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A Synopsis of Rodent Species in the Caribbean Islands, Endemic and Invasive

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ABSTRACT
Rodents form an important part of an ecosystem. Introduced rats and mice can have devastating consequences on indigenous rodent populations via inter-specific competition; competition for food and spread of disease. It is incumbent upon the Caribbean authorities, therefore, to actively prevent new species from becoming established by providing funding for interdiction efforts, research before an invasive species becomes widespread, and restricting the movements of species. The colonization of the Caribbean by South American mammals between the Palaeocene and the Middle Miocene included hystricognath rodents. A rodent nearly the size of the American black bear inhabited the small islands of Anguilla and St. Martin until it was apparently hunted to extinction by natives. Hutias (*Geocapromys* spp.), large rodents that resemble South American agoutis, proliferated into a variety of species on the large islands of the Greater Antilles. There are two endemic rodent families: Solenodontidae and Capromyidae. The family Solenodontidae includes two surviving species, the Cuban solenodon (*Solenodon cubanus*, EN), and Hispaniolan solenodon (*S. paradoxus*, EN), which are rare giant shrews threatened by human exploitation and invasive species, including mongooses, feral cats, rats and dogs. Invasive species include the Norway (Brown) Rat (*Rattus norvegicus*), the House Mouse (*Mus musculus*) and the Black/Roof/Ship/House Rat (*Rattus rattus*). Invasive predators have devastating consequences on endemic species, often as a consequence of successful reproductive rates, short generation times, a generalised diet, smallish in stature and secretive. Live collections of rodents should be housed in the zoo in Port of Spain, Trinidad for educational purposes. It is most unfortunate that the museum at the Department of Life Sciences at UWI does not have in its collection sufficient taxidermied rodent specimens, or enough literature on them. Eradication of nuisance predators like cats and mongooses in order to protect endemic rodent species should incorporate effective quarantine programmes, and enforcing policies prohibiting the presence of potentially invasive pets should be a major component of conservation plans in insular environments such as those found on small islands.

Key words: Caribbean, endemic, invasive rodents.

INTRODUCTION

Rodents form an important part of an ecosystem often consuming waste vegetable matter and seeds, and providing themselves food for predators (Cooper 1998, 1999, 2000; Smithers 1975). However, the irresponsible activities of mankind have allowed the rat to become invasive in many parts of the world, often via shipping routes (Cooper 2006). Introduced rats and mice can have devastating consequences on indigenous rodent populations via inter-specific competition; competition for food and spread of disease. Inappropriate housing (Cooper and Erlwanger 2007) has prompted escapees as evidenced by the African Giant Rat, *Cricetomys gambianus* [Rodentia: Nesomyidae] (Epperson 2005) (Fig. 1). It is unfortunate that during previous human invasions and coloniser activities that no due regard was made for the regulation of animal movement and inspection of products was lacking or took no regard of impacts on native ecosystems (Pitt and Witmer 2007). It is incumbent upon the Caribbean authorities therefore, to actively prevent new species from becoming established by providing funding for interdiction efforts, research before an invasive species becomes widespread, and restricting the movements of species.

Fig. 1. A museum specimen of the African Giant Rat (*Cricetomys gambianus*), National Museum of Zimbabwe, Harare, Zimbabwe.

RODENTS, HABITS, LOCALITY AND CONTROL

The colonization of the Caribbean by South American mammals between the Palaeocene and the Middle Miocene included hystricognath rodents, which fitted the pattern of divergence from the mainland implied by the Gaarlandia hypothesis (Dávalos 2004). This hypothesis basically describes the dispersal of animal groups via the link between North and South America at a time when the western portion of the Greater Antilles was separated from the Central American landmass by two narrow straits (Pennington and Dick 2004). Murid rodents, however, show patterns of divergence from the mainland that are inconsistent with the Gaarlandia hypothesis and seem to require taxon-specific biogeographical explanations (Dávalos 2004).

Cuba, Puerto Rico, Hispaniola and Jamaica had a variety of unusual native rodents and shrew like insectivores prior to the arrival of European explorers and settlers in the 1600s; many were ancient species (Nilsson 1983). When native Caribbean populations settled the islands after the Ice Ages, rodents as big as marmots inhabited the larger islands (Nilsson 1983). A rodent nearly the size of the American black bear inhabited the small islands of Anguilla and St. Martin until it was apparently hunted to extinction by natives. Cuba, Puerto Rico and Hispaniola were once attached to the mainland of Central America, but this large land mass became separated and drifted off into the Caribbean (Nilsson 1983). Some of the native fauna and flora present more than a million years ago survived until a few thousand years ago. Most of the 40 mammals that became extinct on Caribbean islands after the 1600s were rodents and insectivores (Nilsson 1983). A muskrat and a rice rat became extinct on Martinique when Mt. Pelee erupted in 1902 – one of the few examples of a naturally caused modern extinction. Hutias (*Geocapromys* spp.), large rodents that resemble South American agoutis, proliferated into a variety of species on the large islands of the Greater Antilles (Nilsson 1983). Settlement, deforestation and hunting caused at least five species of Hutias to become extinct, and the few remaining species are now highly endangered. Native marsupials and rodents were gradually eliminated by massive habitat destruction and predation from animals introduced by European settlers (Nilsson 1983).

The Caribbean islands have approximately 90 mammal species, of which more than 40 are endemic (McGinley 2007) and 97 species located in Trinidad including bats. This includes two endemic rodent families: Solenodontidae and Capromyidae. The family Solenodontidae includes two surviving species, the Cuban solenodon (*Solenodon cubanus*, EN), and Hispaniolan solenodon (*S. paradoxus*, EN), which are rare giant shrews threatened by human exploitation and invasive species, including mongooses, feral cats, rats and dogs (McGinley 2007). The Capromyidae includes 20 species of rodents, known locally as Hutias, which are prized for their meat and threatened by hunting, habitat loss and invasive species (McGinley 2007). Meat eating in Trinidad amongst some people includes the large rodents, *Dasyprocta agouti* and *Agouti paca*. It is believed that numerous species of rodents have been made extinct through the activities of invasive rodent species. A new subspecies of *Zygodontomys* rodent has been described (Goodwin 1965). Worth (1967) described the reproduction, development and behaviour of captive *Oryzomys laticeps* and *Zygodontomys brevicauda* in Trinidad.

In the Caribbean, invasive rodent species are exactly the same on all islands, excluding those found on mainland Caribbean countries. The Norway (Brown) Rat (*Rattus norvegicus*) [Rodentia: Muridae], the House Mouse (*Mus musculus*) [Rodentia: Muridae] and the Black/Roof/Ship/House Rat (*Rattus rattus*) [Rodentia: Muridae] pervade the environment (Morton 2008), all of which were introduced during the time of Columbus. The current article is not the place to describe these species' life, habits, feeding and reproduction, details of which can be read via an internet search on Wikipedia. The main diagnostic features between the Black and Norway rat are detailed in Table 1.

Table 1. Notable differences between the black and brown rat.

Name	Black Rat	Brown/Norway Rat
Species	*Rattus rattus*	*Rattus norvegicus*
Swimming	Poor	Excellent
Agility	Excellent climber	Poor climber
Length body (cm)	15-20	25
Length tail (cm)	20	25
Fur	Black-light brown with lighter underside	Brown or dark grey with lighter grey or brown underparts
Habits	Nocturnal & omnivorous	Nocturnal & omnivorous
Nesting	Arboreal	Underground
Breeding	3-6 litters pa, up to 10 pups	5 litters pa, up to 14 pups
Lifespan	2-3 yr.	3 yr.

Only one Caribbean Environmental Health Department provided information on my request for information out of a total of 15 island territories contacted either by fax, letter and/or email. Seven separate listings did not have any rodent information to hand. Additionally, currently the Department of Life Sciences, University of the West Indies, Emperor Valley Zoo, Port of Spain, and the National Museum and Art Gallery, Port of Spain informed me that there are no papers or taxidermied rodent specimens nor

skins. There are, however, extensive listings of mammals in Trinidad by Alkins (1979). Additionally, Boos (1986) provided a checklist of mammals in Trinidad and Tobago and there are mammal skins in the National Museum and a good collection in the Museum of the Caribbean Epidemiology Centre, Port of Spain, some collected by Chapman in 1895.

Unfortunately, there is largely a negative tone and stance associated with all rodents in the Caribbean islands and it is normally the job of the Environmental Health Department to control groups of individuals or populations of rodents in large communities. This is suggestive that people do not like to admit they have a rodent problem. Eradication measures were suggested as those including identification of the rodent species, appreciation of rodent biology [historical background and life history, general activity of rodents, rodent reactions to strange objects, and rodent food habits], and rodent population characteristics (Morton 2008). Proper sanitation is appreciated as the most effective, lasting and efficient measure available for the control of rodents including storage, collection and disposal of refuse. Limiting the availability of food, water and harbourage areas will limit rat populations. Sites of infestation should be cleared rapidly and completely, treatment must cover the entire area irrespective of property boundaries of infested ground or buildings. As rodents are highly active mammals, all adjacent and community areas need equal attention at the same time. Related programmes including rat poisoning operations and refuse management should receive equal importance in eradication procedures. In St. Kitts, vector control programmes include focus on source reduction, community participation, health education and minimal chemical usage (Morton 2008).

Information regarding the threats and eradication of rodents are summarised henceforth. The potential for disease transmission stated includes communicable disease directly via contamination of food and water with faeces and urine, and indirectly via ectoparasites including lice, mites (*Allodermanyssus sanguineus*), ticks and fleas (*Xenopsylla cheopis*). Diseases cited include leptospirosis, salmonellosis, murine typhus fever, rickettsial pox, rat bite fever and bubonic plague (Morton 2008). Significant leptospirosis infestation has been recorded in rats and mice on Barbados (Everard *et al*. 1995). Another infectious disease emerging in the Caribbean include angiostrongyliasis caused by the nematode (rat lungworm) infection with *Angiostrongylus cantonensis* that often expresses itself sub-clinically (Caribbean Islands, 2008), (Lindo *et al*. 2004). Once the larvae migrate to the CNS they cause eosinophilic meningoencephalitis. Nematode infection with *A. costaricensis* of the gastro-intestinal tract (GIT) results in cutaneous, intestinal and pulmonary infestations, and, occasionally, hyperinflation syndrome (Caribbean Islands, 2008). After an outbreak in 2000 of eosinophilic meningitis in tourists to Jamaica, *A. cantonensis* in rats and snails were investigated, revealing 22% (n=24/109) of rats harboured adult worms, and 8% (n=4/48) of snails harboured *A. cantonensis* larvae, with predictable impacts on human eosinophilic meningitis (Lindo *et al*. 2002; Waugh *et al*. 2005). In rats, adult worms recovered from the cardiopulmonary systems of 24 rats (n=20/78 *Rattus norvegicus* & n=4/31 *Rattus rattus*) had microscopic features typical of *A. cantonensis* (Lindo *et al*. 2002). Humans can become infected with *A. cantonensis* following consumption of the intermediate hosts; slugs and snails, and freshwater shrimp serve as paratenic host and reservoirs of infections for humans (Waugh *et al*. 2005). It is apparent that freshwater shrimp or mussels are eaten raw directly from rivers. The application of molluscicide onto lettuce has proved ineffective (Waugh *et al*. 2005). Failure to detect rat-borne *A. cantonensis* in Barbados has been noted (Levett *et al*. 2004). In the Dominican Republic three species of non-endemic rodent introduced originally in post-Columbian times, demonstrated 44 *R. rattus* from one locality being sero-positive for antibodies against *Leishmania* suggesting a role of the rodents in the epidemiological cycle (Johnson *et al*. 1992). Rodent leishmaniasis has been described in Trinidad (Tikasingh 1974). *Trypanasoma cruzi* has been isolated from *Rattus rattus* (Downs 1963). One should not ignore the possibility of infectious diseases caused by rats on cruise ships (Minooee and Rickman 1999). The Trinidad Regional Virus Laboratory made extensive collections on mammals from various parts of Trinidad, e.g. of the biology of two rodents, *Proechimys guyannensis trinitatis* and *Oryzomys capito velutinus* in the Turure Forest, Trinidad (Everard and Tikasingh 1970). In Trinidad, Bush Bush Forest, 262 of Venezuelan equine encephalitis, 71 of Caraparu-like, three of Oriboca, two of Restan, 63 of Bimiti, 56 of Catu and 87 of Guamá, revealed seven virus types which undergo a period of multiplication and viremia in forest-floor rodents and in mosquitoes of the *Culex portesi* type (Jonkers *et al*. 1968). Trinidad virus TRVL 34053-1 was demonstrated to circulate in the blood of naturally and experimentally infected *Oryzomys laticeps velutinus* (Jonkers *et al*. 1964). Studies with 80 experimentally infected animals, 40 *Oryzomys* and 40 *Zygodontomys b. brevicauda* showed that haemagglutination-inhibiting, complement fixing and neutralising antibodies persist for at least one year after infection with 34053-1 virus (Jonkers *et al*. 1964). Nariva virus has been isolated from *Zygodontomys b. brevicauda* trapped in Bush Bush Forest in the Nariva Swamp, eastern Trinidad in 1962/3 (Tikasingh *et al*. 1966). It is essential that scientific attention is paid to rodent populations in terms of their dynamics, longevity and range (Worth *et al*. 1968) if epidemiology of infective viruses is to be understood. Arboviruses and parasitologi-

cal studies in rodents and influence on human health has been discussed (Tikasingh and Everard 1970). This should be followed up by detailed studies of rodents in areas associated with potential disease transmission with effective protocols of trapping, population density determination, home range and longevity studies completed (Everard and Tikasingh 1970).

Destruction to property includes gnawing and undermining wooden constructions, causing fires through short-circuiting electrical cables. Amazingly, rodents in the Caribbean have been associated with physical death including infants attacked in a crib, invalid or inebriated adults, and wrongful straying/trespassing into areas with tremendous rat populations (Morton 2008). Rodents can consume vast quantities of food in fields, homes, food stores, supermarkets and warehouses. One could also add that food may be spoiled by rodents on ships, trains and trucks. In areas with massive rodent populations, annoyance may arise especially at night from fighting/playing rodents, squeaking pups, and gnawing activities. People may be aesthetically repulsed by the presence of rats and mice in their houses. Rats and mice have extremely short gestation periods of approximately 22 and 19 days, respectively. Mating of dows can begin 48 hrs after parturition. At three months of age, young rodents are highly active and completely independent (Morton 2008).

Black rat (*Rattus rattus*) genetic signatures on populations before and three years following eradication procedures on four islets off the Martinique coast (French Caribbean) which demonstrated some incidence of numerous new alleles increasing genetic diversity (Abdelkrim *et al*. 2007). The authors recommended that trapping procedures should prevent individuals surviving and re-invading islets by establishing permanent trapping and poisoning devices in addition to regular monitoring, and the use of molecular biological tools (Abdelkrim *et al*. 2007).

MAMMALIAN PREDATOR POPULATIONS

Invasive predators have devastating consequences on endemic species, often as a consequence of successful reproductive rates, short generation times, a generalised diet, smallish in stature and secretive (Pitt and Witmer 2007). Additionally, ecosystems with a limited assemblage of native are more susceptible to invasion from mammalian predators, often having devastating impacts on prey populations, e.g. destructive activities of black rats, feral cats and the mongoose (Pitt and Witmer 2007). Many native birds and reptiles have become endangered as a result of introduced predator activities. Black rats (*Rattus rattus*) are perfectly capable of co-habiting with feral cats (*Felus catus*) with 42% of the former trapped in the Caribbean National Forest in Puerto Rico (Engerman *et al*. 2006), both potentially endangering rare birdlife, including parrots. Cat predation has had major adverse effects on *Geocapromys* spp. (Nogales *et al*. 2004). Eradication of the cat on Caribbean islands may be problematic due to associations with humans. The Indian mongoose (*Herpestes javanicus*), a voracious and opportunistic predator, introduced to Fiji, West Indies, Mauritius and Hawaii to control rats has instead, caused the local extinction of several endemic species of birds, reptiles, and amphibians (McNeely *et al*. 2004). Another species of mongoose, *H. auropunctatus*, was introduced to assist in removing the massive rat populations in the sugar cane fields with devastating effects on local mammal populations (Nellis and McManus 1974). The Hispaniolan spiny rat (*Brotomys voratus*) was present on Hispaniola in 1930 and is now extinct due to the activity of the Indian mongoose (Hays and Conant 2007; Woods and Ottenwalder 1992). The mongoose introduced to limit cane rats, resulted, in Trinidad, in extreme reductions thereof, although the roof rat populations were as high as 50% in parts of St. Croix (Hays and Conant 2007). Mongooses may drive rats into arboreal habitats as in St. Croix and Jamaica (Hoagland *et al*. 1989). In Puerto Rico, Norway rats are common only in mongoose-free urban areas (Pimental 1955).

CONCLUSION

Live collections of rodents should be housed in the zoo in Port of Spain, Trinidad for educational purposes. It is most unfortunate that the museum at the Department of Life Sciences at UWI does not have in its collection sufficient taxidermied rodent specimens, or significant associated literature. Notes can be provided discussing the ecology of the rat and its possible dangers to man, as illustrated in Fig. 2. With education, the likelihood of rodents causing harm to man will be reduced if appropriate hygienic and environmental measures are taken. Although the dangers of excessive rodent populations cannot be ignored, it is prudent to note the ecological importance of native rodent populations to provide food for predators, a notion completely lacking in reports from the region. Reference to the like could be made in museums and school projects. Local and regional conferences on effects of invasive species, including rodents, would be beneficial to the advancement of science.

Eradication of nuisance predators like cats and mongooses in order to protect endemic rodent species should incorporate effective quarantine programmes, and enforcing policies prohibiting the presence of potentially invasive pets should be a major component of conservation plans in insular environments such as those found on small islands (Nogales *et al*. 2004). A more conjugant assessment of rodent invasion may take cognisance of the following

Fig. 2. Live rodent displays, Birmingham Nature Centre, Birmingham, UK.

considerations: what bio-indicators exist for invasion impact?; does species richness impact community change?; how do impacts on population characteristics affect ecosystem functionality?; do invaders with significant impact utilise extensive ranges, spread rapidly, or develop the greatest abundance?; and how do quantitative measures of invasive species impact depend upon the ecosystem? (Gherardi and Angiolini 2002). National Wildlife Research Centre scientists are studying captive wild rats in order to determine social behaviour and responses to new lures, toxic baits, bait stations and various traps, hopefully, better equipping the Caribbean environmental officers' ability to monitor, manage and eradicate invasive rats (Witmer 2004). The Animals (Diseases & Importation) Act in the Caribbean, and the Animals (International Movement & Disease) Act in Antigua and Barbuda, Dominica, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines (Kairo *et al*. 2003), should continue to be strictly abided by and adhered to.

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