

# Spatial and temporal patterns in *Mastomys cf. natalensis* (Smith, 1834) as revealed by radio-tracking

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## Introduction

*Mastomys natalensis* (Smith 1834) is a common rodent species in Africa and has been extensively studied (e.g. VEENSTRA, 1958; COETZEE, 1975; NEAL, 1977; TELFORD, 1989; LEIRS, 1995; OGUGE, 1995; MONADJEM, 1998). However, knowledge of its spatial and temporal patterns of activity is still scanty. Until now home range sizes of this species have been determined using the capture-mark-release method (CMR) (CHEESEMAN, 1975; LEIRS, 1995; CHRISTENSEN, 1996) except for one investigation that used radio-tracking, in fallow fields in Tanzania (LEIRS *et al.*, 1996). Previous investigations of activity patterns were carried out mainly in the laboratory (VEENSTRA, 1958, DELANY AND KANSIIMERUHANGA, 1970; CHEESEMAN, 1975; DUPLANTIER AND GRANJON, 1990) and little information is available from the field (DELANY, 1964; NEAL, 1970). In this study radio-tracking was used to elucidate home range size, home range utilization and activity pattern of *M. cf. natalensis* in its natural habitat. The data presented here are part of a larger study of the ecology of these populations (HOFFMANN, 1999). The name *Mastomys cf. natalensis* is given here to highlight the fact

that the specimens under study may not belong to *M. natalensis*. Indeed, Volobouev *et al.* (2001) have shown the presence of a 38-chromosome species in the immediate vicinity of the study site, a karyotype that may be closer (although not identical) to the one of *M. erythroleucus*.

## Methods and materials

### *Study area*

The investigation took place in the Queen Elizabeth National Park (00°15'S, 30°00'E), in south-west Uganda. From 1995 to 1997 the ecology of small mammals in different grassland communities was studied using live trapping methods (CMR) throughout the year (HOFFMANN, 1999). For the radio-tracking experiment two live trapping plots of 1 ha each, about 2.5 km apart and with different vegetation types, were selected in the crater region. Radio-tracking was done at the start of the rainy seasons in March (plot 1) and in August (plot 2) and extended over periods of 2 weeks. Plot 1 was in the *Imperata-Cymbopogon* grassland (grass height 150 cm). Plot 2 was in the bushland-grassland-mosaic with 6-8 *Capparis-Euphorbia* bush patches (10-20 m in diameter) per ha, within the *Bothriochloa-Themedra-Chloris* grassland (grass height 70 cm). In plot 2, 6% of the area was covered with those bushes. It was used more frequently by big game than plot 1. Annual fires occurred in both plots.

### *Selection of individuals*

Only adult males and females were selected, which had been resident on the plots for at least 2 consecutive trapping sessions, i.e. for at least 6 weeks. As both home range sizes and activity patterns were to be investigated, it was necessary to take the fixes at short intervals. This limited the number of individuals to be radio-tracked simultaneously to 5.

### *Fitting the collar*

The animals were equipped with radio-collars with TW-4 transmitters (BIOTRACK, UK) of about 2.5 g, which represented 5-7% of the individuals' body weight. This was within the commonly recommended value of less than 10% (KENWARD, 1987). The collars were fitted in the laboratory. Subsequently the animals were kept for a few hours under observation and then released at their original trap sites.

### *Locating the animals*

Generally the signal could be detected at up to 90 m. The position of each animal was determined by the homing-in-technique (WHITE AND GARROTT, 1990) within a 5 x 5 m grid using marker posts. The rats were located within the live trapping grid of 1 ha and beyond. Tracking started in the evening before the animals left their nests and ended in the morning after they had returned. The animals were radio-tracked in each area for 9-10 nights. To check for possible diurnal activity some day fixes were also taken.

### *Analysis*

Size and shape of the home ranges were calculated using the software program RANGES V (KENWARD AND HODDER, 1995) and the Minimum-Convex-Polygon-Method. The latter was found to be adequate as it allows for comparison with our CMR-results and with previous studies (JONES AND SHERMAN, 1983). To minimize the influence of "occasional excursions" (BURT, 1943), the home range sizes were calculated disregarding 5% of the outermost fixes. The core areas were defined as encompassing 60% of the inner fixes.

For comparison, the home range sizes based on recapture data were calculated for all radio-tracked individuals. For this purpose, data from several trapping sessions were pooled. The CMR home range results so calculated are based on 4-9 different trapping locations for each individual over periods of 2-11 months.

Habitat utilization in plot 2 was assessed using all fixes of the 3 individuals when outside the nest. The activity status was determined by

the changes of location of a particular individual during its activity period. In plot 1 fixes were taken at 30 min interval. In plot 2 the larger home ranges of the residents required longer walks and therefore longer lapses between the fixes. This also minimized encounters with lions (*Panthera leo*) and elephants (*Loxodonta africana*). In plot 1 an individual was considered resting after 3 consecutive fixes at the same location, in plot 2 after 2 consecutive fixes. Those nocturnal resting bouts counted still for the active period.

## Results

Seven individuals were successfully radio-tracked, providing a total of 1,375 fixes, 121 to 289 for each individual. In 3 more individuals the transmitter failed ( $n = 1$ ) and the animals disappeared ( $n = 2$ ).

### *Spatial patterns derived by telemetry*

#### *Imperata-Cymbopogon grassland*

One female (F1) and 3 males (M1, M2, M3) were radio-tracked successfully in plot 1. All home ranges were located to a large extent within the trapping grid and they were overlapping. Home range sizes (at 95%) were found to range from 0.119 - 0.255 ha (tabl. 1). F1 and M2 made few excursions, which is expressed by the large differences between the home range sizes calculated from 100% and 95% of the fixes (tabl. 1). During one excursion however, M2 moved 130 m away from his den, but came back to his home range after 1.5 hours.

The sleeping sites were in the central part of the individuals' home ranges. F1 and M3 had their dens in termite structures (*Odontotermes* sp.), M2 in a hole in the ground, and M1 used a den at the base of a grass tussock. With few exceptions, the animals returned to the same dens in the morning and used these sites also for resting bouts during activity phases. The sleeping sites of M1 and F1 were situated in the overlapping zone of their 100% home ranges. Twice during the experiment, both used the same den, once that of the male, once that of the female.

Radio-Tracking						CMR		
Indiv.	Period	Fixes n	100%	HR (ha)		Period	Capture n	HR (ha) 100%
				95%	60%			
Plot 1								
F1	03/96	287	0.315	0.163	0.073	02/96-07/96	9	0.120
M1	03/96	289	0.291	0.255	0.068	02/96-03/96	5	0.135
M2	03/96	265	0.603	0.201	0.064	02/96-05-96	4	0.043
M3	03/96	166	0.153	0.119	0.021	02/96-03/96	6	0.090
Plot 2								
F2	08/96	121	1.018	0.840	0.246	09/95-09/96	6	0.293
F3	08/96	123	0.765	0.701	0.338	09/95-09/96	2	—
M4	08/96	124	0.726	0.656	0.164	09/95-09/96	8	0.275

M = Male, F = Female.

**Table 1**

Home range sizes (HR) of *M. cf. natalensis* in both plots, revealed by radio-tracking and CMR. For F3, an estimate based on CMR results was not possible due to low trapping success.

## Bushland-grassland-mosaic

Two females (F2, F3) and 1 male (M4) were successfully radio-tracked. Their home range sizes (at 95%) ranged from 0.656 - 0.840 ha (tabl. 1) and were on average 4 times larger than those in plot 1. The animals moved far outside the trapping grid and used dens at the periphery of their home ranges, up to 70 m from the edge of the grid. M4 and F2 used dens in different *Capparis-Euphorbia* bushes, F3 used a hole in the ground in the open grassland.

In the mornings the animals returned to their dens. But in contrast to the inhabitants of plot 1, they never came back to their dens during the activity period. Instead, hides in *Capparis-Euphorbia* bushes were used for resting bouts. While home ranges of M4 and F3 overlapped, these individuals met only twice and only briefly during the radio-tracking periods. In total the animals spent about the same amount of time in the grassland and in the bushes (fig. 1). Considering that the bush patches cover only 6% of the area, *M. cf. natalensis* actually utilized 94,4% of the corresponding surface.

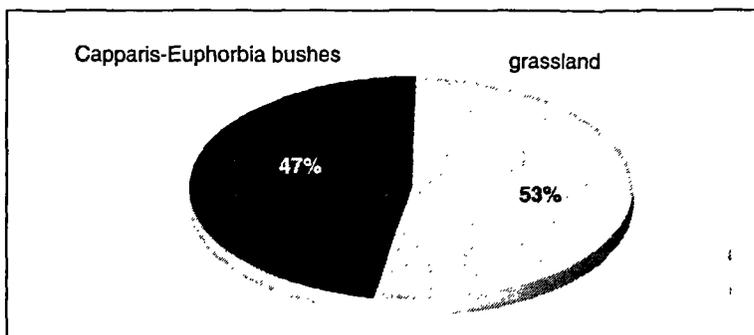


Figure 1  
Habitat utilization of *M. cf. natalensis* [%] in the bushland-grassland-mosaic. Total fixes ( $n = 230$ ) outside the nests of all individuals ( $n = 3$ ) are pooled.

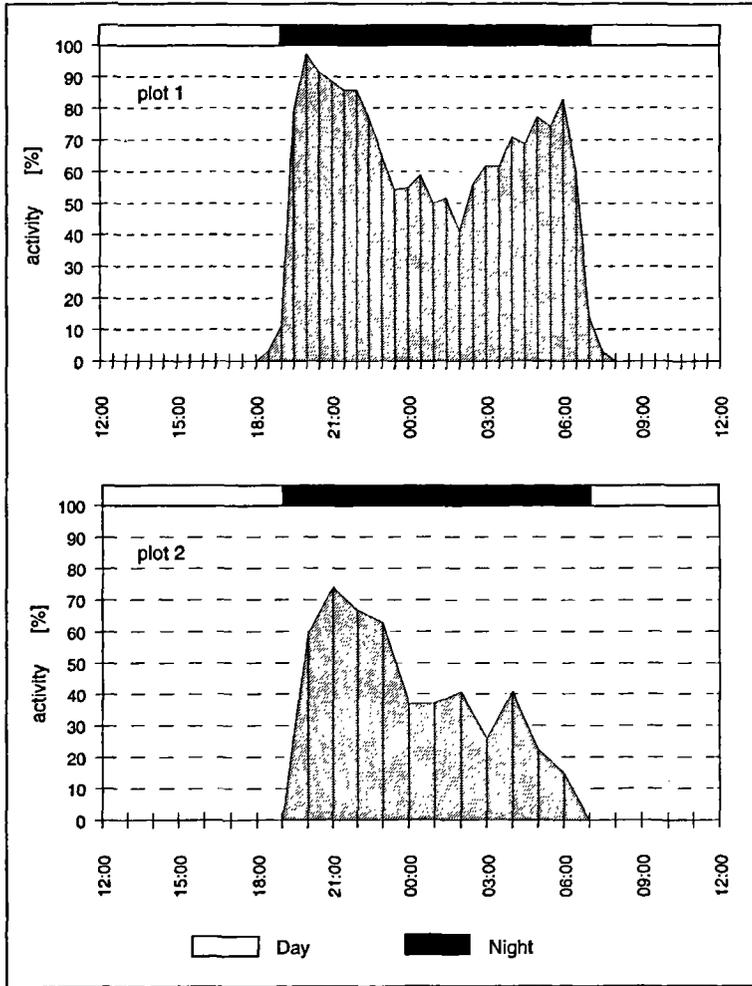
### Spatial patterns derived by CMR-method

Home range sizes derived from the CMR-method were considerably smaller than those assessed by radio-tracking (tabl. 1). The CMR home ranges are about the size of the core areas (60%) as revealed by telemetry.

### Activity patterns derived by telemetry

In both plots *M. cf. natalensis* was strictly nocturnal. The animals left their dens after dusk and returned to them before dawn. But their activity rhythms were different. In plot 1 all animals showed two distinct activity peaks, whereas in plot 2 they had just one (fig. 2). The mean activity patterns of the 2 plots are significantly different (Mann-Whitney  $U = 40$ ,  $Z = -2.283$ ,  $n = 13$ ,  $p = 0.022$ )

In plot 1 the first peak of activity was about 1 hour after dusk, the second one 1 hour before dawn. In comparison with plot 1, activity in plot 2 started later and the one and only peak was delayed by about 1 hour, then the activity declined more or less continuously until dawn. On average the animals in plot 2 returned to their nest sites about 2 hours earlier than those in plot 1. In total, the activity period in the bushland-grassland-mosaic (plot 2) was almost 3 hours shorter



■ Figure 2

Activity records for *M. cf. natalensis* in both plots.

Fixes (N) of all individuals (n) in each plot are pooled:

plot 1 (n = 4, N = 959), plot 2 (n = 3, N = 377).

than in the *Imperata-Cymbopogon* grassland (plot 1). The activity period in the bushland-grassland-mosaic was on average  $8.5 \pm 1.3$  h (n = 26) vs  $11.2 \pm 0.4$  h (n = 25) in the *Imperata-Cymbopogon* grassland (HOFFMANN, 1999).

## Discussion

### *Home range size and utilization*

Home range sizes of *M. cf. natalensis* determined by radio telemetry in different vegetation types vary considerably, from 0.022 ha in a Tanzanian fallow field (LEIRS *et al.*, 1996), to 0.840 ha in a bushland-grassland-mosaic (this study, plot 2). Our plot 1 results and those of CHEESEMAN (1975) from the same *Imperata-Cymbopogon* grassland are intermediate. Home range sizes are likely to be correlated with density: in the fallow field of Tanzania an enormous density of up to 401 ind./ha was found (LEIRS *et al.*, 1996), vs 25 in the *Imperata-Cymbopogon* grassland (CHEESEMAN, 1975; HOFFMANN, 1999), and only 7 in the bushland-grassland-mosaic (HOFFMANN, 1999). These findings suggest that high densities are associated with reduced mobility. Home range overlap suggests a non-territorial range utilization pattern, which supports the conclusions of LEIRS *et al.* (1996).

Home range sizes calculated using the CMR-technique were very much smaller than those revealed by radio-tracking. This was also found by LEIRS *et al.* (1996).

Our sample is not large enough for assessing a possible correlation between spatial or temporal patterns of activity and sex or sexual activity. Home range sizes found with the CMR-method (HOFFMANN, 1999) suggest, for both plots, that the home ranges of males are on average larger than those of females. This is in contrast with the results of CHEESEMAN (1975) and LEIRS *et al.* (1996). Sexually active individuals of both sexes were found to have larger ranges than inactive ones (LEIRS *et al.*, 1996; HOFFMANN, 1999). Seasonal variations in home range sizes could not be found in this species (OGUGE, 1995; CHRISTENSEN, 1996; LEIRS *et al.*, 1996; HOFFMANN, 1999).

### *Activity patterns*

The strictly nocturnal activity of the radio-tagged individuals substantiates previous trapping results (DELANY, 1964; NEAL, 1970). In the laboratory *M. cf. natalensis* has been found to exhibit short bouts of activity during the day (VEENSTRA, 1958; CHEESEMAN, 1975;

DUPLANTIER AND GRANJON, 1990), which may have been caused by the laboratory conditions. In our study an activity peak was found about 1 hour after dusk, whereas a second peak before dawn was not always distinct. The causes for the shorter activity period in plot 2 (fig. 2) are not clear. It may be because the quality and quantity of food available in the bushes were sufficiently high, so that feeding took less time than in plot 1. There, the animals spent less time resting during the nocturnal activity period. These differences can also be explained by differences of habitat use. The smaller home ranges in plot 1 (tabl. 1) may allow the animals additional time for e.g. exploration and foraging, after the main mid-night resting bout, which they spent in their nearby dens. In plot 2 the animals used bushes intensively (fig. 1). As the distances between the frequently used bushes were quite large (up to 80 m), returning to their nest sites for a short resting bout during the activity period would not be economical. The intensive use of the bushes and the reduced activity period in plot 2 should also result in reduced predation. Possibly the patchiness of food resources and shelters in plot 2 does not allow for high population density.

## References

- BURT W.H., 1943 —  
Territoriality and home range concepts as applied to mammals. *Journal of Mammalogy*, 24: 346-352.
- CHEESEMAN C.L., 1975 —  
*The population ecology of small rodents in the grassland of the Ruwenzori National Park, Uganda*. PhD Thesis, University Southampton.
- CHRISTENSEN J.T., 1996 —  
Home range and abundance of *Mastomys natalensis* (Smith, 1834) in habitats affected by cultivation. *African Journal of Ecology*, 34: 298-311.
- COETZEE C.G., 1975 —  
The biology, behaviour, and ecology of *Mastomys natalensis* in southern Africa. *Bulletin of the World Health Organisation*, 52: 637-644.
- DELANY M.J., 1964 —  
A study of the ecology and breeding of small mammals in Uganda. *Proceedings of the Zoological Society London*, 142: 347-370.
- DELANY M.J. and KANSIIMERUHANGA W.D.K., 1970 —  
Observations on the ecology of rodents from a small arable plot near Kampala, Uganda. *Revue de Zoologie et de Botanique Africaine*, 81 (3-4): 417-425.
- DUPLANTIER J.M. and GRANJON L., 1990 —  
Rythmes d'activité chez six espèces de Muridés du Sénégal appartenant aux genres *Mastomys*, *Arvicanthis*, *Myomys* et *Dasymys*. *Mammalia*, 54: 173-182.

- HOFFMANN A., 1999 —  
*Habitatnutzung und Populationsdynamik von Kleinsäugetern im Grasland des Queen Elizabeth National Park, Uganda.* Dissertation, Technische Universität Braunschweig.
- JONES E.N. and SHERMAN L.J., 1983 —  
A comparison of Meadow Vole home ranges derived from grid trapping and radiotelemetry. *Journal of Wildlife Management*, 47: 558-561.
- KENWARD R.E., 1987 —  
*Wildlife radio tagging: equipment, field techniques and data analysis.* Biological Techniques Series. London, Academic Press, 222 p.
- KENWARD R.E. and HODDER K.H., 1995 —  
*Ranges V. An analysis system for biological location data.* Institute of Terrestrial Ecology, Wareham, UK, 66 p.
- LEIRS H., 1995 —  
*Population ecology of Mastomys natalensis (Smith, 1834). Implications for rodent control in Africa.* Agriculture Edition - No. 35, Belgian Administration for Development Cooperation Brussels, 268 p.
- LEIRS H., VERHEYEN W. and VERHAGEN R., 1996 —  
Spatial patterns in *Mastomys natalensis* in Tanzania (Rodentia, Muridae). *Mammalia*, 60: 545-555.
- MONADJEM A., 1998 —  
Reproductive biology, age structure, and diet of *Mastomys natalensis* (Muridae: Rodentia) in a Swaziland grassland. *Zeitschrift für Säugetierkunde*, 63: 347-356.
- NEAL B.R., 1970 —  
The habitat distribution and activity of a rodent population in Western Uganda, with particular reference to the effects of burning. *Revue de Zoologie et de Botanique Africaine*, 81 (1-2): 29-50.
- NEAL B.R., 1977 —  
Reproduction of the multimammate rat, *Praomys (Mastomys) natalensis* (Smith) in Uganda. *Zeitschrift für Säugetierkunde*, 42: 221-231.
- OGUGE N.O., 1995 —  
Diet, seasonal abundance and microhabitats of *Praomys (Mastomys) natalensis* (Rodentia: Muridae) and other small rodents in a Kenyan sub-humid grassland community. *African Journal of Ecology*, 33: 211-223.
- TELFORD JR S.R., 1989 —  
Population biology of the multimammate rat, *Praomys (Mastomys) natalensis*, at Morogoro, Tanzania, 1981-1985. *Bulletin of Florida State Museum, Biological Sciences*, 34 (6): 249-287.
- VEENSTRA A.J.F., 1958 —  
The behaviour of the multimammate mouse, *Rattus (Mastomys) natalensis* (A.Smith). *Animal Behaviour*, 6 (3-4): 195-206.
- VOLOBOUEV V.T., HOFFMANN A., SICARD B. and GRANJON L. (2001) —  
Polymorphism and polytypy for pericentric inversions in 38-chromosome *Mastomys* (Rodentia, Murinae) and possible taxonomic implications. *Cytogenetics and Cell Genetics*, 92: 237-242.
- WHITE G.C. and GARROTT R.A., 1990 —  
*Analysis of wildlife radio-tracking data.* London, Academic Press, 383 p.