Care, husbandry and diseases of the African giant rat (*Cricetomys gambianus*)

R G Cooper[a]

ABSTRACT

The African giant rat lives up to 14 years in captivity, reaching maximum body weights of approximately 2.80 kg in bucks and 1.39 kg in does. In Britain, the African giant rat is increasingly becoming a popular exotic pet. A survey was conducted on 41 licensed pet shops in the UK. The range of ages of giant rat presented for sale, single price per rat, paired prices (buck and doe) and transport costs were 4–12 weeks, £320–£370, £352.50–400.00 including VAT, and £10–37.50, respectively. Ivermectin injected at 200-400 μg/kg subcutaneously once a week for 3 weeks will eliminate ectoparasites (and many endoparasites). Nematode infections can also be treated with fenbendazole or piperazine. Bladder threadworms can be treated with fenbendazole, protozoa with metronidazole (not in gravid does) and cestodes with praziquantel. Treatment of leptospirosis with doxycycline administered 4.29–5.36 mg once a week is useful prophylactically, although for insurance of effectiveness, 10 mg/kg for 5 days is recommended. An identical dosage is recommended for the treatment of rickettsia. African trypanosomosis infection, following diagnosis of parasites in a blood smear, can be treated with a variety of antiprotozoal drugs like diminazene diaceturate at 3.5 mg/kg for 5 days. Leishmaniasis is treated at the same dose. Staphylococcosis is treated with amoxycillian trihydrate at 5 mg/kg 3 times a day for 7 days. Helminthosis is treated with broad-spectrum deworming solution. Coccidiosis is treated with cotrimoxazole at 100 mg/kg daily for 3 days. Non-steroidal anti-inflammatories are administered to combat secondary bacterial infection after viral invasion.

Key words: African giant rat, care, *Cricetomys gambianus*, disease, husbandry.

Cooper R G **Care, husbandry and diseases of the African giant rat (*Cricetomys gambianus*)**. *Journal of the South African Veterinary Association* (2008) 79(2): 62–66 (En.). Division of Physiology, Birmingham City University, 704 Baker Building, Franchise Street, Perry Barr, Birmingham B42 2SU, UK.

INTRODUCTION

The African giant rat or the Gambian pouched rat, *Cricetomys gambianus* (Waterhouse 1840) (order Rodentia; family Muridae) (Fig. 1), is the world's largest nocturnal rat and is native to tropical Africa, where it is recorded from 29 countries, many thriving in urban settings[1,9,10]. Their ecological range extends from Senegal and the Gambia east across West Africa and the Congo Basin to the Indian ocean coast of East Africa[13,16,32], where it is mainly used as a meat source[25]. It is agriculturally important and is biologically interesting in terms of its matriarchial social structure and its value to humans, for example when trained to detect landmines. Unfortunately, it is still widely persecuted by slash-and-burn and other destructive practices[11]. These animals live up to 14 years in captivity, reaching maximum body weights of approximately 2.80 kg in bucks and 1.39 kg in does[12]. They are easy to tame, frequently eating out of a trainer's hand shortly after capture[9]. They are being trained effectively by the Belgian firm Apopo at Sokoine University of Agriculture in Morogoro, Tanzania, to detect landmines and sniff out tuberculosis. Apopo was registered under the Belgian law as a non-commercial company, and started its 1st experiments in early 1998. The giant rat is not listed on CITES as rare or endangered.

In Britain, the African giant rat is increasingly becoming a popular exotic pet supplied legitimately through reputable pet dealers. Pet shop suppliers must be licensed through the local authority (LA). Current stipulations for housing small mammals in the UK (formerly Pet Animals Act, 1951 and currently ETS no. 123, 2007) specify that for a single rat, 500 cm^2 are required in a cage with a height of 20 cm. Each additional rat requires 125 cm^2 of space to be added. Obviously this should be trebled when housing young African giant rats. Given the housing of African giant rats in countries with colder climates, adequate measures must be taken to ensure that correct procedures are followed to ensure the proper care and keeping of this rat. The aim of this article is to familiarise the small-animal veterinary practitioner with the biology, care, husbandry and diseases of this species of rat. This is not an extension of popular articles written by enthusiasts, but a more conjugant analysis of the factors affecting successful domestication and keeping of

Fig. 1: **An adult female African giant rat (*Cricetomys gambianus*) aged *c.* 18 months** (reproduced with permission from A Bickers, www.pouchedrats.co.uk).

[a]Division of Physiology, Birmingham City University, 704 Baker Building, Franchise Street, Perry Barr, Birmingham B42 2SU, UK.
E-mail: rgcooperuk@yahoo.com

Received: October 2007. Accepted: April 2008.

a wild rodent. Given that the source of this exotic animal is from breeders in Africa, it is important that wildlife officials and veterinarians on that continent understand and appreciate the manifestations of giant rat handling and export. Literature dealing specifically with the giant rat is largely lacking and therefore reasonable assumptions have been made concerning the husbandry and treatment of the giant rat based on information available on *Rattus rattus* and the Sprague-Dawley rat. It is hoped that this paper will provide the impetus to conduct more scientific studies of this species in captivity.

Table 1: **Notable differences between the black and giant rat.**

Name	Black Rat	Giant Rat
Species	*Rattus rattus*	*Cricetomys gambianus*
Swimming	Poor	Moderate
Agility	Excellent climber	Excellent climber
Length body (cm)	15–20	90–100
Length tail (cm)	20	85
Fur	Black-light brown with paler underside	Light brown with lighter brown under parts, and a white tipped tail up to 15 cm in length.
Habits	Nocturnal and omnivorous	Nocturnal and omnivorous
Nesting	Arboreal	Subterranean
Breeding	3–6 litters p.a., up to 10 pups	5 litters p.a., up to 5 pups
Lifespan	2–3 yr	7–14 yr

MATERIALS AND METHODS

Literature search

Literature was gathered from a number of web sites specifying imports and diseases of the African giant rat, notably the Department for Environment, Food and Rural Affairs (DEFRA), UK, and the United Nations Environment Programme (UNEP). Articles specific to the African giant rat were sought on PubMed, Agricola and Medline web sites.

Questionnaire survey of pet shop owners in the UK

A survey of 41 licensed pet shops in the UK that either specialised in selling rats or sold a variety of mammals was conducted. Questions were devised and distributed by e-mail or letter to determine the incidence of rats sold according to age, if the rats are sold singly or in pairs, the price per rat and transport costs.

RESULTS

No peer-reviewed literature or articles were available on some aspects of keeping the African giant rat. Suggestions were therefore made based on the experience and expertise of the author and some personally published information of a popular nature. A comparison between *Rattus rattus* and the giant rat is given in Table 1.

Handling

In the wild the giant rat is commonly captured from a branch in a tree up which it has scampered to avoid dogs. The rat is usually captured by placing a sack over its body, and interestingly, it usually does not resist. The rat is then allowed to move around in a basin or cage and readily takes bread to eat, usually out of its captor's hands. Indeed, recently acquired giant rats from a pet shop may be nervous, and a good way to encourage them to get used to their new owner is to hand-feed them. The association with food reception and the attenuation of stress in the animal cannot be divorced. This includes allowing them to take some solid food from one's hand, rather than presenting it in a dish. They tame very easily and are highly intelligent, readily participating in a variety of activities. The rat should be gently supported by one hand under its belly and the other at the base of its tail. It should never be lifted by its tail or head.

Housing and bedding

As the rat is nocturnal, the cage must have a dark compartment in which it can take refuge. It is essential that the cage is maintained as dark and cool as possible. Giant rats like torn-up newspapers as bedding, and use it together with straw or pine needles to construct a nest into which they burrow. Given the high absorptive capacity of newspaper, the bedding should be replaced regularly due to its tendency to soak up urine. Sprague-Dawley and Wistar rats kept on aspen have greater sneezing rates and lung pathology than those on paper bedding, raising concerns about aspen, which is relatively inert compared with other wood beddings, but nevertheless more harmful than paper[7]. Cage-cleaning rates have little effect on rats' sociability[7]. Indeed, the introduction of fresh bedding encourages exploratory activity and nest building by the giant rat, and is likely to have beneficial cardiovascular and behavioural effects. The giant rat is more hygienic than the domesticated rat, as it prefers to urinate and defaecate in one corner of its cage. However, because of the inevitability of faeces entering the drinking and food containers, it is recommended that these be provided from elevated platforms and/or drinking bottles. Regular disinfection of cages will maintain a healthy colony.

Temperature and relative humidity requirements closely match those for the domesticated rat, with a range of 20–25 °C (68–77 °F) and 50–55 %, respectively[8]. Giant rats sleep during the day and it is preferable not to disturb them. Exposing them to light sources at night should be avoided. Like the domesticated rat, they have an acute sense of hearing, and should not be exposed to irritating noises exceeding 85 decibels[4].

Breeding, lactation and weaning

The gestation period for a pregnant doe is 31 ± 4 days. The litter size is 1–5 pups with a sex ratio of 1:1. Sexual maturity as described at the attainment of the 1st breeding assignment is 23 weeks ± 12 days. The weight of a pup at birth varies from 21 to 36 g. Does can produce up to 5 litters per year, weaning occurring between days 26 and 35. The mortality rate pre- and post-weaning is 2 %. There are no documented scientific data regarding the length of the oestrus cycle, although one might assume that it is comparable with other rat species (4–5 days). Additionally, no documented evidence exists to describe the appearance of vaginal plugs of coagulated semen in the giant rat as an indication of mating. Presumably the giant rat has post-partum oestrus as seen in *Rattus rattus,* but unfortunately there are no specific studies detailing this. Cooper suggested a matriarchal interaction in rat colonies numbering up to 35, commonly found in old termite mounds or in burrows with several bolt-holes[9]. The author observed that in the event of the dominant female being killed, the sister rats successfully take over the care of the young and at least 1 will come into oestrus. Although there is no scientific evidence to prove this, it is assumed that the sister does respond to the feeding cries of the pups. There may be a pheromone-mediated mechanism as seen in mice, *i.e.* the Whitten-Bruce effect. It has been suggested that the sequestration of sister does into adjoining chambers of the colony results in anoestrus in the majority. Additionally, pheromones released from the bereaved buck may prevent implanta-

tion of fertilised ova in the sister rats, but still stimulate lactation. In captivity, however, their interaction is unusual and sometimes a buck and doe will fight. Commonly it is the buck that becomes aggressive and bites the doe. This is unexplained and may be due to the high sociability trait in giant rats, making them more vulnerable to anhedonia elicited by chronic stress in conditions of single housing[34]. In some cases they will simply not mate. If mating takes place successfully within 3 weeks, however, the doe should be isolated from the buck until parturition. Pups are born naked, blind and deaf.

Food

Natural food habits indicate a preference for vegetable items (especially grass, grains and tubers); oil-palm nuts and kernels; insects (especially ants, crickets, etc.) and other invertebrates. When feeding the rats commercial pig rations, growth performance improved when the protein level was raised from 10 to 13 %[2]. At research centres, giant rats can be successfully fed on tubers (sweet potatoes or cassava), fruits of all varieties, stale bread, amaranth, peanuts and rabbit pellets.

Dog meal is a useful carbohydrate and bulk feed (Table 2). Peanut butter is a favourite, and when mixed into the meal provides a stimulus for its consumption. Sometimes cooked chicken can be given, but not *ad libitum* as there is a tendency to hoard it in bedding material.

Cage requirements

Galvanised metal should be avoided for cages, as gnawing may result in the ingestion of zinc. Indeed, chronic exposure to zinc has been shown to increase levels of neuropeptide Y, a factor implicated in seizures[33]. Chronic zinc exposure in an African giant rat resulted in lethargy, withdrawal, soft, mucus-impregnated faeces and diarrhoea, foot twitching and icterus[12]. Indications of moderate zinc toxicosis following ingestion and stress-associated glucosuria have been reported[12]. Aluminium cages should also be avoided, especially for young rats that are susceptible to aluminium-induced changes in the metabolism of essential nutrients[30]. It is recommended that cheap but strong wood from pallets be used and, if necessary, nailed double-length and strengthened with windows covered with chicken wire. Some cages made of polypropylene have been used, but they are not always suitable, especially in climates with high relative humidity, as condensation easily forms inside them. Dried pine needles or grass and sawdust used as bedding and floor covering should be changed at regular intervals to reduce cage contamination. Compared with the albino rat, the giant rat has less malodorous urine and its habit of urinating in one corner ensures less cage contamination. Ammonia build-up is significantly reduced if absorbent bedding is used under solid tray inserts. It is important to avoid wire-bottomed cages for adult rats in order to minimise foot injuries, abscesses or discomfort due to pressure experienced on the feet. It is probably reasonable to assume that studies of caging type on foot lesions in other species of rat would have similar manifestations in the giant rat. For instance, notable abnormalities of the plantar surface of the hind foot, including ulcers or nodular swellings, were common after 1 year in heavier Sprague-Dawley rats housed on wire flooring compared with polycarbonate cages[28]. The microenvironment of polycarbonate cages housing Sprague-Dawley rats showed that contact bedding was useful in controlling ammonia generation and that a raised floor walk insert reduced significantly the aerosolization of bedding particles that could be ingested or inhaled by the rats[31].

Table 2: **Nutrient composition of dog meal suitable for feeding an African giant rat.**

Nutrient	Percentage
Crude protein	Min. 20
Carbohydrate	Max. 60
Crude fibre	Max. 5
Fat	Min. 5
Vitamins and trace elements	0.2

The reduction in ammonia is important, as the fumes exacerbate respiratory problems, particularly from mycoplasma infections[6]. A well-ventilated room is important to blow away these fumes. It is vital to use uncontaminated bedding, to avoid exposing the rats to diseases, particularly mites and tapeworms. Overcrowding should be avoided, with a maximum housing density of 3–4 adults/m^2. Cage design should ensure the sequestration of sleeping, feeding and play quarters. It is convenient to supply water in a drinking spout and feed in a food bowl. A minimum cage height of 1 metre and total floor area of 2×1.5 m^2 will accommodate this large species. Some owners construct a run of 10×15 m^2 into which the rat can be released for exercise and play.

Diseases and treatment

Giant rats are naturally infested with *Hemimerus talpoides* and may have ticks. The former is harmless and non-transmissible to other species, serving to eat dead skin and wax. Injection with 1 release% Ivomec® (ivermectin) (Aceta Pharma GmbH, Hamburg, Germany) at a dose of 200–400 μg/kg subcutaneously once a week for 3 weeks will eliminate ectoparasites (and many endoparasites). Studies have shown no adverse effects of ivermectin on pregnant rats[29]. Topical liquid applications dropped on the back of the neck may be useful and include Xeno release450 (Genitrix Ltd., Billingshurst, UK), the active ingredient being ivermectin. It therefore acts as an endectocide for the control of mites, roundworms and lice. Nematode infections can also be treated with fenbendazole or piperazine. Bladder threadworms can be treated with fenbendazole, protozoa with metronidazole (not in gravid does) and cestodes with praziquantel, niclosamide or thiabendazole. Fenbendazole-medicated chow remains an effective and practical method to eliminate pinworm infections in mice and rats[18]. Studies using rats that were naturally infested with *Syphacia muris* and kept in forced-air, individually ventilated cages showed that ivermectin given orally at a dose of 2 mg/kg for 3 treatments at 7- or 9-day intervals resulted in eradication[19]. Paired ivermectin treatments given at 7- or 9-day intervals were ineffective in eliminating parasites[19].

Abscesses may occur more frequently when cages have sharp areas and unhygienic conditions. The African giant rat has been linked, along with 2 other imported African species, to the spread of monkey pox virus in the USA[21], the Democratic Republic of Congo[20] and possibly the Caribbean[10], although there have been no substantiated reports in the UK. Other diseases/infections associated with the giant rat should be noted, as they could potentially be transmissible to owners, especially if they were caught, tamed and reared from the wild. These include: cestode infestations[25], nematodes[14], leptospira serovar infection[26], trypanosomiasis[17], rickettsia[24], *Leishmania tropica*[23], Potiskum virus[27], Ife virus[15], coagulase-positive *Staphylococci*[1], helminth infections[22] and coccidia[35]. Treatment of leptospirosis infection involves the use of drugs like doxycycline, penicillin, ampicillin and amoxicillin. Doxycycline is administered orally at 2.14 mg every 12 h for 7 days. Doxycycline administered 4.29–5.36 mg once a week is useful prophylactically, although to ensure effectiveness, 10 mg/kg for 5 days is recommended (R. Cooper, Veterinary Clinic, Bulawayo, Zimbabwe, pers. comm., 2008). An identical dosage is recommended for the treatment of rickettsia. African trypanosomosis infection, following diagnosis of parasites in a blood

smear, can be treated with diminazene diaceturate at 3.5 mg/kg for 5 days. Leishmaniasis treatment is dispensed at the same dose. Staphylococcosis is treated with amoxycillian trihydrate at 5 mg/kg 3 times a day for 7 days. Helminthosis is treated with deworming drugs. Coccidiosis is treated with cotrimoxazole at 100 mg/kg daily for 3 days. Non-steroidal anti-inflammatories are useful supportive medications for secondary bacterial infection as a consequence of viral infection.

No evidence of periodontal disease exists in the giant rat, unlike in the Sprague-Dawley rat, in which a finely milled diet, a wire mesh floor and tap water, instead of a regular diet, bedding and acidic water, attenuates its incidence[5].

Legislation on the import of rats into the UK

Directive 2003/459/EC (Art. 2) prohibits the import of non-domestic species of rodents originating in 3rd-world countries of sub-Saharan Africa (including *Cricetomys gambianus*) under Commission Decision of 20/06/2003 for protection against monkey pox virus. Pet rodents can be imported from Europe without undergoing quarantine under Reg. 998/2003 Art. 7, assuming there are no CITES or DWA implications. Rats should ideally be treated against parasites in the country of origin. According to the Department for Environment, Food and Rural Affairs (DEFRA), UK, rats can be imported under the Balai Directive 92/65/EEC and PETS Passport from EU countries to the UK. The Balai Directive applies when rats are collected from the breeder and were born and kept in captivity at the breeder's premises, and PETS Passport allows an individual to transport up to 5 rats in and out of the UK, with no legal requirements for quarantine. Movement between European Union (EU) countries or into the EU from Andorra, Iceland, Liechtenstein, Monaco, Norway, San Marino, Switzerland and the Vatican are not subject to any requirements with regard to rabies. When imported into the UK directly from any non-EU country, pets must be licensed into quarantine for 6 months. On 15 June 2007, Appendix A of the European Convention for the protection of vertebrate animals used for experimental and other scientific purposes (ETS no. 123) came into effect. There is, for example, a detailed section on procedures for handling an animal captured from the wild to include details of acclimatisation, quarantine, housing, husbandry and care.

Results of a survey of vendors

The percentages of positive and negative responses were 64 and 25 % (n = 41), respectively. In England, Wales and Scotland, there were 26, 10 and 5 respondents respectively. The county of Oxfordshire had the greatest return rate of questionnaires (56 %). Positive respondents either sold or ordered giant rats. Some pet shops acted as middlemen by ordering the rats on behalf of private breeders. Rats were principally ordered from breeders in Africa or in Europe. The range of ages of giant rats presented for sale, price per single rat, prices per pair (buck and doe) and transport costs were 4–12 weeks, £320–£370, £352.50–400.00 (including VAT), and £10–37.50, respectively. Most shops were reluctant to indicate the percentage of sales of giant rats for profit and confidentiality reasons, although some said that they sold 5–10 giant rats per year.

DISCUSSION

The African giant rat is an extremely interesting and entertaining exotic pet and lives for a longer time that the domestic rat. It is highly intelligent and friendly and its care is relatively easy although it does require a higher protein intake than the domesticated rat. It is assisting mine-clearing in former war-torn countries and greatly reducing costs for the detection of diseases like tuberculosis. Although it has the potential to act as a vehicle in spreading disease, strict quarantine and veterinary inspection of animals obtained legally will eliminate the vast majority of such infections. Further investigations on bedding material, food and social interaction in captivity of this species are warranted. The small animal veterinarian needs to be prepared to treat a giant rat and should not necessarily make assumptions that drug regimens are the same as those for the domestic rat or the hamster.

ACKNOWLEDGEMENTS

Veterinarians Dr J Horrocks in the UK and Dr R Cooper in Zimbabwe provided advice on diseases and treatment.

REFERENCES

1. Adegoke G O, Ojo M O, Adetosoye A I 1985 Serological characteristics of coagulase-positive staphylococci isolated from man and animals. *Journal of Applied Bacteriology* 58: 359–362
2. Ajayi S 1977 Field observations on the African giant rat *Cricetomys gambianus* in southern Nigeria. *East African Wildlife Journal* 15: 191–198
3. Ajayi S S, Tewe O O 1977 Performance of the African giant rat (*Cricetomys gambianus* Waterhouse) on commercial rations and varying dietary protein levels. *Laboratory Animals* 12: 109–112
4. Baker H J, Lindsey J R, Weisbroth S H 1979 Housing to control research variables. In: Baker H J, Lindsey R J, Weisbroth S H (eds) *The laboratory rat. Biology and diseases* Vol. 1. Academic Press, New York: 169–192
5. Björnsson M J, Velschow S, Stoltze K, Havemose-Poulsen A, Schou S, Holmstrup P 2003 The influence of diet consistence, drinking water and bedding on periodontal disease in Sprague-Dawley rats. *Journal of Periodontal Research* 38: 543–550
6. Broderson J R, Lindsey J R, Crawford J E 1976 The role of environmental ammonia in respiratory mycoplasmosis of rats. *American Journal of Pathology* 85: 115–130
7. Burn C C, Peters A, Day M J, Mason G J 2006 Long-term effects of cage-cleaning frequency and bedding type on laboratory rat health, welfare, and handleability: a cross-laboratory study. *Laboratory Animals* 40: 353–370
8. Canadian Council on Animal Care 1980 *Guide to the care and use of experimental animals* Vol. 1. Canadian Council on Animal Care, Ottawa, Ontario
9. Cooper R G 2000 Giant rats in Zimbabwe. *Rat & Mouse Gazette* 6: 26
10. Cooper R G 2006 The possibility of naturalisation of the African giant rat (*Cricetomys gambianus,* Waterhouse, 1840) in the Caribbean. *Living World, The Journal of the Trinidad and Tobago Field Naturalists' Club:* 54–55
11. Cooper R G 2008 Animal welfare. In: Cooper J E, Cooper M E *Introduction to veterinary and comparative forensic medicine.* Blackwell Publishing, London: 81
12. Cooper R G, Erlwanger K H 2007 Hyperzincaemia in a pet African giant rat (*Cricetomys gambianus,* Waterhouse, 1840). *Journal of the South African Veterinary Association* 78: 163–165
13. Coryndon S C, Gentry A W, Harris J M, Hooijer D A, Maglio V J, Howell F C 1972 Mammalian remains from the Isimila prehistoric site, Tanzania. *Nature* 237: 292
14. Diouf M, Durette-Desset M C 2002 Two new species of Nippostrongylinae (Nematoda, Trichostrongylina) parasites of *Cricetomys gambianus* and *Arvicanthis niloticus* (Muridae) from Senegal. *Parassitologia* 44: 97–101
15. Ezeifeka G O, Umoh J U, Ezeokoli C D, Ezealor A U 1987 Prevalence of Ife virus infection in wild rodents and birds from Zaria, Nigeria. *Journal of Wildlife Diseases* 23: 663–665
16. Halcrow J G 1958 The giant rat of East Africa. *Nature* 181: 649–650
17. Herder S, Simo G, Nkinin S, Njiokou F 2002 Identification of trypanosomes in wild animals from southern Cameroon using the polymerase chain reaction (PCR). *Parasite* 9: 345–349
18. Hill W A, Randolph M M, Lokey S J, Hayes E, Boyd K L, Mandrell T D 2006 Efficacy and safety of topical selamectin to eradicate pinworm (*Syphacia* spp.) infections in rats (*Rattus norvegicus*) and mice (*Mus musculus*). *Journal of the American Association of Laboratory Animal Science* 45: 23–26
19. Huerkamp M J 1993 Ivermectin eradication of pinworms from rats kept in ventilated cages. *Laboratory Animal Science* 43: 86–90
20. Hutin Y J, Williams R J, Malfait P, Pebody R, Loparev V N, Ropp S L, Rodriguez M, Knight J C, Tshioko F K, Khan A S, Szczeniowski M V, Esposito J J 2001 Outbreak of human monkeypox, Democratic Republic of Congo, 1996 to 1997. *Emerging Infectious Diseases* 7: 434–438
21. Hutson C L, Lee K N, Abel J, Carroll D S, Montgomery J M, Olson V A, Li Y, Davidson

W, Hughes C, Dillon M, Spurlock P, Kazmierczak J J, Austin C, Miser L, Sorhage F E, Howell J, Davis J P, Reynolds M G, Braden Z, Karem K L, Damon I K, Regnery R L 2007 Monkeypox zoonotic associations: insights from laboratory evaluation of animals associated with the multi-state US outbreak. *American Journal of Tropical Medicine and Hygiene* 76: 757–768

22. Ibrahim M A, Ogunsusi R A, Nwude N, Aliu Y 1984 Helminths of the African giant rat (*Cricetomys gambianus* Waterhouse) in Zaria, Nigeria. *Revue d'Élevage et de Médecine Vétérinaire des Pays Tropicaux* 37: 304–307
23. Johnson R N, Ngumbi P M, Mwanyumba J P, Roberts C R 1993 Host feeding preference of *Phlebotomus guggisbergi*, a vector of *Leishmania tropica* in Kenya. *Medical and Veterinary Entomology* 7: 216–218
24. Julvez J, Michault A, Kerdelhue C 1997 (Serological study of rickettsia infections in Niamey, Niger). (Article in French). *Médécine Tropicale: Revue du Corps de Santé Colonial* 57: 153–156
25. Lacasse C, Travis E, Gamble K C, Craig T 2005 Cestode cysts in two African giant pouched rats (*Cricetomys gambianus*). *Journal of Zoo and Wildlife Medicine* 36: 95–99
26. Machang'u R S, Mgode G F, Assenga J, Mhamphi G, Weetjens B, Cox C, Verhagen R, Sondij S, Goris M G, Hartskeerl R A 2004 Serological and molecular characterization of leptospira serovar Kenya from captive African giant pouched rats (*Cricetomys gambianus*) from Morogoro Tanzania. *FEMS Immunology and Medical Microbiology* 41: 117–121
27. Omilabu S A, Fagbami A H, Olaleye O D 1989 Susceptibility of laboratory and domestic animals to experimental infection with Potiskum virus. *Microbios* 60: 53–58
28. Peace T A, Singer A W, Niemuth N A, Shaw M E 2001 Effects of caging type and animal source on the development of foot lesions in Sprague Dawley rats (*Rattus norvegicus*). *Contemporary Topics in Laboratory Animal Science* 40: 17–21
29. Pereira J, Möller V M, Dallegrave E, Coelho R, Langeloh A 2003 Effect of Ivermectin (Ivomec 1 % injection) on pregnant female Wistar rats. *Brazilian Journal of Veterinary Research and Animal Science* 40: 328–333
30 Peterson A T, Papeş M, Reynolds M G, Perry N D, Hanson B, Regnery R L, Hutson C L, Muizniek B, Damon I K, Carroll D S 2006 Native-range ecology and invasive potential of *Cricetomys* in North America. *Journal of Mammalogy* 87: 427–432
31. Raynor T H, Steinhagen W H, Hamm T E Jr 1983 Differences in the microenvironment of a polycarbonate caging system: bedding *vs* raised wire floors. *Laboratory Animals* 17: 85–89
32. Sanchez D J, Gomez M, Llobet J M, Corbella J, Domingo J L 1997 Effects of aluminium on the mineral metabolism of rats in relation to age. *Pharmacology and Toxicology* 80: 11–17
33. Schwartz P J, Grote S K, Stephans K L, Adler E M 2000 Zinc elevates neuropeptide Y levels in rat pheochromocytoma cells by a mechanism independent of L-channel mediated inhibition of release. *Brain Research* 877: 12–22
34. Tõnissaar M, Herm L, Eller M, Kõiv K, Rinken A, Harro J 2008 Rats with high or low sociability are differently affected by chronic variable stress. *Neuroscience* 152: 867–876
35. Vassiliades G 1966 A new coccidium, *Eimeria moreli* n. sp. (Protozoa: Eimeriidae) of the Gambia rat (*Cricetomys gambianus*). *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Série D: Sciences Naturelles* 262: 2473–2475 (In French, with English summary)