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THE USE OF RAINFALL PATTERNS IN PREDICTING POPULATION DENSITIES OF MULTIMAMMATE RATS, Mastomys natalensis

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ABSTRACT: During 3 years we studied a population of multimammate rats, Mastomys natalensis (Smith 1834), in Morogoro, Tanzania. Data were collected in both removal and capture-recapture schemes. We present evidence that patterns of growth and reproduction were related to onset and abundance of rains. This partially explains differences in densities. Additionally, we investigated available literature data and related them with climatological data. A scenario is presented which enables us to predict how densities of multimammate rats may evolve in the following year and whether there will be a risk of outbreaks. The use and implications of this scenario in planning control actions are discussed.

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INTRODUCTION

Murids of the genus Mastomys, also known as multimammate rats, are very common and widespread in subsaharan Africa. They form a complex grouping, several species of which are morphologically hard to distinguish but have different karyotypes (Robbins and van der Straeten 1989). They are not only important agricultural pests causing problems every year, but also reservoirs of human diseases such as plague and Lassa-fever. Eventually serious population outbreaks may occur during which disastrous damage may be provoked. Fiedler (1988a) gives a list of such outbreaks.

It is unknown which factors induce these outbreaks but in many instances they occurred after a year of heavy rains. To examine how rainfall can possibly influence population numbers, it is necessary to investigate the relationships between rainfall patterns and population processes like reproduction, growth, and survival. Knowledge of these relationships will be useful to understand population dynamics and eventually can help to predict changes in population density.

Several researchers studied the population dynamics of Mastomys and suggested a relationship between rainfall and reproduction. An overview is given by Neal (1977). Fiedler (1988b) concluded from literature data that outbreaks were likely to occur when rains started again after several years of extensive drought. This enabled him to predict the 1985-86 outbreak in Sudan. While his conclusions are useful for the Sahelian region, they are less applicable in subsaharan Africa since such long periods of extremely dry years do not occur there.

To examine the situation in Tanzania, we studied the relationship between rainfall and growth and reproduction in Mastomys populations as well as annual variations in growth and densities. A more detailed discussion of parts of this paper can be found in Leirs et al. (1989) and Leirs et al. (submitted). Finally, we will investigate some published data on Mastomys outbreaks in Africa and try to explain them using rainfall data.

MATERIAL AND METHODS

Collecting Animals

Our study area consisted of approximately 5 sq km of maize fields or fallow fields on the campus of the Sokoine University of Agriculture in Morogoro, Tanzania, approximately 200 km west of Dar es Salaam. Monthly, between September 1986 and February 1989, we collected animals using Sherman live traps or Museum Special break-back traps set along traplines with traps spaced 5 to 10 m apart. Traps were baited with peanut butter, set in the afternoon, and left in the field overnight. Trapping went on during a variable number of nights, depending on trap success. Traplines were relocated each month. In total, 3,356 animals were caught, measured, dissected, their sexual condition noted, and subsequently fixed in formalin and preserved in alcohol.

Additionally, we performed a capture-mark-release study (CMR) between March 1987 and February 1989. Monthly during 3 consecutive nights, animals were live-trapped in two 1-ha grids of 100 trapping stations, using Sherman live traps baited with peanut butter. The animals were weighed and their sexual condition was noted; they were marked by toe-clipping and then released. We realised 8,715 catches for 3,332 individuals. The multimammate rats were determined as Mastomys natalensis (A.Smith, 1834), chromosome number 2n=32.

Densities

Population densities were estimated during the capture-recapture study, using the Minimum Number Alive (MNA) method. This method totals the number of animals caught during a given month, plus the animals not caught during that month but in earlier and later months.

Age Estimation and Growth

Using the dry-eye lens-weight technique, we estimated the age of 1,773 animals obtained from the removal trapping and assigned these animals to cohorts of individuals born in the same month. With these data, we also determined a "critical value" to estimate age from body weight in very young animals. Animals weighing less than this value at first capture in the CMR-study were considered to be born during the previous month and grouped in the appropriate cohort. A full description of these age-estimation techniques will be published elsewhere (Leirs et al., submitted).

Climatological Data

Climatological data for Morogoro during the study period were obtained from the meteorological station on the university campus. Rainfall data from other localities or periods were obtained from the Meteorological Office, Bracknell, Berks., UK, or collected from literature.

RESULTS

The rainy season in Morogoro lasts from October to May but with a bimodal pattern : usually there is a small peak of rainfall in November-December (in Kiswahili "mvuli"-rains) while most of the rain falls in March-May (in Kiswahili "masika"-rains). However, this pattern can vary considerably from year to year (Fig. 1).

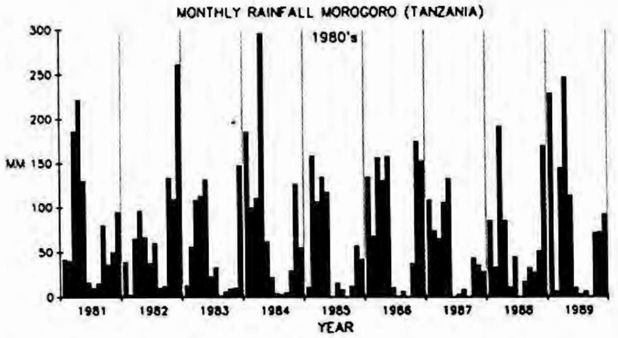

Figure 1. Monthly rainfall in mm for Morogoro 1981-1989.

Figure 2 shows the presence of pregnant females in the population. Mastomys starts breeding 1 month after the onset of the masika-rains of March-May and the breeding season extends until October. However, if mvuli rainfall in November-December is abundant (e.g., 1986), there is a short off-season breeding period in the beginning of the following year.

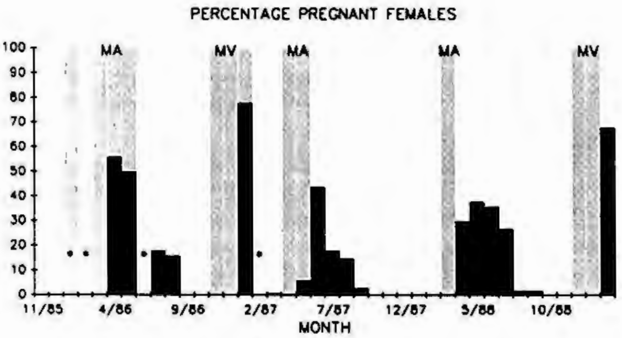

Figure 2. Percentage of pregnant females per month for Morogoro. The shaded areas show months with more than 100 mm rainfall. (MV=mvuli-rains; MA=masika-rains). Asterisks indicate months for which no data are available.

To evaluate growth, we calculated the mean weight of all non-pregnant individuals for each cohort every month (Fig. 3). Animals born during the main breeding season (June-September) grow fast when they are young but enter a growth stop near the end of the dry season. Growth is resumed only after the first heavy rains, which can occur already in December or otherwise wait until about March. Animals born during the additional breeding season in the beginning of the year grow fast without a growth stop, reach their final weight by March-April, and participate in breeding during the same year (Fig. 4).

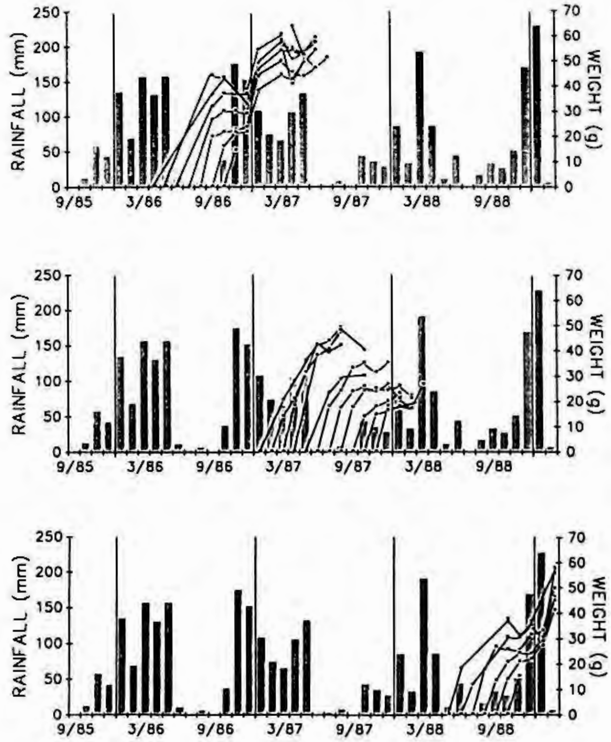

Figure 3. The evolution of mean body weights per month for all cohorts (lines) in relation to monthly rainfall (shaded columns); upper: 1986-born cohorts; middle: 1987-born cohorts; lower: 1988-born cohorts. The vertical lines indicate the beginning of a new year.

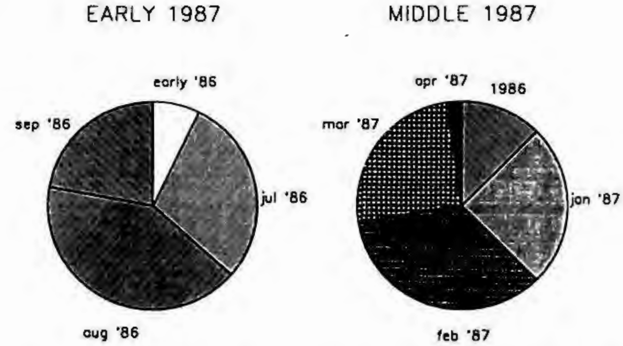

Figure 4. Age composition of pregnant females in early 1987 (off-season breeding in January) and middle 1987 (main breeding season). The animals are grouped according to month of birth.

Densities varied considerably during the study period (Fig. 5). Maximum numbers were reached around November, minima around the middle of the year. Densities at the beginning of the year were higher when rainfall during the end of the previous year had been abundant.

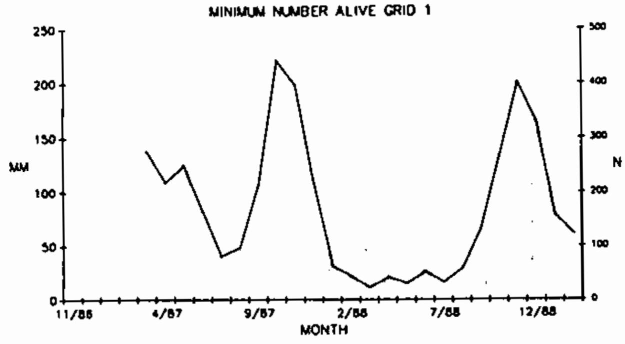

Figure 5. Evolution of Minimum Number Alive on a 1-ha plot during the capture-mark-release study. Dotted columns show monthly rainfall.

DISCUSSION

The results show a clear relationship between rainfall and reproduction, growth, and densities. Survival could only be expressed as a local survival rate but this was difficult to interpret due to effects of migration and age-dependant variations which will not be dealt with in detail here. Nevertheless, the sharp density decrease at the end of the year is less marked after heavy mvuli-rains, suggesting that survival is higher in such conditions.

Without discussing the proximate factors which cause animals to breed, grow, or die, we suggest the following scenario. Young animals born during the main breeding season have a growth stop near the end of the dry season (October). In most years mvuli-rains are not abundant and survival is poor. As a result, densities are low in March. The animals resume growth after the start of the masika-rains and start reproducing. Newborn animals show the same pattern all over again, most of them without reproducing the same year. However, if mvuli rains are heavy near the end of the year, survival is higher, the animals resume growth very soon and start reproducing shortly afterwards. The resulting animals grow fast without any growth stop and start reproducing after the onset of the masika-rains of the same year. Abundant mvuli-rains will therefore result in higher numbers of possibly reproducing animals at the start of the main breeding season. This increases the potential for higher densities later in the year. The fate of the population after the masika-rains remains uncertain, but even without being able to predict how densities will change during the dry season, it is sure that high rodent numbers will be more likely when the starting population is larger. It should be pointed out that not only the mere quantity of rain is important in this scenario, but also the distribution of rains through the whole rainy season.

To test this scenario, we applied it to some literature data. Mastomys populations from the same university campus in Morogoro had been studied before, between 1981 and 1985, but the first results were published only very recently (Telford 1989). Although the data do not allow the same analysis as ours, we can use them to check our own hypotheses. Telford (1989) reported off-season reproductive activity in early 1983 and 1984, as we would expect after the abundant rains at the end of the preceding years (Fig. 1). According to the above scenario this would create a potential for high densities later in the year and indeed, Telford (1989) estimated density in late 1983 to be "much greater than in the other years" and recorded very high densities in October 1984.

Harris (1937) discussed the 1930-1931 Mastomys outbreak in Kimamba, Tanzania, about 60 km away from Morogoro. We collected rainfall data from Morogoro for this period from the Tanganyika Territory Department of Agriculture Annual Reports and were able to apply our scenario. A look on Fig. 6 reveals that rainfall in late 1929 and early 1930 was extremely high, and rodents were very numerous in November 1930 (Harris 1937). The end of 1930 was dry and Harris (1937) noted a serious decrease in rodent numbers. The 1930 mvuli rains were not particularly rich but abundant masika-rains started already in January 1931 and rodent numbers became high again. The 1931-1932 rains were moderate and population densities declined.

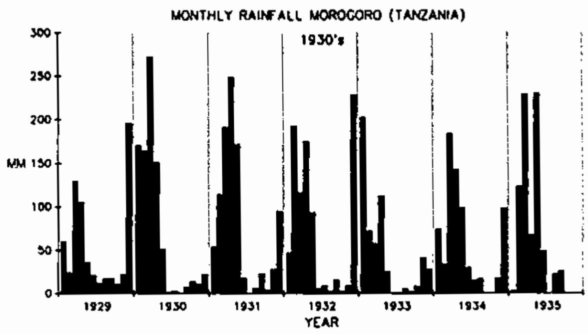

Figure 6. Monthly rainfall in mm for Morogoro 1929-1935.

Multimammate rats in Zambia also start reproducing soon after the onset of rains (Chidumayo 1984); the rainy season has the same timing as in Tanzania, but it is not bimodal: rains start in October-November and continue until April with one peak somewhere in between (Fig. 7). Sheppe (1973) reported a Mastomys outbreak in 1966. Rainfall was abundant that year but not extraordinary and the temporal distribution of rain was normal for the region, although rather much of it fell during the first part of the rainy season. Maybe the same biological mechanisms as in Morogoro have been involved in this case but our scenario cannot be well applied in such conditions, and outbreaks in regions with only one annual rainfall peak need further study.

Therefore, the Morogoro scenario seems useful in bimodal rainy season systems. It can predict whether the potential for outbreaks is present in the following year and at least it will tell if densities will be high around March. The beginning of masika-rains is also the start of a new planting season, and rodent damage in this season has very negative effects on the final yield. If agricultural officers realise that abundant rains early in the rainy season will be followed by higher Mastomys densities in the planting season of the following year, damage could be anticipated by preventive measures. Of course, decreasing the number of animals in the starting population is no guaranteed way to prevent high densities later in the year; Myllymaki (1987) reported that control actions of Mastomys in April are successful in the beginning, but dispersing animals from neighboring populations take all the empty places in a few months. Still, since cumulative losses due to rodent damage at planting time are probably as important as those due to the more spectacular outbreaks, the Morogoro scenario can help in ameliorating pest control planning in some areas.

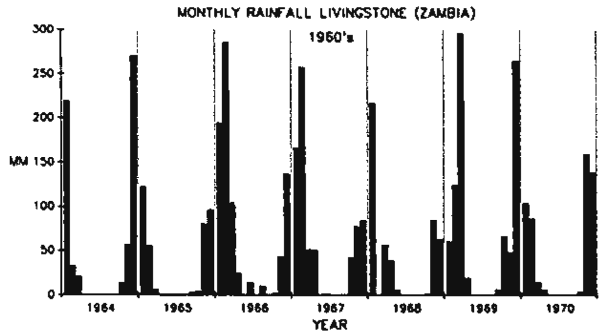

Figure 7. Monthly rainfall in mm for Livingstone (Zambia) 1964-1970.

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