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Methods for Assessing Rat Damage to Growing Wheat in Bangladesh, with Examples of Applications

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ABSTRACT: Methods for assessing damage by the lesser bandicoot rat, *Bandicota bengalensis*, to growing wheat crops are described and compared with other methods. Damage was related to yield, density of wheat stems, agricultural practices, and the foraging range of the rodent species. Applications of the damage assessment are given for estimating the annual losses to growing wheat over several large wheat districts in Bangladesh, and uses of the assessment in evaluating the efficacy of rodenticides in field trials and farmer use of rodenticide treatments are shown.

KEY WORDS: damage assessments, wheat, Bangladesh, crop loss estimation, rodenticides, evaluation methods, efficacy, *Bandicota bengalensis*, zinc phosphide, difenacoum, brodifacoum, calcium cyanide, vertebrate pest control

The methodologies for rodent damage assessments in wheat are still in the developmental stages. Bindra and Sagar [*1*] did some work on wheat losses in India, and Fulk et al [*2*] reported on similar studies in Pakistan. Studies of rat damage to growing wheat crops in Bangladesh were carried out by Haque et al [*3*], Poché et al [*4*], and Posamentier and Alam [*5*], and methods of rodent control were developed by Poché et al [*6*]. Throughout most of the wheat growing areas of South Asia the primary rodent pest is the lesser bandicoot rat, *Bandicota bengalensis*. This species digs elaborate burrow systems and caches large amounts of grain, both rice and wheat.

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The purpose of the present paper is to outline the methods used in Bangladesh for assessing rat damage to wheat and to show how these methods were used to quantify the extent of rodent damage, to determine the effects of stem cutting on yield, and to demonstrate other applications of damage assessment methods.

Methods

Wheat fields were selected for sampling by random sampling procedures. For determining rat damage to wheat in major wheat-producing districts in Bangladesh, four districts were first chosen [*4*]. Eight thanas (a smaller administrative jurisdiction within a district), two from each district, were selected randomly from district maps, and villages within each thana were numbered. Lots were drawn and four villages chosen per thana. Eight wheat fields were then selected from each village by using the cardinal compass directions and sampling at 100 and 200 m from the village center along each transect line. The field lying nearest the transect line was selected.

Within wheat fields, ten 50- by 100-cm quadrats were examined for rat damage [*4*]. Wooden frames were used to delineate the quadrats. Two rows of five quadrats were laid out in accordance with the length and width of the field and then sampled. Total stems and the number of rat-damaged stems were counted within each quadrat. Bandicoot rat damage to wheat stems was of two types: the stem was bent over and cut at the base of the panicle or the stem was cut about 4 to 15 cm above the ground, the plant felled, and the panicle then removed and cached in the burrow [*4*]. Lesser bandicoot rat foraging was most intense near the burrow openings; the heaviest feeding was within 2.5 m of the burrow system center and decreased sharply beyond 6 m [*4*]. Rat damage is, accordingly, clumped within a field.

The effect of rat stem cutting on wheat yield was evaluated in one thana by preselecting 20 fields with varying degrees of rat damage [*4*]. Field dimensions were measured in metres and the diagonal field length was determined. Along one diagonal, five evenly spaced square-metre quadrats were examined and the number of cut and uncut stems was counted. All panicles on each quadrat were harvested, deposited in plastic bags, and labeled. They were threshed by hand, sun dried for 8 h and weighed to the nearest gram. The observed yield, Y_0, and potential yield, Y_p, were compared for each field. The potential yield was calculated as

$$Y_p = Y_0 \frac{N}{n}$$

where Y_0 was the weight of grains harvested, n was the number of undamaged panicles, and N was the total number of damaged and undamaged panicles [*7*].

We assessed rat damage reduction to farmers' fields following farmer use of prepackaged baits in Gazaria Thana by first selecting 12 villages at random from the 48 total villages in the thana [8]. At each village, transects were laid out in three directions at 0, 120, and 240°. Along each transect line, the wheat fields closest to a 100-, 200-, and 300-m distance from the village were selected, giving a total of nine fields per village.

Within each field, the nearest corner was chosen and a diagonal line to the opposite corner was followed. Five steps along this diagonal line were paced off and a 50- by 100-cm area was sampled for both damaged and undamaged wheat stems. This was repeated until five quadrats had been sampled.

Results

Countrywide Wheat Damage, 1979

Rat damage to wheat was assessed in four districts in Bangladesh in 1979 [4]. Only 0.5% of the stems were cut by rats before the booting stage. The average percentage of cut stems for all fields remained under 1% until the crops attained an age of more than 60 days. Between 60 and 120 days after sowing, rat damage increased from 2 to 12% (Fig. 1). Dacca district had the highest dam-

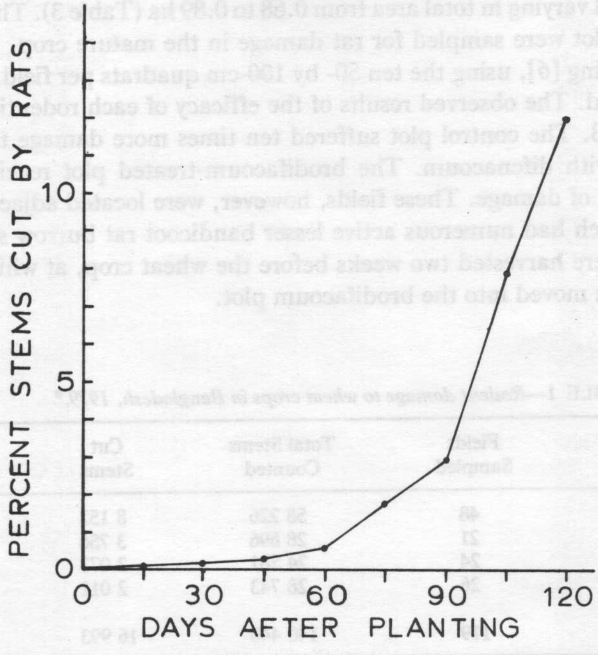

FIG. 1—*The accumulation of rat damage in fields during the 1979 wheat-growing season in Bangladesh (taken from Fig. 2 in Ref 4).*

age (14%) and Jessore the lowest (7%). The overall damage in mature wheat for the four districts was 12.1% (Table 1).

Relationship of Damage and Yield

A study of damage and yield was carried out in Gazaria Thana [*4*]. A summary of the data is given in Table 2. A total of 567 (17%) of the wheat stems damaged by rats had only the panicles removed, whereas 2725 (83%) were cut within 15 cm of the ground surface. Panicles fit more easily into burrow storage chambers if the excess stem is removed. As shown in Fig. 2, there was a strong relationship ($r = 0.978$) between rat-damaged stems and yield loss, expressed by the regression formula, $Y = 13.12x - 17.38$.

Rodenticide Evaluations

Four rodenticides were evaluated [*6*] as rodent control agents in wheat fields: calcium cyanide (a fumigant), difenacoum bait (0.005%), brodifacoum bait (0.005%), and zinc phosphide bait (2%). The baits and fumigant were applied in fields beginning at the booting stage of crop maturity, and applications were made weekly thereafter.

Five study plots were selected, each containing five to eight contiguous wheat fields and varying in total area from 0.68 to 0.89 ha (Table 3). The wheat fields in each plot were sampled for rat damage in the mature crop, 12 to 14 weeks after sowing [*6*], using the ten 50- by 100-cm quadrats per field, as previously described. The observed results of the efficacy of each rodenticide are given in Table 3. The control plot suffered ten times more damage than the fields treated with difenacoum. The brodifacoum-treated plot received the greatest amount of damage. These fields, however, were located adjacent to a potato field which had numerous active lesser bandicoot rat burrow systems. The potatoes were harvested two weeks before the wheat crop, at which time many of the rats moved into the brodifacoum plot.

TABLE 1—*Rodent damage to wheat crops in Bangladesh, 1979.*[a]

District	Fields Sampled	Total Stems Counted	Cut Stems	Percent Damage
Dacca	48	58 226	8 152	14.0
Comilla	21	28 896	3 756	13.0
Pabna	24	24 581	3 073	12.5
Jessore	26	28 743	2 012	7.0
Total/average	119	140 446	16 993	12.1

[a]Taken from Table 1 in Ref *4*.

TABLE 2—*Relationship between the level of rat damage and yield in 20 fields of Gazaria Thana.*[a]

	Total Stems	Cut Stems	Percent Damage	Observed Yield, Y_0	Potential Yield, Y_p	Loss
	554	0	0.0	512	512	0
	716	2	0.3	760	762	2
	971	13	1.3	850	862	12
	1399	35	2.5	956	980	24
	776	23	3.0	776	800	24
	1171	60	5.1	753	794	41
	1003	66	6.6	789	844	55
	987	87	8.8	936	1026	90
	1537	138	9.0	1028	1129	101
	1294	117	9.0	1100	1209	109
	1560	144	9.2	1007	1109	102
	1225	113	9.2	1073	1182	109
	1455	176	12.1	1028	1170	142
	1028	132	12.8	701	804	103
	1255	170	13.5	896	1036	140
	1835	261	14.2	1119	1305	186
	1781	382	21.4	831	1058	227
	1828	464	25.4	811	1087	276
	1755	463	26.4	1075	1460	385
	1489	446	30.0	958	1368	410
Average	1281.0	164.6	12.8	898.0	1024.9	126.9

[a]Data from 5-m^2 quadrats each field. Yield and loss are expressed as grams per 5 m^2. Modified from Fig. 5 and Table 2 in Ref *4*.

A linear regression analysis of the treated plot data [*6*], examining stem density, x, and percentage of rat damage, y, gave the equation $y = 0.0122x - 3.024$ ($r = 0.92$, $P < 0.05$). This indicated there was little observed difference between the control materials tested and the rat damage correlated with stem density.

Farmer Use of Prepackaged Rodenticide Baits

Seven hundred packets, each containing 100 g of 2% zinc phosphide bait cakes, were made up at the Vertebrate Pest Laboratory, Joydebpur, Bangladesh, and were sold at cost in the central market in Gazaria Thana to wheat farmers during the 1981 wheat season. Just before harvest, wheat fields were assessed at random for rat damage. After damage assessment, it was determined whether the farmer had used the prepackaged bait, had used other rodenticide bait, or had conducted no control [*8*].

A summary of the results of the survey of 108 wheat fields is given in Table 4. Twenty farmers (18.5%) had used the prepackaged zinc phosphide bait in their fields. Their damage level was only 28% of that of the farmers using other rodenticide baits or doing nothing [*8*]. A reduction in damage was achieved

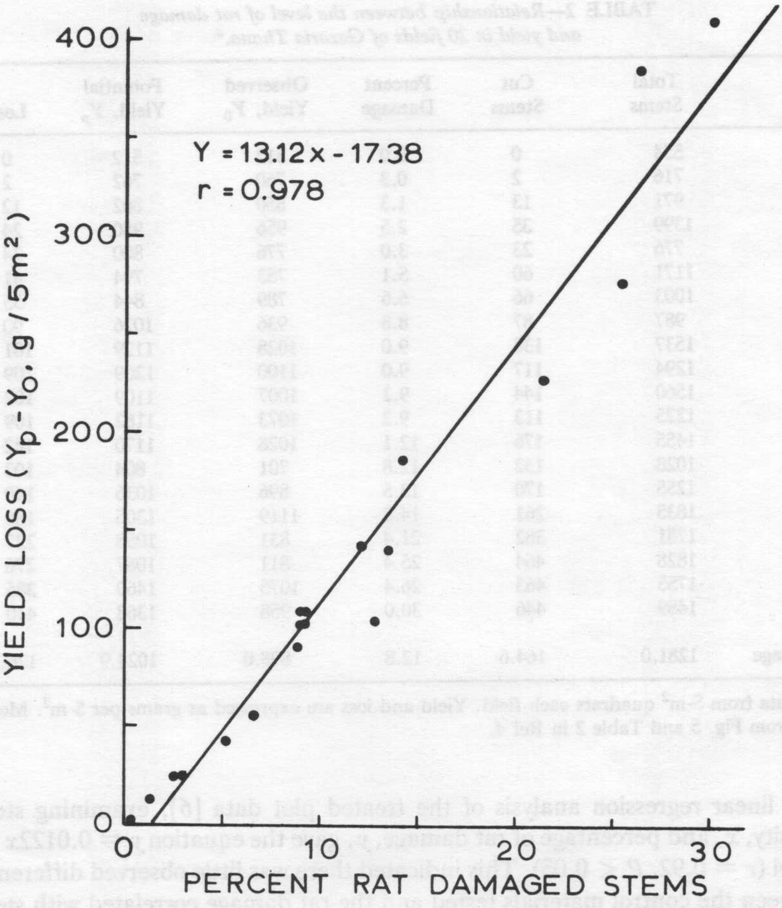

FIG. 2—*Regression line illustrating the relationship between rat damage to wheat stems and yield loss (modified from Fig. 4 in Ref 4).*

TABLE 3—*Summary of data for rodenticide field trials in wheat fields.*[a]

	Calcium Cyanide	Difenacoum	Zinc Phosphide	Brodifacoum	Control
Number of fields	8	8	6	5	6
Total area, ha	0.89	0.68	0.75	0.69	0.72
Number of quadrats sampled	46	32	46	24	50
Uncut stems	6561	4436	7579	4055	8148
Cut stems	38	13	63	53	262
Total stems	6599	4449	7642	4108	8410
Percentage rat-damaged stems	0.58	0.29	0.82	1.29	3.10

[a]Data are from Ref *6*.

TABLE 4—*Rat damage observed in wheat fields treated by farmers in Gazaria Thana with prepackaged zinc phosphide baits, other rodenticide baits, or no poison.*[a]

Treatment	Number of Farms	Cut Stems	Total Stems Counted	Percent Damage
Zinc phosphide	20	334	12 752	2.6
Other rodenticide	8	432	4 820	9.0
No poison	80	4480	48 523	9.2

[a]Data are from Ref *8*.

with very little supervision of the farmer. Our only contact was to give simple instructions at the time of bait sale.

Discussion

Fulk et al [*2*] traveled a predetermined auto route in surveys of rodent damage to wheat in Pakistan. They stopped at intervals of 10 to 20 km, and at each stop three to five field workers each walked a straight line (transect) through the crop. As they walked, they placed a 1-m^2 frame at 5- to 10-m intervals at 25 locations. At each quadrat they examined the wheat stems for rodent damage and estimated the percentage of rodent damage in six damage classes: 0 = no damage, 2.5 = 0.1 to 5% cut stems, 15.0 = 5 to 25%, 37.5 = 25 to 50%, 62.5 = 50 to 75%, and 87.5 = 75 to 100% cut stems.

These estimates were standardized by the field workers during a one-day training period by counting the actual number of cut and uncut stems in five quadrats per transect. After several hours the workers could estimate with accuracy. From their subsequent field estimates, they derived the percentage damage for all fields examined in 1979 ($n = 294$) at 2.0%. They used the damage frequency (x = number of quadrats with damage) to convert estimates of the percentage damage, y, for data collected in 1978 by the regression formula $y = 0.14x - 0.83$. This gave a damage estimate of 2.8% rat damage in 1978.

The field estimates and the grouping of the fields by damage classes are not as accurate as counting the actual cut and uncut stems, and they allow less precision in estimating the reliability of the data. The irregular spacing of the quadrats (5 to 10 m) along the transect line can lead to unconscious bias on the part of the field worker to select areas with obvious damage, leading to a higher damage estimate.

Posamentier and Alam [*5*] used ten quadrats per field spaced equidistant on a transect along one of the field diagonals. The quadrat size was 0.093 m^2, giving a total of 0.929 m^2 sampled per field. Damage assessments carried out in this manner in the 1980 wheat-growing season in 433 fields in 20 thanas in Bangladesh showed only 2.5% rat damage. This same year in Gazaria Thana we observed only 3.2% rat damage in an area where the year before damage had averaged 12.8% and that in the year following was 9.2%. This indicates good agreement between the data. We believe, however, that the use of the 50- by 100-cm sampling quadrat (which is 5.4 times larger than the 0.093-m^2 quadrat) gives greater accuracy. The time and expense involved in selecting and then visiting the fields are considerable, so the little extra time devoted to counting stems in a larger quadrat is well justified, just as making stem counts is superior to simply making percentage estimates, as the workers in Pakistan did. The issue of the size of the quadrat is, however, open to testing, and an optimum size should be determined.

The importance of these damage assessment methods lies (1) in the random selection of the fields to be surveyed, whether by picking villages at random or by driving a preselected route and stopping at regular intervals, (2) in setting the quadrats at regular intervals based on the length of a field or its diagonal, (3) in counting all the stems, cut and uncut, and (4) in timing the survey to coincide with the last week or two before harvest. This results in data that are relatively free from bias and can be statistically analyzed in several ways.

Acknowledgments

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References

[*1*] Bindra, O. S. and Sagar, P., "Study on the Losses of Wheat, Groundnut and Sugarcane Crops by the Field Rats in Punjab," *Proceedings*, International Symposium on Bionomics and Control of Rodents, Kanpur, India, 1968, pp. 28–31.

[*2*] Fulk, G. W., Akhtar, M. T., Salam, S. A., and Smiet, A. C., "Rodent Damage to the 1978 and 1979 Wheat Crops in Pakistan," *Pakistan Journal of Agricultural Research*, Vol. 1, No. 1, 1980, pp. 19–23.

[*3*] Haque, M. E., Sultana, P., Mian, M. Y., Poché, R. M., and Siddique, M. A., "Simulated and Actual Rat Damage in Wheat," Bangladesh Agricultural Research Institute, Vertebrate Pest Section, Technical Report No. 9, 1980.

[*4*] Poché, R. M., Mian, M. Y., Haque, M. E., and Sultana, P., "Rodent Damage and Borrowing Characteristics in Bangladesh Wheat Fields," *Journal of Wildlife Management*, Vol. 46, No. 1, 1982, pp. 139–147.

[*5*] Posamentier, H. and Alam, S., "Rodent Damage and Control in Wheat in Bangladesh During the 1980 Season," *Bangladesh Journal of Zoology*, Vol. 8, No. 2, 1980, pp. 99–101.

[*6*] Poché, R. M., Haque, M. E., Siddique, M. A., Sultana, P., Mian, M. Y., De Grazio, J. W., and Thompson, D., "Rodent Control in Wheat Fields," Bangladesh Agricultural Research Institute, Vertebrate Pest Section, Technical Report No. 10, 1980.

[*7*] Gomez, K. A., "Techniques for Field Experiments with Rice." International Rice Research Institute, Los Baños, Philippines, 1972.

[*8*] Fiedler, L. A., Poché, R. M., Sultana, P., and Siddique, M. A., "A Demonstration of Rodent Control in Wheat in Gazaria Thana, Bangladesh," Bangladesh Agricultural Research Institute, Vertebrate Pest Section, Technical Report No. 12, 1981.