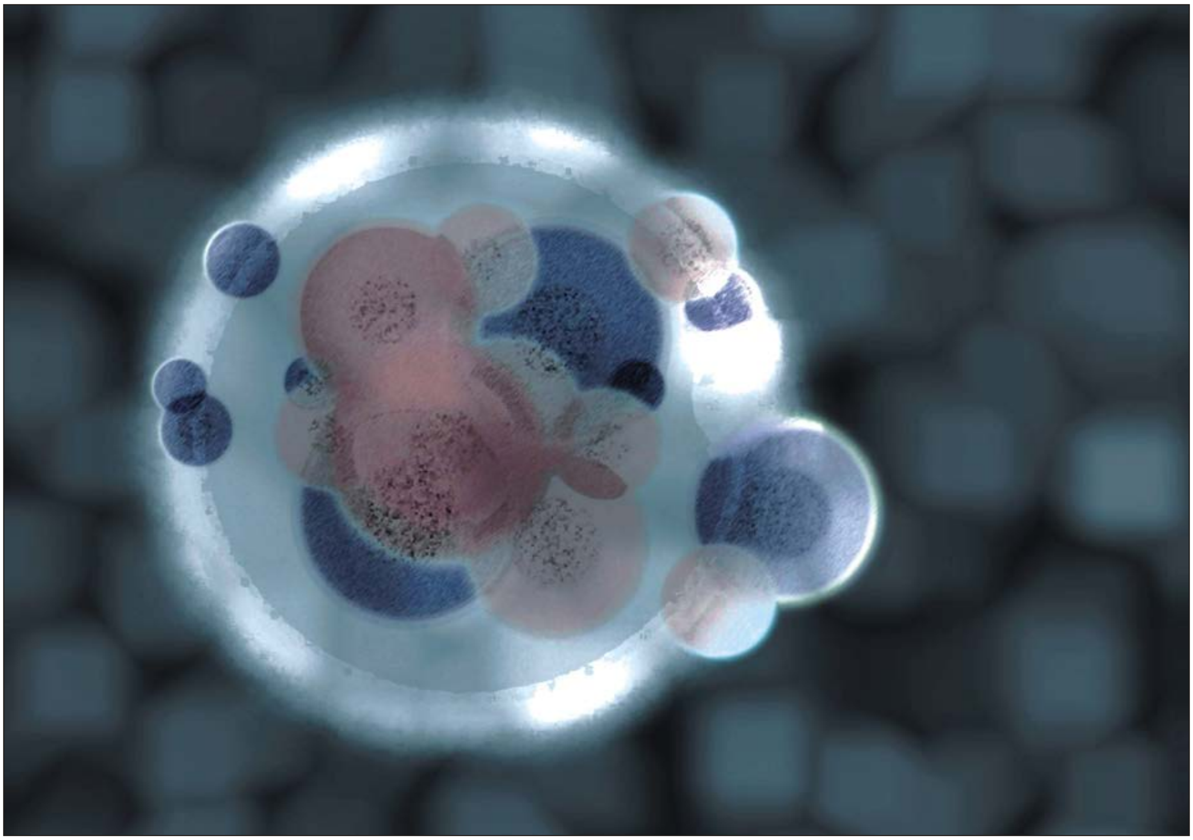

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Winning the Fight Against Rodent Pests: Recent Developments in Tanzania

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Abstract: Rodent management programs in Tanzania have been reactive and did not consider the population ecology of the target species. The strategies used to manage rodents were probably most suited to managing low-density rodent populations and were selected to solve localised rodent problems in certain areas. These included bounty schemes, burning of homes and vegetation, trapping and poisoning. In recent years, new developments in rodent pest management include a system designed to provide early warning of potent damage. An understanding of the population processes that give rise to rodent pest's problems provides the framework for evaluating the causes and solutions. Population models for predicting outbreaks have been developed. These have incorporated simulations and aspects of economics in the implementation of control strategies. Simulation based on Bioeconomics models have shown that the most economically rewarding strategies differ significantly from current practices of symptomatic treatment when severe rodent damage is noticed in the fields. Therefore, shifting from symptomatic practices and controlling rodents on a calendar basis can substantially improve the economic conditions for the majority of maize producers in Tanzania.

Key words: Economics, predictive models, rodent management, rodent outbreaks, symptomatic control

INTRODUCTION

Rodent pest management in Tanzania started as early as 1912 when rodent (*Mastomys natalensis*) outbreaks in Tanzania were reported in Rombo district in Kilimanjaro region (Lurz, 1913). However, in the past, strategies used were probably most suited to managing rodent populations at low density (Makundi *et al*., 1999; Mulungu *et al*., 2006). The selected strategies focused on localised rodent problems. They included bounty schemes, burning of houses and vegetation, trapping and poisoning (Mkondya, 1977; Mulungu *et al*., 2007). In modern times, rodenticides have been an important element in managing rodent pests (Buckle, 1999; Mulungu *et al*., 2006). Often but not always, application of rodenticides is a reactive approach, which does not consider some important aspects of the ecology of the pest species (Myllymäki, 1987). It has often been argued that researchers concentrate first on the study of control technologies and that the attitude of those involved in practical rodent control leans towards the immediate implementation of management programmes (Walker, 1990). The current thinking is that effective management of rodents should involve strategic actions that preventatively limit population growth so that damage is kept below the threshold of economic concern of farmers (Leirs *et al*., 1999; Mulungu *et al*., 2005). The purpose of this study is to review the advances that have been made in rodent control strategies in Tanzania, based on past and current experiences.

RODENT PROBLEMS IN TANZANIA

Several factors, including diseases and pests have major impact on crop production in Tanzania. Rodents contribute to the worsening drop in crop production (FAO, 1980; Mulungu *et al*., 2007). It has been estimated that rodents cause an average 15% yield loss (Makundi *et al*., 1991), which amounts to 382,673 tonnes per year of the actual maize production. This amount of maize would be enough to feed 2.0 million people for a whole year (at about 0.5 kg/day/person) or an estimated value of 32.5 million US$ (at 8.5 US$ per 100 kg bag of maize). However, in many locations, this figure may be considerably higher, most noticeably in places where rodent outbreaks occur (Mwanjabe *et al*., 2002; Mulungu, 2003). It is not unusual for smallholder maize farmers in Tanzania to report chronic rodent damage of 5-15% per annum (Mwanjabe and Leirs, 1997) and in some cases more than 80% in certain cropping seasons and locations (Mulungu *et al*., 2003).

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Rodents also pose great risks to human health due to certain zoonotic diseases including plague and leptospirosis. Studies have shown that certain strains of *Leptospira* isolated from rodents could be pathogenic to humans. Therefore, rodent borne diseases could be occupational health problem and those persons who handle rodents in any form could be at a high risk of infection (Machangu *et al*., 2003). Makundi *et al*. (2003) have reported the potential of transmission of plague to humans due to interaction between rodent species and humans in agro-forestry habitats in the western Usambara Mountains, Tanzania.

A number of studies have been carried out in Tanzania focusing on population ecology of rodents (Leirs, 1994; Leirs *et al*., 1997), taxonomy and systematics (Fadda *et al*., 2001; Castiglia *et al*., 2003; Corti *et al*., 2005). Farming systems have been shown to affect the population dynamics of rodents, which gives them the potential to cause crop damage (Massawe *et al*., 2003). Increasing densities of rodents beyond certain “threshold” have been shown to result to increased crop damage and losses, which reduces the economic return to farmers (Mulungu *et al*., 2003).

Rodent control strategies

Rodenticides: Generally, management of rodent pests in Tanzania relies on the ad hoc use of chemical rodenticides (Myllymäki, 1987; Makundi *et al*., 1999; Ngowo *et al*., 2005). Rodenticides used in this way, however, are rarely economically and ecologically sustainable and often they are applied only when damage has already occurred (Makundi *et al*., 1999; Mulungu, 2003; Skonhoft *et al*., 2006). Rodenticides application is not widely practical on individual farms. The success in the use of rodenticides (whether acute or anticoagulants) depends on: (1) availability of the required rodenticides (often influenced by available funds for their purchase), (2) acceptability of baits formulations to rodents (often influenced by palatability under field conditions. For example, the current used bait formulation for *M. natalensis* is Bromadiolone in cracked maize and sardines. Rice is more acceptable by rodents than maize but it is a highly valuable crop that the government can not afford to use as bait) and (iii) the timing of bait application. This is critical for alleviating damage (Makundi *et al*., 1999; Mulungu, 2003).

Chemical control measures against rodents in Tanzania continue to be used extensively (Ngowo *et al*., 2005). Fast-acting, acute rodenticides, namely zinc phosphide is used widely by smallholder farmers (Buckle, 1999) but is mostly supplied free of charge by the government during outbreaks. Up to date, however, zinc phosphide is not registered in Tanzania but it is strictly used under the supervision of Ministry of Agriculture, Food Security and Cooperative and not allowed to be sold in open market. The decision to use this toxic compound has been made by the government as currently there are no equally cheap alternative rodenticides to be used during outbreak. Farmers also favour this compound because its effect is immediately apparent after application. However, correct application can be a problem under farmer’s situation. The compound is supplied as a concentrate, which must be mixed with high-quality cereal baits if it is to be effective and many smallholder farmers have insufficient resources and knowledge to be able to do this accurately and safely and therefore, need a close supervision. In fact, a programme for rodent control which is solely a government responsibility would be difficult to implement due to shortage of manpower, apart from the exorbitant costs involved (Mkondya, 1977).

Rodents are well known for being suspicious of new objects (neophobic), a characteristic which is poorly understood or accounted for by smallholders (Myllymäki, 1987). Rodents also develop bait shyness (toxiphobia), leading to avoidance of baits used against them following violent reactions of the chemical. In order to avoid bait shyness, more potent anticoagulants such as bromadiolone have been developed. Bromadiolone is effective against 'naturally resistant' species to the first generation anti-coagulant poison (Myllymäki, 1987). Anticoagulant rodenticides are probably best for an Integrated Rodent Management (Buckle, 1999). Even with an integrated rodent management strategy that uses monitoring systems to target the timing of rodenticides applications, it is felt that the emphasis of such an approach is on control rather than management. Similar concerns have arisen with insect pests (Flint and van Der Bosch, 1981) and weeds (Higley and Pedigo, 1999).

Integrated rodent management very little has been done on integrated rodent pest management (IPM) in Tanzania. A rodent IPM package for rice crop in Morogoro region has been developed. This package includes: (1) population monitoring before land preparation (2) application of rodenticides when population is high; (3) cleaning or preparation of the farms; (4) population monitoring and application of rodenticides before planting; (5) reduction of rice bund size to minimize building of nests and burrows; (6) cleaning of rice bunds; (7) monitoring population before booting stage and application of rodenticides if the population is still high and weeding; (8) permanent water buckets along bands for daily trapping of rodents (9) timely harvesting without pilling of harvested rice in the farms. An IPM programme for rodents is not applicable during outbreaks because the mortality may not be high enough to reduce damage while the remaining population often compensates due to better survival and breeding performance (Leirs, 1994; Myllymäki, 1987).

Biological control of rodents in Africa in general is an almost unexplored area (Vibe-Petersen, 2003). The importance of predation in vertebrate prey population dynamics has been debated for many years, particularly in populations exhibiting regular density fluctuations in the northern temperate zones (Hansson and Henttonen, 1988; Norrdahl, 1995; Krebs, 1996; Abrams, 2000). Considerably less attention has been directed to the role of predation in tropical rodent population dynamics. Handwerk (1998) investigated the predator-prey relationship of rodents in Egypt, but monitored predators and rodents in areas distant from each other. Leirs *et al.* (1997) showed that survival of non-reproducing *M. natalensis* is an inverse density-dependent process, an effect that would be predicted if predation is an important mortality factor.

In Tanzania, Van Gulck *et al.* (1998) reported that raptor activity increased in areas with perch poles and an increased survival of *M. natalensis* in areas excluding avian predators. Vibe-Petersen (2003) investigated the effects of different levels of predation pressure on the population dynamics of *M. natalensis* in maize fields and its consequences on crop damage and maize yield production. The author showed that (1) population growth during the annual increase phase was faster in the absence of predators and peak population size increased, (2) predators may be a strong driving force for rodent emigration and (3) manipulating predation pressure by perch poles and nest boxes did not affect rodent population dynamics directly, but may have an indirect beneficial effect on maize yield by changing the rodents' foraging behavior.

Early warning and rodent management: Rodent outbreaks, particularly of the multimammate rats, *M. natalensis*, are experienced regularly in Tanzania (Mwanjabe *et al.*, 2002). A system designed to provide early warning of potent damage must therefore form an integral part of any control strategy (Mwanjabe and Leirs, 1997). Studies have enabled the development of a forecasting model (Fig. 1), which could be used for prediction of outbreaks of the *M. natalensis* rats in Tanzania (Leirs *et al.*, 1996). Davis *et al.* (2004) discussed how to find the economically optimal cut-off value in such a prediction model, based depend on the cost of damage, the cost of control actions and the reduction of damage when control is undertaken.

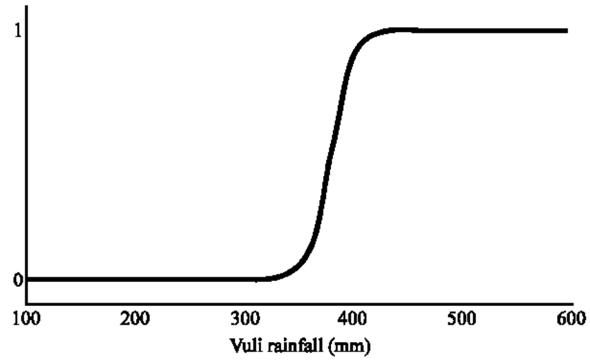

Fig. 1: Logistic regression that allows to predict the probability of a rodent outbreak, based on the amount of rainfall during the early peak of the rainfall (vuli-season) in Tanzania (after Leirs *et al.*, 1996)

Also a more mechanistic model was developed that allows simulating populations of *M. natalensis* in Tanzania (Leirs *et al.*, 1997). This model uses recent rainfall and density dependence to predict, in monthly steps, how a population of these rodents develops. By including time series of rainfall it can simulate the dynamics of the population. Due to the stochastic nature of precipitation, however, it cannot be used for actual forecasting. It does however function well if it is used to find out what conditions the population is sensitive to or how interventions could change the population dynamics (Leirs, 1999).

Control of induced mortality and linking pest control measures to population dynamics of rodents: Stenseth *et al.* (2001) have explored how a population model behaves when a simple and fixed control-induced mortality is introduced. They showed that not only the magnitude of rodent population is important, but also over which period the control is applied; a permanently applied control may reduce the population considerably (and even drive the population to extinction) (Fig. 2a), while there is little effect when control is applied at high densities only, even when there is large increase in

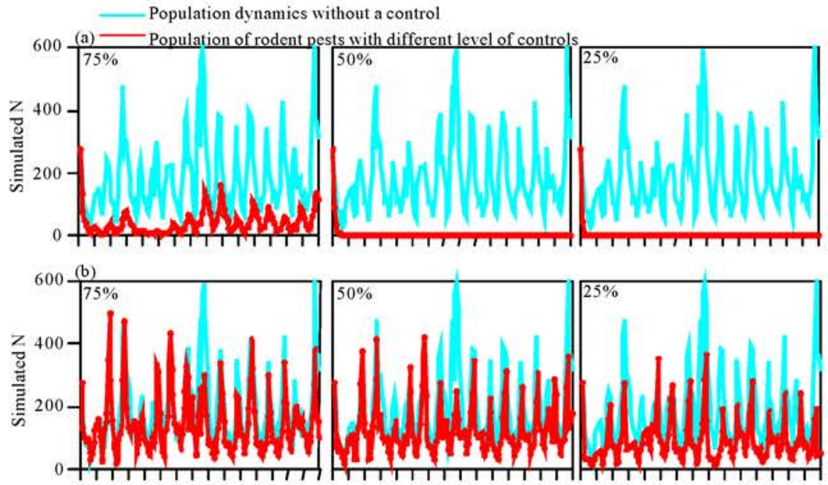

Fig. 2: Simulation of lethal control of simple and fixed control-induced mortality. (a) Permanent reduction of survival and (b) Reduction of survival under high density condition only (after Stenseth *et al*., 2001)

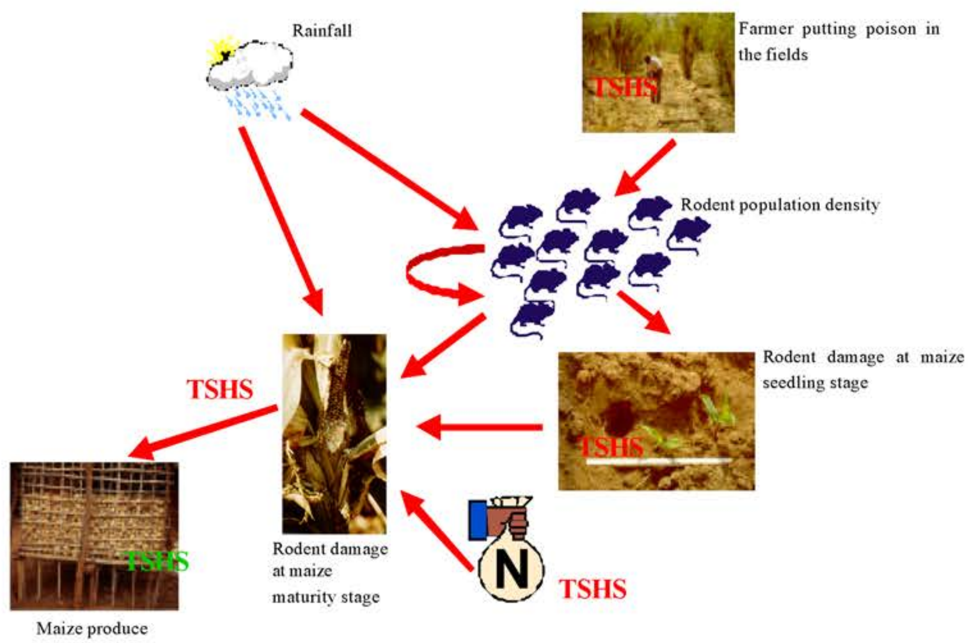

Fig. 3: A skeleton of Skonhoft *et al*. (2006) account of the Bioeconomics interactions in agricultural rodent pest systems

mortality (Fig. 2b). Furthermore, the reduction levels used in this model could not be monitored in the fields because since killing some rodent species may reduce populations initially but the remaining animals are often found to compensate because there is density-dependence (Leirs, 1994; Myllymäki, 1987).

Benefit and cost functions on rodent control in population model: Skonhoft *et al*. (2006) developed a model, which can both predict rodent population dynamics and economics of different control strategies (Fig. 3). Figure 3 can be described as: the rodent population is influenced by rainfall and intrinsic factors, which generate a particular density-dependent structure. Farmer's revenue derives from the sale of agricultural products minus the costs of production. The link between economics and rodents is both through the damage reducing the potential yield and through the cost of controlling the

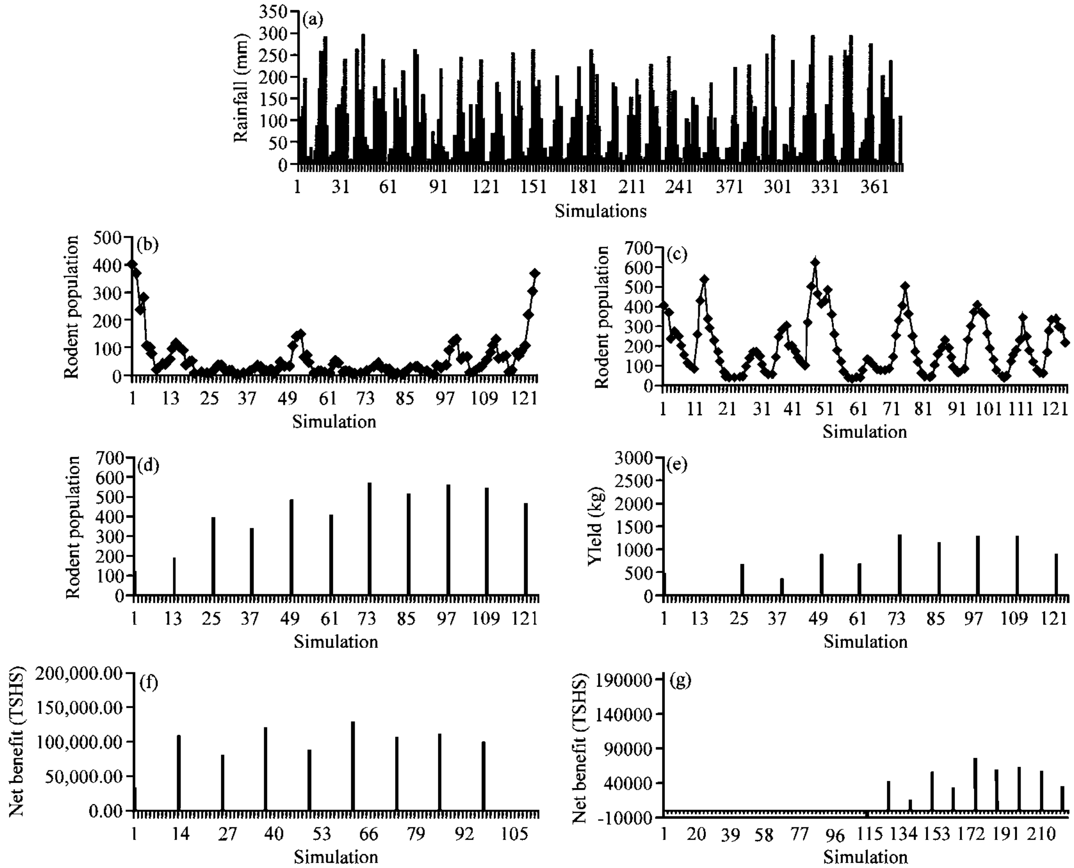

Fig. 4: Two examples of model runs (with resulting graphs for (a) Rainfall, (b, c) Rodent populations, (d, e) Realized harvest and (f, g) net benefit) under two different control strategies; control applied in two months February and November each year and no control (after Skonhoft *et al*., 2006)

rodent pest, both of which enter the net income. The net income over a number of years, dependent on the planning horizon, is summed as the present value (PV = FV $*(1+i)^{-n}$, which is optimized. Where: FV = future value, i = discount, n = time (years). The results from the model illustrated that for a given baseline values (prices and costs) pest control is economically rewarding when control is carried out in certain months only. In this model, the most economically profitable control period is just before the planting season of maize crop. The damage at planting accounts for such a large portion of the total losses due to rodents (Mulungu, 2003) that minimizing the population during that short period is enough to reduce yield losses. Controlling for a longer period will reduce rodent populations at a time when they do not damage the crop and due to the very high reproductive capacity of the rodents, the population will increase fast as soon as control operations are stopped and repressing any long term effects (Leirs, 1994).

Mulungu (2003) explored the bioeconomics model developed by Skonhoft *et al.* (2006) with a sigmoid function for the relationship between rodent density and rodent damage at planting time in maize field. Similarly, Mulungu (2003) described the rodent population as influenced by rainfall and intrinsic factors (Fig. 4a), which generate a particular density-dependent structure (Fig. 4b). Farmer's harvest is the results of both no control (Fig. 4d) and a control at a certain period (Fig. 4e). The results from the model illustrated that for a given baseline values (prices and costs) pest control is economically rewarding when control is carried out in certain months only (Fig. 4f and g). Therefore, according to the model, it is more profitable to control rodents than not to control (Fig. 4). It is profitable to control rodents in February and January than other months, whereas if rodenticides are applied two months every year, the most rewarding time to control rodents will be February and November followed by February and October (Table 1). These

Table 1: Ranking of the 10 most economic rewarding control strategies given by timing and length (total number of months of the control). The hypothetical case of no control rodents (upper line) and the case of no control, symptomatic treatment months and control each month (the lower line) is included as well. Present value (in Tshs) is presented by the median and the lower (0.025) and upper (0.975) percentile for the 100 simulations performed for each strategy after Skonhoft *et al.* (2006) and Mulungu (2003)

			Present value		
Ranking	Timing	Length	Median	Lower	Upper
No rodent			1,120,606	996,757	1,260,835
1	February-November	2	931,014	773,896	1,075,264
2	February-October	2	878,199	719,371	1,052,676
3	August-September-November	3	838,413	697,512	987,665
4	July-August-November	3	816,851	634,975	974,015
5	September-October-December	3	813,120	648,320	985,674
6	August-November	2	808,682	600,792	978,686
7	July-August-October	3	782,070	633,179	978,902
8	August-September-December	3	779,424	588,025	984,545
9	January-November	2	777,642	576,058	974,042
10	January-February-November	3	774,406	645,634	914,663
No control			365,138	243,547	513,338
11	July	1	322,608	186,692	476,103
12	March	1	250,907	133,913	399,486
13	March-July	1	230,353	98,824	513,825
14	Controlling all the months throughout the year	12	37,512	-86,344	117,742

economically most rewarding strategies differ significantly from today's practice of symptomatic treatment in Tanzania when heavy rodent damage is noticed.

CONCLUSION

It is obvious that there is great need to conduct studies on the impact of rodents in Tanzania. Such studies should put emphasis on economic and health aspects as well as the contribution of rodents in the functioning of whole ecosystems. These studies need to be widened in scope in order to put into place a functional rodent management system to alleviate crop damage, yield losses and disease transmission to man.

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