Sección 3.2

Cane rat farming in Gabon. Status and perspectives

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Abstract

Gabon is an equatorial country with one of the highest consumption of bushmeat in Africa. With the goals to create an alternative source of income and reduce pressure on wildlife, a cane rat farming project was initiated in 1994 by the Gabon's Government and the NGO Vétérinaires Sans Frontières.

A pilot farm with a capacity for 300 animals was created out of a stock of animals adapted to captivity imported from Benin. During the first 18 months, performances achieved were 4,06 ± 1,4 young/litter, 1,86 litter/female/year and 6.77 weaned young/female/year. Since 1995, an extension programme was undertaken in Libreville's surrounding area. Candidates were installed with a reproductive group after receiving some training and building up their facilities.

During 1998, a survey was performed in 19 farms. The average number of animals per farm was of 25 individuals and performances were slightly lower than in the pilot farm: Average litter size was 4.47±1,06 and numeric productivity averages 2,48 ±2,22 (n=90 litters). Global mortality was high averaging 26% and pre weaning mortality reached 40%. During 1997, 13 farms managed to sell 661 kg of meat equivalent to 189 individuals at 5 US $/ kg.

Today, zootechnical parameters in the experimental station have considerably improved, particularly litter size (5,5 young/litter) and growth rate (commercialisation of 3.5 kg males at 8 months of age). The promotion of this activity proves technically feasible and difficulties encountered are social rather than technical. The number of farms is still increasing and cane rat production is becoming a valid animal production activity for the country, offering a complement to domestic economies. However, performances are still low compared to its potential and a large margin of improvement still exists.

The production of more than 2 metric tonnes meat of cane rat per year can hardly compete so far with the bushmeat trade. However, its development will certainly have an impact in the mentalities of the Gabon's population, offering good prospects for the development of game farming in Gabon as well as other surrounding countries of the Congo Basin.

Key words

Thryonomys swinderianus, cane rat, grasscutter, wildlife farming, bushmeat, Gabon, meat production, rural extension, Central Africa, West Africa.

Introduction

The Giant cane rat or grasscutter (*Thryonomys swinderianus*) is being developed as a minilivestock species in several countries of Western, Central and Southern Africa. Domestication of this rodent started in Ghana 25 years ago (Asibey, 1974) and continued in Benin during 1980's, with the help of a co-operation project between Germany and this West African country (Baptist and Mensah, 1985; Schrage and yewadan, 1995). As a result of this action, Benin holds at the moment the largest population of cane rats in captivity in the African continent reaching 19.000 individuals distributed in more than 500 private farms (Mensah, 2000), and cane rat farming is extending to many countries in Central and West Africa.

Gabon is a central African country where consumption of game is one of the greatest of the Congo Basin and where gross domestic product per inhabitant is one of the highest in the region. Therefore, this country was chosen to develop a cane rat farming programme that started in 1994 in the outskirts of Libreville. The present paper describes the methodology followed since 1994, the results achieved and an analysis of this activity in the country after six years of activity.

Study Context

Located in the west coast of Africa, Gabon straddles the equator. With a surface area of 267 677 km^2, Gabon is sparsely populated in comparison with other Central African countries,. The most recent estimations give a total population of 1,1 million inhabitants (FAO, 2001) and a demographic density of 4,1 inhabitants /km^2. Half of the population lives in urban areas, and this trend continues to grow as a result of rural exodus.

Only a very small proportion of Gabon's soil is used for agriculture which represents only 7% of the gross domestic product. Today, as in the past, agricultural production for the majority of cultivators is limited to subsistence crops (cassava, peanuts, bananas, plantains, corn and tubers) and commercial crops are controlled by parastatal organisations.

Animal husbandry projects are few and 65% of the protein consumed is obtained from game (FAO, 2001). This is partially attributed to the faunal wealth of Gabon's ever green forests, to the important tradition of hunting and game consumption, to the lack of suitable areas for

pasture (85% of the country is covered by forest) and to the equatorial climate and associated diseases which limit livestock development. As a result, in 1998, the amount of imported chicken was valued in 20.000 US$ and the value of imported beef reached 10.000 US$ (FAO, 2001). Indeed, Gabon is not self sufficient in food production and imported food items represent more than 50% of the annual consumption (Steel, 1994).

This socio-economic context explains the fact that Gabon has one of the highest consumption of bushmeat in the African continent, reaching 21.000 metric tonnes per year (FAO, 2001). The consumption per inhabitant is of 19 kg/year, being more than twice as important as the consumption of beef (FAO, 2001), which confirms the results estimated by Steel (1994). Almost the 130 species of mammals present in Gabon are exploited for food, as are several species of birds and reptiles. The most favourite species are antelopes, rodents and primates (Steel, 1994; Jori, 1997). Most of this consumption takes place in urban centres, and has favoured the organisation of a commercial bushmeat trade which is encouraged by an increasing demand of game towards urban centres.

Characteristics of the Giant cane rat

The grass cutter is, after the African porcupine from the genus *Hystrix*, the biggest of all African rodents (Delany and Happold, 1979). It belongs to the Suborder *Hystricognathi*, Family *Thryonomydae* which holds only one Genus, *Thryonomys*, containing two species: *T.swinderianus* or Giant cane rat and *T. gregorianus* or Small cane rat. The Giant cane rat has a thickset body, measuring 40 to 60 cm in addition to a 20-25 cm tail. Its average weight fluctuates between 2 and 4 Kg. in females and 3 to 6 Kg. in males. Its fur holds a mixture of brown, reddish and grey hair that varies depending on its habitat.

Offspring are born with 4 incisives and grow continuously, during the life of the animal. It is a monogastric herbivore easy to feed. Like the rabbit and other rodents, it is a good food transformer and practices coprophagy (Holzer *et al.*, 1986). Gestation length is 5 months. It is able to reproduce all along the year (Asibey, 1974b), and two litters from two to six youngsters can be detected per year (Baptist and Mensah, 1986; Adjanahoun,1992a,b).

Current grasscutter rearing situation in Africa

Although performances can still improve, the technical feasibility of grasscutter production has been demonstrated in Benin, and nowadays there is a selected breed of animals adapted to narrow captivity (Senou *et al.* , 1992). The many demands coming from other African countries, proves the existence of a potentially good market for cane rat meat and the easy

spread of the Benin's know-how to other parts of the continent. Today experimental and private grasscuter farms exist already in several countries in West and Central Africa (Jori et al., 1995; Mensah, 2000).

The initial livestock for farming was established originally from animals captured in the wild. At that stage, mortality could reach 50% or more and zootechnical performances were lower (Yewadan & Shcrage, 1992). However, keeping animals in captivity for almost 20 years, has allowed the establishment of a strain of cane rats adapted to production (Jori *et al.,* 1995).

Cane rat farming in Gabon

Despite the cane rat is a popular and sought after species in Central Africa, the species is less common than other forest species in the markets of urban centres of Gabon. It represents only 6% of the species found in the market (Steel, 1994).This is due to the fact that the species is found manly in savannah areas and around village crops but rarely in deep forest where bushmeat trade hunters operate.

In 1991, the first experience of cane rat farming started in the Southern Gabon as a result of a private initiative. A Gabonese businessman imported some animals from Benin, to rear them in captivity as a complement of its private integrated farm.

Three years later, an official cane rat farming programme started in the country with funding from the French Co-operation Office. This co-operation programme implemented by the Gabon's Government (Ministry of Agriculture and Ministry of Forest and Water) and the French NGO Vétérinaires Sans Frontières had the following goals:

To test the technical viability of cane rat farming in Central Africa

To promote and diffuse the breeding of cane rats throughout the country

The programme was supposed to generate, at a later date a new economic speculation in the outskirts of major Gabon's cities and a reduction of poaching by supplying markets with legal game meat produced in captivity.

Materials and Methods

Experimental station

A pilot station was constructed in the outskirts of Libreville with a capacity for 300 animals and the first animals arrived from Benin in May and August 1994. The technicians and the veterinarian in charge of the farm were trained by Beninese technicians in several aspects of cane rat farming.

Diet consisted on 80% of *Penisetum purpureum* and *Panicum maximum* completed with a mixture of corn, wheat and mineral salts. The composition of the mixture varied between 1994 and 1999, being gradually improved according to performances. Three different complements were tested (see Table 3).

Zootechnical performances in the farm were recorded between 1994 and 1996 and compared with those from the 1997- 2000 period (Ntsame Nguema and Edderai, 2000), and those from Benin (Yewadan and Chrage, 1992).

Sex determination is done at birth on the basis of the ano-genital distance (Schrage and Yewadan, 1995;). Weaning of young animals was performed on average at 35 days of age. Sexual maturity is achieved at 1500 g of living weight (six months for females and five months for males on average) and breeding in paddocks is performed in polygamous groups of one male per 5 females (Jori and Noël, 1996). Individual cages were used to keep males at rest and pregnant females. Gestation was determined between 6 weeks and 10 weeks of pregnancy on the basis of the test developed by Adjanohoun (1992a,b). Whenever possible, females separated from the group at the end of gestation and were reintroduced in the breeding group after a period of two weeks after weaning.

Preventive medication was limited to worm control every 6 months (Jori & Cooper, 2001). Routine management consisted of forage supply, livestock inspection, gestation tests of females every fortnight (Adjanohoun,1992a,b) and preventive hygienic precautions.

From 1997 to 1999, animals were genetically selected according to zootechnical performances such as prolificacy of females, body weight or docile behaviour.

Extension programme

The diffusion of technical skills among local farmers started in March 1995. Candidate farmers were volunteers who came on their own to gather information at the experimental station. There, modalities of partnership were explained to them. After visiting the area chosen to install the farm, they received a short training where they learned about materials and necessary skills to build their facilities. Only when these were ready, candidates received a training course on farming techniques during two to four weeks, according to education level. Once technically trained, they received, 2 to 5 castrated males at a subsidised price (6 US$ each). After 70 to 90 days, if the males where in good condition, they received as a loan a reproductive group of one male and six females (two of which were pregnant).

The candidates commit themselves to return to the project a total of seven animals during the first three litters.

Initially a close guidance from the project was provided through a couple of visits a months, which was reduced subsequently to once a month (after first litters) and later to once every two months.

During 1996 and 1998, two technical surveys were performed in the existing farms in order to analyse the zootechnical performances of the cane rat farmers installed by the programme.

All farms were visited and husbandry practices and production performances recovered with the help of questionnaire sheet. Data on reproduction, mortality and exploitation rate were recovered. Numerical productivity was considered as the product of weaned young per litter and number of litters per year in each farm. Mean values ± SE and percentages were calculated based on the number of data available. Level of significance between proportions and means was tested by comparing confidence intervals (Scherrer, 1984).

Results

Experimental station

In April 1996 the experimental station had reached the majority of its goals, allowing the constitution of very good data base about the husbandry of cane rat farming in Central Africa. Imported cane rats acclimated easily and zootechnical performances became rapidly similar to those achieved in Benin. A comparison of zootechnical parameters can be observed in Table 1.

Growth rate

The improvement of the diet complement allowed a substantial improvement in the growth results and the yearly weight gain of the animals. In Table 3, we can observe the substantial weight gain between the three different kinds of complement. Average weight improved from 8 to 13 gr. per day depending on the kind of complement given.

The best performances were obtained during the 1997-1999 period with a mixture of 60% of wheat, 30% of corn and 10% of rabbit pellets, which allow the performance of full grown males (3500 gr.), ready for marketing at an age of 8 months (Ntsame Nguema & Edderai, 2000).

Reproductive performances

Reproductive parameters obtained along the two periods of the programme can be compared in Table 4. A significant margin of improvement exists in the prolificacy of the litters, which passed from 4,06 ± 1,39 young /litter during the 1994-1996 (n=130) period to 5,5 in the 1997-1999 period (n=253). Number of weaned young per litter also followed an important evolution passing from 3,64± 1,41 (n=529) to 4,6 (n=730) during the period of the study.

Rate of fertility for females was 85 % in Benin [83%;87%] and 93% [88%;97%] and 94% [91%;97%] of mated females in Gabon during 1994-1996 and 1997-1999 respectively. Pregnancy was detected successfully in 87% of the pregnant females since the 6^{th} week of pregnancy with a specificity of 100% (Ntsame Nguema and Edderai, 2000).

Mortality

Pre weaning mortality was significantly decreased from 10,34% [5%;16%] (n=130) in 1994-1996 period to 8,7% [8,2%;9,1%] (n=233) between 1997 and 1999.

Evolution of yearly mortality can be observed in Figure 2. Global mortality decreased from 24% in 1994 (Jori & Copper, 2001) to an average of 15% between 1995 and 1999 period and increased suddenly to 50% during 2000 after a non identified infectious outbreak in the farm (Ntsame Nguema & Edderai, 2000).

Extension programme

Between 1995 and 2000, a total of 68 farmers had been installed and 971 animals distributed within the extension programme (Charbonnier and Edderai, 2000).

During the last survey in 19 farms (Jori, 1998), mean age of farmers was 43 years, mainly composed of man (90%). Most of the farmers (39%) were public officials, 17% were agriculturists and 17% belonged to the private sector. The mean age of the farms was 22 months, 30% of the farms had however less than one year of life. Two thirds of the farms were localised in the area of Libreville, and the rest was found in rural areas throughout the country. The mean number of animals per farm was 39 ± 60 animals, the largest farm holding 173 animals. The paddock systems with polygamous reproductive groups was by far the most widespread (15/19). Construction materials were more sophisticated in neighbouring areas of Libreville (bricks, cement, wire), while other used local materials such as bamboo, wood, mud, or recycled materials.

Concerning feeding, all of the farmers were giving green forage as base of the cane rat diet; The ratio was completed with corn, wheat, roar rice, dried bread, sugarcane, palm nuts, coconut depending on availability of products. Water was provided regularly.

Zootechnical parameters

The reproductive parameters observed during the two surveys are exposed in Table 4.

Global mortality has passed from 19% [16%;22%] (n=761) to 26%[34%;28%] (n=522) in two years. Mortality was particularly high during the period before weaning, pre-weaning mortality reaching 18,8% [14%;23%] and 31% [27%;35%] of the kits respectively during 1996 and 1998 surveys.

Reproductive parameters

Reproductive parameters in 1996 and 1998 surveys are summarised in Table 4. Mean litter size passed from 4,47±1 (n=62) in 1996 to 4,59±1 (n=90) in 1998. Unfortunately, numeric productivity is reduced by an important kit mortality that increased significantly between 1996 and 1998, passing from 2,09 ±0,74 kits/litter(n=62 litters) [range 1,4:3,1] to 2,48 ± 2,22 kits/litter (n=90 liiters) [range 0,57: 6,86], respectively.

Exploitation rate

A large majority of the farmers was exploiting some of its stock mainly for meat (80%) and only 2 had started selling some animals as livestock founders. Average exploitation rate of the livestock kept in captivity passed from 19% [16%;22%] in 1996 (n=522) to 31% [28%;32%] (n=761). The number of animals exploited per year per farm averaged 17 ± 13 cane rats (n=11) and ranged between 4 and 39 animals . During 1997, 13 farms managed to sell 661 kg of meat equivalent to 189 individuals (14 individuals/farm) .Animals in urban centres were sold for meat at 5 US$ per kg of living weight while only about 2 US$ could be charged per kg in rural areas. Reproductive stock was sold at 7,2 US$ per kg of living weight.

Discussion

Cane rat farming is often proposed as a model of wildlife production for sustainable development in West and Central Africa (Baptist and Mensah, 1986; Jori *et al*. ,1995; Caspary,1999; Auzel & Wilkie, 2000). On the other hand, literature on long term cane rat farming surveys is in fact scarce and the results reported here should contribute to establish new reference for this activity in Central Africa. Many of the productive data obtained in the

experimental farm in Gabon are significantly higher than those quoted in the literature by the German Beninese project (Yewadan & Schrage, 1992; Schrage and Yewadan, 1995). The significant improvement of most production parameters such as prolificacy of females, growth rate of cane rats or the number of weaned kits per litter are probably the result of a cautious husbandry , an improved diet and a genetic selection programme initiated in 1997.

Tameness of the animals has considerably improved since the beginning of the project. Several measures to reduce stress were undertaken in the experimental farm (McCoy et al., 1997; Jori & Cooper, 2001) and could have contributed to increase docility and reduce stress induced mortality. Since 1995, some animals with a paler-almost white- fur started to born among the stock. This kind of coat has never been observed before among cane rats by the authors.

According to Hemmer (1992), the observation of a paler coat in wild mammals in process of domestication is a sign of adaptation to captivity. However further genetic studies should be necessary to confirm the correlation.

The results confirm that cane rat farming is technically feasible in Gabon and that there is a margin of improvement in the zootechnical performances of this species.

Building a breeding centre in order to establish a local reference and provide founding stock to candidate farmers was certainly a good approach. In fact, starting a farm with wild captured animals leads to very high mortalities (Yewadan and Schrage, 1992; Adu *et a*l., 2000).

In that sense, the co-operation with Benin to obtain captive born animals and to train local technicians proved extremely useful and allowed the project to obtain results in a limited lapse of time.

Published evaluations of cane rat farming extensions programmes in Africa are scarce and relate to West African countries such as Benin and Ghana (Adu et al, 2000; Mensah, 2000). Mortality during the first extension trials in Benin was high, reaching 56,4% of the stock (Adoun, 1992; Yewadan, 1995). In our survey, results among farmers were generally lower than those obtained in the experimental station. Mortality was higher and reproductive management to optimise production was lacking.

Surprisingly, litter size in 1998 was higher than those obtained experimentally in Benin (Schrage & Yewadan, 1995) and during the first period in the experimental station in Gabon.

A survey of spontaneous cane rat farms in Ghana (Adu et al, 2000) also reported outstanding prolificacy performances close of 4,7 young/litter in 58 farms. A possible explanation might be that the animals receive good feeding ratios. Adu & Yeboah (2000) suggested a positive role of maternal nutrition in increasing litters size in the grasscutter. Unfortunately, performances of pre weaning mortality and yearly litters per female were very low, reducing numeric productivity of the females.

As seen in Figure 4, production performances were very diverse and a large margin of improvement exists for increasing productivity in those farms if measures are taken to reduce kit mortality and intensify reproductive management of females to tend to optimal performances.

The evolution of farmers and animals in captivity in Gabon has been exponential: While there was only one farm with 40 animals before 1994, there are today 52 farms and more than 1200 grasscutters in captivity. The number of candidates and farms is still increasing and abandonment rate initially high, is being reduced (Houben, 1999). In fact, among the 68 farms installed since 1995, more than 75% are still running today, although 88% have less than 2 years of life (Mensah, 2000).

Most of the farmers installed by the project were localised in areas surrounding large cities. In fact, cane rat farming shows better prospects of success in peri-urban than in rural areas due to the high demand in bushmeat, reduction of transport costs and the high prices of paid for game in large urban centres. In rural areas, hunting management of wild cane rats shows certainly more promise than farming since these rodents are abundant, and their capture reduces predation and damages on feeding crops. Moreover, prices in rural areas are at least twice lower than those paid in urban centres. (Steel, 1994).

From an environmental point of view, cane rat rearing in surrounding protected areas has failed, due to the same reasons of motivation mentioned for rural areas. A possible option to increase motivation, is to link production with tourists restaurants in areas where ecotourism is developped. However, this option is of limited value in Gabon.

In the capital city, wild cane rat meat is sold at 2,8 US$ /kg (1 US$= 695 FCFA). Despite cane rat is rarely found in the city markets, It is widely consumed and production is currently insufficient to satisfy the demand. A survey among 930 citizens from Libreville, showed that

57% of them consumed regularly cane rat when they visited their families in the countryside (Injielley,1999 pers. comm.)

A World Bank study in Ghana showed that small scale cane rat farming with a yearly stock of 260 animals (40 reproductive females) was the most profitable system of animal exploitation, followed by poultry and rabbit (Tutu et al, 1996). In Gabon, a farm of this size but with average production performances obtained a profitability threshold between 350 and 450 US$ per year with the sale of 14 to 20 animals for meat (Chardonnet & Bonnet, 1996). Despite it can complement domestic economies with little extra work, this level of production can hardly make a living in Gabon. However, profitability can be substantially increased by improving management methods and by selling live cane rats as stock founders or technical know-how to other farmers. Several authors in different African countries (Mensah, 2000; Dabogrogo, 2000) seem to agree that a small scale grasscutter farm of 40 reproductive does is the most profitable scale of production and that well managed cane rat farms can substantially contribute to local economies and produce enough profit to make a living. (Table 5).

Conclusion

Despite the opinion of some authors (Fa, 2000), substantial progress is being made in the domestication and exploitation of the cane rat in West and Central Africa. This activity is technically viable in Gabon and productivity under experimental conditions is good and can certainly be improved. Productivity and profitability under local small scale conditions is still low, but the margin of improvement is very important. Our results indicate that difficulties to promote cane rat farming are social rather than technical. Since livestock and agriculture are practically irrelevant in Gabon, this issue certainly represents a big obstacle to the promotion of agronomic activities of any kind. This might explain why productive parameters in the field are far beyond those obtained under experimental conditions.

The amount of cane rat meat produced in Gabon has considerably increased, passing from a few kilos to 2 metric tonnes per year in 6 years. However, it is unlikely that cane rat farming on its own can compete with such an enormous bushmeat trade (Wilkie & Carpenter, 1999).

In fact, at the current level of production, more than 200.000 farms would be necessary in Gabon to provide an amount of meat similar to the one that is extracted from the forest. Despite this figure is so far unrealistic, it means that many more farms are needed and level of production should be improved the development of bushmeat substitutes needs to be

accompanied by other measures such as taxationa and price manipulation (Wilkie and Carpenter,1999).

Nevertheless, the potential of cane rat farming for protein production, economic development and for changing the mentalities of African populations towards wildlife use should not be underestimated. The enormous demand of bushmeat provides evidence of the great potential of this activity in periurban areas of West and Central Africa, which will hopefully continue to develop and improve.

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References

ADJANOHOUN, E. (1992a): Le cycle sexuel et la reproduction de l'aulacode (T.O. TEMMINCK 1827). Mammalia, .56 (1): 109-119.

ADJANOHOUN, E. (1992b): Gestation diagnostic of the grasscutter (Thryonomys swinderianus): field and laboratory methods. Proc. 1st Conf. Grasscutter Prod., Cotonou, Benin, pp. 123-131.

ADOUN, C. (1992a): Pre-extension of grasscutter production: Concepts and experience of the Benin/German Grasscutter Project. Proc. 1st Conf. Grasscutter Prod., Cotonou, Benin, pp. 203-209.

ADU EK.; ALHASSAN, W.S.; NELSON, F.S. (2000): Smallholder farming of the greater cane rat, *Thryonomys swinderianus*, Temminck, in southern Ghana: a baseline survey of management practices. Tropical Animal Health & Production, 31(4):223-32.

ADU EK; YEBOAH S. (2000): The efficacy of the vaginal plug formation after mating for pregnancy diagnosis, and embyonic resorption in utero in the greater cane rat (*Thryonomys swinderianus*, Temminck). Tropical Animal Health and Production, 32(1):1-10.

ASIBEY, E.O.A. (1974a): The grass cutter, Thryonomys swinderianus TEMMINCK, in Ghana. Symp. Zool. Soc. London, 34, 161-170.

ASIBEY, E.O.A. (1974b): Reproduction of the grass cutter in Ghana. Symp. Zool. Soc. London, 34, 251-263.

AUZEL, P and WILKIE, D.S. (2000): Wildlife use in Northern Congo: Hunting in a commercial logging concession. In: Robinson, J.G. and Benett, E.A., Editors ; Hunting for sustainability in tropical forests. 413-426.

BAPTIST, R. and G.A.MENSAH (1986): The cane rat: Farm animal of the future? World Animal Review, 60 (4): 2-6.

CASPARY, H.U. (1999): Wildlife utilization in Côte d'Ivoire and West Africa-potentials and constraints for development cooperation, GTZ publication, Eschborn, 183 pp.

CHARBONNIER, A. et EDDERAI, D. (2000): Diffusion de l 'aulacodiculture au Gabon. Startégies et résultats. Actes du Séminaire International sur l'élévage intensif de gibier à but alimentaire en Afrique, Libreville. 144-148.

CHARDONNET, P et BONNET, P. (1996): Evaluation indépendante du projet d'élevage de petit gibier au Gabon. Rapport CIRAD EMVT n° 960029, 34 pp.

DABOGROGO, M (2000): La Ferme pilote d'aulacodiculture de Ouagadougou. Actes du Séminaire International sur l'élévage intensif de gibier à but alimentaire en Afrique, Libreville, pp 167-170.

DELANY, M.J and D.C.D.HAPPOLD (1979): Ecology of African Mammals. Longman, London.

FA, J.E. (2000): Hunting Animals in Bioko Island, West Africa: Sustainability and Future. In: Robinson, J.G. and Benett, E.A., Editors ; Hunting for sustainability in tropical forests. 168-198.

FANTODJI, A. et MENSAH, G.A (2000): Rôle et impact économique de l'élevage de gibier en Côte d'Ivoire. Actes du Séminaire International sur l'élévage intensif de gibier à but alimentaire en Afrique, Libreville, pp 25-42.

FAO (2001): Statistical Database.http://apps.fao.org/default.htm.

HOLZER, R.,; MENSAH, G.A. and BAPTIST, R. (1985): Aspects pratiques en élevage d'aulacodes (T.S): 11- Comportement de coprophagie. Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux, 39 (2), pp 247-252.

HOUBEN, P. (1999): Elevage d'aulacodes au gabon. Elements de bilan. Canopée, 15, 7-8.

JORI, F.; MENSAH, G.A.; ADJANOHOUN, E. (1995): Grasscutter (*Trynonomys swinderianus*) production: an example of rational exploitation of wildlife. *Biodiversity & Conservation, 4 (2)*: 257-265, 1995.

JORI, F. and NOËL, J.M. (1996): Guide pratique de l'élevage d'aulacodes au Gabon. VSF/Coopération Française, 1996, 64 pp.

JORI, F. (1998): Evaluation de la diffusion de l'aulacodiculture au Gabon. Acquis, VSF Report, Libreville, 41 pp.

JORI, F. (1997): Etude de faisabilité de l'élevage commercial d'espèces suavages au Gabon. WWF/UNDP/GEF Report, 76pp.
JORI, F. and COOPER, JE. (2001): A survey of pathology on captive cane rats (*Trynonomys swinderianus*). The Veterinary Record, In press.

McCOY, J. JORI, F. and STEM, C. (1997): Tranquillisation of cane rats (*Trynonomys swinderianus*) with a long acting neuroleptic (Pipothiazine palmithate). *Journal of Veterinary Pharmacology and Therapeutics, 20:233-239*, 1997.

MENSAH, G.A. (2000): Présentation générale de l'élevage d'aulacodes. Historique et état de la diffusion en Afrique. Actes du Séminaire International sur l'élévage intensif de gibier à but alimentaire en Afrique, Libreville. 75-77.

NTSAME NGUEMA, M et EDDERAI, D.(2000): Résultats zootechniques de la station d'aulacodiculture d'Owendo. Actes du Séminaire International sur l'élévage intensif de gibier à but alimentaire en Afrique, Libreville. 75-77.

SCHERRER, B. (1984): Biostatistique. Gaëtan Morin Editeurs, Montréal, 647 pp.

SENOU, M.; L.T.YEWADAN and R.SCHRAGE (1992): Contribution to the genetic improvement of grasscutters (Thryonomys swinderianus). Proc. 1st Conf. Grasscutter Prod., Cotonou, Benin. pp 175-185.

STEEL, A. E. (1994): Study of the value and volume of bushmeat commerce in Gabon. WWF Gabon Programme Report, 78 pp.

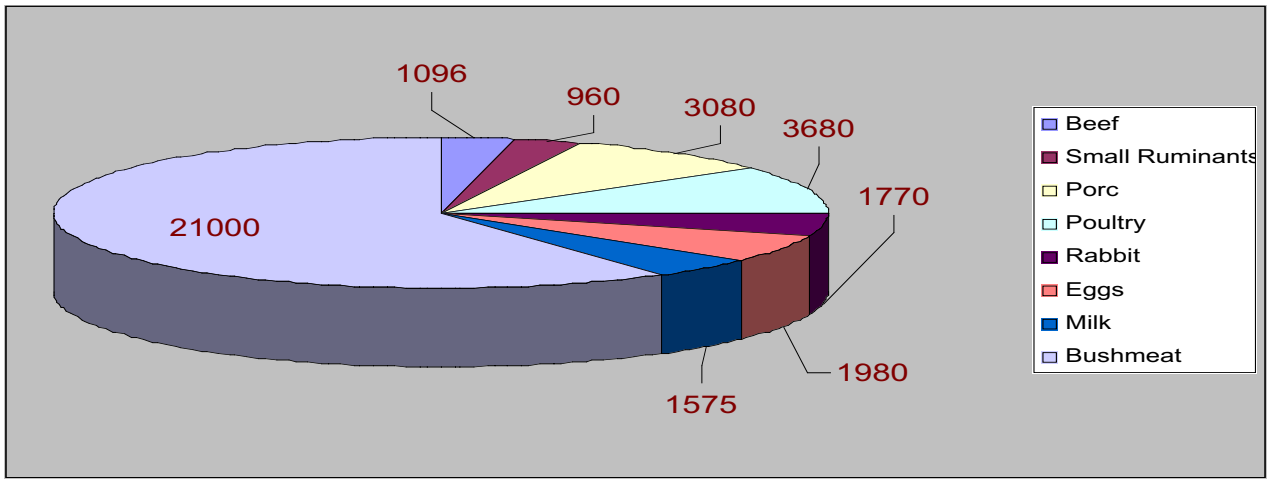
TUTU, K.A. NTIAMOA-BAIDU, Y. and ASUMING-BREMPONG, S. (1996): The Economics of living with wildlife in Ghana. In Bojo, J: The Economics of wildlife. AFTES Working Paper n°19, The World Bank, 11-37.

WILKIE, D.S and CARPENTER, J.F. (1999): Bushmeat hunting in the Congo Basin: an assessment of impacts and options for mitigation. Biodiversity and conservation, 8: 927-955.

YEWADAN, L.T. (1992) : L'alimentation des aulacodes élevés en captivité étroite. Proc. 1st Conf. Grasscutter Prod., Cotonou, Benin. 143-149.

YEWADAN, L.T. and SCHRAGE, R. (1992): The zootechnical performances of the grasscutter (Thryonomys swinderianus) reared in close captivity. Proc. 1st Conf. Grasscutter Prod., Cotonou, Benin. 165-175.

Figure 1: Production of animal protein in Gabon (metric tonnes)



source FAO, 2001

Table 1: Comparison of reproductive parameters of cane rat farming in the experimental farm in Gabon and in Benin

Parameters	*Benin[1] 1992*	*Gabon[2] 1994-1996*	*Gabon[3] 1997-1999*
Number of litters observed	1553	130	243
Number of kits born	6147	529	1337
Mean litter size (offspring/litter)	4	4,06 ± 1,4	5,5
Medium litter weight (g)	489	567	-
Sex ratio at birth (male :female)	1:1	1:1,2	1:1
Number litters/adult female/year	1,73	1,86	1,2
Number young weaned/litter/year	3,56	3,64 ± 1,4	4,6
Number young weaned/adult female/year	6,16	6,77	5,52
Average weight of young	133	138± 22	133,3
Fertility rate	85	93	94

1:Yewadan & Schrage, 1992; 2: Jori, 1998;3: Ntsame Nguema & Edderai, 2000

Table 2: Comparison of mortality data in the experimental farm in Gabon and in Benin

Parameters	*Benin[1] 1992*	*Gabon[2] 1994-1996*	*Gabon[3] 1997-1999*
Global mortality 2nd year(%)	35,1		
Global mortality 3rd year (%)	26,3	17,8	13,3
Weaning mortality (at six weeks) (%)	11		
Weaning mortality (at five weeks) (%)			8,7
Weaning mortality (at four weeks) (%)		10,34	

1:Yewadan & Schrage, 1992; 2: Jori, 1998;3: Ntsame Nguema & Edderai, 2000

Figure 2: Evolution of mortality in the cane rat experimental station between 1994 and 1999

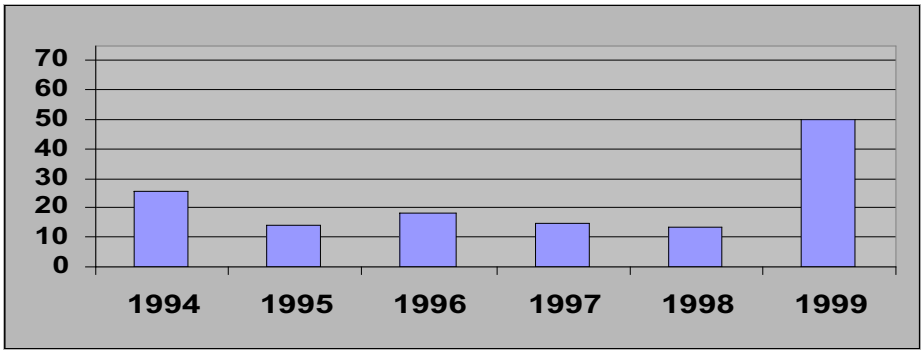


Table 3: Evolution of cane rat weights (gr) according to different complements to green fodder

Age	Benin 1992		Gabon 1994-1996		Gabon 1997-1999	
	Diet 1		**Diet 2**		**Diet 3**	
	Weight	**N**	**Weight**	**N**	**Weight**	**N**
Birth	134 ± 24	163	137 ± 30,3	226	133,3	730
Weaning	-		493,67±138**	234	612*	609
4th month	1114 ± 279	163	1069 ± 347	225	1679	388
8th month	2417 ± 552	163	2074 ± 575	116	3565	76

*45 jours ** 35 jours

Diet 1. Wheat 43%; Corn 21%; Brewers grain 26%; Molasses 5%; Leucaena leucocephala leaves 3%; Vitamines and salt 2%; Oyster shell 1% (Yewadan, 1992)
Diet 2. Corn 60% Wheat 30%; Oyster shell 8%; Vitamines and salt 2%
Diet 3. Wheat 60% Corn 30%; rabbit pellets 10%. (Ntsame Nguema & Edderai, 2000)

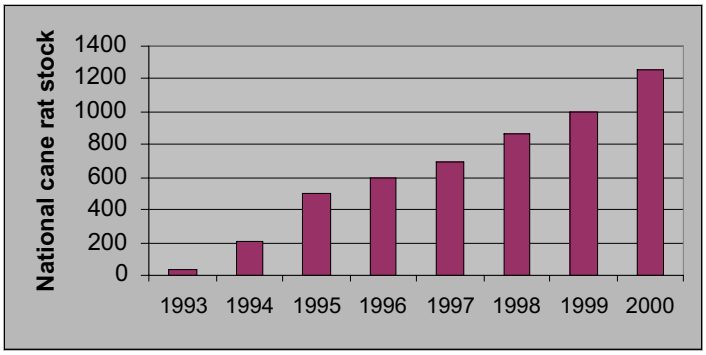
Table 4: Comparative parameters recovered during different cane rat extension programmes

	Gabon[1],1996	Gabon[2], 1998	Benin[3],1993	Ghana[4],1992
Number of farms surveyed	10	19	16	31
Total number of litters reported	62	142	-	-
Total number of kits born	283	603	-	-
Global mortality (%)	18,8	26	56,43	
Pre weaning mortality (%)	18,9	31	-	-
Mean litter size	4,47	4,59	-	4,63
Number of weaned animals/litter	3,62	3,04	-	-
Number of litters/year	0,62	0,78	-	-
Numeric productivity	2,24	2,37	-	-

1: Chardonnet, 1996; 2: Jori, 1998; 3: Adoun, 1992; 4: Adu et al., 2000

Figure 3: Evolution of cane rat farming in Gabon between 1993 and 1999 :

A) National cane rat stock



B) Number of farmers

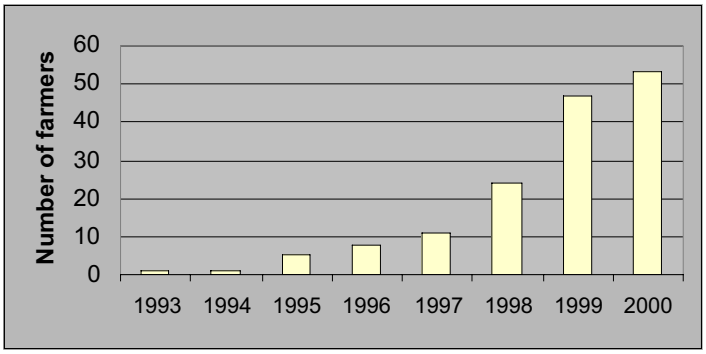
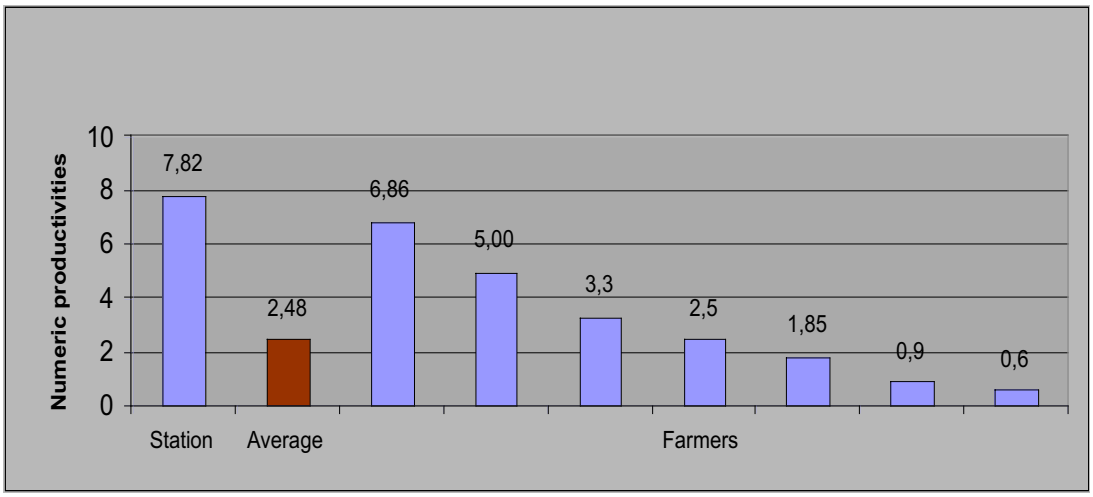


Table 5: Comparative real profitability of a small scale grasscutter farm in different African countries (1US$=695 FCFA)

	[2]Gabon	[1]Burkina Faso	Benin	Ivory Coast
Minimal salary	50,36	41,73	31,44	64,75
Reproductive stock	50,00	50,00	50,00	50,00
Stock sold as game	18,00	39,00	83,00	83,00
Stock sold as founders	31,00	94,00	80,00	80,00
Total stock sold	49,00	133,00	163,00	163,00
Price of a kg of game	5,04	3,60	1,64	2,88
Price of a stock founder	28,78	21,58	10,50	28,78
Profit on the 3rd year	37,50		16,34	143,56
Profit on the 4th year		73,69	177,54	663,78
Profit on the 5th year		156,77	177,54	663,78

Source : Fantodji & Mensah, 2000 except [1]Dabogrogo, 2000 and [2] the authors

Figure 4: Graphical representation of numeric productivities in different farms during the 1998 survey



Capitulo 4

La patologia del aulácodo (*Thryonomys swinderianus*) en Gabón

Sección 4.1

A survey of pathology on captive cane rats (*Trynonomys swinderianus*)

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Summary

Despite being increasingly reared in captivity in many African countries, data on diseases of farmed grasscutters (*Thryonomys swinderianus*) are scarce. This paper analyses causes of morbidity and mortality in a population of cane rats from an experimental farm in Gabon over a period of 21 months. A total of 94 necropsies was performed and complementary laboratory examinations were carried out in 36 cases in order to provide reference data on post-mortem lesions. The cumulated mortality of a total population of 546 animals was 15.4 %. Monthly mortality averaged 2.5% during the period of the study and affected mainly subadult individuals (42%), preweaned and adult individuals representing 28% and 30% of the deaths respectively. The most frequent cause of death was non-infectious, trauma being responsible for more than 31% of deaths. Among pathological causes, 12% of the cases were found with septicaemia,12% with primary respiratory lesions, 5% with gastro-intestinal disorders, 4% with reproductive problems and 3% with urinary lesions. In 29% of the cases, the diagnosis could not be ascertained. The study suggests that stress is an important predisposing factor to cane rat diseases. Moreover, it shows that causes of mortality in cane rats can vary according to geographic location, health status of the herd and management methods.

Introduction

The cane rat or grasscutter (*Thryonomys swinderianus*) is a very popular food item in many parts of Central and West Africa (Asibey 1974; Baptist and Mensah 1986; Jori and others 1995) where attempts are being made to breed the species in captivity. Data on the diseases and pathology of cane rats are scarce (Akomédi 1988; Tondji *et al* 1992; Müller 1995; Mpoame 1994; Oboegbulem and Okoronkwo 1990) and more work is needed if the situation is to be rectified (Adu and others 2000).

In this paper we report *post-mortem* and laboratory findings of 94 autopsies performed on captive cane rat carcasses from an experimental farm in Gabon, Central Africa. This was a preliminary investigation aimed at determining baseline data on the common background pathology of this species under captive rearing conditions.

Materials and methods

Study site

Animals in this study belonged to an experimental breeding farm set up in Gabon by the NGO Vétérinaires Sans Frontières, with the aim of promoting cane rat farming in the suburban area of Libreville.

The climate in Gabon is hot and humid, with a yearly mean temperature of 26ºC, a daily range of 10ºC and a yearly variation of 4ºC. Annual rainfall is close to 2000 mm, with 80 - 90% relative humidity.

Animals

The average number of stock consisted of 200 animals. The initial 80 animals arrived in May and August 1994 from Benin and Togo, where similar private cane rat farms already existed. All the animals belonged to a selected strain of animals adapted to captivity (Jori and others 1995).

Housing

Grasscutters were kept in $2m^2$ floor paddocks or 1.5 m^2 wire cages. Weaning of young animals was performed on average at 35 days of age. At this stage, animals were grouped according to sex and age and put together in lots at an average density of 7-8 individuals/m^2 until sexual maturity (Jori and Noël 1996).

Puberty is reached at 1500 g of body weight (equivalent to six months for females and five months for males, on average). Adult males are territorial and fight to the death if housed in

the same facility. Nevertheless, castrated males can be kept together at densities of 4-5 individuals / m^2 until commercial weight is achieved at 3500-4000 g.

Reproductive management

Breeding groups in cages were composed of one male with 2 females. In floor paddocks, polygamous groups of 6 to 8 females were established. Females were tested for pregnancy at 6 to 8 weeks after mating (Adjanohoun, 1989). If gravid, they were separated from the breeding group and put together with other pregnant females or housed individually in cages. After birth, the mother remained with the litter until weaning and was remated after two weeks of rest.

Diet

The cane rats were fed with an average daily ratio of 100 g of fresh *Pennisetum purpureum* and *Panicum maximum* green supplemented with a 20-50g of mixture composed of maize and weed grains, calcium carbonate and salt. Water was provided daily.

Preventive measures

Preventive medication was limited to worm control with fenbendazole (Panacur 2.5%; Hoechst) *per os* at a dose of 20 mg/kg of bodyweight, 5% Pyrantel tartrate solution (Exhelm; Pfizer) *per os* at a dose of 200-250 mg/ kg of bodyweight every 6 months (Schrage and Yewadan 1995).

To minimise transmission of parasites between free-living and captive grasscutters, fodder was left exposed to sunlight for 24 to 48 hours before distribution to the animals (Adjanohoun 1989).

A hide was provided in paddocks to give the animals a greater feeling of security. Big bones or pieces of dead coral reef were given to the animals to gnaw and thus to prevent dental overgrowth.

Monitoring of mortality

Between May 1994 and January 1996, every animal found dead was recovered and its age, sex, weight, date of death and clinical history were recorded. Animals were classified as *Kits*, S*ubadults* or A*dults* according to age - categorising *Kits* as pre-weaned animals, *Subadults* as individuals from weaning to sexual maturity and *Adult*s as animals from sexual maturity onwards.

Mortality was calculated on the basis of true mortality rate and risk of mortality, following to Martin and others (1987). True mortality rate was calculated as the ratio between the sum of deaths and the sum of the population at risk on a monthly basis during the period of study.
Mortality after the arrival of animals at the farm was calculated as a risk rate by dividing the number of deaths by the number of animals that entered. Preweaning mortality was calculated as the number of animals that died between birth and the weaning period. Embryonic and perinatal mortality was not analysed.

Monitoring of pathology

Necropsies followed a standard protocol. Highly decomposed animals had internal organs which were discoloured, misshapen or ruptured and difficult to recognise. Moderately decomposed carcasses were visibly autolytic, but the internal organs were intact and recognisable and could be assessed for the presence of lesions. Fresh carcasses had no visible signs of autolysis.
Cane rats that died spontaneously between May 94 and January 96 were examined within a few hours of death. Carcasses were classified as being in good, moderate or poor body condition. Animals in good body condition had well developed rump musculature, and visible amounts of fat in the intestinal mesentery or abdominal subcutis, perirenal area and coronary groove of the heart.
Animals in moderate body condition had moderately well developed rump musculature, visible fat in the perirenal area and coronary groove, but not in the intestinal mesentery or abdominal subcutis; Animals in poor body condition had poorly developed rump musculature and no visible fat in the coronary groove.
Tissues taken *post mortem* were fixed in 10% non-buffered formalin, and processed in Europe where they were embedded in paraffin wax, sectioned at 5μm and stained with haematoxylin and eosin (H&E) for examination by light microscopy. From April 1994 to January 1996, 94 carcasses of cane rats were autopsied and 23 samples were sent for histological examination.
Thirteen other cases from later periods after the study survey or from other farms with the same rearing conditions were also included in the histopathological analysis.
Tissues sampled for histology were lung, trachea, kidney, ureter, liver, spleen, stomach, jejunum, ileum, adrenal gland, lymph nodes, uterus, skeletal muscle, bone, skin, and brain.

Two clinically healthy animals were culled to be sold as bush meat, and samples from different tissues were processed as control material. When gross lesions were suggestive of bacterial or fungal infection, samples were taken to be cultured on aerobic routine media.

Endoparasites encountered during autopsies were kept in ethanol 90% until identification was performed in the Faculty of Pharmacy's Laboratory of Parasitology, at the University of Barcelona . Parasites were identified according to Durette-Desset and Chabaud (1981) and Soulsby (1982). Microscopic faecal investigation was not performed.

On the basis of macroscopic and laboratory findings a suspected cause of death was determined and animals were then grouped under seven main headings: "Trauma", "Respiratory diseases", "Digestive diseases", "Urinary diseases", "Septicaemia" and "Others". The heading "Unknown" included those cases in which a diagnosis could not be determined.

Results

Mortality distribution along the study

The cumulated mortality of a total population of 546 animals was 15.4 % and monthly mortality averaged 2.5% during the period of the study. Cumulated pre-weaning mortality in the farm during the study was calculated at 5.7%.

During 1994 there were two months when mortality was particularly high, coinciding with the arrival of animals on the farm. During the first month , mortality rate reached 14.5% 9/62) of the animals that entered the farm. During the first month after the second arrival of animals, the figure was similar reaching 12.5% (5/40) of the animals introduced.

The crude mortality true rate during the period of the study -excluding the first month after arrival- was 2.38 per 100 animal-months. Between June and December 1994 true mortality was 4.24 per 100 animal-months. During 1995 mortality stabilised, reaching a value of 1.9 per 100 animal-months and the only important episode occurred in April 95 when mortality reached 4.06 per 100 animal-months (Figure 1).

Causes of mortality

Results of the autopsies performed are summarised in Table 1. The most frequent cause of death was trauma, this being responsible for 31% of known deaths. Depending on the clinical history, trauma was classified as accidental trauma or intraspecific aggression. Among pathological causes of death, septicaemia and primary respiratory lesions were the most common, diagnosed in 13% and 11% of the cases respectively. Other lesions encountered were gastro-enteric disorders (5%), reproductive disorders (3%) and urinary pathology

(4%). A third of the examined carcasses remained without a conclusive diagnosis and was classified as "unknown".

Pathology

Most histological sections proved of good quality despite the use of non-buffered formalin as fixative. Varying degrees of *post-mortem* autolysis were present, reflecting delay, under tropical conditions, prior to examination. A range of gross and histopathological changes was detected and these, in general, were similar to conditions reported in other species of wild rodents in captivity (Martino & Stanchi 1998; Dollinger and others 1999).

Trauma

This was the most important cause of death in our study. It was more prevalent in subadult animals (40% of cases) and less so in adults (18%). Physical trauma occurred through intraspecific aggression (55%), transport (7%) and attempts by particularly stressed animals to escape (38%). Individuals with a very nervous temperament were recognisable at autopsy by a cachectic body condition, wounds on the muzzle and an empty stomach. Some were found dead with their teeth locked in the cage mesh. Those animals could have died of asphyxia (Alogninouwa and others 1996) or internal bleeding.

Accidental deaths due to improper manipulation were often accompanied by clinical signs of paralysis, or fractures due to accidental falling. This was particularly common during the first week after transport. Histologically, no particular lesions were found other than internal haemorrhages and haemosiderosis.

In cases of intraspecific aggression, animals presented with wound bites or haematomas and died from bleeding, infected wounds or anorexia. Intraspecific dominance within a group of animals was also considered to be a form of aggression, despite the fact that it did not always result in physical trauma.

Respiratory disease

This was the most prevalent infectious finding, being suspected as the primary cause of death in 11% of the carcasses. Nevertheless, 36% of the autopsies showed at least moderate pathological changes in the lungs. Pneumonia and lung oedema were frequent, and lung emphysema and abscesses were also found repeatedly. Primary respiratory lesions were more commonly found in young and adult animals, while in subadult animals lesions in the lungs appeared as a part of a septicaemic picture. *Klebsiella pneumoniae* and

Staphylococcus aureus were isolated from pneumonic lesions on several occasions (see Table 2). Most of the cases (90%) appeared more frequently in the dry season, between the months of May and September.

Histologically, macroscopic lesions consisted of congestion, oedema, subacute bronchopneumonia, acute or chronic pneumonia, emphysema and foci of perivascular mononuclear inflammatory infiltration of the lung parenchyma. A significant number of animals, including those submitted as control material, was observed with pulmonary oedema and congestion, associated with infiltration by macrophages.

Septicaemia

This was the most frequent infectious cause of death encountered in our study, being twice as common in subadult than in young or adult individuals. Animals were classified under this section when several vital organs were petechiated and other lesions suggesting infection (inflammation, abscesses) were present. A large proportion of the septicaemic cases (6/12) had a history of a recent stressful event in the few days prior to a sudden death (cage mate aggression, change of facility, weaning). In those cases where bacteriological analysis was performed, *Staphylococcus aureus* and *Klebsiella pneumoniae* were isolated from different organs.

Streptococcus D haemolyticum was also isolated on one occasion (see Table 2). Ninety percent of the animals had lesions in the lung, and 60% had lesions in liver, spleen and kidney. Lesions observed ranged from acute hepatic necrosis and acute pneumonia to splenic necrosis and petechiated kidneys.

Digestive disorders

Digestive lesions were rarely observed and were reported in only 5% of the animals. Young animals appeared more affected in our study although the number of cases was too small to be representative (see Table 1). No deaths related to dental overgrowth or malocclusion were observed. Gastric lesions such as gastritis, ulcer, and stomach perforation were reported on two occasions.

Dead specimens of some endoparasites could be recovered occasionally (see Table 3). The most prevalent species was *Paralibyostrongylus hebreniticus*, a nematode that was detected in 6 samples. Other nematode or cestode species were found only sporadically. Lesions due to parasitosis were rarely observed in the mucosa, except for eosinophilic infiltration and moderate enteritis. Intussusception was found in two animals with moderate numbers of

parasites. Caecal impaction was frequently found but the cause could not be determined. Occasionally, we observed in the liver fatty changes, necrosis, and congestion; however, hepatic changes were not a relevant finding in our study.

Renal pathology

Nine cases of renal disease were submitted for histopathology. Most of the animals found with kidney lesions (7/9), were adults showing a history of sudden weight loss, poor body condition, hair loss and occasional hyperkeratosis.

At autopsy, kidneys showed a grey coloration and rugosity of the surface. In two cases, ureters were hypertrophied and filled with mucus or blood, showing marked metaplasia and periureteric oedema. The urinary bladder appeared occasionally enlarged and full of urine with white flocculations. In several cases, one of the kidneys was hypertrophied, with the surface of the renal pelvis or cortex occupying up to a third of the renal parenchyma.

In all these cases, changes were also observed in lungs, liver and spleen. Most animals showed an empty digestive tract with mucous contents and caecal impaction. Histologically, we observed cases of interstitial nephritis, dysfunction of the Bowman's capsule, and fibrosis of the renal capsule. Crystal deposition of unknown origin (Figure 3) and calcification of tubules was also observed with concomitant epidermatitis and parakeratosis. Other cases showed dilatation of the tubules with glomerular nephrosis or a combination of the latter with interstitial nephritis.

Reproductive problems

All cases of reproductive pathology affected females. Those included three cases of dystocia, two of them in primiparous females. One case appeared with emphysema of the fetus and another with severe renal disfunction and signs of pyometra.

Others

Other causes of death were mainly iatrogenic, such as death during anaesthesia or post-operative infection after castration or other surgical interventions. They represented only 4% of the cases. Three cases of neoplasia were also diagnosed and are currently being investigated

Unknown

A significant number of cases had to be classified under this category because no lesions were found; carcasses were too decomposed or some animals had been frozen and it was difficult to distinguish between *post mortem* and pathological changes. A number of cases in this category showed minor lesions in different organs.

Discussion

Domestication of the grasscutter is growing in interest and rapidly expanding in West and Central Africa since the 1970's (Asibey 1974; Afolayan and Anadu 1980; Baptist and Mensah 1986; Jori and others 1995; Adu and others 2000). Nevertheless, very few pathological surveys have been undertaken on this animal under farm conditions and those that exist are related to a pilot project in Benin (Akomédi 1988; Tondji and others 1992, Shrage and Yewadan 1995) or to farming experiences with small number of animals in Nigeria (Afolayan 1980) and Ghana (Adu an others 2000). Therefore, we felt it necessary to compile information on the common background pathology of this species with data from a different geographic location.

Mortality rates reported here are within normal rates for semi-domesticated rodents. Schrage and Yewadan (1995) mention that cumulated yearly mortalities in well-kept cane rat farms can reach rates of 15% in one-year old animals. Unpublished reports from the farm in this study revealed yearly mortality lower than 14% (VSF 1998). Moreover, mortalities of 6 to 15% are reported in other semi-domesticated rodents such as coypus (*Myocastor coypu*) in Argentina (Martino and Stanchi 1998).

Our results also confirm the importance of psychogenic stress in captive grasscutters – already mentioned in other studies (Hemmer 1992; Schrage and Yewadan 1995; Adu and others 2000). The fact that the highest rates of mortality occurred after arrival of the animals and the importance of accidental trauma or septicaemia after stressful events add weight to this hypothesis. As a prey species, the cane rat is a nervous animal susceptible to stress, that frightens easily at the proximity of humans, one of its natural predators. Such behaviour has also been observed in other wild rodents and lagomorphs in captivity (Dollinger and others 1999). Transport, environmental changes and regular manipulations, act as important stressors, with negative consequences for their health. Our study identified different quantities of macro and microvacuolation of the adrenal gland in particularly nervous animals (Figure 2). However, further studies are needed to understand the significance of these findings and their relationship to psychogenic stress.

Hemmer (1992) questions the suitability of the grasscutter as a farmed animal. However, data show that the annual mortality in experimental farms has been continuously declining since the initial attempts at captive breeding. In Benin, the annual mortality dropped from 78.1% in 1983 to 26.3% in 1991 (Yewadan 1992).

Despite a progressive reduction of mortality rates, economics and concern for animal welfare demand a solution to this problem. Long acting neuroleptics, can have an effect in reducing stress-related behaviour in cane rats (MacCoy and others 1997). However, their use in small-scale African conditions might not be a long-term solution. Further research on more practical measures, such as genetic selection and proper husbandry, are necessary to reduce this problem. Weaning at 45 days has proved to be helpful in reducing mortality (Schrage and Yewadan 1995).

The administration of preventive antibiotics and vitamins in the drinking water a few days after weaning is another possible measure that deserves further investigation.

In our study, 50% of the respiratory cases were detected in kits and 90% of the cases occurred during the dry season. Cold weather during this period could have contributed as a predisposing factor to respiratory disease. The occurrence of infectious pneumonia in cold and damp periods has also been reported in farmed coypus (*Myocastor coypu*) (Martino and Stanchi 1994;1998). Our survey reports septicaemia and respiratory disease as the most prevalent pathological findings on the farm. These data match only partially with those reported by other authors (Akomédi 1988; Adu and others 2000) where pneumonia was associated with pleuritis and isolation of *Diplococcus pneumoniae* and *Staphylococcus aureus* (Tondji and others 1992). However, pneumonia is recurrently reported in cane rat surveys and further studies are necessary to understand the aetiology and pathogenesis of respiratory diseases in this species.

Subadult animals were the age category in which the greatest number of deaths occurred (42%). The post-weaning period is particularly stressful for the animals which have to face a change of food and environment. Environmental change (surroundings, food) and the fact of housing together animals from different origins may predispose the cane rats to opportunistic pathogens associated with immunosuppression or anorexia.

Adult mortality was characterised by the high frequency of renal disease. Typical lesions of non- inflammatory nephrosis observed in captive grasscutters are histologically similar to those observed in laboratory rodents (Casey and others 1978). It is worth mentioning that *Corynebacterium* and *Citrobacter* spp*.,* reported previously as causing abscesses and renal

infection in cane rats (Akomédi 1988; Tondji and others 1992) , were not recovered in our study.

Diseases of the digestive tract were the main causes of death in Benin (Akomédi 1988; Müller, 1995). Dental pathology was occasionally found in some animals in our study but did not appear to contribute to mortality. Vaccination of cane rats against enterotoxaemia is feasible (Younan and others 1995) but was not used in Gabon. Even so -and allowing for the fact that microbiological analyses were limited- it is noteworthy that very few cases of gastroenteric disorders were seen. Nevertheless, some common enteric pathogens of captive wild rodents (Dollinger and others 1999) can occur in wild grasscutters (Oboegbulem and Okoronkwo 1990). Some outbreaks with severe digestive signs were reported in other cane rat farms in Gabon but could not be properly investigated.

Despite our parasitological results were relying only on macroscopic findings, this study revealed just a few nematodes (see Table 3). To our knowledge, this is the first report of *Paralibyostrongylus hebreniticus* in the cane rat. Although the effectiveness of the parasitic preventive treatment was not assessed, the low number of endoparasites recovered in treated animals suggests that the anthelmintic therapy suggested in the literature (Adjanohoun 1989; Akomédi 1988) was effective.

Although the time and duration of studies in Benin and Gabon are different, and limited diagnostic methods were used, these data suggest that cane rat pathology varies according to farm health status, geographic location or degree of domestication and confirms the need for more reports on the pathology of this species.

Our study has thrown light on some causes of morbidity and mortality of the cane rat, to supplement the very limited existing data. Although only limited pathology was performed and full screening laboratory methods- as might be routine when dealing with laboratory rodents- could not be undertaken, this work illustrates that routine necropsy is a worthwhile procedure. *Post-mortem* examinations yield preliminary data that are relevant to the management and welfare of captive cane rats even under low-budget tropical conditions. A standardised and rigid protocol for the collection of samples is necessary to minimise variability in methodology when animals are examined by different people. Such a systematic approach will provide more reliable diagnoses and greatly facilitate the establishment of databases on this economically important species.

Acknowledgements

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References

ADJANOHOUN, E. (1989): Contribution au développement de l'élévage de l'aulacode (*Thryonomys swinderianus*, Temminck 1827) et à l'étude de sa reproduction. Thèse doctorale, Maisons-Alfort, Paris, A.C.C.T. 198 pp.

ADU, E.K., ANING, K.G., WALLACE, P.A. & OCLOO, T.O. (2000): Reproduction and mortality in a colony of captive greater cane rats, *Thryonomys swinderianus*, Temminck. Tropical Animal Health and Production 32(1), 11-7.

AFOLAYAN, T.A. & ANADU, P.A. (1980): Preliminary observations on the ecology and domestication of the grasscutter-(*Thryonomys swinderianus*, Temminck). *Journal of the Institute of Animal Technicians* 31 (1), 31-38.

ALOGNINOUWA, T., AGBA, K.C., AGOSSOU, E. & KPODEKON, M. (1996): Anatomical, histological and functional specificities of the digestive tract in the male grasscutter (*Thryonomys swinderianus*, Temminck 1827). *Anatomy Histology Embryology* 25, 15-21.

AKOMÉDI, C.T. (1988): Aperçu sur la pathologie de l'aulacode. *Nature et Faune* 4(4), 29-37.

ASIBEY, E.O.A. (1974): The grass cutter, *Thryonomys swinderianus* Temminck 1827, in Ghana. *Symposium of the Zoological Society of London* 34, 161-170.

BAPTIST, R. & MENSAH, G.A. (1986): The cane rat: farm animal of the future? *World Animal Review* 60(4), 2-6.

CASEY, H.W., AYERS, K.M. & ROBINSON, F.R. (1978): Progressive renal disease in rats (glomerulonephrosis). In Pathology of Laboratory Animals. Edited by Benirschke,K.; Garner, F.M. & Jones, J.C. Springer-Verlag, New York & Heidelberg, Vol I, pp.142-145.

DOLLINGER, P., BAUMGARTNER, E., ISENBÜGEL, E., PAGAN, N. TENHU, H. & WEBER, F. (1999): Husbandry and pathology of rodents and lagomorphs in Swiss zoos. *Verhandlungsbericht des 39 Internationalen Symposiums über die Erkrkungen der Zoo und Wildtiere*, Vienna, 39, 241-253.

DURETTE-DESSET, M.C. & CHABAUD, A.G. (1981): Nouvel essai de classification des nématodes Trichostrongyloidea. *Annales de Parasitologie*, 56, 3, 297-312.

HEMMER, H. (1992): Domestication- concept and consequences- *Proceedings 1st International Conference. Grasscutter Production*, Benin. pp 189-200.

JORI, F., MENSAH, G.A. & ADJANOHOUN, E. (1995): Grasscutter production. A model of rational exploitation of wildlife. *Biodiversity & Conservation* 4 (3), 257-265.
JORI, F. & NOËL, J.M. (1996): Guide pratique de l'élevage d'aulacodes au Gabon. VSF/Coopération Française, 64 pp.

MAC COY, J., JORI, F. & STEM, C. (1997): Tranquillisation of captive cane rats (*Trynonomys swinderianus*) with a long acting neuroleptic (Pipothiazine palmithate). *Journal of Veterinary Pharmacology & Therapeutics, 20:233-239*.

MARTIN, S.W., MEEK A.H. & WILLEBERG, P. (1987): Veterinary Epidemiology : Principles and Methods. Iowa State University Press, pp 56-57.

MARTINO, P.E. & STANCHI, N.O. (1994): Epizootic pneumonia in Nutria. *Journal of Veterinary Medicine-Series-B*, 41, 561-566.

MARTINO, P.E. & STANCHI, N.O. (1998): Causes of death in captive nutria (*Myocastor coypus*) in Argentina. *Israel Journal of Veterinary Medicine*, 53 (3), 83-87.

MPOAME, M. (1994): Gastro-intestinal helminths of the cane rat *Thryonomys swinderianus* in Cameroon. *Tropical Animal Health and Production* 26, 239-240.

MÜLLER, W. (1995): Is enterotoxaemia in grasscutters (*Thryonomys swinderianus*) caused by C. perfringens toxovars? *Journal of Veterinary Medecine -Series-B*, 42:9, 569-571.

OBOEGBULEM, S.I. & OKORONKWO, I. (1990): Salmonellae in the African great cane rat (*Thryonomys swinderianus*). *Journal of Wildlife Diseases* 26, 119-121.

SCHRAGE, R. & YEWADAN, L.T. (1995): Abregé d'aulacodiculture. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)-Rossdorf, Germany, 103 pp.

SOULSBY, E.J.L. (1982): Helminths, Arthropods and Protozoa of Domesticated Animals. 7th Ed, Baillière Tindall, U.K, 809 pp.

TONDJI, P.M., AKOMÉDI, C.T. & AKPONA, S.A. (1992): Les aspects de la pathologie de l'aulacode (*Thryonomys swinderianus*) en captivité étroite: expérience de la République du Bénin. *Proceedings 1st International Conference. Grasscutter Production*, Benin, 95-105.

VSF (1998): Projet B7-6201/96/14 VIII/FOR "Développement au Gabon de l'Elevage de Gibier" DGEG. Rapport Annuel, Lyon, 60pp.

YEWADAN, L.T. (1992): Système d'élevage en aulacodiculture. *Proceedings 1st Inernational Conference. Grasscutter Production*, Benin, 131-142.

YOUNAN, M.. MÜLLER, W & BOROWY, N. (1995): Vaccination of grasscutters with a multicomponent clostridial vaccine. *Journal of Veterinary Medecine -Series-B,* 42, 369-375.

List of Tables

Table 1: Results from the autopsies performed in 94 carcasses of cane rat

Cause of mortality	Kits	Subadults	Adults	Total of cases	Percentage
Trauma	8	16	5	29	31
Septicaemia	3	6	3	12	13
Respiratory	5	1	4	10	11
Digestive	3	1	1	5	5
Urinary	-	1	3	4	4
Reproductive	-	-	3	3	3
Others	-	3	-	3	3
Unknown	7	12	9	28	30
TOTAL	**26**	**40**	**28**	**94**	**100**

Table 2: Results of microbiological analysis from lesions in captive cane rats

Bacteria isolated	Number of cases	Tissue sampled	Final Diagnosis
Klebsiella pneumoniae, Staphylococcus aureus	3	Lung and kidney	Septicaemia
Klebsiella pneumoniae, Staphylococcus aureus Escherichia coli	2	Lung	Septicaemia
Klebsiella oxytoca, Streptococcus D haemolyticum	1	Peritoneal abcess	Interstitial nephritis
Candida albicans	1	Lung	Septicaemia
Klebsiella pneumoniae, Staphylococcus aureus Candida albicans	1	Skin abcess	Septicaemia
Proteus mirabilis	1	Genital discharge	Chronical nephritis

Table 3: Parasites recovered and identified in cane rat carcasse

Parasites	Location	Age	Number of cases
Paralibyostrongilus hebreniticus	Stomach, duodenum	All ages	6
Trichuris spp.	Caecum	Young	1
Taenia spp	Duodenum jejunum	Adult	1

List of Figures

Figure 1: Evolution of monthly crude mortality rate between May 94 and January 96

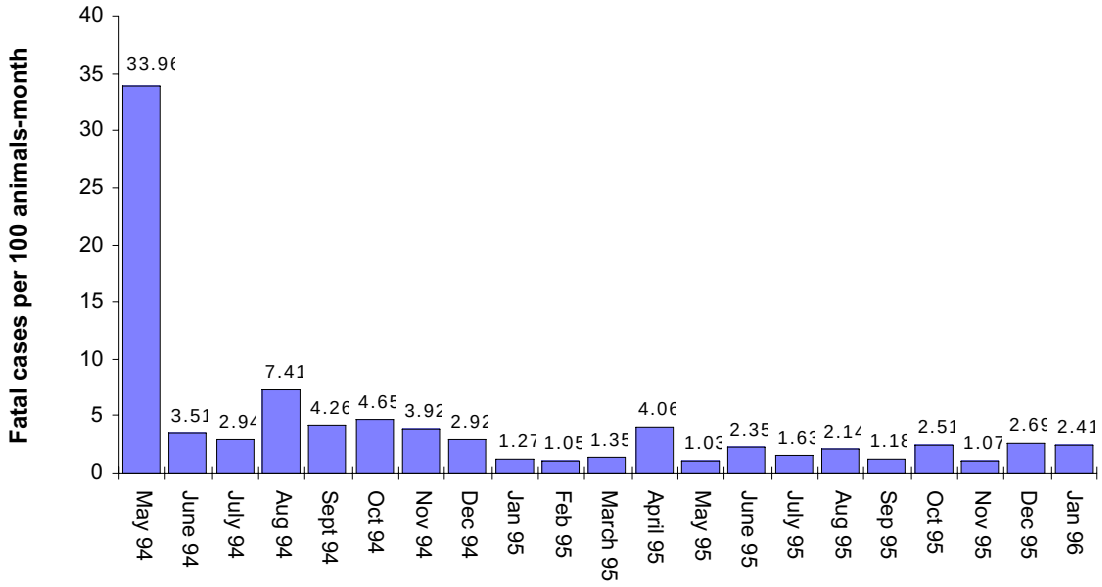


Figure 2: Adrenal gland cortex. H/E. The tissue shows a small amount of diffuse macrovacuolation and a moderate amount of microvacuolation. Its significance is unknown. X 1000

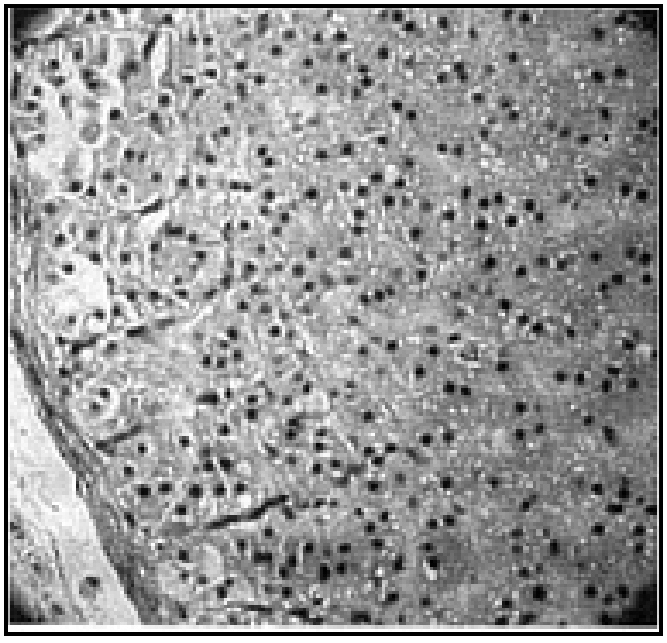
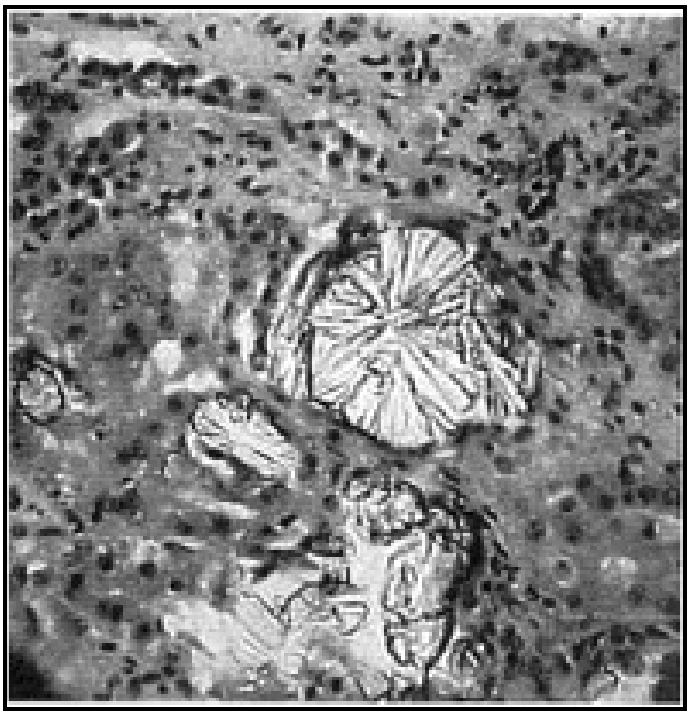


Figure 3: Kidney. H/E. Extensive deposition of crystals associated with inflammatory changes. In some areas, giant cells are present. X 1000



Sección 4.2

Spontaneous neoplasms in captive cane rats (*Thryonomys swinderianus* Temminck, 1827)

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Abstract

Despite the increasing importance of cane rat farming in Africa, diseases of *Thryonomys swinderianus* in captivity remain insufficiently known. Survey of a colony averaging 235 cane rats in Gabon over a period of 36 months allowed the observation of several suspected tumors and the confirmation of three cases of neoplasms. Within a period of eight months, a chondroma was diagnosed in an adult female, an hemangiosarcoma in a subadult male and a chondrosarcoma in an elderly female. An incidence of at least 1.3 % of neoplams in the cane rat colony in such a short period is uncommon. Neoplasms in rodents might be induced by such factors as a high inbreeding coefficient, an oncogenic virus or chemical agent intoxication. Although the etiology remains undetermined, description of these cases is reported to enrich baseline data on the pathology of this species in captivity.

Key words

Cane rat - Chondroma - Chondrogenic osteosarcoma - *Thryonomys swinderianus* - Tumors - Hemangiosarcoma - Virus.

The cane rat (*Thryonomys swinderianus*) is a large African rodent, very popular as a source of meat in many parts of West and Central Africa. As a result, several attempts are being undertaken to domesticate this species and extensive research has been conducted on its biology and management in captivity[4]. However, its pathology is insufficiently studied and reports on the diseases of this species are scarce. The present study constitutes what seems to be the first report of neoplasms in cane rats. Animals mentioned in this study belonged to an experimental farm set up in Libreville, Gabon's capital city. The climate in Gabon is hot and humid, with a yearly mean temperature of 26ºC, and a daily range of 10ºC. The initial stock of animals arrived in May 1994 from West Africa and was monitored thereafter for 36 months. The cane rat population between the first and the last case averaged 235 individuals and 45% of the colony was sexually immature. The management of the animals is described elsewhere[4].

Between February and August 1996, three suspected cases of tumors were detected during routine handling. These animals were treated and managed in the same way as the rest of the stock, until they showed signs of disease that threatened their survival. Full autopsies were performed by trained technical staff from the farm, and material taken for laboratory investigations consisted of the tumoral masses. In addition to the cases reported here, two other animals with suspected tumors died but samples were accidentally damaged and could not be processed.

Samples were fixed in non-buffered formal saline and kept for several weeks until they could be processed for laboratory investigation. Calcified and bone-like material was sectioned, washed and decalcified until soft. Samples were then embedded in paraffin wax, sectioned and stained with hematoxylin/eosin stain.

Case N°1: A 36 month old healthy looking female from West Africa, presented with a 4 cm diameter circular swelling on the right side of the neck, involving the jugular vein and vena cava, after 2,5 years on the farm. The mass was calcified and well encapsulated (Fig. 1). Four months later, following two days of anorexia, the female was found dead. No other lesions were reported at necropsy.

Histologically, there were areas of cartilaginous tissue growing from a thin layer of perichondrium-like cells. Some of these areas contained very large cells, with large nuclei, but in other areas these cells grew in an orderly pattern, resembling normal cartilage. Calcification of the cartilaginous matrix was widespread. There were areas where the

mineralized cartilaginous tissue had become necrotic. The growth was classified as a chondroma.

Case n° 2: A 6 month old male born on the farm, was found with a 2.5 cm diameter swelling on the left side of its rump. The mass which was well encapsulated and of soft muscle-like consistency, protruded 3.5 cm from the body, and the surface of the skin in this area had become hairless and ulcerated.

The animal died a few weeks later from unknown cause and the tumor was collected for histopathological analysis. No lesions were observed in other organs. The neoplastic tissue was composed of large fusiform and rounded, elliptic cells, exhibiting diffuse growth, with less than 5% of stroma. The margins were irregular and poorly defined. The mitotic index was low. Many neoplastic cells showed karyorrhectic nuclei with margination and fragmentation of the chromatin. Multinucleated cells were present in small numbers. The tissue was well vascularized throughout, with many distended capillaries filled with erythrocytes and sometimes thrombosed. The neoplastic tissue was infiltrated diffusely by degenerating neutrophils. A zone showed bacterial colonization, possibly due to secondary infection of the ulcerated area. The lesion was classified as an hemangiosarcoma on the basis of the proliferation and abundance of blood vessels and endothelial cell polymorphism (Fig. 2).

Case n°3: After two years on the farm, a 29-month-old female, imported from West Africa, was found with an invasive, multilobular, calcified mass affecting its left hind leg. The swelling was hard, and invaded the whole leg from the femur to the interphalangeal area. However, the animal was in good condition, ate well, and did not show other signs of disease except impaired locomotion. The hind limb was surgically excised under general anesthesia but the animal died two days later from post-operative complications.

Margins of the lesion were sharp. Samples contained normal bone tissue and an adjacent neoplastic proliferation of chondroid tissue (Fig. 3). The latter arose multifocally from a thin layer of perichondrial-like cells. Chondroid cells were pleomorphic, with aberrant contours, and large nuclei. Mitoses were not visible. There was extensive mineralization of the chondroid matrix and near these areas, groups of large spindle cells formed non-mineralized bone matrix. In one area, neoplastic chondroid tissue was present near to the normal long bone. Many areas of the chondroid tissue showed necrosis. The growth was classified as a chondrogenic osteosarcoma.

Most information about tumors in rodents relates to laboratory and pet animals but the breeding of wild rodents allows the recording of diseases of species from which very little information has been published to date [1,4]. This appears to be the first record of tumors and one of the few pathological reports for *Thryonomys swinderianus* in captivity[4]. Two of the tumors described in this paper involved chondrogenic tissue. This is an uncommon finding in pet and laboratory animals[6,8], bone tumors being occasionally reported in wild mice and gerbils[7,9]. Many lesions diagnosed as chondromas are actually low grade chondrosarcomas[6] and both types of tumor can be equivocal. In mice, spontaneous tumors with an osseous appearance appear to be potentially malignant[10]. Osteosarcomas have been occasionally reported in wild[1] and laboratory rodents, with a predominance in aged females and localization in the hind legs[7,10]. Besides no metastatases were observed, the histologic appearance of case n°1 was such that it seemed unequivocally benign and confusion with an osteosarcoma appears unlikely.

Hemangiosarcomas are more common in pet and laboratory rodents, being reported in gerbils, mice and rats[8].They are highly malignant and metastasize easily, since they have easy access to vascular channels. Unfortunately, the existence of possible metastases could not be determined in our study.

After 3 years of monitoring an average of 400 cane rat from several farms in Gabon, no other cases of neoplasms were ever detected nor found in the literature. The cases described here appeared in a period of 8 months, and at least 3 suspected cases presented simultaneously within a three-month period. Therefore, the incidence of 3/235 (1.3%) in the colony seems abnormally high. The causes of such an incidence in the farm remain unclear. However, due to the size and nature of the lesions described, it is doubtful that detection ability was influenced by closer attention.

In some rodent species, frequency of neoplasms increases with age[8,9]. However, ageing could not be considered as the predisposing factor in this colony. Cane rats can live for up to 4 years in captivity[3] and only the female in case n°1 might be considered to be old. Case n°2 was only 6 months old, and one of the cases not analyzed in this paper was less than a year. A high inbreeding coefficient has been suggested as a possible cause for high tumor prevalence in hamster colonies[2]. This seems unlikely in this case as the founder colony came from at least 8 separately established farms and the cases reported here include founders and descendants from the same colony. Their sudden appearance in a short period and presentation in animals of different age and sex, may indicate an oncogenic virus on the

farm. DNA polyoma virus are enzootic in wild and laboratory mice although tumor production seems to be a rare manifestation of the infection. Bone tumors and hemangio-endotheliomas of laboratory rodents can be induced in experimentally infected newborn[5]. Several types of RNA C-type oncornavirus induce bone tumors in mouse colonies, the neoplasms developing in the cranium, vertebral column and ribs[7]. Chemical agent intoxication through contaminated food can induce cancer in different soft tissues in laboratory rodents. As green fodder for the cane rats was recovered from a peri-urban industrial area, this possibility is not excluded. Further toxicological analysis should be necessary in order to identify possible carcinogenic products in the cane rat diet.

The etiology of the cases reported here remains unknown. However, evaluation of additional tumor cases should be encouraged, in order to understand the etiology and importance of tumors in farmed cane rats.

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References

1. Cooper JE, Greenwood AG: A chondrosarcoma in an African Crested Porcupine. Vet Pathol, **16:**734-736, 1979.

2. Cooper JE, Knowler C and Pearson AJ: Tumours in Russian hamsters (*Phodophus sungorus*). Vet Rec **128:**335-336, 1991.

3. Haltenorth, T. and Diller, H: Collins Field Guide. Mammals of Africa, 4th ed., pp. 157-158. Harper Collins, England, 1994.

4. Jori, F and Cooper, JE: Post mortem findings in captive cane rats (*Thryonomys swinderianus*) in Gabon. Veterinary Record. *In press*, 2001.

5. Moreno-López J: Polyomavirus of mice. *In:* Virus infections of Vertebrates: Virus infections of rodents and Lagomorphs, ed. Osterhaus ADME. pp 171-174. Elsevier Science, The Netherlands, 1994.

6. Pool RR: Bone and Cartilage. *In:* Tumors in Domestic Animals, ed. Moulton, JE, 3rd ed., pp.157-250. California Univ. Press, USA, 1990.

7. Stanton MF: Tumors of the bone. *In:* Pathology of Tumors in Laboratory Animals, ed. Turusov, VS, pp.577-591I ARC Scientific Publications nº 23, WHO, 1979.

8. Toft, JDII: Commonly observed spontaneous neoplasms in rabbits, rats, guinea pigs, hamsters and gerbils. Sem Avian Exotic Pet Med **1:** 80-92, 1992.

9. Ringler, DH, Douglas, ML and Gerlad, DA: Spontaneous neoplasms in aging gerbillinae. Lab Anim Sci, **22:** 407-414,1972.

10. Wadsworth, PF: Tumours of the bone in C57BL/10J mice. Lab Anim,**23:** 324-327, 1989.

Figure Legends

Figure 1: Chondroma. Case n°1.Sagittal section. Note the well-defined encapsulation of the neoplasic mass and the bone-like appearance of then tissue growing from the center. Bar = 1.3 cm

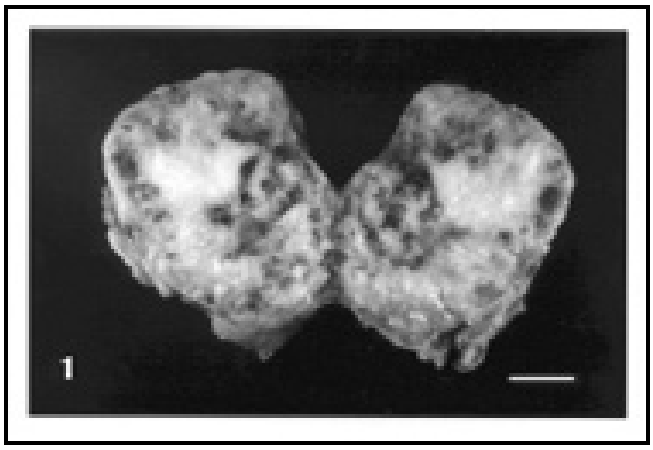

Figure 2: Hemangiosarcoma. Case n° 2. Neoplastic tissue composed of large fusiform and rounded cells in a stroma that is well vascularized, giving a cavernous appearance. HE. Bar = 20 μm.

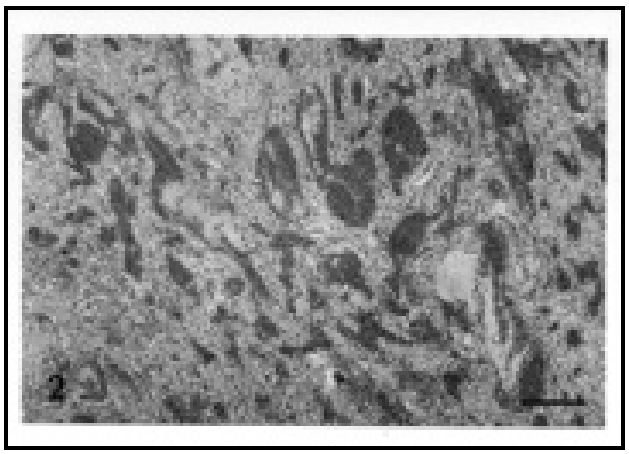

Figure 3: Chondrogenic osteosarcoma. Case n°3. Gradual transition of osteoid tissue, some of it mineralized, into chondroid tissue with chondroblasts. HE. Bar = 50 μm.