DAMAGE TO WHEAT BY ENCLOSED POPULATIONS OF *RATTUS NORVEGICUS*

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(With Plates 3 and 4)

There is very little quantitative information on the damage done by pests to stored foods. Freeman (unpublished) has reviewed the various guesses which have been made on rat damage in Britain, and none has any validity. For the common brown rat the average daily consumption of wheat is accurately known (Leslie, unpublished), but this gives little help in assessing the losses caused by the present rat population of a large area: on the one hand, the size of the rat population is not known accurately for any area; on the other, the damage done by rats to the food they feed on is not confined to eating it, since a great deal is fouled and made either inedible or edible only after cleaning. The experiments described here were designed to give some information on the relationship of rat numbers to the amount of damage done, and on the precise form of the damage.

METHOD

A farm building which had been previously used as stables was divided into rooms, three of them (nos. 1, 2 and 5) of approximately 180 sq.ft., and another (no. 6) of about 340 sq.ft. The rooms were rat proofed. In each, biscuit tins and a pile of sacking were left in one corner for nesting sites (Pl. 3, fig. 1): water was always available. Adult wild rats which had been trapped and kept for a time in the laboratory were taken at random, and ten (four males and six females) were put in each room and fed on wheat. Each rat had its ears clipped so that it could be identified when the experiment ended. Six weeks later approximately 1 ton of English wheat in excellent condition (water content 13·5 %) was put in each room. The wheat was in sacks, nine to each room, and the sacks were stacked in the manner shown in Pl. 3, fig. 2. The rats used these stacks for nesting, as well as the sites established for the purpose.

The rats were thereafter left undisturbed except for weekly visits to replenish the water and to leave a supply of cabbage; about 500 g. horse liver was also left in each room every fortnight. This procedure was found to be satisfactory after early attempts to keep the rats healthy without food supplements had failed.

These conditions were maintained for 12, 20, 23 and 28 weeks respectively in the four rooms. For each room the date on which the experiment began was 31 March 1949. When the experiment ended in a particular room all the rats were caught, weighed and sexed. The wheat was collected, swept up and rebagged in accordance with normal warehouse practice: that is, wheat still in the sacks and

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evidently unfouled was as far as possible kept apart, while the fouled wheat (Pl. 4, figs. 3 and 4) was rebagged separately; during the sweeping the larger tufts of chewed sacking were removed. The wheat so collected was weighed.

Samples of wheat from three rooms were sent, after rebagging, to the Cereals Research Station, St Albans, for a report on their condition.

RESULTS

(*a*) *The rat populations*

In each room the numbers of rats had increased (Table 1). In room 1, after only 12 weeks, there were twelve rats, a net increase of 20 %; in room 6, after 28 weeks, the number found was twenty-six. These figures do not, however, give an adequate picture of the population changes that took place, since they take no account of mortality or of the weights of the rats. In room 1, for instance, the increase in weight of rats (or of biomass) was 59·2 %, a figure higher than that for rooms 2 and 5: even room 6 showed an increase of only 64·5 % after 28 weeks.

Table 1. *Details of rat populations*

		Rats put in		Rats taken out		Increase (%)	
Room	Period (weeks)	No.	Wt. (g.)	No.	Wt. (g.)	No.	Wt.
1	12	10	2280	12	3630	20	59·2
2	20	10	2520	17	3430	70	36·1
5	23	10	2930	18	4420	80	50·8
6	28	10	2240	26	3685	160	64·5

The discrepancy between weight and numbers is related to the fact that in every room there was an early but variable mortality among the rats. The ear marks made at the beginning of the experiment were not entirely satisfactory, partly because of subsequent damage, partly because some had evidently healed. The probable situation was as follows: in room 1 only five of the ten original rats remained after 12 weeks; in room 2 two remained after 20 weeks; in room 5 none remained after 23 weeks; and in room 6 three remained after 28 weeks. All these survivors were females.

(*b*) *Wheat losses*

The figures of wheat lost and of wheat fouled are given in Table 2. The wheat wholly lost is attributable both to consumption by the rats, and to the small losses inevitable during sweeping up and rebagging.

Table 2. *Record of wheat lost and wheat fouled*

			Wheat recovered			
Room	Period (weeks)	Wheat put in (kg.)	Fouled (kg.)	Clean (kg.)	Fouled (%)	Wheat lost (%)
1	12	1034·7	323·4	684·5	31·2	2·6
2	20	1036·2	848·2	126·3	81·8	5·9
5	23	1036·6	985·6	0·0	95·1	4·9
6	28	1037·1	762·0	230·9	73·5	4·3
Total		4144·6	2919·2	1041·7	70·4	4·4

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The greater part of the damage was by fouling of the wheat and destruction of the sacks. In rooms 2 and 5 considerable spillage had occurred after only 3 and 4 weeks respectively. This was evidently due to the use of fragments from the sacks for nesting. The extent of the fouling for the various samples is shown in

Table 3. *Extent of fouling of wheat*

	Rat dung					Rodent hairs (found after different degrees of cleaning)		
	Pellets (no.)		Pellets (weight)					
Room	Whole (no./kg.)	Fragments (no./kg.)	Whole (g./kg.)	Fragments (g./kg.)	Sacking weight (g./kg.)	Hand picked only (no./kg.)	Hand picked + aspiration (no./kg.)	Hand picked + aspiration + scouring (no./kg.)
1	11·8	11·2	—	0·6*	—	—	—	5·2
5	211	92·5	13·9	0·92	1·34	Too many to count	320	75·5
6	80·5	110	4·00	0·65	—	—	—	44·4

* Weight of whole pellets and fragments together.

Table 3. If the loss for all four rooms taken together is expressed in terms of money, the result is as follows:

Wheat put in	36 sacks	Wheat lost	Cost of cleaning	Cost of 31 sacks destroyed
£89. 14*s*.	£12. 12*s*.	£3. 19*s*.	£2. 3*s*.	£10. 17*s*.

That the loss was not greater was due to the fact that the fouled wheat, after cleaning, was still deemed fit for human consumption and was therefore sent for milling. The cost of labour required for sweeping up the wheat, rebagging it and sweeping the rooms in which it was stored, was approximately five man-hours for each room, at 2*s*. 2½*d*. per hour. The total labour cost for the four rooms was therefore £2. 4*s*. 2*d*. The cost of the rat infestations was therefore 18·23 % of the original value of the wheat and sacks.

DISCUSSION

Two aspects of these results require discussion: (i) the behaviour of the rat populations; (ii) the character of the losses incurred. The growth of the rat populations was greatly affected by the early mortality among the rats. This phenomenon is further discussed elsewhere (Barnett & Spencer, 1950); it is probably due to the absence of established social relationships among the rats (Calhoun, 1948, 1949). A result of the mortality was that the populations had only just begun to increase when the experiments ended. Had the experiments continued it is likely that little further increase in numbers would have occurred during the winter, though there would probably have been a considerable increase in biomass. Assuming that the nesting sites were adequate the main population increase would have occurred in the second year, when breeding recommenced. The problems of rat population changes are discussed further elsewhere (Barnett, Bathard & Spencer, 1950). Here the only point that need be made is that where

Fig. 1. Nesting site in room 6, after the rats had established their nests.

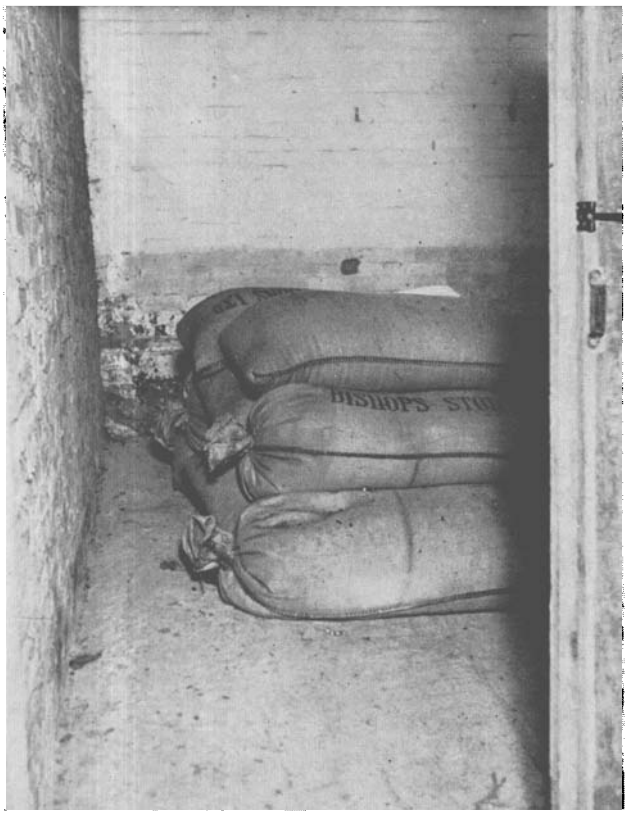

Fig. 2. Wheat sacks in room 2 at the beginning of the experiment.

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Fig. 3. Wheat in room 6 after exposure to rats for 10 weeks

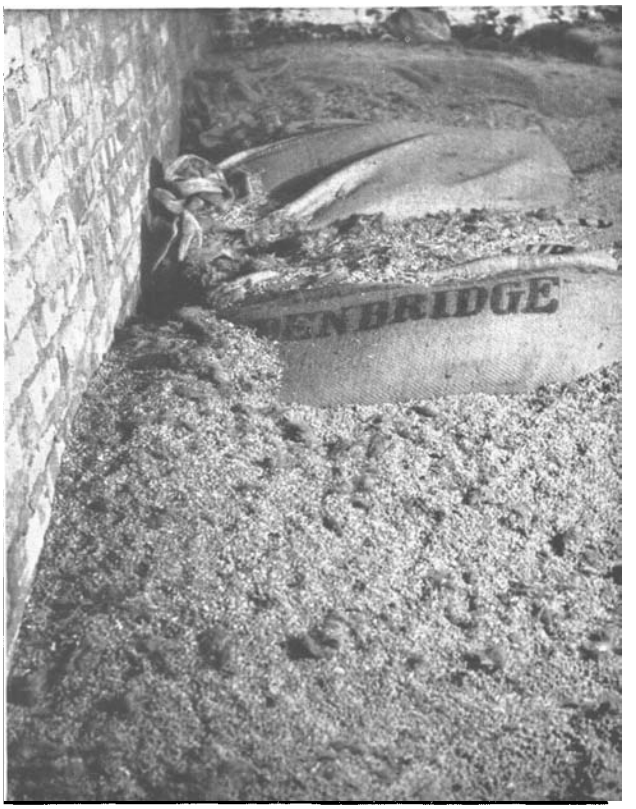

Fig. 4. Wheat in room 2 after exposure to rats for 6 weeks.

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populations are at a low level it is possible that the most satisfactory control programme would involve annual rather than more frequent treatments. This proposition can be put forward only in a tentative way on the basis of the present results.

As for the character of the damage, it is remarkable that the main monetary loss was due to the damage to the sacks and not to the wheat. It is probable that in more typical conditions, with many tons of wheat stored instead of only one, the discrepancy would be even more marked: it would be expected that the rats would range more widely, attack more sacks and of course foul a larger quantity of wheat. If this happened the net loss by weight of wheat would be negligible compared with the cost of cleaning and of replacing or repairing the sacks. If, however, rat populations were allowed to multiply unchecked over two breeding seasons it is probable that this would no longer be the case, since actual consumption by the large population produced would be heavy. Further experiments are required to make possible quantitative statements on these points.

SUMMARY

Small enclosed populations of the common brown rat (ten to twenty-six rats), each with access to one ton of sacked wheat for 12–28 weeks, caused a loss in weight of 4·4% of the wheat. 70·4% of the wheat was fouled and had to be cleaned before use. The main monetary loss was due to damage to sacks. Total monetary loss was 18·23 % of the original value of the wheat and sacks.

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