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Small mammals and stored food losses in farm households in Bangladesh

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ABSTRACT. Small-mammal activity indices were obtained with inked tracking tiles before and after 3 nights of removal trapping in farmers' households in Bangladesh. This procedure was followed for 12 months, using 12 different households during each monthly cycle. From the change in proportion of positive tracking tiles before and after trapping, and the number of animals removed, it was possible to estimate the pretrapping population of small mammals: house mice (*Mus musculus*) constituted 53% of total captures, and the Asiatic house shrew (*Suncus murinus*) accounted for 34%; of lesser importance were bandicoot rats (*Bandicota bengalensis*) and roof rats (*Rattus rattus*). The estimated small-mammal population varied from 170 in December 1982 to 40 and 34 in March and August 1983, respectively. The rodent population estimated in the farmers' households averaged 8·3 mice and 2·0 rats per household. These rodents were estimated to consume and hoard about 53 kg of rice per farm family per year. Because tracking tiles and traps were placed only on the floors of the structures, data collected on rodent activity and trap captures underestimated the small-mammal populations; consequently, stored food loss estimates represent a minimum per year.

Introduction

Direct measurement of stored grain losses due to rodents is difficult, time-consuming, and rarely attempted (Greaves, 1978). However, techniques for the estimation of rodent populations are well established. Because the extent of stored grain losses depends upon the distribution, abundance and species composition of the rodent populations involved, it is necessary first to establish some quantification of these factors. The amount of food grains stored at farm and village levels in Bangladesh far exceeds that held in large government-owned or private food storage facilities, as there are some 12 million farm households as opposed to approximately 2000 grain warehouses and a small number of private warehouses. The vast majority of farm households are infested with rodents. The cumulative losses at the farm level due to these pests, therefore, must be the most significant source of postharvest stored grain losses in the country.

We initiated a preliminary study of stored food loss assessment methods in farm and village households in Bangladesh in September 1982. Our objectives were to establish which small-mammal species live in farmers' houses, to find what seasonal changes occurred in animal abundance, and to estimate the monthly abundance of small mammals. From the animal population estimates and a knowledge of the amounts of food grains consumed daily by each small-mammal species, an indirect estimate of the stored food consumption and hoarding losses due to rodents in farmers' storage structures could be made. There are, of course, additional stored food losses caused by rodents through contamination by urine, hair and faeces.

Materials and methods

Study site

A village area about 5 km west of Bangladesh Agricultural Research Institute (BARI), Joydebpur, comprised the study site. Farm households occur in small clusters of two to seven structures, surrounded by intervening fields. Each cluster represents one or more related farm households situated around a central courtyard. Twenty-four structures (two per farm family) were set with traps each month; each successive month, 24 fresh structures were selected adjacent to the area of the previous month's trapping. During the 12-month study, a total of 146 farm house-

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holds comprising 503 structures were used. The trapped structures numbered 292 of the 503 total and comprised usually the building(s) containing stored paddy (unhusked rice) and the living and sleeping quarters of the farm family. Other structures not set with traps were additional living and storage quarters, kitchens, and those structures housing livestock and poultry.

The cropping pattern in this area is the planting of early monsoon rice (aus variety) at the beginning of the rains in April and late monsoon rice (aman variety) following the aus harvest in July/August. The aman crop is generally harvested in November/December. Fields then lie fallow and dry until the next rainy season.

Tracking tiles

Four inked, vinyl floor tiles (approximately 23 × 23 cm) were set inside each of two structures of each farm family, generally on the floor, and two each were placed outside. This took place for 1 night before the removal trapping and again for 1 night immediately following the last night of trapping. Tiles were recorded as positive or negative for footprints the following morning, and the small-mammal species making the prints was noted. The tiles were scored for the number of prints of each species on a scale of 1–5, representing one set of prints at the lowest to five sets or more at the highest.

Trapping

Snap-traps baited with dried fish were set for 3 nights. Initially, two rat traps and two mouse traps were set inside each structure on the floor, and two rat traps were set outside each house. In January, this procedure was changed and two additional mouse traps were set inside. All captured animals were identified, sex was determined, and they were weighed and measured.

Population estimates

Pretrapping small-mammal populations were estimated by the change-in-ratio method (Davis and Winstead, 1980), using the formula

$$\frac{T_1 - T_2}{n} = \frac{T_1}{N_1} = \frac{T_2}{N_2}$$

where n is the number of animals captured, N_1 is the population before removal, N_2 after removal, T_1 is the percentage of tiles tracked before trapping, and T_2 is the percentage of tiles tracked after trapping. The method is simple but assumes that the ratio of objects counted (number or percentage of positive tracked tiles in this case) to the animals captured is the same both times. This assumption should hold for the short period between each measurement (4 days).

Animal populations were also estimated from the trapping data. The linear regression of new individuals captured by unit effort was plotted and calculated against the cumulative number of animals captured (De Lury, 1947, 1951) and the estimate derived. The second method used was to compare the decline in trap captures between the first and second day (Zippin, 1956). Using this method, the population (N) equalled the number caught the first day (y_1) squared, divided by the difference between the number caught on the first day (y_1) and the second day (y_2).

Results

Animal captures

A total of 610 small mammals were captured in the 12 monthly trapping periods of which 2 (0·3%) were *Bandicota indica*, 46 (7·5%) *B. bangalensis*, 31 (5·1%) *Rattus rattus*, 326 (53·4%) *Mus musculus*, and 205 (33·6%) *Suncus murinus*. House mice and shrews were captured every month.

Tracking tile activity and population estimates

Pre- and post-trapping tile activity indices and estimated small-mammal population numbers are summarized in Table 1. Using the change-in-ratio

TABLE 1. Tracking tile activity, animals captured, and estimated original small-mammal populations in farm households in Bangladesh

Month	Pretrapping (% positive tiles)	Post-trapping (% positive tiles)	Animals captured	Methods of estimation of original populations: Change-in-ratio	Zippin	Removal regression
October	41·7	14·9	74	115	136	103
November	50·0	23·1	74	138	157	270
December	50·0	27·1	78	170	77	83
January	33·3	6·2	80	98	130	125
February	27·8	12·5	52	95	53	57
March	27·8	11·1	24	40	36	34
April	36·1	18·1	43	86	44	50
May	34·7	26·4	34	142	48	44
June	25·0	15·3	46	118	98	74
July	30·6	19·4	57	155	361	76
August	22·2	8·3	21	34	50	28
September	19·4	13·9	27	95	36	46
Mean	33·2	16·6				
Total			610	1286	1226	990

TABLE 2. Relative densities of small mammals from trapping results in Bangladesh

Month	Small mammals captured Day 1	Day 2	Day 3	Total captures	Total trap-nights	Catch/unit effort
October	35	26	13	74	349	0·212
November	28	23	23	74	468	0·158
December	49	18	11	78	480	0·162
January	36	26	18	80	576	0·139
February	31	13	8	52	576	0·090
March	12	8	4	24	576	0·042
April	23	11	9	43	574	0·075
May	17	11	6	34	576	0·059
June	28	20	9	57	576	0·099
July	19	18	9	46	576	0·080
August	10	8	3	21	576	0·036
September	12	8	7	27	576	0·047

estimates and the proportion of each species trapped each month, the estimated numbers were as follows: *B. bengalensis,* 102; *B. indica,* 4; *R. rattus,* 65; *M. musculus,* 700 and *S. murinus,* 415. The total estimated initial population over the 12-month period was 1286 animals, using the change-in-ratio estimate, and 1226 using Zippin's methods; the removal regression gave a lower estimate of 990 animals. For reasons discussed later, we have accepted the change-in-ratio estimate as being the most accurate. The removal of 610 animals reduced the activity at tracking tiles by exactly one-half over the course of the 12 months.

Relative animal densities from trapping results

Relative densities of small mammals, when determined from catch/unit trapping effort, varied from highs of 0·212 in October to lows of 0·036 in August (Table 2). Relative densities were highest in the months of October to January, inclusive; these levels were never attained again during the course of the study. A secondary peak of higher density occurred during June and July.

Infestation rates

The proportion of houses infested with small mammals was determined both from tracking tiles and trapping results. The proportion of houses infested with both rodents and shrews was 81·4% as measured by either method. However, only 64% of all houses were infested with rats or mice out of the total studied during the year.

Discussion

Animal captures

House mice were the predominant rodent species in Bangladesh farm households. Rats, both bandicoots and house rats, were much less abundant. House mice and house rats were captured indoors, whereas bandicoots and house shrews were captured both indoors and outdoors.

Three nights of removal by snap-trapping was successful overall in reducing tracking tile activity by one-half (Table 1). Reduction in activity, however, varied widely from month to month, with a maximum of 81·4% in January and a low of 23·9% in May. The reasons for this are unknown. There was a slight correlation between pretrapping tile activity and number of animals captured (r=0·2768), but it was not statistically significant.

Population estimates

Of the three small-mammal population estimation methods used, only the change-in-ratio method used another set of observations besides the trapping date, namely, the change in activity at tracking tiles before and after removal trapping. For this reason, we have placed more credence in the estimates obtained from this method than in the other two. Simple vagaries in data can sharply affect the results obtained solely from trap captures. For example, as there was no decline in catch from the second to the third day in November (Table 2), an overestimate (about twofold) occurred when using the removal regression method (Table 1). Similarly, the sharp decline from the first to the second nights' capture in December led to an underestimate when using either Zippin's method or the removal regression method. In another example, the decrease by only one animal from the first to the second night's catch in July led to an excessive estimate when using Zippin's formula. In general, both Zippin's method and the removal regression method tend to give lower estimates than those obtained by the change-in-ratio method.

Possible errors that could bias estimates when using the change-in-ratio method can arise from several factors. When a few animals are left behind after removal trapping, they may mark more tiles proportional to their numbers than they did before trapping. This would lead the observer to overestimate the survivors and, consequently, to overestimate the initial population. Underestimates could result from the converse, i.e. the surviving animals do not individually mark as many tiles per animal as they did before trapping. To test for these possible errors, the mean tracking tile scores (see Methods section for tile scores) for pretrapping and post-trapping were calculated: pretrapping $=4\cdot12\pm1\cdot33$ SD ($n=248$) and post-trapping $=4\cdot21\pm1\cdot19$ SD ($n=141$). These two mean scores do not differ significantly ($t=0\cdot686$).

Another factor that could contribute to misleading estimates would be if not enough tiles were placed to obtain adequate activity measures. As never more than 50% of all tiles placed were tracked, this factor did not play a part in activity measures where tiles were placed on the floor. Of critical importance, however, is the location of the tiles and traps within the structures: as, in most cases, they were placed on the floor, and because *M. musculus* and *R. rattus* are climbing rodents and spend a lot of time above the floor, these species may not have adequately encountered tracking tiles or traps and, consequently, were underestimated in the populations. After the study was completed, we returned to some of the same houses and placed tracking tiles not only on the floor, but on *machas* (any shelf or platform raised above the floor) and in the open rice storage *doles* (baskets) made of woven split bamboo and generally set above the floor. The results showed that of 62 tiles placed on the floor, 17·8% were tracked; of 30 tiles placed on *machas*, 40% were tracked; and of 66 tiles placed in *doles*, 21·2% were tracked. It is apparent from these data that there was much more activity off the floor by climbing rodents than we suspected, and our methods used in the study described here underestimated the number of *M. musculus* and *R. rattus* in farmers' household structures.

In this study, we estimated the presence of 102 *B. bengalensis*, 4 *B. indica*, 65 *R. rattus*, 700 *M. musculus*, and 415 *S. murinus* in the 292 structures of 146 farm households where we set traps. As the 146 households consisted of 503 total structures, the total projected population in all structures would be 176 *B. bengalensis*, 7 *B. indica*, 112 *R. rattus*, 1206 *M. musculus*, and 715 *S. murinus*, or an average of 2·0 rats and 8·3 house mice per farm household.

Seasonal fluctuations

There were demonstrable fluctuations in seasonal abundance as shown in catch/unit effort, total captures, and population estimates. Animal densities were highest in the months of October through January and again rose in abundance in the months of May, June, and July. Both periods of abundance correlate well with periods of changing weather followed by major harvests of aus and aman rice.

Loss estimates

Using the estimates of 8·3 *M. musculus*, 1·2 *B. bengalensis*, and 0·8 *R. rattus* obtained per household, and using daily consumption of rice of 3·1, 19, and 8 g per species, respectively, the daily amount consumed by rats and mice per household would equal 54·9 g. *B. bengalensis* hoard at least four times their daily consumption (Parrack, 1969); therefore, we added 91·2 g. The average rice loss is 146·1 g/farm family/day or 1022·7 g/farm family/week. The accumulated loss of paddy per farm family in the study area would be 53 kg/year.

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