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CONTROL OF THE AFRICAN STRIPED GROUND SQUIRREL, *Xerus erythropus*, IN KENYA

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ABSTRACT: The African striped ground squirrel, Xerus erythropus (E. Geoffroy), has been found to constitute a serious pest to maize seed at the planting stage, causing mean losses of 9.7% and accounting for 57.3% of total damage found. A feature of ground squirrel damage is its unpredictable nature. Methods of reducing losses of planted maize seed to X. erythropus at the subsistence farmer level in southern Kenya were investigated. Constraints affecting a control programme by farmers were identified as follows: low standards of living and education, limited financial resources, strong individualistic attitude of farmers and small field size in relation to the home range size of squirrels. Removal trapping and poison baiting were selected for trial as meeting requirements of ease and simplicity, and involving materials available to farmers at the time. Field trials of bromadiolone and difenacoum anticoagulant rodenticides and removal trapping over periods of 1 month and 3 months prior to the expected onset of the rains failed to affect damage levels significantly on individual field units. Underbaiting and a high reinfestation rate were considered to be the primary causes of failure, and the habit of scatterhoarding exhibited by X. erythropus further complicates the poison baiting trials. The unpredictable nature of ground squirrel attack discourages farmers from expending valuable resources on control. Alternative strategies for farmers are discussed.

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INTRODUCTION

The African striped ground squirrel. Xerus erythropus (E. Geoffroy) was found to be a serious pest to preharvest maize crops in southern Kenya (Key, in press). An average of 9.7% of maize seedlings was damaged and ground squirrels constitute the most important agent of damage to maize seed, accounting for 57.3% of total damage found. Maize cobs were attacked to a lesser extent, with an average of 5.4% damage accounting for 34% of total damage found. Pest status was considered to justify control as yields realized in the area studied are low, 250-750 kg/ha (Bakhtri et al. 1982, Nadar 1983) and an average increase of 9.7%, representing 24-73 kg/ha, would be of considerable practical importance in these marginal lands where farming is close to the subsistence threshold.

The ground squirrel is an inhabitant of semi-arid areas and the people affected by its activities are typically poor, with low standards of living and education, and limited financial resources. Individual effort is therefore restricted to activities requiring small capital expenditure, minimal labor input and ease of application. The nature of the habitat presents a problem, cultivated fields being small and readily accessible from areas of uncleared bush having a high refuge potential for ground squirrels. The mobility of X. erythropus further complicates this problem as field size averages 1 to 3 ha while ground squirrels may cover twice this area in 1 day and up to 50 ha in 1 week (Key 1985). Individual farmers are therefore unlikely to be able to affect the ground squirrel population utilizing their own single field units owing to the potentially high reinfestation rate, and the very local and unpredictable nature of ground squirrel damage discourages them from expending time, effort, or money on preventative measures (Key, in press). However, Hoque (in press) found that, contrary to expectations, Filipino farmers in a comparable situation were able to protect their crops from rice rats on an individual basis, and the possibility was examined in this project.

Poison baiting and removal trapping were selected as potentially suitable methods for testing, employing materials familiar and normally available to farmers and technologically simple to apply.

THE STUDY AREA

Work was conducted at Wanzauni village in Machakos District (1’ 32’S, 37’ 23.5’E). Natural vegetation falls into eco-climatic zones 1V and V of Pratt and Gwynne (1978), consisting of semi-arid Acacia bush or woodland of marginal agricultural potential. Mean annual rainfall is 500 to 600 mm, falling in two seasons from October-December and March-May, and there is a preponderance of heavy rain and light showers. Temperatures vary annually from 12°C to 29°C at an elevation of 1600 m. Soils, red sandy alfisols, are low in organic matter and deficient in the essential soil nutrients nitrogen, phosphorus, and potassium. Soil structure is weak and liable to run-off and erosion in heavy rains (Bakhtri et al. 1982, Fenner 1982).

Maize is the staple crop and is normally grown in conjunction with beans, cowpea, green grams, and/or pigeon pea. Seed is planted twice a year at the onset of the rains in some system of intercropping; beans and cowpeas are harvested approximately 6 weeks after planting and maize 6 weeks later. Farming is at the subsistence level, with field sizes ranging from 1 to 3 ha and yields generally low, 240 to 750 kg/ha of maize (Bakhtri et al. 1982, Nadar 1983). Maize is at risk to ground squirrel attack four times a year, at planting and before harvesting each season. Seed and seedlings are attacked for up to 15 days after germination, and maize cobs within 40 cm of the ground are also damaged; ground squirrels are unable to climb to reach higher cobs.

METHODS

The experiment was designed to exploit the initial effect expected with depletion of the resident population prior to extensive immigration. Three to 4 weeks were postulated for this initial depiction (Rennison 1977, Richards 1983). Poison baiting and removal trapping therefore commenced 1 month prior to the expected "at risk" period for maize seed, this being the onset of the rains. For comparison, the effect of removal trapping was examined over this critical month alone and also over the entire 4 months of the dry season, July-October. Background data on maize losses to ground squirrels were available for 10 fields in Wanzauni village, over three seasons (seasons 3, 4 and 5). Efficacy of each method was determined by surveying maize seed losses in season 6 posttreatment, the untreated fields functioning as controls in indicating the seasonal trend in squirrel damage levels which are primarily related to rainfall pattern (Key, in press).

Procedure

Sample fields had a mean area of 1.5 ha and lay adjacent to each other or separated by small areas of uncleared bush. The squirrel population could therefore move freely between treated, untreated, and neighboring fields. For the poison baiting, two second-generation anticoagulants, bromadiolone and difenacoum, were selected for their combination of high toxicity and low hazard, and were tested on two different fields chosen in the interests of safety with respect to the absence of young children and the responsible attitude of farmers. Rains for season 6 were expected early to mid-October and poison baiting and short-term removal trapping were commenced in early September.

Removal Trapping

A total of 18 cage traps was available and all were placed on field 24 from 16/7/84 until 31/8/84. Thereafter traps were shared equally between fields 24 and 33 until 26/10/84, at which time the germinated maize seed was approximately 2 weeks old and damage surveys began. Trapping intensity therefore varied over the long-term removal trapping project, but trap density was at all times greater than the recommendation of one trap/ha for the control of the tree squirrel, Sciurus carolinensis (Rowe 1973). Traps were placed around the edges of fields in areas of high expectation of catch and near burrows known or suspected to harbour squirrels. Captured squirrels were run into a canvas holding bag and killed by a sharp blow on the head.

Poison Baiting

Bromadiolone maize bait was prepared by soaking 500 g of maize in 0.51 of 0.005% bromadiolone concentrate for 24 hours. Maize was then drained of surplus liquid and air-dried for storage. Difenacoum maize bait was prepared in the same way, soaking dry maize seed in a 0.5% liquid concentrate diluted to 0.05% with water.

Untreated maize was distributed around fields 21 and 25 from 1/9/84. On 7/9/84 bait stations (5 per ha) were selected in areas with repeated signs of squirrel feeding activity, and untreated maize was replaced with bromadiolone-treated maize (field 25) and difenacoum maize (field 21). Bait stations were protected against game birds and domestic livestock by placing treated bait in a shallow trench roofed with sticks and dried grass and covered in a loose tangle of thorny scrub. This proved only partially effective in deterring game birds.

Bait stations were checked once weekly and bait replenished as required, i.e., a pulsed baiting system was used (Dubock 1979). Bait was stored in 2-kg units, and one or two units were distributed over each field according to the intensity of squirrel activity as judged by the proportion of bait consumed by squirrels overall. At each weekly check the amount of bait estimated to have been consumed by squirrels at each bait point was scored on an arbitrary scale.

Damage Surveys

Transects of 50 plants, or 50 planted points (as appropriate), were taken within maize plots 2 to 3 weeks after germination. Numbers of undamaged plants and damaged seeds and seedlings were recorded and the agents of damage identified as far as possible by examination of patterns of damage and associated signs of animal activity (e.g., footprints, droppings), and by direct observation of the crop concerned. Ground squirrel damage is readily identifiable as squirrels discard the testa of maize seed to leave a characteristic litter pile. Transects were randomized in so far that positions were determined prior to visiting the field.

RESULTS

Removal Trapping

In the long-term removal trapping trial, a total of 15 ground squirrels were caught in 945 trap days, eight males and seven females; see Table 1. In the short-term removal trapping trials, seven squirrels were caught in 315 trap days, four males and three females; see Table 2.

Table 1. Results of field trials for ground squirrel control; long-term removal trapping on field 24. Numbers and sexes of squirrels caught, and variation in percent trap success over the period of trapping.

Trap no.	Trap days	Number of squirrels caught	Number males	Number females	Percentage trap success
18	90	4	3	1	4.4
18	90	3	1	2	3.4
18	90	5	2	3	5.5
18	90	2	2	0	2.2
18	90	0	0	0	0.0
18	90	1	0	1	1.1
18	90	0	0	0	0.0
9	45	0	0	0	0.0
9	45	0	0	0	0.0
9	45	0	0	0	0.0
9	45	0	0	0	0.0
9	45	0	0	0	0.0
9	45	0	0	0	0.0
9	45	0	0	0	0.0

Poison Baiting

A total of 8 kg of bromadiolone bait was distributed on field 25, and a total of 18 kg of difenacoum maize on field 21; see Table 3. After 3 weeks of treatment on field 25, excessive interest shown in the poisoned bait by young children of neighboring farms was considered to constitute a serious safety risk and poison baiting was discontinued. Figure 1 shows the sum of the values of "takes" from the bait stations on field 21 at each checking time: a complete ground squirrel "take" was given a value of 1.0, a half "take" a value of 0.5, and so on. Difenacoum-treated maize was analyzed and found to contain 0.00066% difenacoum.

Table 2. Results of field trials for ground squirrel control; short-term removal trapping on field 33. Numbers and sexes of squirrels caught, and variation in trap success over the period of trapping.

Trap days	Number squirrels caught	Number males	Number females	trap success
45	1	0	1	2.2
45	0	0	0	0.0
45	1	1	0	2.2
45	1	1	0	2.2
45	2	1	1	4.4
45	1	1	0	2.2
45	1	0	1	2.2

Table 3. Results of field trials for ground squirrel control; poison baiting. Amount of treated bait placed (kg), proportion estimated to have been consumed by ground squirrels at each bait station (squirrel "takes"), and the sum of ground squirrel "takes" at each visit (complete "take" value = 1, half "take" value = 0.5, quarter "take" value = 0.25.

Date checked	Total bait placed (kg)	Squirrel "takes" complete	Squirrel "takes" half	Squirrel "takes" quarter	Total value of "takes"
Field 25, Bromadiolone rodenticide.					
17/9/84	2	5	1	0	5.5
24/9/84	2	6	0	0	6.0
1/10/84	4	6	1	0	6.5
4/10/84	-	2	2	3	3.75
Field 21, Difenacoum rodenticide.					
5/10/84	2	2	0	3	2.75
8/10/84	2	4	0	0	4.0
15/10/84	4	2	2	0	3.0
22/10/84	4	4	0	0	4.0
29/10/84	4	5	1	0	5.5
30/10/84	2	3	4	0	5.0
4/11/84	-	3	1	0	3.5

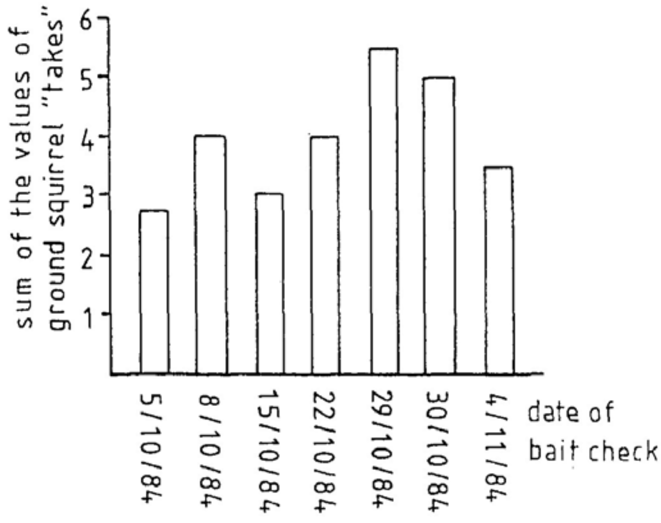

Figure 1. Field trials of difenacoum rodenticide. The sum of ground squirrel "takes" (complete "take" value = 1, half "take" value = 0.5, quarter "take" value = 0.25) from ten bait stations in field 21, at seven bait checks from 5/10/84 to 4/11/84.

Damage Surveys

The results of the damage surveys are summarized and presented in Figures 2 and 3 in comparison with the previous three seasons' data for losses to both ground squirrel and other agents of damage in the fields 21 to 30 at Wanzauni, and field 20 at a neighboring village. Using one-way analysis of variance, a significant difference in losses attributed to squirrels was found between season 5 (mean 9.65% ± 5.3) and season 6 (mean 5.5% ± 4.9) posttreatment ($P < 0.01$). Differences in squirrel damage levels among fields in season 5, pretreatment, were found to be significant ($P < 0.01$), but nonsignificant in season 6, posttreatment ($P > 0.05$). Losses attributed to other agents of damage were not significant between season 5 (mean 11.8% ± 4.1) and season 6 (mean 12.6% ± 4.4), and significant among fields for both seasons ($P < 0.01$). Those fields subject to either removal trapping or poison baiting are not implicated in this variation.

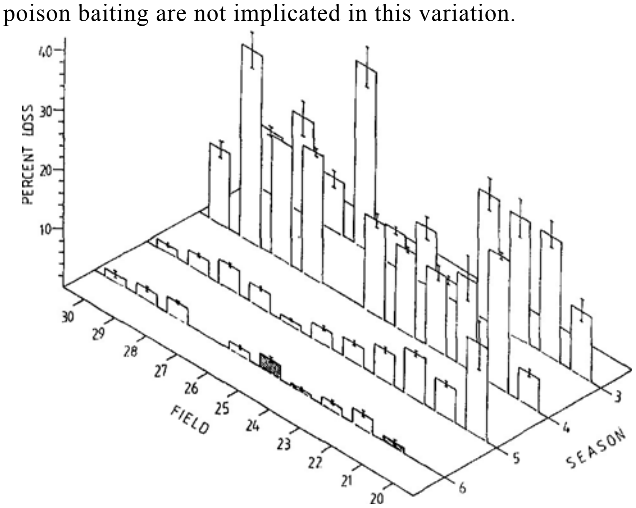

Figure 2. Percentage losses of maize seed and seedlings to ground squirrels in 11 fields over four seasons. In season six long-term removal trapping (light shading) was conducted on field 24, and poison baiting (dark shading) on fields 21 (difenacoum) and 25 (bromadiolone).

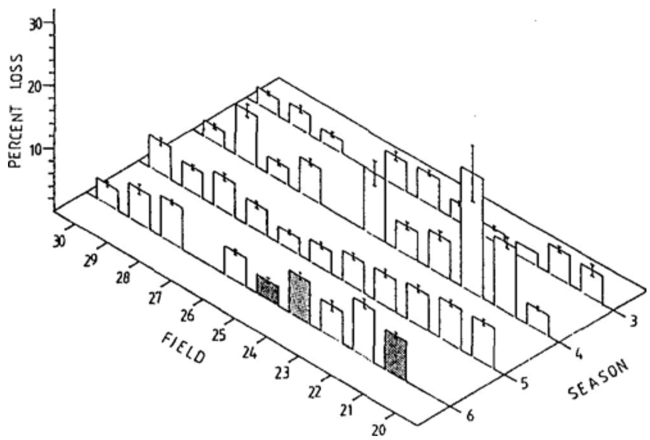

Figure 3. Percentage losses of maize seed and seedlings to other (non-squirrel) agents of damage in 11 fields over four seasons. In season six long-term removal trapping (light shading) was conducted on field 24, and poison baiting (dark shading) on fields 21 (difenacoum) and 25 (bromadiolone).

DISCUSSION

Removal trapping was capable of removing the trappable squirrel population within 6 to 7 weeks, but did not significantly reduce damage levels, and trapping out a field for 3 months was as ineffective as trapping for 1 month. Poison baiting individual fields had no discernable effect on squirrel activity in 7 weeks of treatment. An important cause of the failure of poison baiting may be due to inadequate bait formulation and underbaiting; the concentration of difenacoum in treated maize was found to be 0.00066% instead of the recommended 0.05% (this estimate of concentration is conservative due to the difficulties of extraction), and it is likely that concentration of bromadiolone in bait was also low due to the similar method of mixing. Infrequent utilization of bait stations by ground squirrels is also suspected, possibly due to both intra- and interspecific disturbances to feeding squirrels which are not social animals and are intolerant of the close proximity of conspecifics. This factor would severely limit a campaign of elimination based on the consumption of treated bait. In addition, in other some areas X. erythropus is known to scatterhoard seeds, which not only reduces the amount actually consumed but also increases the risk of poisoning to nontarget organisms by distributing bait unpredictably over a large area.

Large quantities of bait were regularly consumed by game birds, despite attempts to discourage them at bait stations, further reducing the amounts available to squirrels. Dead and dying game birds were found by local people in the vicinity of treated fields and were reported to be "full of blood"; they are assumed to be victims of poisoning by anticoagulants. The number of bait points used (5/ha) was relatively low for a pulsed baiting technique, which stresses the use of a large number of small bait points (Richards 1983). In addition, only 1 to 2 kg/ha of treated maize were laid at each check, compared to the 6 to 12 kg/ha recommended by Kok (1980). The extent of the trial was severely limited by the small quantity of treated maize available following a three-season drought and by the amount of toxicant available for research. Rains in this area are unreliable and provision was made to allow continued baiting until early November in event of delayed rain. This proved unnecessary as rains began in early October.

The success of elimination trapping was also ineffective at significantly reducing losses to squirrels despite the initial success at removing squirrels from the population. The large home-range size relative to the average field size means that, of the total number of squirrels including any one field in their home range, only a portion may be utilizing that fields at any one time. Ground squirrels have widely overlapping home ranges and advertise their continued presence in the population by scent marking (Key 1985), thus the loss of a resident is quickly detected by the remaining animals. The trappable population may take several weeks to remove, allowing neighboring squirrels time to expand their home ranges in the absence of the resident animal, or for immigrants to establish themselves.

The primary cause of the failure of the field trials to reduce squirrel damage is therefore considered to be the high rate of reinfestation, coupled with underbaiting. The individual farmer can only achieve marginal protection from ground squirrels, and community involvement is only considered possible if attempted in the context of a government-backed scheme able to supply the farmers with materials and provide training for village extension workers in the necessary techniques. A different approach is required for the individual. The ground squirrel is a large animal and a potentially valuable source of meat, and as such it is hunted or food by people in various locations in Kenya, including the people in Machakos District (Kamba tribe). The Kamba people over much of their range are farming in marginal lands, are very poor, and suffer from high levels of malnutrition. Child mortality is high, and adult life expectancy low. There are thus benefits to be gained by harvesting the squirrel population, which may outweigh the crop losses caused, in terms of food gained and lost. Traditional dead-fall traps, made of local materials, can be used, and maximum efficiency will be achieved in the dry seasons of February-March and August-September when alternative food is sparse and farmers have spare time to make the regular trap checks. Culling the squirrel population at the time may also give some protection to the crop at the subsequent planting season. This proposition is conceptually simple, requires no capital expenditure, and is an extension of an already existing practice.

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