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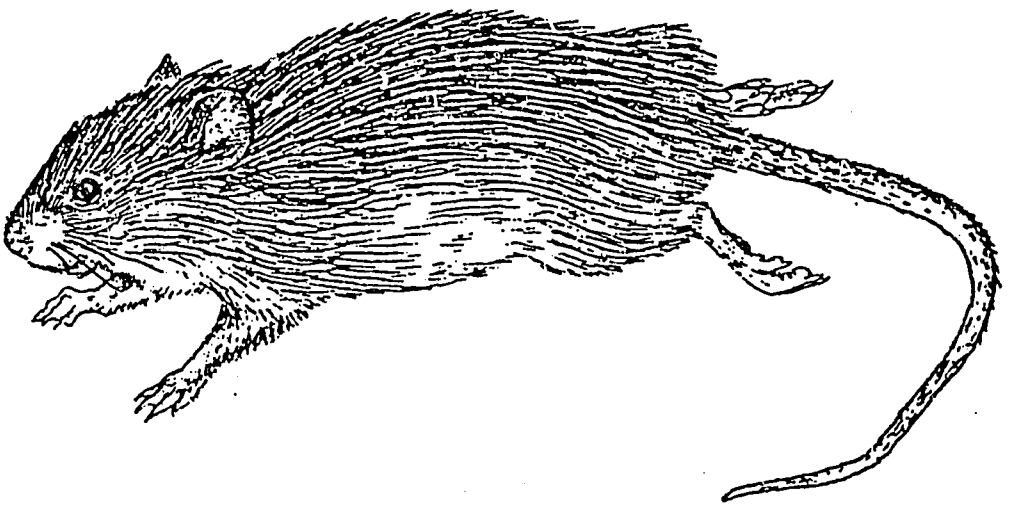
A Preliminary Research Bibliography of Rodent Pests of the Sahel, Africa

Technical Report No. 1

Chad Rodent Control Research Project

November 1991



A Cooperative Program

of

Government of Chad/Ministry of Agriculture,
U.S. Agency for International Development,
and
U.S. Department of Agriculture/Animal and Plant Health Inspection Service/
Science and Technology/Denver Wildlife Research Center
P.O. Box 25266
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By G. K. LAVOIE, L. A. FIEDLER, J. E. BROOKS
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CHAD RODENT CONTROL RESEARCH PROJECT

TECHNICAL REPORT NO. 1

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A Cooperative Program of the

Government of Chad/Ministry of Agriculture/Crop Protection Service
&
U. S. Agency for International Development
AID/N'Djamena & AID/Africa Bureau
Project No. 698-0517, Africa Emergency Locust/Grasshopper Project
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Introduction

The Sahel region of Africa is a broad band stretching across the continent just south of the Sahara Desert. It encompasses about 20 percent of the African land-mass and includes portions of nine African nations, with a population of over 30 million people. From west to east the Sahel encompasses parts of Mauritania, Senegal, Mali, Burkina Faso, Niger, Nigeria, Chad, Sudan, and Ethiopia. The Sahel previously was a major food-producing area for northern Africa, but because of droughts and crop depredations by birds, rodents, and insects, it is now a food-deficit region.

Periodic rodent population irruptions, such as those of 1962, 1977 and 1986/87, probably have occurred in the Sahel for centuries. Although Sahelian rodent outbreaks often have been widespread and have severely reduced food production, these phenomena have been poorly documented and little studied. Even the major rodent species involved in crop depredations often have not been identified, nor has their reproductive biology or basic population dynamics been determined. Methods to quantitatively assess rodent and bird damage to selected Sahelian crops, most notably vegetables, have not been developed. Rodent and bird control methods have not been thoroughly evaluated under Sahelian conditions.

Because of widespread and significant damage to agricultural crops resulting from irruptive rodent populations in the Sahel, a cooperative project was initiated between the Chad Ministry of Agriculture (MOA)/ Crop Protection Service, the U. S. Agency for International Development (USAID)/ Agriculture Development Office, and the U. S. Department of Agriculture/ APHIS/S&T/Denver Wildlife Research Center (DWRC), with funding provided by the Bureau of Africa/AID under the African Emergency Locust/Grasshopper Assistance Project.

The Chad Rodent Control Research Project was initiated in October 1989 with the objectives of (1) developing safe, effective, economical, and acceptable rodent control measures to protect crop production and improve food security in the Sahel, and (2) providing training and guidelines to the Chad MOA for long-term rodent population monitoring and control. In order to achieve these objectives, there is a need, insofar as possible, to gather available information on Sahelian vertebrate pests. Hence, this "Preliminary Research Bibliography of Rodent Pests of the Sahel, Africa" has been compiled. An attempt has been made to include pertinent citations relating to Sahelian rodent problems and to the three principal rodent genera involved in population irruptions in the Sahel. Thus, some references on rodents in East and South Africa are included.

Happold (1987) states "Mammals of the Sahel savanna zone experience a very severe environment characterized by high daytime temperatures, cool or cold nights, high insolation, low unpredictable rainfall, and low plant productivity. For all species, the problems of obtaining adequate water and food, and maintaining the body temperature at a constant level in spite of the widely fluctuating ambient temperature, determine all aspects of their ecology and behaviour." He characterizes the mammals of the Sahel as follows:

"(1) Population numbers of small mammals fluctuate greatly from very low numbers during droughts to high numbers after good rain when food is plentiful.

(2) All small mammals are nocturnal; during the heat of the day, they remain in burrows, hollow trees, caves, and other micro-habitats which are comparatively cool and moist.

(3) Efficient conservation of body fluids is essential for survival. All mammals combine a number of methods to ensure that the limited water in their food is not wasted. These include the production of dry faeces and very small volumes of concentrated urine, the selection of foods which contain relatively high amounts of water, the production of metabolic water, and the minimal use of water for evaporative cooling.

(4) Reproduction occurs only when food and water are plentiful. Consequently, several years of drought can mean the cessation of reproduction for several years, and therefore a dramatic fall in population numbers."

During and following the rodent population irruptions that occurred in the Sahel in 1986/87, APHIS/DWRC personnel made 19 consultative trips to various Sahelian countries. These consultations were undertaken in response to the 1986/87 rodent irruptions and because there was a lack of knowledge concerning rodent pests in the Sahel. DWRC biologists have identified the three principal genera of rodents involved in the trans-Sahel irruptions: *Praomys (Mastomys)*, *Arvicanthis*, and *Gerbillus*. Although other rodent genera, such as *Mus*, *Tatera*, *Jaculus* and *Taterillus*, may be associated with population irruptions, rarely do they present more than localized pest problems.

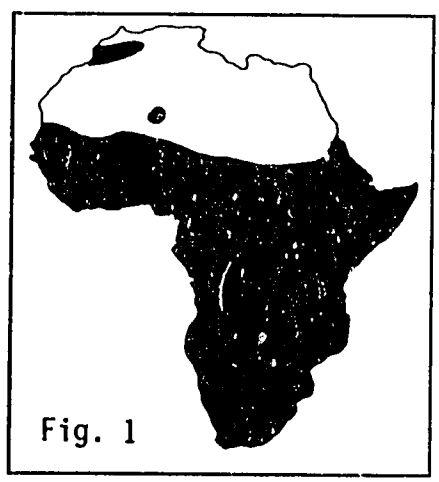

Fig. 1

The species complex of multimammate mice or rats, *Praomys (Mastomys) natalensis*, is widespread in Africa (Fig. 1). It occurs from Morocco in the northwest to the tip of South Africa and from Senegal in the west to Somalia in the east. The multimammate rat is closely associated with man and commonly inhabits huts, houses, barns, and cultivated fields. Only rarely does it live disassociated from human activity. However, it is now being replaced in many human habitations by the commensal "roof" or "black" rat, *Rattus rattus*.

The multimammate rat typically is an unspecialized rodent, intermediate in size between a mouse and rat. It rarely exceeds 100 grams in weight. It is best identified by its silky grey-based fur, a tail shorter than head and body and, in females, the presence of up to 12 pairs of mammae. This species is extremely important because it is a principal host of human plague and in the past 20 years has been found infected with and a vector of the deadly Lassa fever virus.

The Nile rat, *Arvicanthis niloticus*, also known as the "unstriped grass rat", inhabits virtually the entire Sahel region, wherever water is available. Its range extends north along the Nile Valley through Egypt and south along the Rift Valley of Zambia (Fig. 2).

The Nile rat essentially is a "grass-loving" species, inhabiting primarily north African savannas, where it feeds mainly on the seeds, leaves and shoots of grasses. It is the dominant rodent species in cultivated wadis or oases in Chad, where it typically lives in surrounding thorn bush fences.

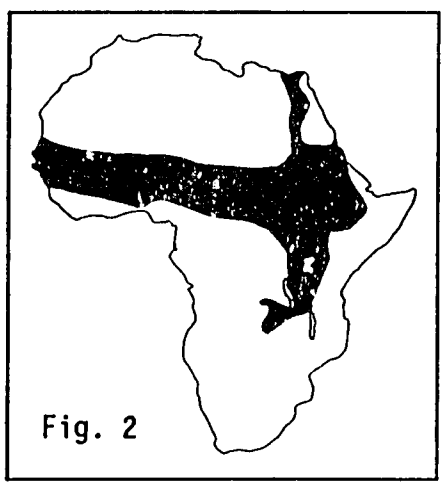
Fig. 2

Unlike most rodents, the Nile rat often is active during the day. Thus it usually inhabits areas with dense cover that provide shelter from predators. It is a medium-sized rat, weighing about 80 grams, with a head and body length of about 145 mm, and a somewhat shorter tail. It has a dark, heavily speckled back and a grey belly. It is also distinguished from similar rats by its rather harsh, grizzled coat, and by having smooth incisor teeth.

The more than 50 species of gerbils, *Gerbillus* species, are distributed over the drier parts of Africa and Arabia, through Palestine into Iraq, Syria, Iran, and across Pakistan into northern India. They typically inhabit open, dry, sandy, and sparsely vegetated areas.

The gerbils are small rodents which are distinguished by having long hind legs and short front legs. They are also characterized by a slender form, a long, somewhat bristly tail, and fairly long ears. They are divided into two groups, the " hairy-footed" and the "naked-footed" gerbils, dependent upon whether or not they have hair on the soled of their hind feet. They feed primarily on grass seeds, stems and roots, as well as upon insects. They are strictly nocturnal, and typically inhabit sandy soils, in which they dig oblique burrows which they usually block with sand from the inside during daylight hours - in order to escape daytime high temperatures.

A "sand" gerbil, *G. andersoni*, has been identified as the major rodent pest of dune or dryland cereal crops in the Sahelian region of Chad. Because they forage over extensive areas, gerbils may also cause damage to other cultivated crops that are on or adjacent to sandy areas.

REFERENCES

*** Indicates the article is in the reprint files of the Chad Rodent Control Research Project, N'Djamena, Chad.**

Abramsky, Z. 1989. Communities of gerbilline rodents in sand dunes of Israel. Spec. Publ. Mus. Tex Tech. Univ., No. 28. pp. 205-218.

*Adam, F. and B. Hubert. 1985. Outbreaks of *Mastomys erythroleucus* and *Taterillus gracilis* in the Sahelo-Sudanian zone in Senegal. Acta Zool. Fennica, 173:113-117.

Adesuyi, S. A. 1966. Control of rodents in the groundnut storage site in Kano (Nigeria). Nigerian Stored Prod. Res. Inst., Ann. Rept. 25-31.

*Akande, M. 1986. The economic importance and control of vertebrate pests of graminaceous crops with particular reference to rice (*Oryza sativa*) in Nigeria - A review. Proc. Vert. Pest Conf., 12:303-306.

*Alibhai, S. K. 1986. Reproductive response of *Gerbillus harwoodii* to 6-MBOA in the Kora National Reserve, Kenya. J. Trop. Ecol., 2:377-379.

Anadu, P. A. 1979. The occurrence of *Steatomys jacksoni* Hayman in south-western Nigeria. Acta Theriol., 24(37):513-526.

Baker, C. M. and J. Meester. 1977. Postnatal physical and behavioral development of *Praomys (Mastomys) natalensis*. Z. Säugetierk., 42:295-306.

Bellier, L. 1973. Rodent pests in West Africa. Span, 16:28-

*Bernard, J. 1977. Damage caused by the rodents Gerbillidae to agriculture in North Africa and countries of the Middle East. EPPO Bull., 7(2):283-296.

Booth, A. H. 1960. Small mammals of West Africa. Longmans, Green and Co. London.

Bowland, A. E. 1986. The effect of the 1982/83 drought on small mammals in Umfolozi Game Reserve. Cimbebasia 8:194-198.

Bowland, A. E. and M. R. Perrin. 1988. The effect of fire on the small mammal community of Hluhluwe Game Reserve. Z. Säugetierk., 53:235-244.

*Braide, E. I., N. Maduka and M. O. E. Iwuala. 1980. Observations on the food habits of some African rodents. Rev. Biol. Trop. 28:227-236.

*Brambell, F. W. R. and D. H. S. Davis. 1941. Reproduction of the multimammate mouse (*Mastomys erytholeucus* Temm.) of Sierra Leone. Proc. zool. Soc. Lond., Ser. B, 111:1-11.

*Bronner, G. and J. Meester. 1987. Comparison of methods for estimating rodent numbers. S. Afr. J. Wildl. Res., 17:59-63.

*Bronner, G., I. L. Rautenbach and J. Meester. 1988. Environmental influence on reproduction in the Natal multimammate mouse *Mastomys natalensis* (A. Smith, 1834). S. Afr. J. Wildl. Res., 18:142-148.

*Brooks, J. E. 1991. Rodent control research and damage assessment activities in Chad. DWRC Unpublished Trip Report, 12 pp.

*Bruggers, R. L. 1987. Guinea-Bissau. DWRC Unpublished Trip Report. 12 pp.

*Bruggers, R. L. 1989. Chad, Italy, and Morocco. DWRC Unpublished Trip Report. 7 pp.

*Bruggers, R. L. and J. B. Bourassa. Niger. DWRC Unpublished Trip Report. 7 pp.

*Buffenstein, R. and J. U. M. Jarvis. 1985. Thermoregulation and metabolism in the smallest African gerbil, *Gerbillus pusillus*. J. Zool., (Lond.), 205:107-121.

*Chapman, B. M., R. F. Chapman and I. A. D. Robertson. 1959. The growth and breeding of the multimammate rat, *Rattus (Mastomys) natalensis* (Smith) in Tanganyika Territory. Proc. zool. Soc. Lond., 133:1-9.

Chidumayo, E. N. 1980. Ecology of rodents at an old quarry in Zambia. S. Afr. J. Zool., 15:44-49.

*Chidumayo, E. N. 1984. Observations on populations of multimammate mice at Livingstone, Zambia. Mammalia 48:363-376.

Christian, D. P. 1979. Comparative demography of three Namib desert rodents: Responses to the provision of supplementary water. J. Mammal., 60:679-690.

Christian, D. P. 1980. Patterns of recvovery from low numbers in Namib desert rodents. Acta Theriol., 25(36):431-450.

*Cockrum, E. L. 1976. On the status of the hairy-footed gerbil, *Gerbillus hirtipes* Lataste, 1881. Mammalia 40:523-526.

*Cockrum, E. L. 1977. Status of the hairy-footed gerbil, *Gerbillus latastei* Thomas and Trouessart. Mammalia 41:75-80.

*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.

*Coetzee, C. G. 1975. The biology, behaviour, and ecology of *Mastomys natalensis* in southern Africa. Bull. World Hlth. Organ., 52:637-644.

Cross, R. M. 1977. Population studies on *Praomys tullbergi* (Thomas) and other rats of forest regions of Sierra Leone. Rev. Zool. Africaine, 91:345-399.

*Davis, D. H. S. and A. G. Otellé. 1958. The multimammate mouse *Rattus (Mastomys) natalensis* Smith: a laboratory-adapted African rodent. Proc. zool. Soc. Lond., 131:293-299.

*Dean, W. R. J. 1973. Age distribution of *Praomys natalensis* prey in *Tyto alba* pellets. Zool. Afr., 8(1):140.

*Delany, M. J. 1964. A study of the ecology and breeding of small mammals in Uganda. Proc. zool. Soc., Lond., 142:347-370.

Delany, M. J. 1972. The ecology of small rodents in tropical Africa. Mammal. Rev., 2:1-42.

Delany, M. J. 1975. The rodents of Uganda. Brit. Mus. Nat. Hist., London.

Delany, M. J. 1986. The ecology of small rodents in Africa. Mammal Rev., 16:1-41.

*Delany, M. J. and 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. and R. H. Monro. 1986. Population dynamics of *Arvicanthis niloticus* (Rodentia: Muridae) in Kenya. J. Zool. Ser. A (Lond.), 209:85-103.

*Delany, M. J. and R. H. Monro. 1986. Movement and spatial distribution of the Nile rat (*Arvicanthis niloticus*) in Kenya. J. Trop. Ecol., 1:111-130.

Delany, M. J. and B. R. Neal. 1969. Breeding seasons in rodents in Uganda. J. Soc. Reprod. Fertil. (Suppl.) 6:229-236.

Delany, M. J. and C. J. Roberts. 1978. Seasonal population changes in rodents in the Kenya Rift Valley. Bull. Carnegie Mus. Nat. Hist., No. 6.

Degen, A. A. and M. Kam. 1991. Average daily metabolic rate of gerbils of two species: *Gerbillus pyramidum* and *Gerbillus allenbyi*. J. Zool., (Lond.), 223:143-149.

Demartini, J. C., D. E. Green and T. P. Monath. 1975. Lassa virus infection in *Mastomys natalensis* in Sierra Leone. Bull. Wrld. Hlth. Org., 52:651-663.

*Demeter, A. 1978. Food of a barn owl *Tyto alba* in Nigeria. Bull. Nigerian Ornithol. Soc., 14:9-13.

Dempster, E. and M. Perrin. 1989. A comparative study of agonistic behaviour in hairy-footed gerbils (Genus Gerbillurus). Ethology 83:43-59.

Downs, C. and M. Perrin. 1989. An investigation of the macro- and micro-environments of four Gerbillurus species. Cimbebasia 11:41-54.

Duplantier, J. 1988. Biologie evolutive de populations du genre Mastomys (rongeur, Muridae) au Senegal. Thesis, Academie de Montpellier Univ. des Sciences et Techniques du Laguedoc.

Duplantier, J. and L. Granjon. 1990. [Activity pattern of six species of murids in Senegal (Genus *Mastomys, Arvicanthis, Myomys* and *Dasymys*).] Mammalia 54:173-182. (In French, Eng. summ.)

Duplantier, J., L. Granjon and K. Ba. 1991. [Discovery of three species new for Senegal: A supplementary test of the desertification of the north of the country]. Mammalia 55:313-315. (In French, Eng. summ.).

*El-Deeb, H. I. 1985. Effect of admixing cotton seed oil with the rat bait on the acceptance of the Nile rat, *Arvicanthis niloticus* [Egypt]. Zagazig J. Agric. Res. 12:733-738.

*El-Deeb, H. I. 1985. Bait preference and bait consumption of the Nile rat, *Arvicanthis niloticus* [Egypt]. Zagazig J. Agric. Res., 12:725-731.

*Fall, M. W. 1976. Rodent control in Senegal: Present problems, future needs. DWRC Trip Report (Unpublished). pp.

Fall, M. W. and M. V. Garrison. 1979. Vertebrate damage control research bird and rodent problems in African agriculture. DWRC Unpublished Trip Report. 7 pp. + attachments.

Farrag, H. A. 1983. Reproductive biology and social behaviour in the Nile rat (*Arvicanthis niloticus*). Ph.D. thesis, University of Reading.

Fiedler, L. A. 1985. The status of rodent control in five east African countries. Unpublished DWRC Report prepared for the Food and Agriculture Organization (FAO) of the United Nations. 12 pp. and appendices.

*Fiedler, L. A. 1987. An assessment of the current rodent outbreak in Sudan. DWRC Trip Report (Unpublished). 12 pp. + appendices.

*Fiedler, L. A. 1987. Training program for rodent control in Sudan villages using warfarin rodenticide. DWRC Unpublished Trip Report. 15 pp + appendices.

Fiedler, L. A. 1988a. Rodent pest problems and management in eastern Africa. FAO PLant Prot. Bull., 36(3):125-134.

*Fiedler, L. A. 1988b. Rodent problems in Africa. *In*: Rodent Pest Management (I. Prakash, ed.), CRC Press, Boca Raton, Florida, pp. 35-65.

*Fiedler, L. A. 1989. Planning for the establishment of the proposed rodent control project in Chad. DWRC Unpublished Trip Report. 9 pp.

*Fiedler, L. A. 1990. Rodent pests in Guinea-Bissau. DWRC Unpublished Trip Report, 8 pp. + appendices.

Fiedler, L. A. and G. K. LaVoie. 1990. Solving rodent pest problems in the Sahel. Unpublished paper presented at 2nd Regional Conference on Integrated Pest management, Sahel Institute of CILSS, Bamako, Mali, Jan. 4-9, 1990.

*Field, A. C. 1975. Seasonal changes in reproduction, diet and body composition of two equatorial rodents. E. Afr. Wildl. J., 13:221-235.

*French, N. R. 1975. Evolution of demographic parameters of native rodent populations and implications for control. Bull. World Health organ., 52:677-688.

*French, N. R. 1985. Test of model with field data for a population of *Mastomys huberti*. Acta Zool. Fennica 173:119-121.

Funmilayo, O. 1976. Vertebrate pest damage to maize ears and control recommendations. Niger. J. Plant Protect., 2:15-18.

Funmilayo, O. 1980. Mammals and birds affectinmg food production and storage in Nigeria. Proc. Vert. Pest Conf., 9:

Funmilayo, O. and M. Akande. 1977. Vertebrate pests of rice in southwestern Nigeria. PANS, 23:38-

*Gautun, J.-C. and B. Sicard. 1985. [Records of fertility in *Mastomys huberti* from Burkina Faso (Ex Haute-Volta)]. Mammalia 49:579. (In French, Eng. summ.).

Gautun, J. -C., M. Tranier and B. Sicard. 1985. Liste préliminaire des rongeurs du Burkina Faso. Mammalia 49:537-542.

*Ghobrial, L. I. and A. S. K. Hodieb. 1973. Climate and seasonal variations in the breeding of the desert jerboa (*Jaculus jaculus*) in the Sudan. J. Reprod. Fert. Suppl. 19:221-233.

Ghobrial, L. I. and A. S. K. Hodieb. 1982. Seasonal variations in the breeding of the Nile rat (*Arvicanthis niloticus*). Mammalia 46:319-332.

*Giban, J. 1978. Control of the multimammate rat, *Mastomys natalensis* (A. Smith) in the irrigated fields of the Republic of Burundi. Proc. Vert. Pest Conf., 8:40-43.

*Gill, J. E. and R. Redfern. 1977. Some laboratory tests of five rodenticides for the control of *Arvicanthis niloticus*. PANS 23:33-37.

*Gill, J. E. and R. Redfern. 1979. Laboratory tests of seven rodenticides for the control of *Mastomys natalensis*, the rodent pest of crops and stored product in Africa. J. Hyg., Camb., 83:345-352.

Gliwicz, J. 1985. Rodent community of dry African savanna: population study. Mammalia 49:509-516.

Gonzalez, J. P., J. B. McCormick, J. F. Saluzzo, J. P. Herve, A. J. Georges and K. M. Johnson. 1983. An arenavirus isolated from wild-caught rodents (*Praomys* species) in the Central African Republic. Intervirology 19:105-

Goodfriend, W., D. Ward and A. Subach. 1991. Standard operative temperatures of two desert rodents, *Gerbillus allenbyi* and *Gerbillus pyramidum*: the effects of morphology, microhabitat and environmental factors. J. Therm. Biol., 16:157-166.

Gordon, D. H. 1978. Distribution of sibling species of the *Praomys (Mastomys) natalensis* group in Rhodesia (Mammalia: Rodentia). J. Zool., (Lond.), 186:397-

*Gordon, D. H. et al. 1980. The distribution, identification, and naming of the *Mastomys natalensis* species complex in Southern Africa (Rodentia: Muridae). J. Zool., (Lond.), 192:17-23.

*Granjon, L. and J.-M. Duplantier. 1987. Spatial structure and distribution of populations of the Genus *Mastomys* in Senegal: a study at three levels of perception. Mammalia 51:471-472.

*Green. B. and D. T. Rowe-Rowe. 1987. Water and energy metabolism in free-living multimammate mice, *Praomys natalensis*, during summer. S. Afr. J. Zool., 22:14-17.

Green, C. A., D. H. Gordon and N. F. Lyons. 1978. Biological species in *Praomys (Mastomys) natamensis* (Smith), a rodent carrier of lassa virus and bubonic plague in Africa. Amer. J. Trop. Med. Hyg., 27:627-629.

Green, C. A., H. Keogh, D. H. Gordon, M. Pinto and E. K. Hartwig. 1980. The distribution, identification and naming of the *Mastomys natalensis* species complex in southern Africa (Rodentia: Muridae). J. Zool., (Lond.), 192:17-23.

Green, M. G. and K. D. Taylor. 1975. Preliminary experiments in habitat alteration as a means of controlling field rodents in Kenya. Ecol. Bull., 19:175-

*Green, M. G. and K. D. Taylor. 1976. The influence of rainfall on diet and reproduction in four African rodent species. J. Zool., (Lond.), 180:367-389.

*Haim, A. 1984. Adaptive variations in heat production within gerbils (Genus *Gerbillus*) from different habitats. Oecologia 61:49-52.

*Haim, A. 1987. Metabolism and thermoregulation in rodents: are these adaptations to habitat and food quality? S. Afr. J. Sci., 83:639-642.

*Hanney, P. 1965. The Muridae of Malawi (Africa:Nyasaland). J. Zool., (Lond.), 146:577-633.

Happold, D. C. D. 1967. Biology of the jerboa, *Jaculus jaculus butleri* (Rodentia, Dipodidae), in the Sudan. J. Zool., (Lond.), 151:257-275.

Happold, D. C. D. 1970. The rodents of Yankari Game Reserve, northern Nigeria. Mammalia 34:491-495.

Happold, D. C. D. 1975. The effects of climate and vegetation on the distribution of small rodents in Western Nigeria. Z. Säugetierk., 40:221-242.

Happold, D. C. D. 1975. The ecology of rodents in the Northern Sudan. *In:* I. Prakash and P. K. Ghosh, *Rodents in Desert Environments*. Monogr. Biologicae, Junk, The Hague. pp. 15-45.

Happold, D. C. D. 1987. The mammals of Nigeria. Clarendon Press, Oxford.

Hickman, W. K. and G. C. 1986. Some responses of *Otomys irroratus*, *Mastomys natalensis* and *Rhabdomys pumilio* (Rodentia:Cricetidae, Muridae) to food deprivation. Cimbebasia 8:147-153.

Hooper, E. T. and El Hilali, M. 1972. Temperature regulation and habits in two species of jerboa, Genus *Jaculus*. J. Mammal., 53:574-593.

Hubbard, C. A. 1970. A new species of *Tatera* from Tanzania with a description of its life history and habits studied in captivity. Zool. Africana, 5:237-248.

Hubert, B. 1977. Ecologie des populations de rongeurs de Bandia (Sénégal) en zone sahélo-soudanienne. Rev. Ecol. (Terre et Vie), 31:33-100.

Hubert, B. 1982. Dynamique des populations de deux espèces de rongeurs du Sénégal, *Mastomys erythroleucus* et *Taterillus gracilis* (Rodentia, Muridae et Gerbillidae): I. Etude demographique. Mammalia 46:137-166.

Hubert, B. and F. Adam. 1975. Reproduction et croissance en élévage de quarte éspéces de rongeurs senegalais. Mammalia, 39:57-73.

Hubert, B. and F. Adam. 1983. The regulation of the population dynamics of two sahelian rodents in Senegal: an hypothesis. Ann. Musée Royal de l"Afrique Centrale, Sciences Zool., 237:193-201.

*Hubert, B. and F. Adam. 1985. Outbreaks of *Mastomys erythroleucus* and *Taterillus gracilis* in the Sahelo-Sudanian zone in Senegal. Acta Zool., 173:113-117.

Hubert, B., F. Adam and A. R. Poulet. 1973. Liste preliminaire des rongeurs du Sénégal. Mammalia, 36:76-87.

Hubert, B, F. Adam and A. Poulet. 1978. Modeling the population cycles of two rodents in Senegal. Bull. Carnegie Mus., 6:88-91.

Hubert, B., G. Couturier, A. Poulet and F. Adam. 1981. Les conséquences d'un supplément alimentaire sur la dynamique de population de rongeurs au Sénégal. I. Le cas de *Mastomys erythroleucus* en zone sahélo-soudanienne. Rev. Ecol. (Terre et Vie), 35:73-95.

Hubert, B., D. Gillon and F. Adam. 1981. Cycle annuel du régime alimentaire des trois principales espèces de rongeurs (Rodentia; Gerbillidae et Muridae) de Bandia (Sénégal). Mammalia 45:1-20.

Hubert, B., A. Meylan, F. Petter, A. R. Poulet and M. Tranier. 1983. Different species in genus *Mastomys* from western central and southern Africa (Rodentia, Muridae). Ann. Musée Royal de l'Afrique Centrale, Sciences Zool., 237:143-148.

*Isaäcson, M. 1975. The ecology of *Praomys (Mastomys) natalensis* in southern Africa. Bull. World Hlth. Organ., 52:629-635.

*Iyawe, J. G. 1988. Distribution of small rodents and shrews in a lowland rain forest zone of Nigeria, with observations on their reproductive biology. Afr. J. Ecol., 26:189-195.

Johnston, H. L. and W. D. Oliff. 1954. The oestrous cycle of female *Rattus (Mastomys) natalensis* (Smith) as observed in the laboratory. Proc. zool. Soc. Lond., 124:605-613.

Keenlyside, R. A., J. B. McCormick, P. A. Webb, E. Smith, L. Elliot and K. M. Johnson. 1983. Case-control study of *Mastomys natalensis* and humans in Lassa virus-infected households in Sierra Leone. Amer. J. Trop. Med. Hyg., 32:829-

*Keith, J. O. 1987. Assessment of the rodent outbreak and the 1987 zinc phosphide control program in Sudan. DWRC Unpublished Trip Report. 17 pp. + appendices.

*Khammar, F., R. Brudieux and Z. Amirat. 1977. [Seasonal comparisons of the variations in sexual activity of two rodent species (*Psammomys obesus* and *Gerbillus gerbillus*) in the western Algerian Sahara]. Mammalia 41:341-356. (In French, Eng. summ.).

*Kilonzo, B. S., J. I. K. Mhina and E. K. Komba. 1985. The baseline susceptibility levels of Chunya *Praomys natalensis*, the commonest plague reservoir and crop pest in Tanzania, to warfarin. Beitr-Trop-Landwirtsch-Veterinarmed , 23:417-423. Karl Marx Universitat., Leipzig, East Germany.

Kingdon, J. 1974. East African mammals. An atlas of evolution in Africa. IIB. Academic Press, London.

Kock, D. 1978. The identity of *Gerbillus bottai* Lataste, 1882 (Mammalia:Rodentia) from Sennar, Sudan. Bull. Carnegie Mus. Nat. Hist., 6:31-37.

*Kuehnert, G. F. 1986. Estimation of rodent damage in tomato crop in upper and middle Egypt. Acta Hortic., Wagenigen, 190:139-143.

*LaVoie, G. K. 1987. Chad. DWRC Unpublished Trip Report. 10 pp. and attachments.

*LaVoie, G. K. 1989. Senegal and Mauritania. DWRC Unpublished Trip Report. 16 pp.

*LaVoie, G. K. 1989. Chad and Guinea-Bissau. DWRC Unpublished Trip Report, 10 pp.

*LaVoie, G. K. 1990. Chad. DWRC Unpublished Trip Report. 7 pp. + Appendix.

*LaVoie, G. K. and D. J. Elias. 1987. Senegal. DWRC Unpublished Trip Report. 8 pp. and attachments.

*LaVoie, G. K. and D. J. Elias. 1987. Mali. DWRC Unpublished Trip Report. 7 pp. and attachments.

*LaVoie, G. K. and D. J. Elias. 1987. Burkina Faso. DWRC Unpublished Trip Report. 5 pp. and attachments.

Lay, D. M. 1983. Taxonomy of the genus *Gerbillus* (Rodentia:Gerbillinae) with comments on the applications of generic and subgeneric names and an annotated list of species. Z. Säugetierk., 48:329-354.

*Leirs, H., W. Verheyen, M. Michiels, R. Verhagen and J. Stuyck. 1989. The relation between rainfall and the breeding season of *Mastomys natalensis* (Smith, 1834) in Morogoro, Tanzania. Annals Soc. r. Zool. Belg., 119:59-64.

Leirs, H., J. Stuyck, R. Verhagen and W. Verheyen. 1990. Seasonal variation in growth of *Mastomys natalensis* (Rodentia: Muridae) in Morogoro, Tanzania. Afr. J. Ecol., 28:298-306.

Leirs, H. R., R. Verhagen and W. Verheyen. 1990b. The use of rainfall patterns in predicting population densities of multimammate rats, *Mastomys natalensis*. Proc. Vert. Pest Conf., 14:135-138.

*Lyons, N. F., A. C. Green and D. H. Gordon. 1978. Biological species in *Praomys (Mastomys) natalensis* (Smith), a rodent carrier of Lassa virus and bubonic plague in Africa. Amer. J. Trop. Med. Hyg., 27:627-629.

Maddalena, T., B. Sicard, M. Tranier and J. C. Gautun. 1988. Note sur la présence de *Gerbillus henleyi* (de Winton, 1903) au Burkina Faso. Mammalia 52:282-284.

*Martin, G. H. G. 1985. A population study of small rodents in a dry sub-humid grassland in Kenya. J. Trop. Ecol., 1(3):217-224.

*Martin, G. H. G. and N. M. Dickinson. 1985. Small mammal abundance in relation to microhabitat in a dry sub-humid grassland in Kenya. Afr. J. Ecol., 23:223-234.

*Meester, J. 1960. The early post-natal development of multimammate mice *Rattus (Mastomys) natalensis* A. Smith. Ann. Transv. Mus., 24:35-52.

*Meester, J. and H. W. Setzer (Eds.). 1971. The mammals of Africa - An identification manual. Smithsonian Institution Press, Washington, D. C.

Mitchell, G. C. 1987. Chad. DWRC Unpublished Trip Report. 10 pp. + Appendix.

Monath, T. P., V. F. Newhouse, G. ER. Kemp, H. W. Setzer and A. Cacciapouti. 1974. Lassa virus isolation from *Mastomys natalensis* rodents during an epidemic in Sierra Leone. Science 185:263-

Monro, R. H. 1983. Ecology of the Nile rat, *Arvicanthis niloticus* (Demarest) (Rodentia; Muridae), in Kenya. Ph.D. thesis, University of Bradford.

Monro, R. H. and M. J. Delany. 1985. Movement and spatial distribution of the Nile rat (*Arvicanthis niloticus*) in Kenya. J. Trop. Ecol., 1:111-130.

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

Moro, D. and B. Hubert. 1983. Production et consommation de graines en milieu sahelo-soudanien au Senegal. - Les rongeurs. Mammalia 47:37-57.

Muller, J. P. 1977. Populations ökologie von *Arvicanthis abyssinicus* in der Grassteppe des Semien Mountains National Park (Athiopien). Z. Säugetierk., 42:145-172.

Nandwa, S. M. 1973. Feeding ecology of rodents in Kenya. East Afr. Wildl. J. 11(3&4):407-408.

Neal, B. R. 1977. Reproduction of the multimammate rat, *Praomys (Mastomys) natalensis* (Smith) in Uganda. Z. Säugetierk., 42:221-231.

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

Neal, B. R. 1982. Reproductive biology of three species of gerbils (Genus Tatera) in East Africa. Z. Säugetierk., 47:287-296.

Neal, B. R. 1990. Observations on the early post-natal growth and development of *Tatera leucogaster*, *Aethomys chrysophilus* and *A. namaquensis* from Zimbabwe, with a review of the pre- and post-natal growth and development of African muroid rodents. Mammalia 54:245-270.

Okia N. O. 1973. The breeding pattern of the soft-furred rat, *Praomys morio*, in an evergreen forest in southern Uganda. J. Zool., (Lond.), 170:501-504.

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

*Oufara, S. and J. Chatonnet. 1987. [Metabolic adaption of gerbils (*Grebillus campestris*) to desert environment: comparison with white mice]. C. R. Seances Soc. Biol. Fil. 181:640-644.

*Packer, C. 1983. Demographic changes in a colony of Nile grassrats (*Arvicanthis niloticus*) in Tanzania. J. Mammal., 64:159-161.

Perrin, M. R. and J. R. Clarke. 1987. A preliminary investigation of the bioenergetics of pregnancy and lactation of *Praomys natalensis* and *Saccostomus campestris*. S. Afr. J. Zool., 22:77-82.

Perrin, M. R. and P. Swanepoel. 1987. Breeding biology of the bushveld gerbil, *Tatera leucogaster*, in relation to diet, rainfall and life history theory. S. Afr. J. Zool., 22:218-227.

Petter, F. 1961. Rèpartition geographique et ècologie des rongeurs desertiques. Mammalia (Suppl.) 25:1-222.

*Petter, F. 1965. Les *Praomys* d'Afrique centrale. Z. Säugetierk., 30:54-60.

*Petter, F. 1975. Les *Praomys* de Republique Centrafricaine (Rongeurs, Murides). Mammalia 39:51-56.

*Petter, F. 1977.Les rats à mamelles multiples d'Afrique occidentale et centrale: *Mastomys erythroleucus* (Temminck, 1853) and *M. huberti* (Wroughton 1908). Mammalia 41:441-444.

*Poulet, A. R. 1972a. Recherches écologiques sur une savane sahelienne du ferlo septentrional, Sénégal; les mammiferes. La Terre et la Vie, 26:440-472.

*Poulet, A. R. 1972b. Charactéristiques spatiales de *Taterillus pygargus* dans le sahel sénégalais. Mammalia 36:579-606.

*Poulet, A. R. 1974. Recherches écologiques sur une savane sahelienne due ferlo septentrional Sénégal; quelques effets de la sécheresse sur le peuplement mammalian. La Terre et la Vie, 28:124-130.

Poulet, A. R. 1978. Evolution of the rodent population of a dry bush savanna in the Senegalese sahel from 1969 to 1977. Bull. Carnegie Mus. Nat. Hist., No. 6:113-117.

*Poulet, A. R. 1980. [Age determination by eye lens for five rodent species (Muridae and Gerbillidae) from west Africa]. Mammalia 44:381-398. (In French, Eng. summ.)

*Poulet, A. R. 1980. The 1975-76 rodent outbreak in Northern Senegal irrigated farmland. Biotrop Special Publ. No. 12, pp. 123-138.

*Poulet, A. R. 1985. The ecological basis of forecasting rodent outbreaks in a Sahelian agrosystem. Acta Zool. Fennica 173:107-111.

Poulet, A. R., G. Couturier, B. Hubert and F. Adam. 1981. Les consequences d'un supplement alimentaire sur la dynamique des populations de ronguers an Sénégal. II. Le cas de *Taterillus pygarus* en zone sahelienne. La Terre et la Vie, 35:195-215.

*Poulet, A. R. and H. Poupon. 1978. L'invasion d'*Arvicanthis niloticus* dans le sahel sénégalais en 1975-76 et ses consequences pour la strate ligneuse. La Terre et la Vie, 32:161-193.

*Rampaud, M. 1986. Les rongeurs nuisibles au Tchad. Rapport d'une visite du 27 Octobre au 16 novembre 1986. ICI Plant Protection Div., Fernhurst, Haselmere, Surrey, England.

Ranque, P., M. Quillici and P. Camerlynck. 1974. *Arvicanthis niloticus* (Rongeur, Muridae), a primary reservoir of leishmaniasis in Senegal. Bull. Soc. Pathol. Exot., 67:167- (In French).

Robbins, C. B. and E. van der Straaten. 1989. Comments on the systematics of *Mastomys* Thomas 1915 with the description of a new West African species (Mammalia: Rodentia: Muridae). Senckenbergiana Biologica 69:1-14.

*Rosevear, D. R. 1969. The rodents of West Africa, London, Trustees of the British Museum (Natural History).

Sanderson, I. T. 1940. The mammals of the North Cameroons Forest Area, being the results of the Percy Sladen Expedition to the Mamfe Division of the British Cameroons. Trans. Zool. Soc. Lond., 24:623-725.

*Savarie, P. J. 1990. Rodent control research and training activities in Chad. DWRC Unmpublished Trip Report. 7 pp. + appendix.

Schlitter, D. A. 1978. Ecology and taxonomy of African small mammals. Bull. Carnegie Mus. Nat. Hist. No. 6,

*Schmidt-Ott, U. 1986. Distinction of the African rodents *Praomys natalensis* (Muridae) and *Saccostomus campestris* (Cricetidae) in owl pellets. Säeugetierkd. Mitt., 33:267-268.

*Senzota, R. B. M. 1982. The habitat and food habits of the grass rats (*Arvicanthis niloticus*) in the Serengeti National Park, Tanzania. Afr. J. Ecol., 20:241-252.

Senzota, R. B. M. 1984. The habitat, abundance and burrowing habits of the gerbil *Tatera robusta* in the Serengeti National Park, Tanzania. Mammalia 48:185-

Shalaby, A. A. A. 1966. *Jaculus* in relation to its body water economy. Ain Shams Univ. Sci. Bull., 10:165-184.

*Sheppe, W. A. 1972. The annual cycle of small mammal populations on a Zambian flood plain. J. Mammal., 53:445-460.

*Sheppe, W. A. and T. Osborne. 1971. Patterns of use of a flood plain by Zambian mammals. Ecol. Monogr., 41:179-205.

Smythe, W. R. 1986. Rodent control in East Africa. Proc. Vert. Pest Conf., 12:188-190.

Stenseth, N. C. 1977. Forecasting of rodent outbreaks: models amd the real world. EPPO Bull., 7:303-

*Stiemie, S. and J. A. J. Nel. 1974. Nest-building behaviour in *Aethomys chrysophilus*, *Praomys (Mastomys) natalensis*, and *Rhabdomys pumilio*. Zool. Afr., 8:91-100.

*Suliman, S. 1980. The feeding behavior of the Nile rat (*Arvicanthis niloticus*). M. S. thesis, Bowling Green State University, Ohio.

Suliman, S. 1986/87. Age estimation in *Gerbillus pyramidum* (Rodentia: Cricetidae) and *Arvicanthis niloticus* (Muridae) from Egypt. Proc. Egypt. Acad. Sci., 36:177-190.

*Suliman, S., S. A. Shumake and W. B. Jackson. 1984. Food preference in the Nile rat *Arvicanthis niloticus*. Trop. Pest Manage., 30:151-158.

Suliman, S. and K. Wassif. 1985. Monthly age structure in populations of *Gerbillus andersoni* (Critetidae) from the western deserts of Egypt. Acta Zool. Fennica 173:87-88.

Swanepoel, C. M. 1980. Some factors influencing the breeding season of *Praomys natalensis*. S. Afr. J. Zool., 15:95-98.

*Tawill, S. A. and J. Neithammer. 1989. On *Gerbillus pyramidum* (Rodentia, Gerbillidae) in the Sudan. Z. Säeugetierkd. 54:57-59. (In Ger., Eng. summ.).

Taylor, K. D. 1968. An outbreak of rats in agricultural areas of Kenya in 1962. E. Afr. Agric. Forestry J., 34:66-77.

Taylor, K. D. and M. G. Green. 1976. The influence of rainfall on diet and reproduction in four African rodent species. J. Zool., (Lond.), 180:376-389.

*Telford, S. R. 1989. Population biology of the multimammate rat, *Praomys (Mastomys) natalensis* at Morogoro, Tanzania, 1981-1985. Bull. Fla. State Mus. Biol. Sci. 34(6):249-287.

*Tranier, M. et al. 1988. Record of *Gerbillus henleyi* (De Winton, 1903) in the Burkia Faso. Mammalia 52:282-284.

Tranier, M. and D. Julien-Laferrière. 1990. A propos de petites gerbilles du Niger et du Tchad (Rongeurs, Gerbillidae, *Gerbillus*). Mammalia 54:451-456.

*Vaughn, T. C., P. J. Vaughn and E. L. Cockrum. 1976. *Gerbillus andersoni* De Winton, a species new to Tunisia. Mammalia 40:467-473.

*Veenstra, A. J. F. 1958. The behaviour of the multimammate mouse, *Rattus (Mastomys) natalensis* (A. Smith). Anim. Behav., 6:195-206.

Vesey-Fitzgerald, D. F. 1966. The habits and habitats of small rodents in the Congo River region of Zambia and Tanzania. Zool. Afr., 2:111-122.

*Wassif, K., R. G. Lutfy and S. Wassif. 1969. Morphological, cytological and taxonomic studies of the rodent genera *Gerbillus* and *Dipodillus* from Egypt. Proc. Egypt. Acad. Sci., 22:77-93.

Wassif, K. and S. Suliman. 1978. Toothwear and age in the gerbil, *Gerbillus andersoni* de Winton (Rodentia, Cricetidae) from the western desert of Egypt. Bull. Zool. Soc. Egypt, 28:73-83.

Wassif, K. and S. Suliman. 1979. The food of some wild rodents in the western desert of Egypt. Bull. Zool. Soc. Egypt, 29:43-51.

Wassif, K. and S. Suliman. 1980. Population studies on gerbils of the western desert of Egypt, with special reference to *Gerbillus andersoni* de Winton. Proc. Vert. Pest Conf., 9:154-160.

*Wassif, K. and S. Suliman. 1983. Further contribution to teeth wear and age in populations of *Gerbillus andersoni* (Rodentia, Cricetidae) from the western desert of Egypt. In: Proc. Third Intl. Colloq. Ecology and Taxonomy of African Small Mammals. E. Van der Straeten, W. N. Verheyen and F. De Vree, eds., pp. 149-151.

*Wassif, K. and S. Suliman. 1980. Population studies on gerbils of the western desert of Egypt, with special reference to *Gerbillus andersoni* De Winton. Proc. Vert. Pest Conf., 9:154-160.

Weinbren, M. P. and P. J. Mason. 1957. Rift Valley fever in a wild field rat (*Arvicanthis abyssinicus*), a possible natural host. S. Afr. Ned. J., 31:427-

Willan, K. 1982. Social ecology of *Otomys irroratus*, *Rhabdomys pumilio*, and *Praomys natalensis*. Ph.D. thesis, University of Natal.

Willan, K. and G. C. Hickman. 1986. Some responses of *Otomys irroratus*, *Mastomys natalensis*, and *Rhabdomys pumilio* (Rodentia:Cricetidae, Muridae) to food deprivation. Staatmuseum, Windhoek, Ser. A, Vol. 8, No. 17.

*Willan, K. and J. Meester. 1987. Food deprivation and drinking in two African rodents, *Mastomys natalensis* and *Rhabdomys pumilio*. S. Afr. J. Zool., 22:190-194.

*Wilson, J. 1989. Chad. DWRC Unpublished Trip Report. 57 pp.

Wulff, H., A. Habiyi and T. P. Monath. 1975. Recent isolations of Lassa fever from Nigerian rodents. Bull. Wrld. Hlth. Org., 52:609-

*Zaime, A. and J. Y. Gautier. 1989. [Comparison of diets of three sympatric Gerbillidae species in the Moroccon Sahara]. Rev. Ecol. (Terre Vie), 44:153-164. (In French).

*Zyadi, F. 1988. [Distribution of *Gerbillus hoogstrali* Lay, 1975 (Rodentia, Gerbillidae) in south Morocco]. Mammalia 52:132-133. (In French, Eng. summ.).