March 1986

APPROACHES TO SMALL-HOLDER RODENT CONTROL

C. G. J. Richards
ICI Plant Protection Division, Fernhurst, Haslemere, Surrey GU27 3JE, England

APPROACHES TO SMALL-HOLDER RODENT CONTROL

C. G. J. RICHARDS, ICI Plant Protection Division, Fernhurst, Haslemere, Surrey GU27 3JE, England.

INTRODUCTION

Rodents are now recognized as one of the most important pests damaging crops in countries as far apart as Indonesia, Tanzania and Venezuela (Benigno and Sanchez 1984, Taylor 1984, Williams and Vega 1984). Damage to crops such as rice may be devastating during periodic upsurges in rodent numbers, with yields often reduced by 50% or more. It is being increasingly recognized, however, that continual chronic losses, which commonly occur over very large areas, are economically more significant (Buckle et al. 1985), resulting in yield losses in the range of 5 to 10% of national crops every year in many countries (Hopf et al. 1976). Crops are attacked not only in the field but also postharvest, particularly in farmers' stores at the village level. Physical losses of a further 1 to 3% of grain are typical (Hopf et al. 1976) but much more is contaminated, becoming one of the routes by which rodent-borne diseases reach humans and domestic animals (Gratz 1984). While it is difficult to estimate the prevalence of rodent-borne diseases or the consequences of their debilitating effects, public health is often considered a sufficient reason on its own to control rodents around villages. Even rodent damage to household property can be economically significant (Brooks et al., in prep.).

In spite of the clear need for rodent control at the village level, few countries have implemented effective rodent control programmes directed at small-holders. Scientists tend to blame this on administrators but, in reality, many proposed programmes are simply not practicable in developing countries. The largest single problem is the organization of the hundreds or even thousands of farmers who may cultivate the large area which it is technically most cost-effective to treat. One way around this problem is to encourage farmers to attempt control on their own, even when their neighbours do nothing. This approach has been followed by projects in the Philippines and Bangladesh (Benigno and Sanchez 1984, Brooks et al. 1985). Reductions in rodent damage can be achieved in this way but the farmers may easily become discouraged by the prolonged effort involved.

The alternative is to adapt the control methods to the organizational constraints. Much simpler control methods are needed, which can be carried out through the co-ordinated efforts of large numbers of farmers. Some examples of such projects have been described by Richards (1986) and Richards and Buckle (1986). This paper summarizes the results of three further projects which illustrate progress towards integrated management programmes.

OPERATION OSKER

Richards (1986) proposed that a systems approach may be useful in identifying which components of the diverse small-holder's agricultural ecosystem should be included in a management programme. The work of Brooks in Bangladesh (Bruggers 1983) is a good example of this type of approach. In the deep-water rice areas characteristic of the river deltas of Southeast Asia, rodents move between fields and villages as the flood waters rise and fall. In Brooks' study area, the principal rat species was *Bandicota indica*, while *Bandicota bengalensis* was of secondary importance. These rats tend to congregate around the villages, which are on higher ground, when the flood-waters first rise and then move out again when the rice reaches the tillering stage. At this time, *B. indica* is more or less amphibious and begins to attack the crop severely. When the fields are flooded, however, control is somewhat difficult; moving about in a boat, for instance, can cause more damage than the rats. Brooks' approach was to attempt a drastic reduction in rat numbers over a large (1 km^2) area, thus preventing the migration of rats between villages and fields (hence OSKER - One Square Kilometre Eradication of Rats).

Two such 1 km^2 areas were selected. One was treated with baits containing 0.005% brodifacoum, the other was an untreated reference area. Baiting was carried out over the whole area, including houses and fields. Three bait applications were made at intervals of 2 weeks, with a fourth application 6 weeks later. Rat activity, as measured by tracking tiles and burrow counts, fell by 85 to 90% after the first three bait applications. Rice yield measurements at harvest showed increases of between 40% and 124% on the treated area compared to the untreated reference area (Table 1). The total cost of the operation was US$1.26/ha (including $0.50 for labour).

BANGSAI PROJECT

The Central Plains of Thailand, around Bangkok, is another area subject to seasonal flooding. As in the Ganges Delta, the main crop is deep water rice. In Thailand, however, *Bandicota indica* is joined as the major rodent pest by *Rattus argentiventer* and *R. losea*. These species react somewhat differently to flooding (Somsook et al. 1985). At peak flooding (September/October), when all the bunds are submerged, *R. argentiventer* leaves the fields altogether, moving onto high ground or even into trees. *R. losea* remains in the fields in lower numbers but *B. indica* flourishes and becomes the dominant species,

Tongtavee et al. (1986) describe a trial carried out in this area to compare the efficacy of wax blocks containing 0.005% brodifacoum (Klerat) with that of zinc phosphide. The trial was carried out in February after the floods had subsided and the monsoon crop harvested and as the dry season crop was

Table 1. Yield (G/M^2) of four varieties of deepwater rice in two areas of Tangail District, Bangladesh, November 1983 (from Bruggers 1983).

Variety	No. fields sampled (treated and untreated)	Mean yield (g/m^2) Untreated	Treated	% yield increase treated/untreated
Injal degha	14	120.5	196.9	+ 63.4
Chamhara	16	150.0	336.1	+124.1
Channa baoalia	2	103.6	220.5	+112.8
Baron baoalia	2	133.1	188.8	+ 41.8

being planted. Rodents are dispersed at this time and most attention was concentrated on the rice fields.

Four villages were involved with the trial; one was treated with brodifacoum, another with zinc phosphide and two were untreated reference areas (Table 2). All baits were applied by farmers after training by extension staff. Brodifacoum 5-g wax blocks were distributed in the rice fields and houses in two applications with an interval of 14 days; a total of 0.77 kg/ha was used in the rice-fields and 200 g in each house. Zinc phosphide on a whole-rice bait was distributed in the fields in two applications totalling 0.80 kg/ha. The farmers refused to place zinc phosphide around the houses because of the danger to chickens (Tongtavee et al. 1986).

Table 2. The study areas used in the Bangsai rodent control project, Thailand, and the rates of application of brodifacoum and zinc phosphide baits.

	Brodifacoum	Zinc phosphide	Untreated
Population	260	217	571
Houses	46	43	101
Rice-fields	480 ha	300 ha	390 ha
Bait application rate (kg.ha)	0.77	1.25	-

In the reference villages, normal practice prevailed, with individual farmers applying zinc phosphide baits, trapping or clubbing rats.

At harvest, rat damage on both treated areas was lower than that on the reference area (Table 3). The lowest damage was recorded on the brodifacoum-treated area.

Table 3. Rat damage at harvest in 25 quadrats taken from 20 fields in areas treated with Klerat or zinc phosphide and in an adjacent untreated area. Bangsai rodent control project, Thailand.

Treatment	% unripe tillers	% cut tillers	n
Klerat	2.3	4.5	20
Zinc phosphide	7.6^{xx}	9.0^{x}	20
Untreated	21.2^{xxx}	22.5^{xx}	20

Significantly more than brodifacoum P $<0.05^{x}$
$<0.01^{xx}$
$<0.001^{xxx}$

During this trial, the opportunity was taken to assess the impact of both rodenticides on nontarget animals (Tongtavee et al. 1986). Some dogs died from both rodenticides because they tended to forage in the fields and would eat either wax blocks or rice. Vitamin K_1 was available for antidoting brodifacoum-poisoned dogs, but the farmers did not consider the animals involved to be of value and so did not use it. No other domestic animals were affected by the brodifacoum treatment. Some chickens and ducks died on the zinc phosphide plot after foraging in the fields; had bait been used around houses, many more would presumably have died. The brodifacoum wax blocks placed around houses did not present a hazard to chickens or ducks because both rejected them even in experimental plots where they were placed unprotected in open ground.

PURBALINGGA PROJECT

In Indonesia, most rice is irrigated and the rodent pest ecology is therefore quite different from that in the examples quoted above. The main rodent species in Indonesian rice is R. argentiventer, while R. rattus diardii is the major house rat (Harrison 1961). Perhaps because of this competition, R. argentiventer appears to move more from fields to uncultivated land after harvest, rather into houses, although some movement into villages does occur (Harrison 1961). Recommendations for rice field rat control in Indonesia centre on the crop itself. Rodenticidal baits are used up to heading; fumigation is recommended for later crop stages (Rochman 1986).

Klerat RM-B (wax blocks containing 0.005% brodifacoum on rice) is recommended but many farmers still use zinc phosphide because of the visible dead rodents. A comparative trial was therefore set up by the Department of Food Crop Protection (Anon. 1986).

A trial was set up at Purbalingga, Central Java, to compare the effectiveness of the intensive use of brodifacoum and zinc phosphide with that of normal farmer practices. Rice growing at Purbalingga is based on the cultivation of terraced hill slopes irrigated for double-cropping. On the 520-ha brodifacoum plot, 10-g wax blocks were applied at 1 kg ha^{-1} in three applications at intervals of 14 days. Zinc phosphide was applied in another area (525 ha), also in three applications of 1 kg ha^{-1}, without prebaiting. In a third area of 618 ha, farmers were allowed to continue their usual, uncoordinated rodent control methods.

Damage assessment at harvest showed that only 0.7% of tillers had been cut by rats on the brodifacoum-treated area, compared to 7.4% on the area treated with zinc phosphide and 11.6% on the reference area.

DISCUSSION

The standard tool for small-holder rodent control in developing countries is zinc phosphide. This is used in conjunction with a range of nonchemical control methods but in very few cases are the efforts of farmers co-ordinated. The trials described above show just how ineffective this strategy is.

In small-scale trials, all anticoagulants are more effective than zinc phosphide or other acute poisons (Rennison 1976, Rennison and Dubock 1978). Warfarin can be effective when used conscientiously by individual farmers, as in the 'sustained baiting' technique (Hoque and Olivida 1986), although the susceptibility of many field rodent species may be so low that a prohibitively large number of applications may be needed (Greaves 1985). When it is necessary to co-ordinate the efforts of many farmers, however, the first criterion for a control method is its simplicity. If more than two or three bait applications are needed, it becomes very difficult to persuade farmers to comply. It is for this reason that first-generation anticoagulants have not been widely used for field rodent control (Dubock 1982). The lower efficacy of acute poisons has been seen as preferable to the high labour and bait costs with first-generation anticoagulants. The only practicable alternatives are therefore acute poisons or a single-feed anticoagulant. The differential in effectiveness between zinc phosphide and brodifacoum is clear from the above trials.

Better control of rodent damage was achieved at Purbalingga and in Operation OSKER than at Bangsai. The major reason for this probably lies in immigration from untreated areas, which was detected before harvest at Bangsai. This may have been related to the shape of the plots at Bangsai, which were long but thin, only 200-m wide in parts. Size may also be involved, and it is possible that in continuous areas of cereal crop the optimal area for treatment may be closer to 1000 ha than 500 ha.

The selection of areas for treatment, however, is an organizational as much as biological problem. An essential feature of large-scale trials is to use a unit, and work through a system, which will maximize the cooperation of farmers. While this will often be through a government system of extension workers, it may alternatively be through voluntary organizations or even commercial networks.

The type of trial reported here and in earlier papers (Richards 1986, Richards and Buckle 1986) shows a way forward in rodent control technology for the small-holders who have such great need for these advances. They show that it is feasible to tackle crop damage, stored products losses, and public health problems at the same time and with simple, cost-effective methods. Two significant elements, however, have tended to form a subsidiary role which underestimates their importance in working towards integrated rodent pest management programmes.

The first is the use of nonchemical control methods. Small-holders have used traps, hunting, and other methods to kill rats since the very beginnings of agriculture--Drummond (1985) describes a clay rat-trap from Iraq dating from 3,000 B.C.--and they have not lost their enthusiasm for them. Although these methods cannot achieve the knock-down in rodent numbers needed at the start of a control programme, they are important in maintaining rodent numbers at a low level after the knock-down. The effect of such methods on rodent pest populations is analogous to the effect of predation on the populations of other rodents; high or increasing populations are not affected by predation but the recovery of low populations may be significantly delayed (Chitty and Southern 1954, Pearson 1966). Just as zinc phosphide is much more effective when applied in a co-ordinated way, so nonchemical control can contribute to rodent control when properly organized. Village-wide 'rat-hunts' have been part of the social structure in some areas for centuries; the basis is there for a very useful supplement to chemical control. Similar co-operation is needed to promote cultural control, especially crop synchrony and weed control. Breakdown in crop synchrony is probably the greatest single contributor to the increase in rodent damage over recent years.

The second is the integration of damage surveillance into management programmes, to ensure that control is carried out at the proper times. Surveillance methods have been developed for rice field rats and shown to be feasible on a large scale (Buckle et al. 1985, Richards and Buckle 1986). Relatively little further research would be needed to develop suitable methodology for other crops.

Rodent control is on the brink of breaking through into scientifically based integrated rodent pest management. Large-scale use and full-scale implementation of the methodology now available is needed to demonstrate that small-holders no longer need to suffer damage to their crops, their stores, or their health from rodent pests.

ACKNOWLEDGMENTS

Grateful thanks to Mr. J. E. Brooks for permission to use his unpublished data from Bangladesh. Also to the many co-operators involved in the reported trials, especially Drs. Tongtavee, Sadji, Buckle, and Brown.

LITERATURE CITED

ANON. 1986. An evaluation of Klerat RM-B for rice rat control at Purbalingga. Proceedings of a Seminar on the Use of Klerat RM-B in Rat Control, 27 March 1986, Jakarta, Indonesia. Indonesian Plant Protection Society. pp. 16. (In Indonesian)

BENIGNO, E. A., and F. F. SANCHEZ. 1984. Rodent problems in the Association of Southeast Asian Nations. In: Proceedings of a Conference on the Organization and Practice of Vertebrate Pest Control (A. C. Dubock, Ed.). 30 August-3 September 1982, Elvetham Hall, England. pp. 37-47.

BROOKS, J. E., P. T. HTUN, R. E. KING, and H. NAING. (in prep.). A field trial to control rats and shrews in Rangoon.

BROOKS, J. E., P. SULTANA, and R. M. POCHE. 1985. Damage by Bandicota bengalensis to growing wheat in Bangladesh and methods of control. Proceedings Third International Theriological Congress, Helsinki, 15-20 August 1982. Acta Zoologica Fennica 173:135-137.

BRUGGERS, R. L. (Ed.). 1983. Vertebrate Damage Control Research in Agriculture. Annual report. Denver Wildlife Research Center, U.S. Fish and Wildlife Service/U.S. Agency for International Development.

BUCKLE, A. P., Y. C. YONG, and A. R. HUSIN. 1985. Damage by rats to rice in Southeast Asia with special reference to an integrated management scheme proposed for Pennisular Malaysia. Proceedings Third International Theriological Congress, Helsinki, 15-20 August 1982. Acta Zoologica Fennica, 173: 139-144.

CHITTY, D., and H. N. SOUTHERN (Eds.). 1954. Control of rats and mice. 3 vols. Oxford, Clarendon Press.

DRUMMOND, D. C. 1985. Pottery rodent traps - a provisional list. Museum Ethnographers' Newsletter 9: 14-15.

DUBOCK, A. C. 1982. Pulsed baiting - a new technique for high potency, slow acting rodenticides. Proceedings 10th Vertebrate Pest Conference, Monterey, California, 23-25 February 1982.

GRATZ, N. G. 1984. The global public health importance of rodents. In: Proceedings of a conference on the Organization and Practice of Vertebrate Pest Control (A. C. Dubock, Ed.), 30 August-3 September 1982, Elvetham Hall, England.

GREAVES, J. H. 1985. The present status of resistance to anticoagulants. Proceedings Third International Theriological Congress, Helsinki, 15-20 August 1982. Acta Zoologica Fennica 173: 159-162.

HARRISON, J. L. 1961. Ecology of the forms of Rattus rattus in the Malay Peninsula. Proceedings Ninth Pacific Scientific Congress 19:19-24.

HOPF, H. S., G. E. J. MORLEY, and J. R. O. HUMPHRIES. 1976. Rodent damage to growing crops and to farm and village storage in tropical and subtropical regions. Centre for Overseas Pest Research and Tropical Products Institute, Ministry for Overseas Development, UK. p. 115.

HOQUE, M. M., and J. L. OLVIDA. 1986. Comparison of baiting methods for rice-field rats in the Philippines. Proceedings of a Symposium on the Control of Mammal Pests, IVth International Theriological Congress (C. G. J. Richards and T. Y. Ku, Eds.), Tropical Pest Management. (in press)

PEARSON, O. P. 1966. The prey of carnivores during one cycle of mouse abundance. Journal of Animal Ecology 35:217-233.

RENNISON, B. D. 1976. A comparative field trial, conducted without pretreatment census baiting, of the rodenticides zinc phosphide, thallium sulphate and gophacide against Rattus norvegicus. Journal of Hygiene, Cambridge, 77:55-62.

RENNISON, B. D., and A. C. DUBOCK. 1978. Field trials of WBA 8119 (PP 581, brodifacoum) against warfarin-resistant infestations of Rattus norvegicus. Journal of Hygiene, Cambridge, 80:77-82.

RICHARDS, C. G. J. 1986. Cost-effective approaches to large-scale rodent control programmes. In: Proceedings Second Symposium on Recent Advances in Rodent Control, Kuwait, 2-6 February 1985.

RICHARDS, C. G. J., and A. P. BUCKLE. 1986. Towards integrated rodent pest management at the village level. Proceedings of a Symposium on the Control of Mammal Pests, IVth International Theriological Congress (C. G. J. Richards and T. Y. Ku, Eds.), Tropical Pest Management. (in press)

ROCHMAN. 1986. Biology and ecology of rats in food crops in Indonesia. Proceedings of a Seminar on the Use of Klerat RM-B in Rat Control, 27 March 1986, Jakarta, Indonesia. Indonesian Plant Protection Society. p. 16. (in Indonesian)

SOMSOOK, S., K. TONGTAVEE, H. D. CATLING, T. KEAWTA, and S. HONGNAK. 1985. Survey of rodents and rodent damage in deep water rice. IRRI Newsletter 10(6):23.

TAYLOR, K. D. 1984. Vertebrate pest problems in Africa. In: Proceedings of a Conference on the Organization and Practice of Vertebrate Pest Control, 30-August-3 September 1982 (A. C. Dubock, Ed.), Elvetham Hall, England. pp. 21-28.

TONGTAVEE, K., S. HONGNARK, T. ARTCHAWAKOM, N. HONINGSBANICH, R. A. BROWN, and C. G. J. RICHARDS. 1986. The safety and efficacy of brodifacoum ('Klerat' wax blocks) and zinc phosphide for rodent control in Thailand. Proceedings of a Symposium on Control of Mammal Pests, IVth International Theriological Congress, (C. G. J. Richards and T. Y. Ku, Eds.). Tropical Pest Management. (in press)

WILLIAMS, J. O., and C. VEGA. 1984. Brodifacoum as a rodenticide to control rodent damage in rice fields in Venezuala: 1- State of Portuguesa. In: Proceedings of a Conference on the Organization and Practice of Vertebrate Pest Control (A. C. Dubock, Ed.), 30 August-3 September 1982, Elvetham Hall, England. pp. 341-345.