Spatial patterns and distribution of damage in maize fields due to *mastomys natalensis* in Tanzania

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ABSTRACT. We describe the spatial distribution of rodent damage to maize seedlings in field studies in Morogoro, Tanzania. The distribution of damage was assessed at the level of the planting hole (with three seeds per planting hole) and at the level of the maize field (where the assessed units were plots of 10x10 planting holes). The most abundant rodent species in the fields were the multimammate rat, *Mastomys natalensis*. At the planting hole level, damage was fairly regular or random. At the field level, damage to seedlings was clustered irrespective of whether the fields were situated in mosaic or monoculture surroundings, but the clusters were not more concentrated near the edges or the near the centre of the field. We conclude that *M. natalensis* does not exhibit specific exhaustive searching behaviour when feeding on seeds and seedlings in maize fields and that several local factors determine the distribution of the damage.

KEY WORDS : *Mastomys natalensis*, spatial distribution, rodent damage, maize.

INTRODUCTION

Rodents have the potential to breed quickly and infest crops leading to serious economic damage (FIEDLER, 1994). In Tanzania, damage to maize crop is largely attributed to *Mastomys natalensis*, and the Nile rat, *Arvicanthis* sp. (MAKUNDI et al., 1991). In one study, more than 98% of the rodents found in maize fields were *M. natalensis* (MASSAWE et al., 2003). Little is known on the spatial distribution of the damage caused by *M. natalensis* in maize fields, although the spatial population patterns in Tanzania are known (LEIRS et al., 1996).

KEY (1990) and REDHEAD & SAUNDERS (1980) reported a strong correlation between rodent damage caused to maize and sugar cane and the presence of surrounding uncultivated land. BUCKLE et al. (1985) and SCHAEFER (1975) reported that at low population densities of *Rattus* sp., damage in rice fields was variable, sometimes clustered or sometimes evenly distributed over the field. At high population densities, the centre of the field was damaged, while border rows sustained little or no attack.

Proper sampling is essential for pest monitoring, surveillance and forecasting damage levels. Sampling methods have to be simple and unequivocal and must find a compromise between costs and desired precision (KRANZ, 1993). Sampling methods, sample size and sampling procedure, therefore, should be based on the spatial distribution of rodent damage in order to ensure that a sample is representative for the entire population in a particular field (APLIN et al., 2003). The aim of the current study was to describe the spatial distribution of rodent damage within maize fields in Tanzania, and establish whether these differ depending on the type of vegetation surrounding the fields.

MATERIALS AND METHODS

Locations and seasons

Field experiments were carried out during the cropping season of 2000 and 2001, in two farms at Sokoine University of Agriculture, Morogoro, Tanzania. The first farm is located at 6º50'S, 37º38'E at an altitude of 510 m above sea level (a.s.l.) and the second at 6º46'S, 37º37'E at 480 m a.s.l. The two areas have a bimodal rainfall pattern (with a long and a short rainy season). The study was conducted during the long rains which is also the main maize growing season. The seeds were sown in early March.

Treatments

The study was carried out in ten plots of 70 x 70 m each. Six of the maize fields were located in mosaic landscape of maize fields surrounded by fallow land; four were part of larger monoculture maize field. All fields received similar standard agronomic treatments, i.e. early ploughing, application of Triple Super Phosphate fertilizer (20 kg P_20_5/ha) before planting, and nitrogen fertilizer (40 kg N/ha) twice as a top dressing, three weeks after sowing and again after booting stage. Three maize seeds (of the local variety Staha®) were planted per hole, at a planting space of 90 x 60 cm between planting holes. Weeding was carried out twice.

Sampling procedures

Crop damage assessment was carried out at seedling stage, ten days after planting, by sampling every individual planting hole in each field. The assessor walked across the field and recorded the number of seedlings at each sampled hole in a row. Since three seeds were planted per hole, damage was expressed as the proportion of missing emerged seedlings. At this stage, there were no other pests causing damage to the seedlings and all missing seedlings were therefore attributed to rodent damage. Germination failure due to drought or seed quality was assumed to be evenly distributed, but was also considered of low importance in the experimental fields.

Determination of rodent damage distribution pattern

The variance-to-mean ratio (s^2/mean) of damage intensity at sampling points was calculated in order to estimate the distribution of rodent damage in each field. When the variance to mean ratio is large, the variation of damage distribution increases, meaning that damage is more aggregate. A small variance to mean ratio indicates a more regular damage distribution. KRANZ (1993) suggested that damage with a variance-to-mean ratio from 0.7 - 1.3 would be classified as random, with a ratio >1.3 aggregate or clustered and with a ratio <0.7 regular.

We analyzed the distribution of damage in the field at two levels. At a first level, the planting hole was used as the sampling unit. The number of missing seedlings was used as an indicator of damage at each planting hole. This could vary from 0 (indicating no seed removal by rodents) to 3 (indicating 3 seeds removed/damaged). A regular distribution at this sampling unit level would indicate that rodents removed an equal number of seeds from each planting hole, while a clustered distribution would mean that the damage was higher in some planting holes while others were left untouched. It should be pointed out that this level of analysis does not provide any information about the spatial distribution of damaged planting holes in relation to each other. For the second level of analysis, the field was divided into small areas of 10 x 10 planting holes. Damage was then calculated as the total number of missing seedlings in each area. An aggregate distribution at this level would indicate that seeds were removed or damaged in planting holes that are close to each other. A regular distribution would indicate that damage is spread uniformly over the field. At both sampling levels, the mean to variance ratio of damage was calculated for each field. Summary statistics of this ratio were then calculated for all fields in a mosaic landscape and for all fields in a monoculture landscape. The spatial distribution of damage was also plotted on a map to visually verify where in the field any clusters would occur.

RESULTS AND DISCUSION

The mean variance-to-mean ratios at the planting hole level were 0.5 and 0.8 in mosaic and monoculture fields, respectively (Table1). These results show a fairly regular distribution of damage in the mosaic fields and a more random distribution in the monoculture fields. However, with the larger sampling units (10 x 10 planting holes), the distribution of damage appeared to be highly clustered (variance–to-mean values of 3.6 and 3.7 for mosaic and monoculture fields, respectively), regardless of whether it was in mosaic or monoculture fields. Fig. 1 shows, as an example, a schematic representation of the spatial distribution of damage in one mosaic field. The nature of damage over the field can be readily seen, with areas of heavy damage and other areas with hardly any damage at all. However, the figure does not suggest clustering of damage in the centre or at the edges of the field. Maps for other fields show similar results.

TABLE 1

Variance to mean ratio and spatial distribution of rodent damage in Mosaic and Monoculture maize fields

	Field categories	
	Mosaic fields	**Monoculture fields**
	Individual planting hole	
Mean	0.49	0.83
Standard Error	0.03	0.07
Median	0.50	0.73
Minimum	0.39	0.70
Maximum	0.56	1.00
Confidence level (95.0%)	0.07	0.19
Number of fields (N)	6	4
	10 x 10 planting holes	
Mean	3.65	3.72
Standard Error	0.99	0.33
Median	3.70	3.73
Minimum	1.27	2.92
Maximum	7.90	4.52
Confidence level (95.0%)	2.55	1.04
Number of fields (N)	6	4

Scale used for variance : mean ratio; <0.7 = regular, 0.7 - 1.3 = random, and >1.3 = cluster. Adopted from KRANZ (1993).

The clustered distribution at the field level indicates that rodents are more active in some parts of the field than in others. This corresponds to observations that also rodent captures in those same fields are spatially clustered (MASSAWE, 2003). Small within-field variation in soil and vegetation cover may contribute to such clustering, and this could be affected by e.g. land preparation methods. As observed in another study, *M. natalensis* can adjust its feeding behaviour depending on prevailing local circumstances such as cover and predation risk (MOHR, 2001). Our study showed no obvious edge effect with more or, conversely, less damage near the field edges as observed in other crops with other rodent species (e.g. BUCKLE et al., 1985; SCHAEFER, 1975).

The random or regular distribution at the planting hole level is informative about the rodents' searching behaviour. The rodents do not necessarily dig up all seeds from single planting holes, rather they seem to move between planting holes without spending a long time searching at each of them. In this way, the rodents may be actually thinning the seedling density but leaving one or more seedlings at each hole. As seen at the field level, however, such thinning is not done evenly throughout the field.

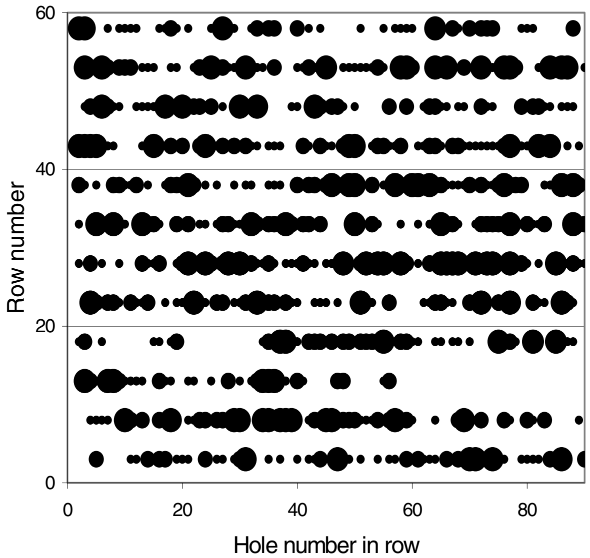

Fig. 1. – Spatial distribution of rodent damage along rows of a maize field in a mosaic landscape. Big bubbles indicate three seeds were removed by rodents, medium size bubbles indicate two seeds were removed, small bubbles indicate one seed removed, and no bubble (empty) indicates no seeds were removed. For clarity, we show on this figure only the observations for every 5th row, starting from row 3.

From our observations we conclude that *M. natalensis* does not exhibit specific exhaustive searching behaviour when feeding on seeds and seedlings in maize fields and that several local small-scale factors determine the distribution of the damage.

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REFERENCES

Aplin, K., P. Brown, J. Jacob, C. Krebs & G. Singleton (2003). Field Methods for Rodent Studies in Asia and the Indo-Pacific. ACIAR Monograph, No.100 : 136pp.

Buckle, A.P., Y.C. Yong & H.A. Rahman (1985). Damage by rats to rice in South-east Asia with special reference to an integrated management scheme proposed for peninsular. *Acta Zoological Fennica*, 173 : 139-144.

Fiedler, L. (1994). *Rodent Pest Management in East Africa*. Rome, Italy : 83pp.

Key, A. (1990). Pre-harvest crop losses to the African striped ground squirrel, *Xerus erythropus*, in Kenya. *Tropical Pest Management*, 36(3) : 223-229.

Kranz, J. (1993). Introduction to sampling in crop protection. In : Kranz, J. & F. Holz (eds), *Basics of Decision - Making and planning for integrated pest management (IPM)*. Deutsche Stiftung für internationale Entwicklung (DSE), Federal Republic of Germany : 33-39.

Leirs, H., W. Verheyen & R. Verhagen (1996). Spatial patterns in *Mastomys natalensis* in Tanzania (Rodentia, Muridae). *Mammalia*, 60(4) : 545-555.

Makundi, R.H., T.J. Mbise & B.S. Kilonzo (1991). Observations on the role of rodents in crop losses in Tanzania and control strategies. *Beitrage zur Tropischen Landwirtschaft und Veterinarmedizin (Journal of Tropical Agriculture and Veterinary Science)*, 29(4) : 465-474.

Massawe, A.W. (2003). Effect of cropping systems and land management practices on rodent population characteristics. PhD Thesis, Sokoine University of Agriculture, Morogoro, Tanzania : 176pp.

Massawe, A.W., H. Leirs, W.P. Rwamugira & R.H. Makundi (2003). Effect of land preparation methods on spatial distribution of rodents in crop fields. In : Singleton, G.R., L.A. Hinds, C.J. Krebs & D.M. Spratt (eds), *Rats, mice and people : Rodent biology and management*. ACIAR, Canberra : 229-232.

Mohr, K. (2001). Feeding decision as an anti-predation strategy in the African multimammate rat (*Mastomys natalensis*). MSc Thesis, University of Copenhagen, Denmark.

Redhead, T.D. & I.W. Saunders (1980). Evaluation of thallium sulphate baits against rats in Queensland sugar-cane fields adjacent to different vegetation types. *Journal of Protection Ecology*, 2 : 1-19.

Schaefer, J. (1975). Field rat control as implemented by the Philippine-German crop protection program. In : *Proceedings of All India Rodent Seminar*. Ahmedabad, India : 345-351.