Breeding patterns of *Arvicanthis neumanni* in central Tanzania

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Abstract

The breeding pattern of the grass rat, *Arvicanthis neumanni,* was investigated in central Tanzania in 2002/2003. Nine hundred and forty-seven animals were captured in three age groups: juveniles, sub adults and adults. These age groups were present in the population for an extended duration, but there was an increase in the number of sexually active individuals and juveniles 2–3 months after the onset of the rains (December 2002–May 2003). A peak in reproductive activity occurred between January and April. Litter size ranged between 5.58 ± 0.42 and 6.1 ± 0.26 in two study sites. There were no significant differences in the number of embryos implanted in the right and left horns of the uterus of pregnant females ($t_{22} = 0$, $P > 0.05$ and $t_{36} = 1.68$, $P > 0.05$, respectively). Sex ratio of *A. neumanni* was not skewed to either males or females. Breeding was seasonal and seemed to be associated with seasonal variations in primary productivity, which relates to rainfall patterns.

Key words: Arvicanthis neumanni, breeding patterns, Tanzania

Résumé

Le schéma de reproduction d'*Arvicanthis neumanni* a été étudié dans le centre de la Tanzanie en 2002/2003. On a capturé 947 animaux appartenant à trois groupes d'âge : juvéniles, sub-adultes et adultes. Ces groupes d'âge étaient présents dans la population pendant une longue période, mais il y avait une augmentation du nombre d'individus sexuellement actifs et de juvéniles deux à trois mois après le début des pluies (décembre 2002-mai 2003). Il y eut un pic d'activité sexuelle entre janvier et avril. La taille des portées allait de 5.58 ± 0.42 à 6.1 ± 0.26 dans deux sites étudiés. Il n'y avait pas de différence significative du nombre d'embryons implantés dans les cornes droite et gauche de l'utérus des femelles ($t_{22} = 0$, $P > 0.05$ et $t_{36} = 1.68$, $P > 0.05$ respectivement). Le sex-ratio d' *A. neumanni* ne favorise ni les mâles, ni les femelles. La reproduction est saisonnière et semble associée aux variations saisonnières de la productivité primaire, liées, elles, aux chutes de pluie.

Introduction

The genus *Arvicanthis* has been described as one of the most highly evolved herbivorous murids, grass-loving species whose main home in Africa is the northern savannahs where it is probably in the process of expanding its range (Kingdon, 1974). A process of chromosomal differentiation of *Arvicanthis* is still going on and may possibly be responsible for speciation (Castiglia *et al.*, 2006). Several species are widely distributed in all the sub-Saharan African savannahs along the Nile valley and down to the Zambezi River. In East Africa, six species are recognized, namely *A. nairobae*, *A. neumanni*, *A. somalicus*, *A. blicki*, *A. abyssinicus* and *A. niloticus* (Castiglia *et al.*, 2006). *Arvicanthis* species have a scattered distribution in Tanzania. Three species of *Arvicanthis*, namely *A. niloticus*, *A. nairobae* and *A. neumanni* are common in some areas of Tanzania. However, Kingdon (1974) reported a wide distribution of *A. lacernatus*, which may include *A. neumanni* and other species. They are diurnal and live under a dense herb mat where they construct long tunnels at ground level, which radiate from their burrows. Their opportunistic and generalized diet makes them very common in agricultural fields, in particular staple crops where they cause serious preharvest damage (Stenseth *et al.*, 2003; Castiglia *et al.*, 2006). Delany (1986) suggested that reproductive activity in tropical

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rodents has conventionally been related to rainfall, and that, in this region rain is the most important factor accounting for seasonal variations in primary productivity. The success of *Arvicanthis* in the savannas of East Africa seems to be associated with fecundity. Kingdon (1974) reported that the young have a rapid growth and that several litters might be born during the wet season with four to six young in a litter. Seasonal breeding in *Arvicanthis* was reported to be triggered by biochemical substances present in green vegetation (Weinbren & Mason, 1957). *Arvicanthis* spp. are well adapted physiologically and ecologically for continuous breeding (Neal, 1981). However, Neal (1981) also reported that immature males and adult females in western Uganda began to mature or increase their reproductive activity the month after the start of rains and peaked 2–3 months after the start of the rains. Taylor & Green (1976) reported cessation of breeding in *Arvicanthis* spp. around the middle of the dry season and they did not begin again until 2–3 months after the start of the rains. Studies on rodents in Tanzania have focused mainly on the multimammate rats, *Mastomys natalensis*, with little or no studies at all of other species, including *A. neumanni*. In the current study, we investigated reproduction and breeding of *A. neumanni* in Central Tanzania. *Arvicanthis neumanni* is one of the common rodent species in this area.

Materials and methods

Location of the study area

The study was carried out at two localities in Gairo, central Tanzania, for a period of 12 months. The first locality was Msingisi village (06°20′S, 36°87′E; 1365 m above sea level) and the second was Ihanda village (06°21′S, 36°87′E; 1367 m above sea level). The two localities have a semiarid climate with unimodal rainfall pattern, averaging 600–900 mm of rainfall annually. The mean temperature ranges from 15 to 30°C. June and July are the coolest months while the period between October and November experiences the highest temperatures.

Trapping techniques

Animals were trapped using the Sherman Live trap, but removal trapping was also carried out with assistance of villagers using locally made traps. These extra trapping efforts were necessary because *A. neumanni* is generally trap-shy and therefore, the need to supplement the data from live trapping. Trapping was conducted at monthly intervals between October 2002 and September 2003.

Handling of animals and data recording

The animals were anaesthetized by diethyl ether and external morphological measurements were taken. They were dissected immediately to examine internal sexual organs (Hayne, 1949). Some were labelled and preserved in formalin for future studies.

The following standard morphological measurements were recorded for each individual caught: head and body (HB) length, tail length, ear length and testis length. Animals were weighed to the nearest gram. The captured animals were categorized as juveniles (HBL < 95 mm), sub adults (HBL = 95–110 mm) and adults (HBL > 110 mm). Determination of age groups was based on morphological measurements. The sexual/reproductive conditions of both males and females were recorded (either perforated or closed vagina for females and scrotal or nonscrotal testes for males). In addition, the animals were autopsied and for females, the number of implanted embryos was recorded.

Data analysis

Sex ratio (removal trapping), i.e. the proportion of males relative to the total number of individuals caught was determined by the following formula:

$\frac{n}{N}$ where n is the number of males captured in the respective month.

N is the total number of animals captured in the respective month.

Captures were grouped according to age and mean numbers (mean ± SE) were calculated. The mean litter size (mean ± SE) was also established from animals examined for embryos. Chi-squared tests were used to test significant variations for the parameter measurements.

Results

Age structure of A. neumanni *population in the study area*

Figures 1 and 2 show the population structure (age class category) distribution of *A. neumanni* males and females in central Tanzania. In October and February, there were very few captures (less than five animals) despite high

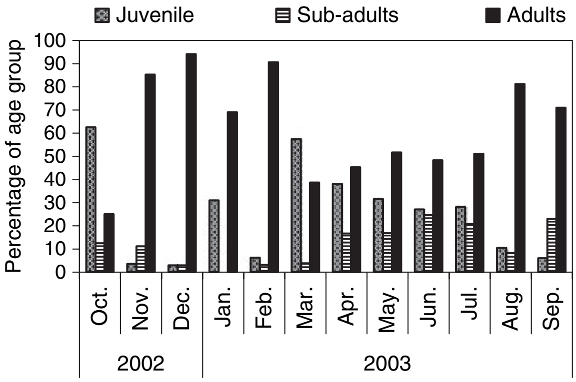

Fig 1 Distribution of adults, sub-adult and juveniles of male *Arvicanthis neumanni* in Central Tanzania (2002/2003)

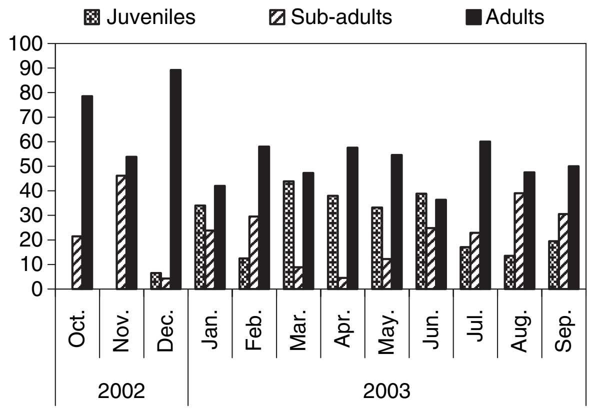

Fig 2 Distribution of adults, sub-adult and juveniles of female *Arvicanthis neumanni* in Central Tanzania (2002/2003)

trapping effort and therefore it was not possible to compare the age structure.

A large number of juveniles were present in the population during the period from January to July. Low numbers of juveniles occurred from August to September. The occurrence of a large number of juveniles in January–July coincided with the main breeding season.

Changes in reproductive conditions of males and females of A. neumanni

Figure 3 shows changes in breeding conditions of male *A. neumanni* in the two localities in central Tanzania. Males with scrotal testes were found in the population every month from November to July. Figure 4 shows the breeding conditions of female *A. neumanni* in the two localities. Females with perforated vagina increased in numbers from November and reached a peak in February, when more than 59% of the individuals captured were reproductively active. However, their numbers decreased until there was none in August and September. Males with scrotal testes were present throughout the study period except in October, with peaks in January and February (Fig. 3) when also the highest number of females had perforated vagina (Fig. 4). In February, the number of animals in nonreproductive conditions dropped drastically to <15% for both males and females. The period with highest nonreproductive individuals was between August and September.

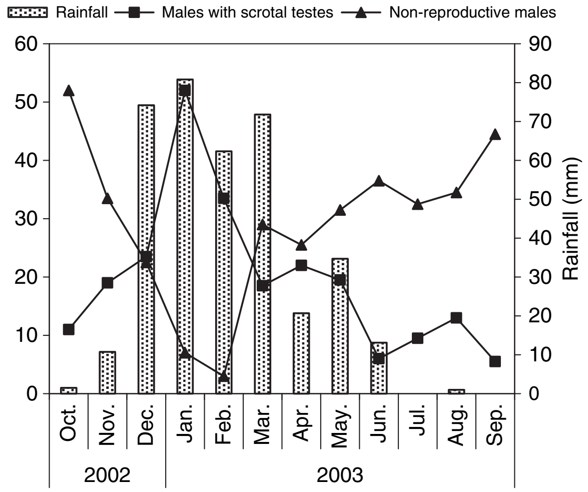

Fig 3 Changes in breeding conditions of male *Arvicanthis neumanni* in Central Tanzania (2002/2003)

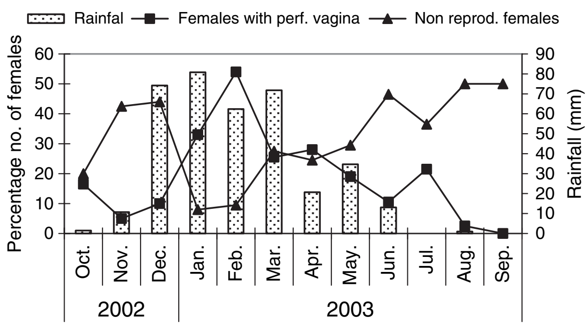

Fig 4 Changes in breeding conditions of female *Arvicanthis neumanni* in Central Tanzania (2002/2003)

Variation in testes size of adult A. neumanni

There were clear seasonal variations in testes size in the two study locations in central Tanzania (Fig. 5). The mean testes size was the highest in February and March when most of the males were in reproductive condition.

Implantation

There were no significant differences in numbers of embryos implanted in the left and right horns of the uterus in both study villages ($t_{22} = 0$, $P > 0.05$; $t_{36} = 1.88$, $P > 0.05$) and therefore equal numbers of embryos were positioned in the right and left uterus horns of pregnant *A. neumanni.*

Litter size

The mean litter size of *A. neumanni* in central Tanzania was 5.85 ± 0.34 (range 4–11 and 1–9 in two localities) (Table 1).

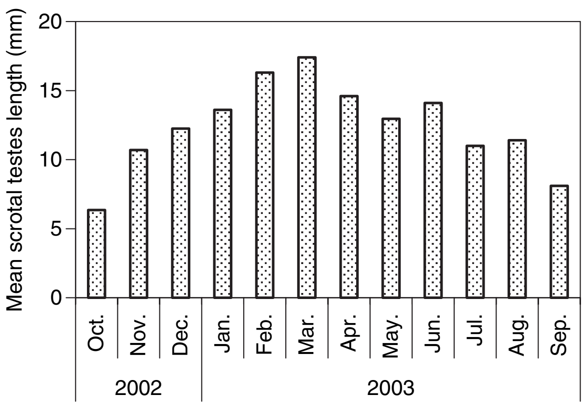

Fig 5 Variation in testes size of *Arvicanthis neumanni* in central Tanzania (2002/2003)

Table 1 Litter size of female *A. neumanni* in Central Tanzania (2002/03)

Village (site)	n	Mean ± SE	Range (minimum–maximum)	SD
Ihanda	37.0	6.10 ± 0.26	4–11	1.6
Msingisi	24.0	5.58 ± 0.42	1–9	2.0
Total	61.0	–	–	–
Mean		5.85 ± 0.34	–	–

Discussion

Neal (1981) observed continuous breeding of *A. niloticus* throughout the year where rainfall was constant. In the current study, the proportion of young animals in the population decreased from July but increased again in January. The appearance of females with perforated vagina and males with scrotal testes nearly throughout the study period indicates that *A. neumanni* has an extended reproductive period. The findings of the current study conform to Neal's (1981) observations that *Arvicanthis* is physiologically and ecologically well adapted for continuous breeding. Peak reproductive activity in central Tanzania occurs in the months of January to April indicating that this is the main breeding period, which coincides with the rainy season. The breeding season of *A. neumanni* in central Tanzania appears to be linked to the rainfall pattern. Delany (1986) attributed this linkage to abundance of primary productivity. Other studies in Africa have also linked reproduction of rodents with rainfall (Weinbren & Mason, 1957; Kingdon, 1974; Reichman & Van de Graaf, 1975; Berger *et al.*, 1981; Neal, 1981; Leirs, 1992; Fiedler, 1994; Madsen & Shine, 1999; Achigan, Codjia & Bokonon-Ganta, 2003; Massawe, 2003; Workneh, 2003). In males, the seasonal gonadal changes have sometimes been attributed to rich foods and unrestricted water (Neal, 1976, 1981), which are more abundant in the wet season.

Litter sizes in *A. neumanni* in central Tanzania were high in comparison with findings in other studies of *Arvicanthis* spp. (comparisons: litter sizes of 4.64 by Petter *et al.*, 1969; 6 by Taylor & Green, 1976; 2–10 by Happold, 1966; 3–5 by Misonne & Verschuren, 1966 and 6 ± 2 by Daouda *et al.*, 2003). Neal (1976) observed that the litter size of *M. natalensis* was the highest near the equator and decreased at higher latitudes, while Sheppe (1972) reported local variations in litter size in Zambia, which may reflect habitat differences.

Populations of African murid rodents are subject to density fluctuations, which have largely been attributed to seasonal changes of weather, particularly rainfall (Delany, 1986). For some of the murids, reproduction appears to be continuous, but there are obvious peaks indicating seasonal influences as shown by *A. neumanni* in the current study. Implantation, litter size and survival from juvenile to reproductive age determine the population size in future generations, but these parameters are also influenced by the food quality and abundance, which change seasonally. In Tanzania, attribution of population fluctuations to seasonal food availability, in both quality and quantity has been reported (Leirs, 1992; Makundi, Massawe & Mulungu, 2005). However, for *A. neumanni*, no studies have been carried out on their food habits to establish how the seasonal changes affect their population dynamics in central Tanzania. In the Serengeti National Park in northern Tanzania, however, the food habits of *A. niloticus* were reported by Senzota (1982). Therefore, there is need to extend further studies on *A. neumanni* to increase our knowledge base on this less studied grass rats of central Tanzania.

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