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ORIGINAL ARTICLE

Soil type limits population abundance of rodents in crop fields: case study of the multimammate rat Mastomys natalensis Smith, 1834 in Tanzania

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Abstract

Studies of populations of the multimammate rat *Mastomys natalensis* in Morogoro, Tanzania, show that soil texture appears to influence the population abundance and distribution of these rats in agricultural fields. The lowest rodent population abundance was found on sandy clay soils ($F_{(2, 5)} = 8.42$; $P = 0.025$). The population abundances of *M. natalensis* on sandy clay loam and sandy loam soils did not differ significantly ($P \leq 0.05$), possibly because these soils have a very similar texture. The results of this study suggest that *M. natalensis* prefers loam-textured soils with a high percentage of sand, which are probably better than clay soils for burrowing and nesting, particularly in the rainy season. The lower preference for clay soils is probably related to the poor aeration in these soils and the waterlogging that occurs during the wet season.

Key words: *Mastomys*, population, soil texture, Tanzania.

INTRODUCTION

Soil type is an important factor determining the distribution, abundance and diversity of plant and animal species. Soil structure and soil fertility are the two principal factors that influence vegetation characteristics and crop diversity in an area. The importance of soil properties in rodent population ecology has been demonstrated in several studies (Booth 1960; Ajayi & Tewe 1978; Yeboah & Akyeampong 2001).

Soil texture influences many other properties, including drainage, fertility, productivity, moisture-holding capacity, rates of water infiltration, and soil consistency. Some studies have reported that the texture of the soil is a primary factor limiting the distribution of some fossorial mammals (Hardy 1945; Miller 1964).

The multimammate rat *Mastomys natalensis* Smith, 1834 is widely distributed in sub-Saharan Africa. In eastern and southern Africa, it is a notorious pest, which attacks cereal crops, particularly maize (Leirs 1995; Makundi *et al*. 1999). Apart from the biological characteristics of the species, environmental factors (e.g. rainfall), farming practices and land preparation type (Massawe *et al*. 2003; Massawe *et al*. 2005) are

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responsible for the high population densities of this species. Soil characteristics, especially soil texture, have infrequently been considered in studies of the population ecology of *M. natalensis*, but they could be important physical properties influencing distribution and abundance. In the current study, we investigated whether different soil types affect the population abundance of *M. natalensis* in crop fields in Tanzania.

MATERIALS AND METHODS

Capture-mark-recapture studies were conducted at the Mazimbu Campus of the Sokoine University of Agriculture, Morogoro, Tanzania. The study area is located at 6°46'S, 37°37'E at an elevation of 480 m a.s.l. and is approximately 15 km to the south-west of the main campus of the Sokoine University of Agriculture. In previous years, maize was cultivated in the experimental fields, but the land was left as fallow for animal pasture for 2 years before the grids were set up for the present study. The dominant vegetation included short grass (seasonal) dominated by jungle rice (*Echinochloa obtusiflora* Stapf and *E. stagnina* Retz. P. Beauv) and tall grass (perennial) dominated by wild sorghum (*Sorghum arundinaceae* Desv de Wet et Harlan) and guineafowl grass (*Rottboellia cochinchinensis* Lour. W.D. Clayton). In the study area, there are two rainy seasons. The short rainy season extends from November to the end of December, sometimes extending to January. In some years, there is no or very little rain. The long rainy season extends from March to the end of May, and is usually characterized by heavy rains (but the rainfall can be marginal in some years). Eight grids of 70 m × 70 m each (49 trapping stations, 10 m apart) were established in the study area. Trapping of rodents was conducted in each grid using Sherman traps (H.B. Sherman Traps, Tallahassee, FL, USA) for 3 consecutive nights at intervals of 4 weeks from April 1999 to July 2001. A single trap was placed at each trapping station. Population size was estimated for each 3-day trapping session using the M(h) estimator of the program CAPTURE. Four to five soil samples were taken randomly from each field at a depth of 30 cm. In total, 37 soil samples were collected. The soil samples were packed in plastic bags for further laboratory processing. Particle size analysis was performed using the hydrometer method (Gee & Bauder 1986). Soil types were characterized using a soil texture triangle to determine the percentage of sand, silt and clay. ANOVA was performed to determine the effect of soil type on rodent population abundance.

RESULTS AND DISCUSSION

During the study period we captured 2874 individuals over 36 456 trap nights. The rodent species caught were 97.8% *Mastomys natalensis*, 1.6% *Tatera swaythlingi* Cretschmar, 1830, and 0.4% *Mus minutoides* Smith, 1834. Two shrews, *Crocidura hirta* Peters, 1852, comprised 0.2% of the captures.

Table 1 shows the soil properties in the different grids used for the study. The relative population abundances of *M. natalensis* in soils of different textures were 348±2.4, 432±2.6 and 467±2.9 for sandy clay, sandy clay loam and sandy loam, respectively. Soil texture was an important factor influencing the abundance and distribution of *M. natalensis* in the fields. Rodent populations differed significantly with soil type in the study area. The lowest rodent population density was found on the sandy clay soils ($F_{(2,5)} = 8.42$; $P = 0.025$). There were no significant differences in population size between sandy clay loam and sandy loam soils ($P \leq 0.05$), which are similar in many respects.

Seasonal rodent population fluctuations in relation to rainfall pattern in the study area are presented in Fig. 1. Rodent population abundance in all the studied fields followed a density pattern influenced by the amount of rainfall. In the fields with sandy clay loam and sandy clay loam soils, the population started to increase earlier (September) during the short rainy season (1999), whereas in the fields with sandy clay soils, which become waterlogged and sticky when wet, the rodent population density started to increase later in the season (November 1999) than in the other types of soils. When there was

Table 1 Physical properties of the different soil types in the study grids at Mazimbu Campus, Sokoine University of Agriculture, Morogoro, Tanzania

Grid no.	Soil pH H_20 (1:2:5)	Particle size analysis (%)			Soil texture (soil type)
		Clay	Silt	Sand	
1	6.2	15.6	8.3	76	Sandy loam
2	6.34	39	9.6	51.3	Sandy clay
3	6.19	24	10	66	Sandy clay loam
4	6.98	34.3	12.3	53.3	Sandy clay loam
5	6.48	35.5	9.5	55	Sandy clay loam
6	6.99	24.5	9	66.5	Sandy clay loam
7	6.46	22.5	8.5	69	Sandy loam
8	6.78	36	10	54.5	Sandy clay

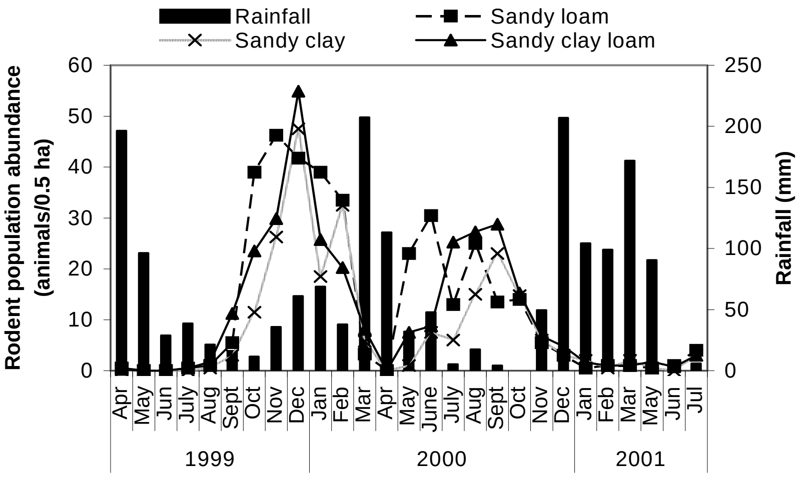

Figure 1 Seasonal population abundance of Mastomys natalensis in relation to rainfall pattern in soils with different textures in Morogoro, Tanzania.

abundant rainfall (Fig. 1), the rodent population abundance in grids with sandy clay soils dropped rapidly, although the difference between the various soil types was not significant ($P > 0.05$). In months when it was relatively dry (from July to October 2000), population densities increased again in these soils. The temporal population density fluctuations of *M. natalensis* in Morogoro, Tanzania, are strongly linked to the rainfall pattern (Telford 1989; Leirs 1992). Although the vegetation type and cover are partly determined by soil type, the species composition of vegetation is very consistent over the study area, which suggests that the spatial abundance of *M. natalensis* was also influenced by soil texture and degree of wetness.

Odhiambo (2005) noted that in south-west Tanzania, sandy clay loam soils had fewer gerbils (*Tatera leucogaster* Peters, 1852) compared with sandy loam soils. He attributed the differences in abundance to variations in the suitability of the soils for burrowing. It appears that for *M. natalensis* also, abundance in soils of different textures is associated with the suitability of the soils for creating nesting places.

It is evident from the present study that loamy soils are preferred by *M. natalensis*, but it is not economically feasible to modify soil texture. Thus, an obvious although not very practical approach is to avoid farming in those soils with a texture that is suitable for *M. natalensis*. A better alternative is to identify those areas with the preferred soil type and concentrate control effort there. The results of this study show that the most effective way to control *M. natalensis* is to establish a long-term rodent control program that takes into account the effect of soil texture on *M. natalensis* distribution, the effect of different types and amounts of vegetation on their activity, and the effect of different cultural control methods. Therefore, the control program would incorporate a variety of different cultural and chemical methods in a long-term, planned rotation of methods, keeping in mind the influences of soil texture and other soil properties, topography and vegetation.

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