Effect of land preparation methods on spatial distribution of rodents in crop fields

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Abstract. A mark–capture–release (CMR) study was carried out in Morogoro, Tanzania, from April 1999 to August 2000 to investigate the effect of slashing and burning versus tractor ploughing on the population of rodents in agricultural fields. We found that the spatial distribution of individuals was significantly affected by the land preparation method. The coefficient of dispersion values (based on variance-to-mean ratio calculations) indicated that more animals clustered around the edges in tractor-ploughed fields whereas in the slashed-and-burnt fields, animals were randomly distributed. Before land preparation, animals were randomly distributed everywhere. This suggests that the slashing-and-burning practice does not affect the rodent population distribution in crop fields while tractor ploughing does affect rodents, probably by reducing cover and food availability or even by killing some individuals. Yet, it seems useful as a management tool when it is practised over a large area and if the surrounding fallow lands, which act as donor habitat, are cleared.

Introduction

Rodents are responsible for substantial damage to food and cash crops and play an important role as reservoirs and carriers of zoonotic diseases in East Africa (Fiedler 1988). A mosaic of small plots of various crops, intermingled with patches of fallow and permanent grassland, combined with minimum land preparation and subsequent flourishing of weeds, creates favourable conditions for opportunistic and prolific species such as *Mastomys natalensis* and results in a high degree of damage to crops (Taylor 1968; Myllymaki 1989; Mwanjabe 1993).

Various studies have been carried out in Tanzania to establish the relationship between ecological parameters and rodent population dynamics. Most studies have largely involved research in areas with natural and semi-natural vegetation (Leirs et al. 1989, 1996; Telford 1989; Leirs 1994; Makundi 1995).

An understanding of factors that influence the population dynamics of rodent pests can provide an indication of the type of strategy that should be employed in their management. This study aimed to establish how cropping systems and land preparation methods influence the abundance and spatial distribution of *M. natalensis*. Here we discuss the effects on spatial distribution.

Materials and methods

The study area is located at 6°46'S, 37°37'E and 480 m above sea level at Solomon Mahlangu Campus (Mazimbu), Sokoine University of Agriculture, Morogoro, Tanzania. The area has a bimodal rainfall pattern with short rains between October and January and long rains between March and May. Two crops per year, depending on the amount and distribution of rainfall, are cultivated.

A capture–mark–recapture (CMR) study was conducted during the 1999–2000 cropping seasons. Eight 70×70 m grids were prepared, consisting of seven parallel lines, 10 m apart, and seven trapping stations per line (total of 49 trapping stations/grid), also 10 m apart. One Sherman live-trap ($7.5 \times 9.0 \times 23.0$ cm, HB Sherman Trap Inc, Tallahassee, USA) was placed on each trapping station. A 200–300 m wide zone of fallow land separated the grids from each other. The grids were subjected to two types of cropping systems (mono-cropping, inter-cropping) and two land preparation methods (tractor ploughing, slashing and burning). The mono-cropping system consisted of a monoculture of maize and the inter-crop consisted of a mixture of maize and beans. The experimental design was a completely randomised design (CRD) with 2×2 factors replicated twice. The grids were ploughed in November 1999 and February 2000 during the short and long rain seasons, respectively. Tractor ploughing was done using a disc plow at a depth of 30 cm—a normal rooting depth for most annual crops. Slashing was done manually close to the surface of the soil and the weeds were left to dry for one or two days, depending on weather conditions, after which they were burned. Maize sowing followed a standard procedure (planting lines 90 cm apart, plant holes 60 cm apart, and three seeds per planting hole). The bean crop was sown 3 weeks after the maize, at a spacing of 50 cm × 10 cm. All necessary agronomic practices such as fertiliser application and weeding were carried out equally on all the plots. Triple superphosphate (20 kg/ha) and nitrogen (40 kg N/ha) were applied before sowing and 3–4 weeks after sowing, respectively.

Trapping was conducted in each grid for three consecutive nights at intervals of 4 weeks. Additionally, trapping was conducted before land preparation (tractor ploughing or slashing and burning), after land preparation, and after seed emergence. Traps were baited with peanut butter mixed with maize bran and were inspected early in the morning. Animals were marked by toe-clipping. The trapping station, sex, weight, and reproductive status of captured animals were recorded. Animals were later released at the station of capture.

Population size was estimated for each 3-day trapping session using the M(h) estimator of the program CAPTURE for a closed population, which allows for individual variations in trapping probability (White et al. 1982). Spatial distribution of animals was established by means of capture maps showing the intensity of captures at different trapping stations. The pattern of distribution of individuals over the different trapping stations was established by determining the coefficient of dispersion (CD) by calculating the variance-to-mean ratio. These ratios indicate whether animals are aggregated, random or regular in their distribution (Kranz 1993). The distribution was considered random when the CD values were 0.7–1.3, aggregated (clustered) when CD values were >1.3, and regular when CD values were <0.7.

Using the established maps, the percentage of animals captured at the centre grids (40 × 40 m from lines 2–6 and trapping stations B–F) was compared between treatments. Since the central grid consisted of 5 × 5 of the 7 × 7 traps of the whole grid, we expected a proportion of 25/49 if animals were evenly distributed throughout the field. Statistical analysis using GLM Factorial ANOVA (analysis of variance) was performed in STATISTICA to compare the effect of the different land preparation methods and the cropping systems on the distribution of animals.

Results and discussion

The population abundance of rodents was influenced by the land preparation method and, to some extent, the cropping system. Trapping after land preparation showed a drop in population size in the slashed-and-burnt fields, but not in the tractor-ploughed fields (data not shown here). After seed emergence, the rodent population increased in all the grids, but a greater increase occurred in the slashed-and-burnt fields than the tractor-ploughed fields. During the long rain season, very few animals were captured and there was no clear pattern in the population trend.

The immediate effect of slashing and burning and tractor ploughing was a drastic drop in the rodent population, but it increased fast in the slashed-and-burnt fields after germination and emergence of weed and maize seedlings. The increased population size was probably due to recolonisation from the surrounding fallow land, but this needs to be investigated further. Figures 1 and 2 show typical examples of the spatial distribution of individuals in tractor-ploughed and slashed-and-burnt fields, respectively, during various growth stages of maize. The animals were randomly distributed in both the treatments before land preparation (Table 1). However, at the seed emergence and vegetative stages of the maize crop, animals occurred in clusters in the tractor-ploughed fields in both the short and long rainy seasons, while they remained randomly distributed in the slashed-and-burnt fields (variance-to-mean ratio, Table 1); the clusters in the ploughed fields were situated near the field edges. The land preparation methods, cropping systems and the season significantly affected the distances occupied by individuals from the centre of the grids. The mean distances were 27.8 m and 21.6 m for tractor-ploughed and slashed-and-burnt fields, respectively, and were significantly different (Tukey HSD test; $p < 0.001$).

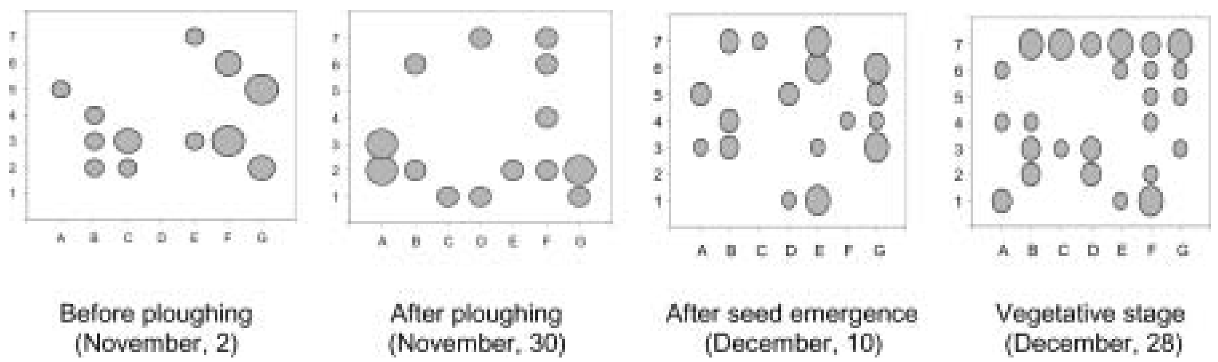

Figure 1. Distribution of trapped individuals over the different trapping stations in the tractor-ploughed fields (mono-crop) during the short rainy season 1999. Dot size increases with number of captures (1–3). Scale: trapping stations A–G and trapping lines 1–7 were 10 m apart. Lines with trapping stations were 10 m apart; the field extended 5 m beyond the outer trap lines; the fields were surrounded by fallow land.

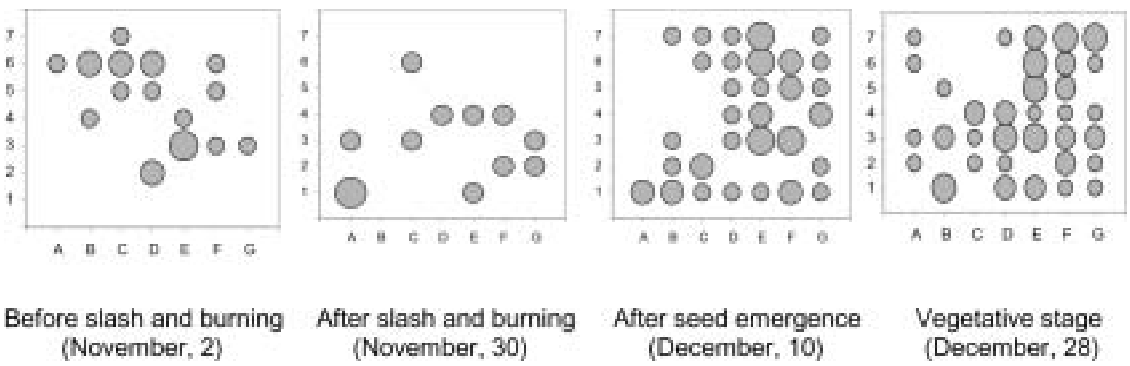

Figure 2. Distribution of trapped individuals over the different trapping stations in the slashed-and-burnt fields (monocrop) during the short rainy season 1999. Dot size increases with number of captures (1–3). Scale: trapping stations A–G and trapping lines 1–7 were 10 m apart. Lines with trapping stations were 10 m apart; the field extended 5 m beyond the outer trap lines; the fields were surrounded by fallow land.

Table 1. Coefficient of dispersion (CD) values (variance (s^2) to mean ratio calculations) and pattern of spatial distribution of rodents before and after land preparation and during growth of maize.

Cropping stage	Tractor-ploughed				Slashed-and-burnt			
	Mean	s^2	CD	Distribution[a]	Mean	s^2	CD	Distribution[a]
Before land preparation	0.65	0.65	0.99	Random	0.24	0.23	0.94	Random
After land preparation	0.51	0.75	1.48	Clustered	0.42	0.54	1.20	Random
After seed emergence	0.67	1.09	1.63	Clustered	0.95	0.87	0.91	Random
At vegetative stage	0.61	1.04	1.58	Clustered	1.20	1.08	0.89	Random

[a] Coefficient of dispersion scale: random distribution = 0.7–1.3; aggregated (clustered) distribution = >1.3; regular distribution = <0.7.

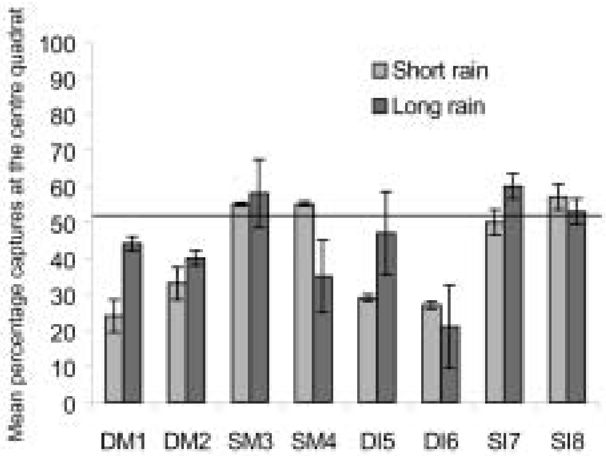

Figure 3. Mean percentage (± se) captures at the centre grid during the short (1999) and long (2000) rain seasons (the mean percentages are for the sum of captures before ploughing, after ploughing, after seed emergence and at vegetative stage). Abbreviations on the X-axis refer to land preparation (D = tractor ploughing; S = slashing and burning) and cropping system (M = mono-cropping; I = inter-cropping). Numbers refer to different replicates. The horizontal line at 51% indicates the expected value if animals were evenly distributed over the grid and the periphery.

For the two cropping systems, the mean distances were 26.0 m and 23.4 m for mono-cropped and inter-cropped fields, respectively, and also varied significantly (Tukey HSD test; $p = 0.007$). In the short and long rain seasons, the distances also differed significantly (Tukey HSD test; $p = 0.041$) (25 m for short rains and 23.8 m for long rains). The concentration of the animals along the edge of the tractor-ploughed grids is probably due to a combination of mortality in the ploughed grid, movement from the centre to the edges, and possibly recolonisation from the surrounding fallow land. Survival analyses, which can elucidate this, will be presented elsewhere. Deep ploughing using a tractor most likely reduces survival within the fields, because weed seeds, which are consumed by rodents, are ploughed under, while the nesting sites and burrow systems are destroyed. Ploughing may also have caused direct mortality of some individuals. Studies in China also showed that ploughing reduced the population of *Cricetulus triton* (Zhang et al. 1999).

Significantly, more animals were captured in the centre (40 × 40 m) grid in the slashed-and-burnt fields than in the tractor-ploughed fields during the two cropping seasons (Tukey HSD test; means, tractor-ploughed = 36.25%, slashed-and-burnt = 51.00%, $p = 0.03$) (Figure 3). The percentage of animals captured at the centre grid in the tractor-ploughed fields was significantly different from the expected value of 51% (equivalent to the ratio of 25/49 traps at the centre) ($\chi^2 = 8.5$; df = 1). In the slashed-and-burnt fields, the centre grid had 51% of the captures which corresponds to the expected proportion of captures for 25/49 traps. This suggests that in the slashed-and-burnt fields there were no differences in the distribution of animals between the centre and the periphery, while in the tractor-ploughed fields there was a tendency for more animals in the periphery than would be expected by chance. Cropping system and season had no significant effect on captures at the centre grid and there was no interaction between ploughing, cropping system and season on the distribution of animals. The observed distribution of animals in the different fields suggests that the slashed-and-burnt fields provided better protection and more resources than the tractor-ploughed fields. It could also be argued that the maize seeds provided more favourable food than weed seeds in the adjacent fallow land. This is consistent with Taylor and Green's (1976) observations that, when there were no cereal crops in the fields, rodents depended on weed seeds and the leaves of dicotyledonous plants, but as soon as the cereals became available, they formed a major part of the diet of *M. natalensis.*

The influence of cropping system on spatial distribution and population abundance of *M. natalensis* is not quite clear in the current study. However, it is plausible that there was increased activity of rodents in both types of cropping system because the weed density increased in the fields. It is also apparent that the population density within the inter-cropped fields increased, which could be attributed to better cover, or an alternative food was available when maize crop was not very attractive for the rodents. Therefore, it will be interesting to investigate how repeated weed control in both types of cropping system, and how the method of land preparation will affect the distribution pattern and population abundance of rodents and whether this could be part of an integrated approach for management of *M. natalensis*.

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