to keep animals in good condition (Garrison & Breidenstein, 1970).

The effect of these environmental differences on some parameters of the rodent populations can be seen in Table 4. *Bandicota* in sugarcane had a litter size about equal to that in rice during the non-harvest months, but much lower than that in rice during the months near harvest. Obviously, maturation of the sugarcane crop did not have the same stimulatory effect on *Bandicota* reproduction as the maturation of the rice crop did, although cane formed 50% or more of the diet for 6 months of the year. *Bandicota* reproduced over most of the year in cane and did not show any sharp peak in pregnancy rate as was the case for the population in rice. Overall, the incidence of pregnancy was higher in the cane population; more young per female per year were produced and the average age was slightly less than in the rice population. The *Bandicota* population in cane turned over more rapidly than the population in rice. From the data in Table 4, *Bandicota* appeared to be slightly more abundant in rice. Actually, this is misleading since the abundance in rice fields is based on data collected from 1974—1976, years that

were more favorable for *Bandicota* (Fulk *et al.*, 1979b) than 1977—1978 when the abundance in cane was measured. When rice field data from 1977—1978 are compared to sugarcane data from the same years, *Bandicota* appeared to be slightly more abundant in cane than in rice (1.8% trap success in cane vs. 1.1% in rice).

The corresponding comparison between rice and sugarcane populations for *Millardia* leads to similar conclusions. Litter size was slightly larger in rice fields, but not significantly so ($p < 0.2$). The incidence of pregnancy for the cane population was much higher; more young per female per year were produced; and the animals in cane were on the average one month younger than in the rice fields. *Millardia* were more able to find energy-rich food in cane than *Bandicota*. *Millardia* ate less cane and had a more varied diet, including insects, weed seeds and cereal seeds. The great stability of the cane habitat and the fact that individuals of *Millardia* managed to find energy-rich food throughout the year enabled this species to maintain a much higher abundance in cane than in rice fields.

The above points about *Millardia* are probably equally true for *Mus*. The principal difference between the two species was their diet: *Mus* ate less cane and more energy-rich food than *Millardia*. The mice were able to find rice and wheat even outside the crop season and ate more insects than *Millardia*.

Sugarcane formed apparently only a marginal habitat for *Tatera*, primarily a desert species associated with open terrain (Prakash & Rana, 1970). In this light it is not surprising that *Tatera* were more abundant in short cane than in tall cane, where cover is dense. Our evidence that reproduction ceased in the winter is in agreement with Beg & Ajmal (1977).

Nesokia was inadequately sampled. Our evidence that they can breed the whole year around supports the view of Roberts (1977). The age structure of the *Nesokia* caught in November and January (Table 3) tends to support our previous conclusion that this species produced more young in the cooler months (Fulk *et al.*, 1979a).

The rodent populations in cane fields were influenced by changes in the surrounding habitats. This was especially true for *Bandicota*. *Millardia* and *Mus* maintained more stable populations in sugarcane. However, in September these species were less abundant than expected on the basis of their reproduction and more abundant than expected in November. We hypothesize that many individuals emigrated to ripening rice fields in September and that they and their offspring immigrated back into the cane after the harvest of rice in November. We made a similar observation while monitoring the recovery of rodent populations after

the application of rodenticides in cane fields; rodent populations were especially quick to recover in November after the rice harvest.

Movements between cane and wheat were probably of a different type from those between cane and rice. Since wheat fields were small and close to cane fields, normal home range activities of rodents living in cane could easily include foraging in wheat fields. Beg & Khan (1977) noted that wheat fields adjacent to sugarcane fields were more damaged by rats than other wheat fields.

Several authors have reported invasion of agricultural fields from the surrounding habitat (Taylor & Green, 1976; Hood *et al.*, 1971; Sumangil, 1965). These movements are adaptive to the quick appearance and disappearance of an abundant food supply. We monitored *Bandicota* movements with radio telemetry equipment and reported long distance movements up to 640 meters (Fulk *et al.*, 1979a). Even longer movements were suspected. We have also reported that harvest operations in rice fields caused individual *Bandicota* to move away from their home fields (Fulk *et al.*, 1979d). Movements between sugarcane and cereal crops give rodent populations in cane more importance than indicated by the damage they cause to the cane alone.

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EKOLOGIA GRYZONI ZAMIESZKUJĄCYCH POLA TRZCINY CUKROWEJ
W PAKISTANIE

Streszczenie

Gryzone łowiono na polach trzciny cukrowej przez 16 miesięcy, zbierając co 2 miesiące dane odnośnie rozrodu (Tabela 2), zagęszczenia (Tabela 4), struktury wiekowej (Tabela 3) i pokarmu. *Millardia meltada* była najliczniejszym gatunkiem i populacja jej występowała przez cały rok (Ryc. 1). Zmiany w zagęszczeniu *Millardia* zgodne były ze zmianami w aktywności rozrodczej, z wyjątkiem września, kiedy to liczebność była niska, przypuszczalnie z powodu migracji na dojrzewające pola ryżowe, i listopada, kiedy liczebność była wysoka, przypuszczalnie z powodu imigracji ze skoszonych pól ryżowych (Tabela 4). W listopadzie, grudniu i styczniu około połowy diety *Millardia* stanowiła trzcina cukrowa (Ryc. 1), w pozostałych miesiącach trzcina była słabo jedzona. Populacja myszy (*Mus* sp.) jest podobna do *Millardia* pod względem sezonowych zmian liczebności i rozrodu, lecz różni

się pokarmem. Myszy zjadają mniej trzciny a więcej owadów (ryc. 3). *Bandicota bengalensis* zjada trzcinę częściej niż *Millardia* (Ryc. 2). W ciągu pół roku stanowiła ona 50 i więcej procent całego pokarmu tego gryzonia. Liczebność *Bandicota* w trzinie była bardzo zmienna i niezależna od rozrodu. *Nesokia indica* prawdopodobnie stale występuje na badanych polach, lecz te gryzonie były bardzo nieliczne w odłowach (Ryc. 4). Obserwacje te porównywano z podobnymi badaniami na polach ryżowych w Sind i różnicami w wykorzystaniu pokarmu. Sugeruje to, że pola trzciny cukrowej mają stałą obsadę różnych gatunków gryzoni, które wychodzą stąd na otaczające tereny rolne.