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POPULATION ECOLOGY OF RODENTS OF MAIZE FIELDS AND GRASSLAND IN CENTRAL ETHIOPIA

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Abstract. We report on the presence of rodents in grassland and maize fields in central Ethiopia, during the course of a 21-month study by means of removal and capture-recapture trapping. In both habitats, the small mammal fauna consisted of the same species but in different relative proportions: *Arvicanthis dembeensis, Mastomys erythroleucus, Tatera robusta, Rattus rattus, Mus mahomet* and *Crocidura olivieri. A. dembeensis* and *M. erythroleucus* were the dominant species. Densities were generally low throughout the study period, but at the end of the breeding season in the second year of the study, the numbers of *A.dembeensis* reached high values in the grassland. Breeding was seasonal and related to rainfall periods: extended rainy seasons resulting in longer periods with breeding females and higher litter sizes and, consequently, population size increases. These observations suggest that rodent population dynamics in the study area are linked to rainfall patterns and this information can be used to develop forecasting models.

Key words: *Mastomys, Arvicanthis, Tatera*, rodent ecology.

INTRODUCTION

Rodent outbreaks over large areas have been reported from many localities in Africa but also in non-outbreak years damage to agriculture may be considerable (FIEDLER, 1988). In Ethiopia, it has been estimated that rodents consume or destroy up to 20% of the cereal crops in some years (GOODYEAR, 1976). The country possesses 70 rodent species of which 15 are endemic (HILLMAN, 1993; YALDEN & LARGEN, 1992 and YALDEN *et al.*, 1996). Despite this diversity, only few studies on the taxonomy, distribution and population ecology of rodents have been conducted in Ethiopia (INGERSOL, 1968; YALDEN *et al.*, 1976, MÜLLER, 1977; RUPP, 1980; YALDEN, 1988a, b; AFEWORK BEKELE *et al.*, 1993 and AFEWORK BEKELE, 1996) and most of these did not focus on pest species. Preliminary surveys showed that there are eleven species of rodents in Ethiopia that can be classified as pests, among which *Arvicanthis dembeensis* (Thomas, 1901) and *Mastomys erythroleucus* (Temminck, 1853) are the major ones in the field (unpublished information).

A sound understanding of population dynamics may allow to predict changes in rodent numbers, which is of prime importance for the development of management strategies. Recently, an outbreak prediction method using rainfall information was presented for Tanzanian populations of *Mastomys natalensis* (Smith, 1834) (LEIRS *et al.*, 1996); the relation between rainfall and life histories, mainly reproduction, was central in that study. In order to investigate to what extent the same underlying biological knowledge could be applied to pest rodent populations in other parts of East Africa, we set up a basic ecological study in Ethiopia. Indeed, although the reproductive pattern and ecology of *Mastomys* and *Arvicanthis* species in different regions of Africa have been studied by different investigators (BRAMBELL & DAVIS, 1941; OLIFF, 1953; JOHNSTON & OLIFF, 1954; MEESTER, 1960; COETZEE, 1965; BAKER & MEESTER, 1977; NEAL, 1981; CHIDUMAYO, 1984; LEIRS *et al.,* 1990 and LEIRS, 1995), very little has been done on the Ethiopian species. Here we report the first results of our study, focusing on the seasonality of reproduction.

MATERIAL AND METHODS

The study area (Koka Dairy Farm Enterprise) is located along the main Rift Valley, 95 km South of Addis Ababa, at 08°25'N 39°02'E, 1700 m asl. The vegetation consists of savanna woodland. It was formerly protected as a ranch and at present serves as a centre for hay preparation and maize farm for feeding dairy cattle. The surrounding area is intensively farmed and degraded. Different sites that represent farmland (maize fields) and grassland (fallow land) were selected after assessing the presence of pest rodents.

Data were collected by using both Capture-Mark-Recapture (CMR) and removal trapping techniques, between April 1995 and December 1996. For the CMR study, a one hectare grid in the maize farm and another one in the grassland were laid out. Each grid consisted of 100 trapping stations, 10 m from each other in a square quadrat. Coded wooden pegs or bricks were used at each trapping station. In each grid, we trapped every month with 100 Sherman live traps for three consecutive days, using peanut butter as bait. The traps were checked daily during early morning and late afternoon. However, in summer, the traps were closed from 10.00 a.m to 3.00 p.m. The captured animals were marked by toe-clipping. The date of capture, trapping station, toe-clipping code, sexual condition and body weight (using a Pesola spring balance, accurate to the nearest g) were recorded for each captured animal prior to release. Population sizes were enumerated as Minimum Number Alive (KREBS, 1966) since recapture/release occurrences in several months were too low to allow statistical estimates; for the same reason, we do not discuss survival patterns in this paper.

Monthly removal trapping was initially carried out with Museum Special mouse traps and Victor rat traps. The Museum Special mouse traps were later on avoided because of their inefficiency in capturing larger-sized rodents. The location of trapping sites was changed every month to cover different vegetation zones. However, since March 1996, removal trapping was restricted to maize field and grassland habitats similar to those of the CMR grids; in the present paper we use only the animals from these two habitat types. The captured animals were weighed, standard external measurements were taken and reproductive condition was recorded. The animals were then preserved in formalin and are being kept in the collections of the Zoological Natural History Museum, Addis Ababa University, Ethiopia. Climatological data on rainfall, minimum and maximum temperature were collected on a daily basis since June 1995 from our own small weather station at the

Koka Dairy Farm; the preceding months of the field study (April-May 1995) had little rain (unquantified observations).

RESULTS

The small mammal fauna in the removal trapping consisted of *Arvicanthis dembeensis, Mastomys erythroleucus, Tatera robusta* (Cretzschmar, 1830), *Crocidura olivieri* (Lesson, 1827), *Mus mahomet* Rhoads (1896) and *Rattus rattus* (L., 1758). In total, the removal trapping yielded 2995 specimens in grassland and maize fields (Table 1). *A. dembeensis* and *M. erythroleucus* were the dominant species, accounting for 87% of the total capture, with *A. dembeensis* being the most common rodent in grassland while *M. erythroleucus* took this position in the maize fields. The species distribution was significantly different between both habitat types (χ^2=231.72, d.f.=5, p<0.001). In the period between April and December 1996, when trapping effort was the same in both habitat types, less species were trapped but the common species showed an equally different habitat preference (χ^2=293.68, d.f.=3, p<0.001) with many more *A. dembeensis* trapped in the grassland and *M. erythroleucus* in the maize fields; in total, considerably more specimens were collected in the grassland (Table 1).

TABLE 1

Number of individuals of different species collected during the removal trapping study and CMR-study in grassland and maize field habitats in Koka. The figures in italics indicate the number of specimens obtained between April and December 1996 when the monthly removal trapping effort was the same in both habitats

	Removal study						*CMR-study*		
	Grass		*Maize*		*Total*		*Grass*	*Maize*	*Total*
Arvicanthis dembeensis	1484	*403*	114	*71*	1598	*474*	149	84	233
Mastomys erythroleucus	730	*76*	293	*228*	1023	*304*	68	87	155
Tatera robusta	202	*109*	67	*57*	269	*166*	57	58	115
Mus mahomet	3	-	-	-	3	-	2	3	5
Rattus rattus	5	-	-	-	5	-	0	1	1
Crocidura olivieri	86	*39*	11	*10*	97	*49*	25	23	48
Total	2510	*627*	485	*366*	2995	*993*	301	256	557

In the CMR-study, we realised 1470 captures of 557 individuals. The same species occurred as in the removal trapping and also here the species distribution differed between grids (χ^2=18.24, d.f.=5, p=0.003). Again *A. dembeensis* was the dominant species in the grassland while *M. erythroleucus* was the most common one on the maize fields (Table 1). The most common rodent species (*A. dembeensis* and *M. erythroleucus*) showed similar fluctuations in population size in the grassland grid (Fig. 1). Although population sizes were low and rather constant during most of the time, both species showed an increase in numbers at the end of the rainy season. In 1995, the populations quickly returned to low numbers, but in 1996 they continued to increase well into the dry season and then decreased again towards the end of the year. Although *A. dembeensis* was not trapped during the initial months of the work in the grassland, this species reached high numbers there in late 1996. The population of *T. robusta* in the grassland showed an increasing trend but no such obvious fluctuations. In the maize grid, the situation was different with more irregular patterns (Fig. 1). Here *A.dembeensis* reached its highest densities, but no sharp peaks, in the dry season of 1995-1996; at that moment the species was rare in the grassland. The reverse happened in late 1996. The numbers of *M. erythroleucus* did not fluctuate considerably but showed throughs in the dry season and higher densities during the rainy seasons.

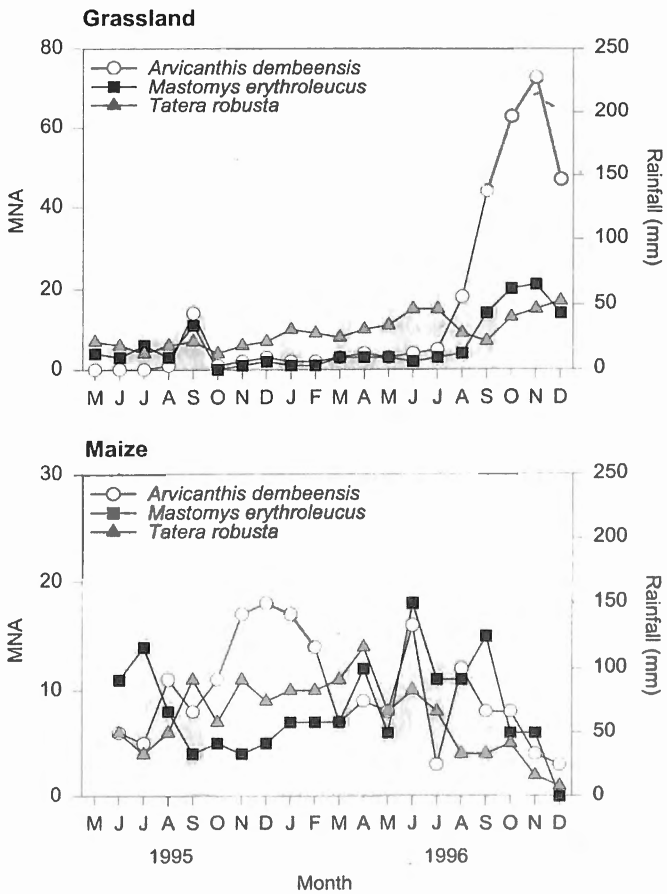

Fig. 1. – Monthly variation of Minimum Number Alive for *Arvicanthis dembeensis, Mastomys erythroleucus* and *Tatera robusta* in the Grassland and Maize field CMR-grids at Koka. Columns show monthly rainfall.

The CMR-data show seasonal breeding in *A. dembeensis* and *M. erythroleucus,* less so in *T. robusta* (Fig.2). Females of *A.dembeensis* and *M. erythroleucus* are pregnant or lactating late in the rainy season and the early dry season. The removal trapping data show similar seasonality in the maize grids but not in the grassland where, throughout the year, nearly every month a small proportion of the females is pregnant (Fig. 3).

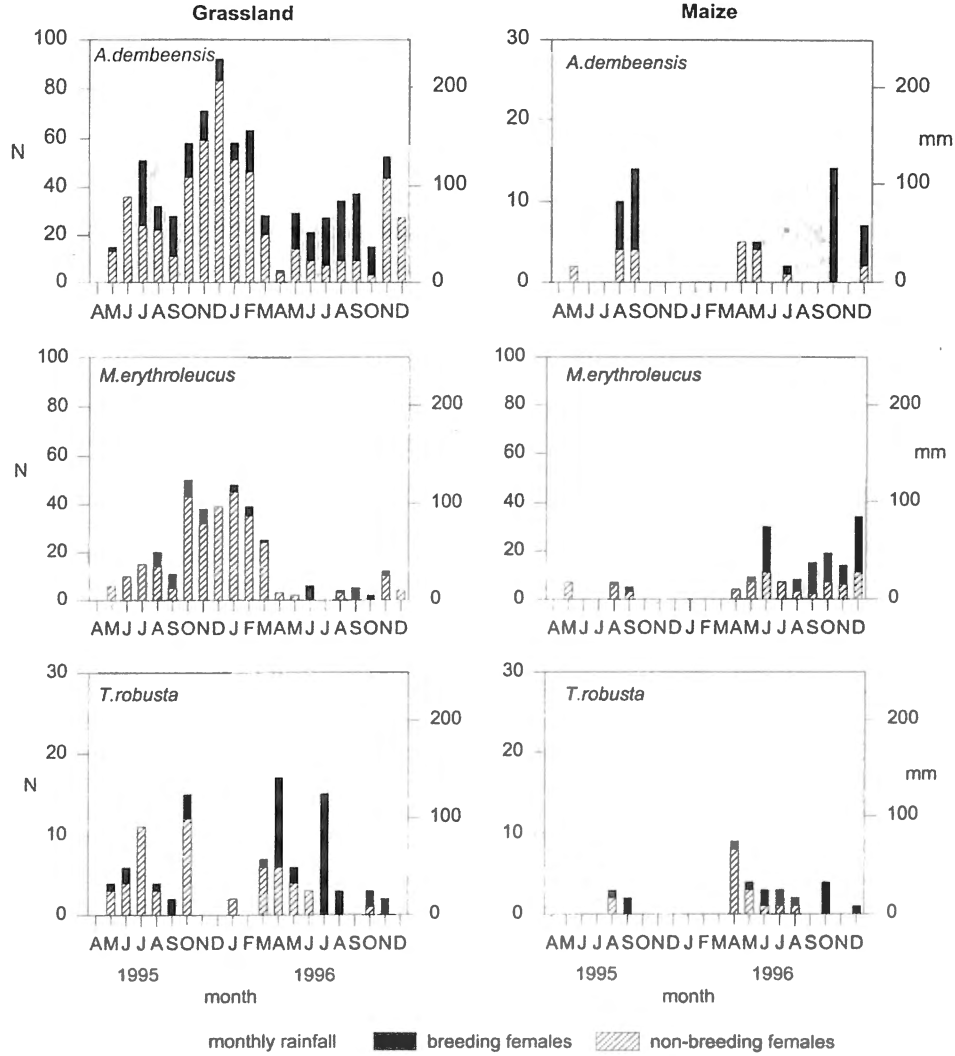

Fig. 2. – Monthly numbers of breeding (lactating or pregnant) and non-breeding females of *Arvicanthis dembeensis, Mastomys erythroleucus* and *Tatera robusta* in the Grassland and Maize field CMR-grids at Koka. Gray background columns show monthly rainfall.

Litter size (number of embryos *in utero*) is also fluctuating seasonally, with higher average values during the second half of the rainy season, both in *A. dembeensis* and *M. erythroleucus*; data for *T. robusta* were too scanty to investigate seasonal patterns (Fig. 4). Overall, litters were smaller in the grassland than in the maize fields for *A. dembeensis*) and *M. erythroleucus* but not in *T. robusta* (Table 2).

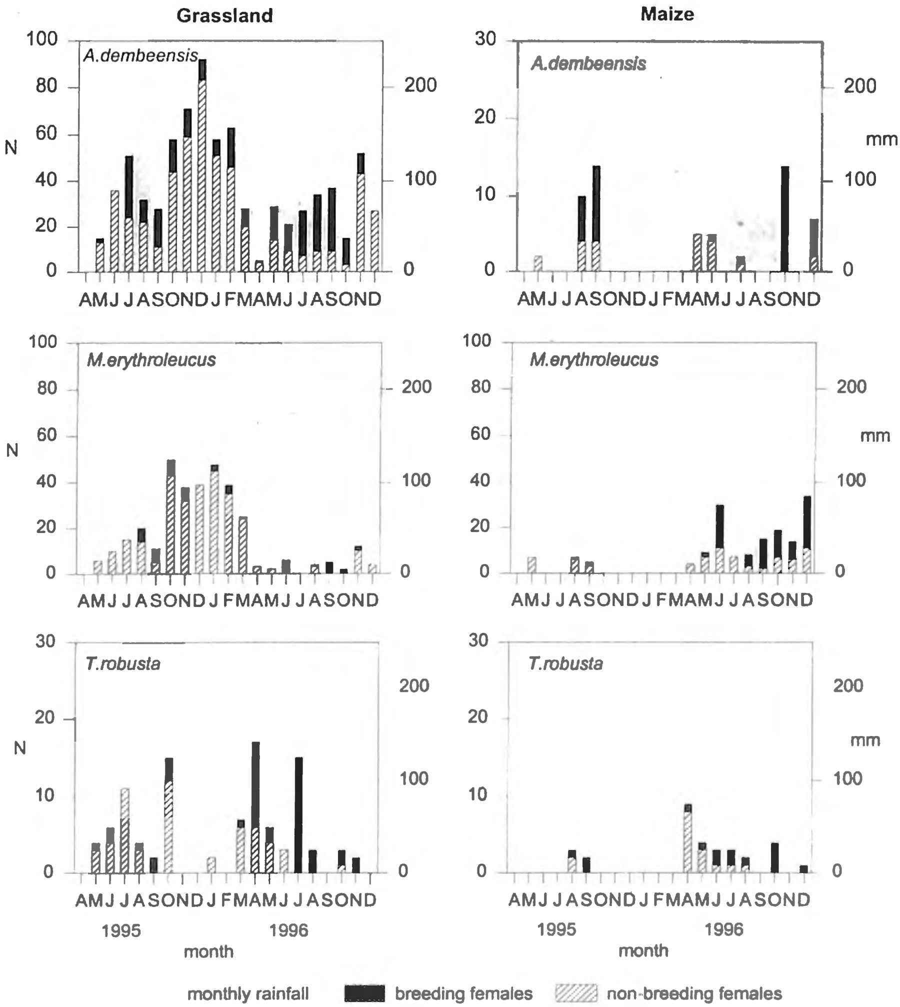

Fig. 3. – Monthly numbers of breeding (lactating or pregnant) and non-breeding females of *Arvicanthis dembeensis, Mastomys erythroleucus* and *Tatera robusta* in the Grassland and Maize removal trapping sites at Koka. Gray background columns show monthly rainfall.

TABLE 2

Litter size for different species in different habitats at Koka and significance of difference between habitats (t-test), (n=sample size)

Species	*Grassland*		*Maize field*		
	mean ± s.d.	*n*	*mean ± s.d.*	*n*	*t-test*
Arvicanthis dembeensis	5.74 ± 2.65	206	7.42±2.63	33	p<0.001
Mastomys erythroleucus	10.21 ± 4.32	32	12.84±3.26	64	p=0.001
Tatera robusta	5.00 ± 1.63	13	5.73±1.72	11	p=0.243

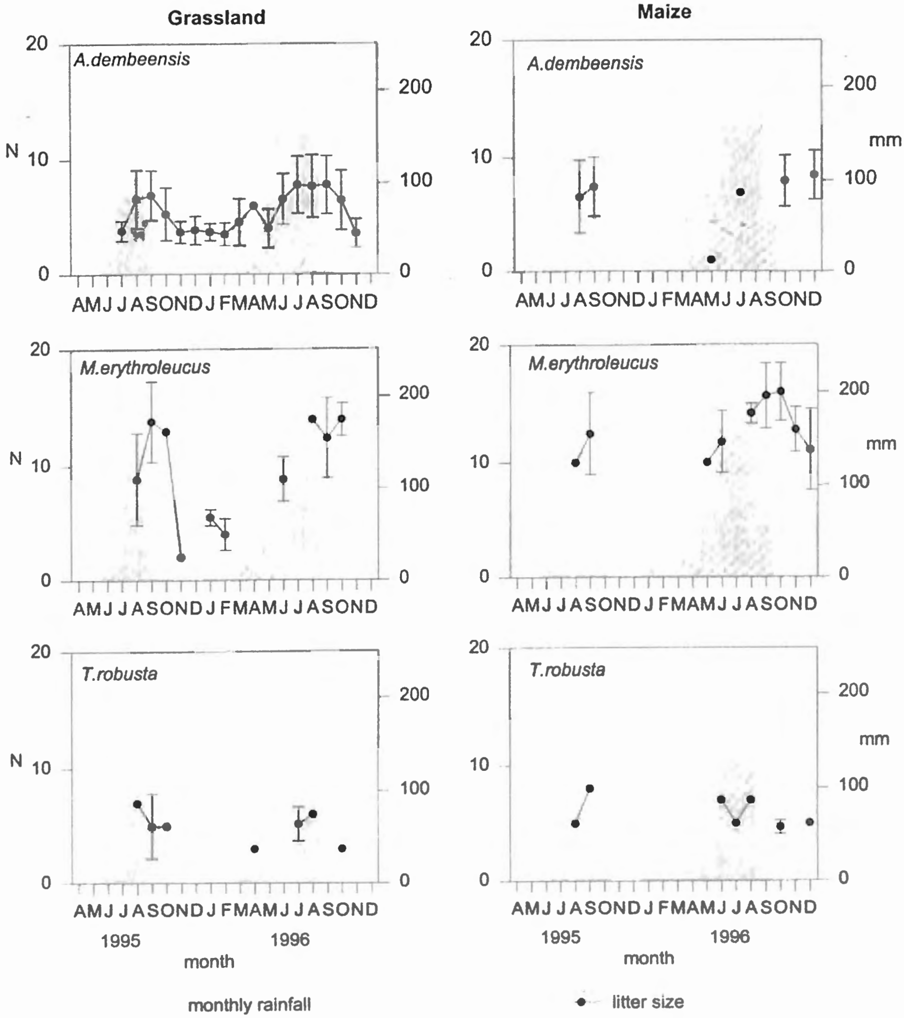

Fig. 4. – Monthly litter sizes (mean ± st.dev) in pregnant females of *Arvicanthis dembeensis, Mastomys erythroleucus* and *Tatera robusta* in the Grassland and Maize field removal trapping sites at Koka. Gray background columns show monthly rainfall.

DISCUSSION

In general, we experienced very low densities of rodents. This was also the case for the two pest species *A. dembeensis* and *M. eryttroleucus* which were nevertheless the most common species in our study and on which we will focus in this discussion. LEIRS (1995) reviewed reported population size estimates for different *Mastomys* species in Africa and found generally much higher fluctuations with maxima of up to a thousand animals per hectare in outbreak years and, more typically, several hundreds during usual seasonal peaks. However, in *M. erythroleucus* in dry Sahel woodland, densities were only around

90 animals per hectare during an outbreak in 1975 and stayed below 10 ind/ha during most other years (HUBERT & ADAM, 1983); similar densities were also reported for *Arvicanthis niloticus* (Desmarest, 1822), which is sometimes considered to include *A. dembeensis* (MUSSER & CARLETON, 1993), during the same outbreak in Senegal (POULET & POUPON, 1978). In a study in Kenya, *A. niloticus* reached higher densities in bushy scrubland but not in grassland (DELANY & ROBERTS, 1978). Thus, although the densities observed in our study are considerably lower than those seen with field mice in Tanzania (LEIRS *et al.*, 1996), they are not atypical. Although our data set is too short for comparisons between years, the literature cited here suggests that, in the grassland, the densities in 1995 were normal, while the increase of numbers in late 1996 could be considered as a small outbreak, at least in *A. dembeensis* and to some extent also in *M. erythroleucus*. Seasonal patterns in density variations were weak, although in both years, there was an increase towards the end of the rainy season; in 1995, however, densities decreased again immediately, while in 1996, the increase started earlier and continued for some months.

In the maize field, densities remained low all the time and there were no clear patterns; also the «outbreak in late 1996» was not seen in the maize fields. Generally lower rodent densities in maize fields, even at peak numbers in grassland, were also observed by GOODYEAR (1976) in the south Central Plateau in Ethiopia. Agricultural activities may play a role in this since the peak densities in the grassland in our study occurred just after the fields were harvested and became, presumably, unfavourable to large rodent populations.

Breeding activity was clearly seasonal in *A. dembeensis* and *M. erythroleucus* in our CMR-study with breeding females in the second half of the rainy season and the early part of the dry season. This is consistent with literature findings from populations of these or related species elsewhere in Africa were breeding also commences a few months after the onset of the rains (*e.g.* DELANY & ROBERTS, 1978; NEAL, 1981; HUBERT & ADAM, 1983; DELANY & MONRO, 1986; LEIRS, 1995 and other references therein). In our removal study, the seasonal pattern was not so clear in the grassland: there, we found breeding females nearly every month. However, our range of fallow-grassland trapping sites was more diverse than that of maize field sites and unsuspected habitat effects may have masked seasonal effects here. In other removal trapping studies, *Arvicanthis* species also showed a less outspoken reproductive seasonality, particularly when habitats were less variable seasonally (DELANY & NEAL, 1969; NEAL, 1981). Obviously, any habitat effects are not visible in a CMR-study on a single, homogeneous site.

Litter sizes in the present study were on the upper side of the published ranges for these species (NEAL 1981; LEIRS, 1995). The seasonal peaks in litter size coincide with the peaks of breeding activity in females in the rainy season and the early dry season. In 1996, when the rains were more abundant than in 1995, the peak of litter size was maintained for a longer period than in the previous year and also the period of intensive breeding activity in females lasted longer. This can explain the higher densities at the end of 1996. The fact that *A. dembeensis* reached higher numbers than *M. erythroleucus*, despite the higher litter size in the latter, may be due to the fact that *Arvicanthis* species have young that mature within a few weeks, while it takes at least two months in *Mastomys* species (DELANY & MONRO, 1985; LEIRS, 1995). This means that *A. dembeensis* young born early in the breeding season in 1996, could probably still participate in breeding in the same year. This relation between rainfall, particularly the length of the rainy season, and reproductive performance is central in the forecasting model that we intend to apply on our data (LEIRS *et al.*, 1996). Although we need to continue the analysis of our data with respect to maturation and survival, it seems that this model may also be of value to the Ethiopian situation. In order to investigate interannual variation, the field studies at Koka are being continued.

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REFERENCES

AFEWORK BEKELE (1996) – Population dynamics of the Ethiopian rodent *Praomys albipes* in the Menagesha State Forest. *J. Zool., Lond.* **238**: 1-12.

AFEWORK BEKELE, E. CAPANNA, M. CORTI, L.F. MARCUS & D.A. SCHLITTER (1993) – Systematics and geographic variation of Ethiopian *Arvicanthis* (Rodentia, Muridae). *J. Zool., Lond.* **230**: 117-134.

BAKER, C.M. & J. MEESTER (1977) – Postnatal physical and behavioural development of *Praomys (Mastomys) natalensis* (A. Smith, 1834) *Z. Säugetierk.,* **42**: 295-306.

BRAMBELL, R. & D.H.S. DAVIS (1941) – Reproduction of the multimammate mouse (*Mastomys erythroleucus* Temm.) of Siera Leone. *Proc. Zool. Soc. Lond., Ser. B,* **3**: 1-11.

CHIDUMAYO, E.N. (1984) – Observations on populations of multimammate mice at Livingstone, Zambia. *Mammalia, **48*** (3): 363-376.

COETZEE, C.G. (1965) – The breeding season of the multimammate mouse *Praomys (Mastomys) natalensis* (A. Smith) in the Transvaal highveld. *Zool Afr.,* **1**: 29-39.

DELANY, M.J. & B.R. NEAL (1969) – Breeding seasons in rodents in Uganda. J. *Reprod. Fert.*, **6** (Suppl.): 229-235.

DELANY, M.J. & C.J. ROBERTS (1978) – Seasonal population changes in rodents in the Kenya Rift valley. *Bull. Carn. Mus. Nat. Hist.*, 6:97-108.

DELANY, M.J. & R.H. MONRO (1985) – Growth and development of wild and captive Nile rats, Arvicanthis niloticus (Rodentia: Muridae). *Afr. J. Ecol.*, 23:121-131.

DELANY, M.J. & R.H. MONRO (1986) – Population dynamics of *Arvicanthis niloticus* (Rodentia: Muridae) in Kenya. *J. Zool.*, 209:85-103.

FIEDLER, L.A. (1988) – Rodent problems in Africa. In: *Rodent pest management.* PRAKASH, I. (Ed.). CRC Press, Inc., Boca Raton: 35-65.

GOODYEAR, J.J. (1976) – Population fluctuations of the rat-like rodents of importance in agricultural fields in Kaffa province, Ethiopia. M.A. thesis University of Bowling Green (72 pp).

HILLMAN, J.C. (1993) – *Ethiopia: a compendium of wildlife conservation information.* NYZS-WCS and EWCO, Addis Ababa, pp. 1-786.

HUBERT, B. & F. ADAM (1983) – The regulation of the population dynamics of two Sahelian rodents in Senegal: a hypothesis. *Ann. Mus. Roy. Afr. Centr. Zool.*, **237**: 193-201

INGERSOL, R.H. (1968) – *The ecological stratification of mammals in the Eastern Chercher Highlands of Harar Province, Ethiopia.* PhD thesis, Oklahoma State University.

JOHNSTON, H.L. & W.D. OLIFF (1954) – The oestrous cycle of female *Rattus (Mastomys) natalensis* (Smith) as observed in the laboratory. *Proc. Zool. Soc. London*, **124**: 605-613.

KREBS, C.J. (1966) – Demographic changes in fluctuating populations of *Microtus californicus. Ecol. Mon.*, **36**: 239-273.

LEIRS, H. (1995) – *Population ecology of Mastomys natalensis* (Smith, 1834). *Implications for rodent control in Africa.* Belgian Administration for Development Cooperation, Agricultural Editions n° 35, (256 pp).

LEIRS, H., J. STUYCK, R. VERHAGEN & W. VERHEYEN (1990) – Seasonal variation in growth of *Mastomys natalensis* (Rodentia: Muridae) in Morogoro, Tanzania. *Afr. J. Ecol.*, **28**: 298-306.

LEIRS, H., R. VERHAGEN, W. VERHEYEN, P. MWANJABE & T. MBISE (1996) – Forecasting rodent outbreaks in Africa : an ecological basis for Mastomys control in Tanzania. *J. Appl. Ecol.*, **33**: 937-943.

MEESTER, J. (1960) – Early post-natal development of multimammate mice *Rattus (Mastomys) natalensis* (Smith). *Ann. Transvaal Mus.*, **24**: 35-52.

MÜLLER, V.J.P. (1977) – Populationsökologie von *Arvicanthis abyssinicus* in der Grassteppe des Simien Mountains National Park. (Äthiopien). *Z. Säugetierk.*, **42**: 145-172.

MUSSER, G.G. & M.D. CARLETON (1993) – Order Rodentia, Family Muridae. In: *Mammal Species of the World.* WILSON, D.E. & D.M. REEDER (Eds). Smithsonian Institution Press, Washington (1206 pp).

NEAL, B.R. (1981) – Reproductive biology of the unstriped grass rat, *Arvicanthis*, in East Africa. *Z. Säugetierk.*, **46**: 174-189.

OLIFF, W.D. (1953) – The mortality, fecundity and intrinsic rate of natural increase of the multi-mammate mouse, *Rattus (Mastomys) natalensis* (Smith) in the laboratory. *J. Anim. Ecol.*, **22**: 217-226.

POULET, A.R. & H. POUPON (1978) – L'invasion d'*Arvicanthis niloticus* dans le Sahel Sénégalais en 1975-1976 et ses conséquences pour la strate ligneuse. *Terre et Vie*, **32** (2): 161-193.

RUPP, H. (1980) – Beiträge zur Systematik, Verbreitung und Ökologie äthiopischer Nagetiere: Ergebnisse mehrerer Forschungsreisen. *Säugetier. mitteil.*, **28**: 81-123.

YALDEN, D.W. (1988a) – Small mammals in the Harenna Forest, Bale Mountains National Park. *Ethiop. J. Sci.*, **11**: 41-53.

YALDEN, D.W. (1988b) – Small mammals of the Bale Mountains, Ethiopia. *Afr. J. Ecol.*, **26**: 281-294.

YALDEN, D.W. & M.J. LARGEN (1992) – The endemic mammals of Ethiopia. *Mammal Rev.* **22**: 115-150.

YALDEN, D.W., M.J. LARGEN & D. KOCK (1976) – Catalogue of the mammals of Ethiopia. 2. Insectivora and Rodentia. *Mon. Zool. ital.* (N.S.) Suppl. **8**: 1-18.

YALDEN, D.W., M.J. LARGEN, D. KOCK & J.C. HILLMAN (1996) – Catalogue of the mammals of Ethiopia and Eritrea. 7. Revised checklist, Zoogeography and conservation. *Tropical Zoology* **9**: 73-164.