

Invasive mammals in Cuba: an overview

Rafael Borroto-Páez

Received: 2 March 2008 / Accepted: 9 December 2008 / Published online: 27 January 2009
© Springer Science+Business Media B.V. 2009

Abstract Invasive mammals in Cuba have a negative impact on the conservation of endemic fauna. Rats, mice, mongooses, cats, dogs, among others, pose a threat to the conservation of the Cuban solenodon, the capromyid rodents, and many species of birds, reptiles, amphibians, and invertebrates. The current state of introduced and invasive mammal species in Cuba, their impact, available information about their introduction, habits, field observations, distribution, etc., is reviewed. A total of 29 species of invasive mammals in 40 islands of the Cuban Archipelago are reported; the black rat, dog, cat, mouse, mongoose, pig, goat, brown rat, and cattle are the most important. A control policy on invasive species of mammals is urgently needed for the conservation of the fauna of the Cuban Archipelago.

Keywords Conservation · Cuba · Cuban mammals · Introduced mammals · Invasive mammals

Introduction

The West Indies comprise one of the world's biodiversity "hotspots" (Myers et al. 2000), due to

the large number endemic and endangered species of flora and fauna; however, the amount of information available for some groups is insufficient. It is the region with one of the highest rates of mammalian extinction in the world in recent times (after the year 1500). Worldwide, 71.6% of all mammalian extinctions have taken place on islands, while 37.5% of all modern-era extinctions occurred in the West Indies (Morgan and Woods 1986; MacPhee and Marx 1997; MacPhee and Flemming 1999).

Invasive species are considered to be one of the most important causes of the loss of biodiversity, and constitute a phenomenon of global scale with the worst consequences occurring in islands (de Vos et al. 1956; Vitousek 1988; Coblenz 1998; Kairo et al. 2003; Courchamp et al. 2003; Borroto-Páez and Woods 2009). In spite of the damage caused to wildlife, research on the impact of introduced species of mammals on endemic animals is rather lacking in Cuba, and more broadly in the West Indies.

The terms *introduced*, *exotic*, *naturalized*, or *invasive* species have been widely used in the literature, however, here the last term is used, as the more common term in recent usage by major institutions and specialized international organizations (GISP: The Global Invasive Species Programme; IABIN, Invasive Species Information Network). In this context, I do not consider all introduced, exotic or naturalized species as being invasive, although they potentially could be. Invasive mammals are here defined as alien species in natural areas, in a

R. Borroto-Páez (✉)
Instituto de Ecología y Sistemática, Carretera de Varona
Km 3.5 Boyeros, A. P. 8029 C. P. 10800, C Habana, Cuba
e-mail: borroto@yahoo.com; borroto@ecologia.cu

wild-living or feral condition that also negatively affect (directly or indirectly) in any form and at any level the autochthonous flora and fauna, leading to an ecological cost and to real or potential loss of native biodiversity.

Methodology

This contribution regarding invasive mammals in Cuban Archipelago is an overview assessment and is an attempt to summarize the existing information gathered from field observations and notes for more than 15 years of surveys, interviews, and literature reviews. It attempts to fill a gap in the available international literature about Cuba.

Invasive mammals account

Carnivora

Dogs (Canis lupus familiaris)

Evidence of the domestication of dogs in North America goes back to 10,000 yBP (Lever 1994). Their presence during pre-Columbian times in the West Indies is controversial. Some authorities believe that they arrived along with Native Americans, others before (Arredondo 1988). Dogs have been definitively present in the West Indies at least since the arrival of the European colonists. The remains of dogs (*Canis lupus familiaris*) in pre-Columbian middens in Cuba are scarce (M. Pino, Archeological Center, CITMA, pers. comm.) and may be evidence that the overlap in time between the arrival of dogs kept by Cuban Native Americans and those brought by Europeans may not be large.

Domestic dogs in wild areas can be a pest for the farmer. For example, in the 1970s in the Escambray Mountains of Central Cuba, the damage done to livestock was intensive, and systematic hunts using shotguns were organized by farmers to eliminate wild dogs.

The two endemic mammals that are most affected by wild dogs are the Demarest or conga hutia (*C. pilorides*) and the almiquí (*Solenodon cubanus*). They are vulnerable since they are ground-dwelling, although other, arboreal species are vulnerable too.

The arboreal species of hutia (*Mysateles prehensilis* and *Mesocapromys melanurus*) may be less vulnerable because dogs have no climbing ability; however, the dogs may wait until these species use the ground. Harm by dogs has been observed for *M. melanurus* in the mountains of Alejandro de Humboldt National Park, in eastern Cuba; this species of hutia takes refuge in land crevices, and climbs trees to look for food at night. This is the time when dogs take advantage of the animals being on the ground to hunt them. Dog excrement with hair of hutia has been commonly found in this national park.

In January 2008, in the Sierra del Rosario Biosphere Reserve, in the western part of Cuba, four groups of scat with hair and bones of Carabali hutia (*Mysateles prehensilis*) were observed in 2 h of walking during an assessment of 2 days.

Wild dogs occupy niches across the whole of Cuban territory. In Cuba, these dogs are a threat to endemic species in natural areas and regions of conservation importance such as Guanahacabibes, Sierra de los Órganos, Sierra del Rosario, Isla de la Juventud, Ciénaga de Zapata, Escambray, Guisa, Sierra Maestra, Alejandro de Humboldt National Park, and Baracoa. In these regions, dog tracks and excrement containing the remains of native vertebrates have been spotted.

In some keys north of Varadero Beach in Matanzas province, the dog is the main agent of extinction. In the 1970s the Conga hutia had very high population in many of these keys, yet now this species has been extirpated from the keys by dogs brought by fishermen to hunt hutias that were then abandoned. Dogs are presently numerous on those islets and have exterminated all *C. pilorides* from Blanco and Mono keys, as well as from other surrounding small keys by swimming from one key to another in search of prey. Tourism employees and mariners have reported seeing the large-sized and dark-furred dogs, which eat the hutia viscera and leave the rest. Dogs are reported recently in Cayo La Vaca at north to Villa Clara Province (Amnerys González Rossell, Centro Nacional de Areas Protegidas, pers. comm.).

Other keys in the Camagüey Archipelago, such as Guajaba, Romano, Cruz, Coco, Sabinal and Santa Maria keys, have wild dogs (González et al. 1994; Rodríguez et al. 1997) and they are a threat to the scarce population of *C. pilorides* and other small vertebrate and invertebrate on the small islands.

According to local residents, wild dogs are not a threat to solenodons since they cannot enter the crevices of the karstic terrain because of their large size (Varona 1983). However, in the mountains of Baracoa (Guantánamo province) in 1991, a number of excavations by wild dogs were observed in areas that were most likely *Solenodon* refuges. During the same field trip, numerous dog excreta were observed to contain “hutia fur”. In Zoilita, in Sierra Cristal (Holguín province), a pair of *Solenodon* killed by wild dogs was found; one had been killed without being eaten, while the other had only the viscera eaten (Rams et al. 1989).

In Cuba, domestic dogs are raised and trained to hunt hutias in some rural areas. Around hutia habitats, domestic dogs are called “perro jutiero” (hutia-hunting dogs). Their phenotype is different according to the habitat and the local hutia species available for hunting. In the terrestrial habitats of *C. pilorides*, the dogs are generally small with short extremities and short hair, facilitating their hunting in caves and karst crevices. In areas with arboreal species such as *Mysateles prehensilis* and *Mesocapromys melanurus*, the dogs used for hunting are usually bigger in size.

These dogs are taught and learn by imitative behavior. The usual practice is for the dog owner to issue through various vocalizations a range of commands. Dogs enter the woods in search of evidence of hutias. They look primarily for urine marks and fresh excreta, but also can detect food remains and sounds with their acute sense of smell and hearing. The dogs demonstrate different behavior patterns. They sometimes locate a hutia minutes away and lead their owner there by continuous barks. Other times they continuously bark, then stay quiet and bark or howl at their master’s call. Individual dogs chasing *M. prehensilis gundlachi* in Isla de la Juventud and *M. melanurus* in the eastern region were observed to howl and bite the base of a tree until they completely stripped the bark off the trunk.

Dogs play an important role in subsistence in rural zones where hunting hutias provides an alternative source of protein. However, they can also decimate or wipe out populations of hutias, since without a human master, they can enter a forest and kill as many hutias as they can for their own survival. The wild dogs are a threat to the fauna in 16 Cuban islands (Table 1).

Cats (*Felis silvestris catus*)

Cats arrived with the first European colonists. They were maintained in Spanish boats to deal with the infestation of rats (*Rattus rattus*, *Rattus norvegicus*) and mice (*Mus musculus*), rather than for companionship. In Cuba, cat remains have not been found in pre-Columbian middens (M. Pino, pers. comm.).

Cats are threats to birds and to nocturnal endemic mammals, since their activity cycle coincides with that of West Indian species of both solenodons and hutias. They occupy and disturb the ecological niches of these endemic species and can also be disease vectors.

In *Mysateles* habitats with trees, lianas and vines, such as South of Isla de la Juventud, wild cats are an important cause of the decline of populations of *M. meridionalis*. Besides competing for the same structural niche, cats can easily prey upon the litters of hutias, and even capture adult hutias not adapted to carnivorous mammalian predators.

In Guanahacabibes, San Diego de los Baños, Macurije, Ciénaga de Zapata, Escambray, Guisa, Sierra Maestra, Monte Verde, Alejandro de Humboldt National Park, and other areas that are protected zones and important refuges for endemic species, wild cats have been reported and are predators of small vertebrates such as amphibians, reptiles and birds, and their terrestrial and arboreal nests. González et al. (1994) observed cats in four keys of the Camagüey Archipelago: Guajaba, Romano, Cruz and Megano Grande; Rodríguez et al. (1997) reported cats on Sabinal key, and recently cats were observed in Santa Maria key (C. Mancina, pers. comm.).

Cats are the most important potential predator of solenodons, since they can enter into their tunnels and dens (Varona 1983), although there is as yet no direct evidence for this. Nonetheless, cats are believed to pose threats to the Hispaniolan and Cuban species of *Solenodon* (Lever 1994). Ebernhard (1988) considers these two insectivores to be the largest prey species to have been affected by cats.

The decline and extinction of small rodents and insectivores such as *Boromys*, *Mesocapromys* and *Nesophontes* in Cuba was likely influenced by and has been attributed to cats, following their arrival with the first Europeans. Cats are present in 13 Cuban islands (Table 1).

Table 1 Invasive mammals in the Cuban Archipelago

Invasive mammals	Islands and keys																Keys total							
	1	2	4	5	7a	7b	9	11	12	18	19	20	21	22	23	25		26	27	28	30	31	33	
<i>Canis lupus familiaris</i>	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
<i>Felis silvestris catus</i>							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	13
<i>Herpestes javanicus</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	4
<i>Rattus rattus</i>	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	39
<i>Rattus norvegicus</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	4
<i>Mus musculus</i>				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	11
<i>Dasyprocta punctata</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
<i>Dasyprocta mexicana</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
<i>Cuniculus paca</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
<i>Cavia porcellus</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
<i>Sciurus granatensis</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
<i>Oryctolagus cuniculus</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	4
<i>Sus scrofa</i>							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5
<i>Odocoileus virginianus</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	4
<i>Bos taurus</i> (Holstein)							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	6
<i>Bos taurus</i> (Zebú)							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	6
<i>Bubalus bubalis</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5
<i>Ovis aries</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	2
<i>Ovis ammon</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	3
<i>Capra hircus</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	2
<i>Dama dama</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	5
<i>Equus caballus</i>							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
<i>Equus asinus</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	3
<i>Antilope cervicapra</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	2
<i>Boselaphus tragocamelus</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
<i>Taurotragus derbianus</i>								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	3
<i>Chlorocebus aethiops</i>				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
<i>Macaca nemestrina</i>				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
<i>Macaca fascicularis</i>				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1

park, one mongoose was captured in 2005. (Gerardo Beque, Unidad de Servicios Ambientales, Guantánamo, pers. comm.).

The mongoose is diurnal in habits and does not climb, which reduces its impact on endemic Cuban mammals, although its impact should not be disregarded. Its impact on other vertebrates such as birds, reptiles, amphibians, and many invertebrate is not quantified or well characterized.

The introduction of the mongoose in the West Indies is one example of irresponsible human interference in nature's equilibrium, comparable to the introduction of rabbits and foxes in Australia (Westermann 1953). Mongooses have successfully occupied various niches in the West Indies since there are no competing carnivores, other than introduced cats and dogs, and mongooses have no important predators on the islands. The mongoose in the West Indies is threatening or has exterminated more species than any other animal deliberately introduced by man in any other region on earth (Lever 1994).

In Cuba, mongooses are known to be present on four islands (Table 1). Not enough is known about the management, monitoring, control, and eradication of this species.

Rodentia

Murid rodents: black rats (Rattus rattus), brown rats (Rattus norvegicus), and mice (Mus musculus)

The rats and mice appeared in the West Indies with the arrival of the Spaniards. The brown rat (*Rattus norvegicus*) and the mouse (*Mus musculus*) were broadly distributed and were common in urban areas across Europe by the beginning of the era of colonization (Borroto-Páez 1988).

The three species are now well distributed in Cuba and occupy a wide variety of habitats such as forests, coastal zones, keys, etc., although they are more common around human settlements and cultivated areas. They are agricultural pests of cocoa, rice, sugarcane, and other crops. In sugarcane fields, *Mus musculus* population density reaches up to 400 mice/ha and *Rattus rattus* 14 rats/ha (Borroto-Páez et al. 1990). In sugarcane fields, *Mus musculus* and *Rattus rattus* have diets with plant and animal components; the animal component (principally insects) comprises

35.4 and 25.6% of the total volume, respectively. Predation on mice by rats was observed (Borroto-Páez and Rodríguez 1990).

Among the three species, the black rat and the mouse are most likely to infest natural ecosystems and interact with the native fauna. *Rattus rattus* is the more aggressive species, with its ability to climb and nest in trees. *Mus musculus* is very often unseen because of its small size, nocturnal habits, and low population densities in the wild.

Valdés and Garrido (1978) reported *Rattus* in Santa Maria and Francés, keys north of Caibarien, and in Cantiles, Maja, Real, and Coco in the southern coast. González et al. (1994) observed black rats in 11 keys and mice in three keys of the Archipelago of Camagüey; Rodríguez et al. (1997) include *Mus* in the Cayos de Piedra (Aguada and Salinas).

Numerous mice and black rats have been captured or detected in many keys of the Canarreos Archipelago, south of Cuba: Largo del Sur y Cantiles (*Rattus rattus* and *Mus*), Campo, del Rosario (*R. rattus*). In a recent evaluation of biodiversity in the south of Zapata Swamp, the black rat was detected at high densities in many keys: Ernest Thaelmann, Las Vacas, Venado, Caoba, Blanco, Sinverguenza, and Diego Perez (Borroto-Páez et al. 2007).

In Cuban natural forests in Guanahacabibes, San Diego de los Baños, Sierra del Rosario, Ciénaga de Zapata, Escambray, Guisa, Sierra Maestra, Monte Verde, and Alejandro de Humboldt National Park, trapping of black rats demonstrated their high densities; however, mice were detected only in areas of human activity.

The black rat occupies the same structural niche as *Mysateles*. In the gallery forests of northern Isla de la Juventud, nests of black rats are abundant among the branches and lianas that formed the preferred substratum for *M. prehensilis gundlachi*. Doubtlessly, human activities and rat infestations are the cause of extirpation of this *M. prehensilis gundlachi* population, since black rats moved to the interior forest consequent to land clearing around the natural forest for agricultural purposes. In the conserved forests in the south of Isla de la Juventud, around Hato de Milan, in the range of *M. meridionalis*, black rats nests are present between the lianas, the best niche for this hutia, and the species has not been detected during the past 35 years (Borroto-Páez and Ramos 2003). *Rattus norvegicus* and *Mus musculus* are

present in Isla de la Juventud, but primarily in areas of human activity.

In Alejandro de Humboldt National Park, surveys during February 1997 revealed an abundance of rats across the entire protected area up to the mountain rain forests, far from the anthropic zones. The rats were found to occupy the abandoned tunnels of Cuban solenodons. Rat population rapid assessment using a small number of traps (up to 12 traps/night) revealed a high percentage of traps occupied (80–100%, with some traps catching rats as many as three times in a night).

In Juan Garcia key, the black rat infestation is considered to be one of the causes of the extinction of *Mesocapromys sanfelipensis*, restricted to this area (Frías et al. 1988). Varona and Garrido (1970) reported *Rattus* in the keys Coco Grande, Coco Chico, La Cucaña y Sijú in the keys of San Felipe, South of Pinar del Río. They also occupied the abandoned nests of *Mesocapromys auritus* in Cayo Fragoso (Manójjina and Abreu 2009) suggesting competition between the species for these refuges.

Rats might have had an impact on *Boromys*, *Nesophontes* (Morgan and Woods 1986) and some extinct species of *Mesocapromys* in Cuba, which comprised the smallest native terrestrial mammals. The presence of *Nesophontes* remains in post-Columbian middens (O. Arredondo, pers. comm.) suggests that their extinction might have been subsequent to the damage done by introduced species of rodents and carnivores. *Mus musculus*, due to its characteristics and habits, appears to be the least competitive and interactive invasive species with the endemic mammals, although in the past it could have competed with small insectivores of the genus *Nesophontes*.

Black rats are reported from 39 Cuban islands, and are the invasive species most widely distributed; while the brown rat and house mouse live in four and 11 Cuban islands, respectively, (Table 1). It is very likely that these three species are distributed in other islands also, so that these numbers will increase in the future.

Other rodents

During the 1930s, three agouti species (*Dasyprocta punctata*, *Dasyprocta mexicana*, and *Cuniculus paca*) were introduced from Mexico to Sierra de los

Organos, Pinar del Río, and in Sierra Cristal, Holguín (Varona 1980). These species are terrestrial and are established in the entire western region up to San Diego, Soroa, and Guanahacabibes, in Pinar del Río since 1967 (Varona 1980). In the eastern part of Cuba there are no reports of them for many years. Both *Dasyprocta* species are diurnal, move with agility on the ground and inhabit the forest or karst. In San Diego de los Baños, these species were observed during different field studies between 1990 and 1993; one local farmer raised about 20 for meat, but freed them because feeding them was too tedious and difficult. In Guanahacabibes, it was possible to detect these animals during different field studies, the last one in 1996. Very recently, in February of 2008, *D. mexicana* was hunted by the locals near Soroa, and one specimen was observed and photographed for the author. These invasive agoutis with terrestrial habits might compete for food and refuges with the Demarest hutia or hutia conga (*C. pilorides*) in the above localities where they are sympatric. However, they do not seem to compete for niche or food with *Mysateles prehensilis*, which is arboreal.

The Guinea-pig (*Cavia porcellus*), in addition to its use as a laboratory animal, is raised by some farmers in Guisa (eastern Cuba) for its meat. There are feral ones near the houses but abundant populations are not known, nor are they known to impact the Cuban fauna.

There is a population of squirrels (*Sciurus granatensis*) around some parts of the margin of Rio Almendares in Havana city. They escaped from captivity from the Havana Zoo. No damage to the native fauna is reported; however, in the future, their impact on the reintroduced hutias of the Metropolitan Park must be anticipated.

Lagomorpha

Rabbits (Oryctolagus cuniculus)

Rabbits were introduced in La Habana Province around 1880 from the Canary Islands (Varona 1974). Although they exist in the wild, they are not abundant in Cuba. There is a sparse population in the northern coastal zones of this province, near Matanzas. In the cliffs and precipices of this region lives a population of *C. pilorides*, not very abundant. Although they do not share the same habitat now, rabbits might cause damages to the terrestrial *C. pilorides*. González et al.

(1994) reported rabbits in the Romano key in Archipelago of Camagüey, and recently they were detected in Santa Maria key (C. Mancina, pers. comm.).

Recently, rabbits were reported in the South of Isla de la Juventud, around Punta del Este (Ignacio Ramos, Instituto de Ecología y Sistemática, pers. comm.). The animals escaped from captivity and their population is very high, which begins to be a problem for the vegetation, and competition for *Capromys pilorides ciprianoi*. Some time ago this subspecies of hutia was very abundant in this area and now the population available for hunting has declined. The species is in four islands, and the possible impact on the flora must be studied.

Artiodactyla

Feral pigs (Sus scrofa)

This species was introduced to the West Indies during the second trip of Columbus to the Americas in 1493; eight pigs were brought from the Canary Islands to Hispaniola (Crosby 1986; Lever 1994).

The pig is well established and distributed in almost all natural forests and some keys in Cuba. The populations were introduced by local people as a food resource. Harm to hutias has not been reported; however, pigs are abundant within the areas of distribution of Cuban solenodons. The feral swine might have a negative impact on solenodons since their burrowing for food can destroy the burrows of this insectivore.

Damage by feral pigs to the forest is known but not quantified. They damage forest regeneration especially in regards to climbing plants such as lianas, and may have indirect effects on *Mysateles* hutias that depend of this type of vegetation for refuges and nests. This type of damages exists in Alejandro de Humboldt National Park in the eastern part of Cuba.

Feral pigs are known from Cuba, Isla de la Juventud, and in the Archipelago of Sabana-Camaguey (Coco, Guajaba, Romano keys). The species is a predator of crabs and eats the eggs of reptiles and birds (Escobar 1995).

Wild pigs might have a negative impact on the invertebrate and small vertebrate fauna since they will eat eggs laid on the ground. They have a profound and invariably negative impact on ecosystems, disrupt

natural successional sequences, out compete or prey upon native species, can act as reservoirs of pathogens, and are implicated in the extinction and endangerment of endemic plant and animals, particularly on oceanic islands (Oliver 1984; Oliver and Brisbin 1993). Their direct and indirect impacts on natural regeneration of vegetation and on soil degradation, and depredation of the fauna (ground-nesting birds, invertebrates and small vertebrates) in Cuba should be researched. Feral pigs are present in five Cuban islands.

White-tailed deer (Odocoileus virginianus)

Deer are established in many forested and mountainous areas in Cuba. This species was introduced around 1850 from Mexico and/or the southern United States (de Vos et al. 1956). The species is present in Isla de la Juventud and the Camaguey Archipelago. Their possible impact on the native flora (vegetation and forest regeneration) needs to be researched.

Other artiodactyla

The introduction in Cuba of peccaries (*Tayassu albirostris* and *Tayassu tajacu*) as livestock in 1930, llamas (*Lama glama*) in 1856 and dromedary camel (*Camelus dromedarius*) in 1832 (Varona 1980) as load animals each failed to be successful.

On Isla de la Juventud, Cuba, several species of Artiodactyla have been reported, including *Dama dama*, *Ovis ammon musimon*, and *Bos taurus*. There are five species of Artiodactyla (Table 1) in Camaguey Archipelago: *Ovis aries*, *Capra hircus*, *Bos taurus* (Holstein and Zebu), *Antilope cervicapa*, and *Boselaphus tragocamelus* (González et al. 1994). The Indian antelopes *Boselaphus tragocamelus* and *Taurotragus derbianus* were introduced in Sierra Najasa, Camaguey, and were observed in an expedition in 2001.

The Asian Water Buffalo (*Bubalus bubalis*) is now a problem in some areas in Cuba (Rio Máximo Reserve and south of Pinar del Rio), this species is very aggressive, causes damage in natural and agriculture ecosystems, and is host of Tuberculosis, Brucellosis, and other diseases. Intent to reduce the wild population has been done (Oscar Pouza Triana, Director National Park Caguane, CITMA, pers. comm.).

Cattle arrived in the West Indies in 1493, brought by Columbus from the Canary Islands to Hispaniola (Crosby 1986). Domesticated cattle, sheep (*Ovis musimon*), and goat (*Capra hircus*) under management do not affect directly the native fauna but they could be a threat to the flora. However, animal husbandry depends on large amounts of land that affects natural ecosystems and the resources available to the native fauna.

Recently, animal introductions have been justified by the creation of shooting preserves in controlled areas as a tourist activity. If there is a negative effect on the flora and fauna it is local, although the risk of the introduced animals escaping is always present.

Artiodactyls cause important damage (not quantified), most likely affecting the vegetation and the regeneration of the forest, as well as invertebrates and ground nesting reptiles and birds. The deer, sheep, and goat are herbivores with a wide range of diet and can affect many species of plants and also cause soil erosion. There is no direct evidence of competition of these other Artiodactyla with the endemic mammals or other elements of the fauna.

Perissodactyla

Two species are present in Cuba: *Equus caballus* and *Equus asinus*. The horses (*Equus caballus*) are beasts of burden that are now widely distributed. They were introduced to the West Indies (Hispaniola) by Columbus in 1493 (Crosby 1986). In Cuba, since the last century there have been herds of feral horses in Romano and Guajaba keys of Archipelago of Camagüey (Varona 1980) and Coco Key (González et al. 1994). In Cuba Island and Isla de la Juventud there are horses present in some natural areas. No effect on the fauna is known but the effect on the flora requires study in some localized areas.

Primates

Green monkey, pigtail macaque, crab-eating macaque, stump-tail macaque (Chlorocebus aethiops, Macaca nemestrina, Macaca fascicularis, and Macaca arctoides)

In the first years of the decade of the 1980s, four species of monkeys were introduced in the keys of

the Archipelagos of the Canarreos and Camagüey in Cuba. The objective of these introductions was to create artificial colonies of monkeys in a semi-free state that would generate a supply of monkeys to institutions conducting biomedical research. This project attempted to replicate similar colonies of monkeys in the USA, and on Santiago and Mapache keys. A colony of green monkeys had existed for over 300 years in St. Kitts Island, derived from animals brought on ships that also carried slaves. This colony provided the green monkeys that initially were introduced to Cuba.

At the moment, the four species have successfully established themselves in Cuba: *Chlorocebus aethiops* on Cantiles key; *Macaca nemestrina* in Cantiles key, *Macaca fascicularis* in Campo keys, and *Macaca arctoides* in Guajaba key (González et al. 1994; Escobar 1995). In Cayo Romano *C. aethiops* (González et al. 1994) have been reported, but today this species is not present (C. Mancina, pers. comm.). The initial quarantine for these introductions was conducted in Cantiles key.

In 1992, an expedition went to several keys of the Archipelago of the Canarreos; on Campo and Cantiles keys monkeys could be observed. Campo Key still had a population of *Macaca fascicularis* (the other introduced species were down to very few individuals or had already disappeared) in the area of tall mangroves. They occupied the same structural niche as an autochthonous population of hutia (*C. pilorides*), notable since by contrast in many keys of the Archipelago the conga hutia had been introduced, from the south of the Isla de la Juventud or from the Zapata Swamp. The native hutia population has diminished considerably in the recent past, due not only to the presence of the monkeys but also to the presence of humans who care for the monkeys and also hunt hutias. In Cantiles key, the few humans who inhabit the island to care for the green monkeys provided information that the hutias there were very scarce.

In the Archipelago of Camagüey monkeys were introduced around the year 1984 (González et al. 1994), in the Guajaba key was *Macaca arctoides*, while information about introduction of 50 green monkeys (*Chlorocebus aethiops*) in this time in Romano keys is not clear, and today this species is not present. Only in Romano key does a (reduced) population of conga hutias (*C. pilorides*) exist.

They are a serious danger to the fauna in a general sense since when they do not find food of vegetable origin in sufficient abundance, they prey upon a great number of species of invertebrates and vertebrates. Although food is provided artificially to the monkeys, it is sometimes not varied and therefore it does not fulfill the necessary requirements for these species, and discontinuities can also exist in the supply. When this happens, the monkeys turn to any available resource, causing serious damage to local species.

General comments

This represents the first general assessment of the distribution and impact of invasive mammals species in the Cuban Archipelago. The presence of 29 invasive species in Cuba reported from 40 islands of the archipelago (Table 1) suggests the need for additional studies in this area. Many of these invasive species are considered to be among the 100 worst invasive species of the world (Lowe et al. 2000). The island of Cuba hosts the largest number of invasive mammal species among all the West Indian islands (Borroto-Páez and Woods 2009) while other islands in the Archipelago also carry large numbers of invasive mammalian species: Cayo Romano (15), Isla de la Juventud (15), and Cayo Guajaba (11). The situation is related to the larger geographic expanse of the Cuban Archipelago. At the same time, the situation is pertinent to conservation because Cuba hosts the highest biodiversity in the region.

Protected areas in Cuba of all categories are infested with many introduced species, and there are no pest control programs to counteract the damages done to the native biodiversity. Often the management plan in the protected areas does not consider the problem of invasive species in its full magnitude, or proposals for management, detection, eradication and control are not executed.

In Cuba, as in other West Indian Islands, invasive species pest control policies are present only with regards to public health or agriculture and are limited to human settlements. Pest control policies are generally lacking for wild areas across the world (Donlan et al. 2003); therefore natural ecosystems turn into pest reservoirs, and are also themselves affected by the harmful invasive.

The impacts of invasive species are very variables and complex. They might affect directly or indirectly endemic flora and fauna. The more direct and evident impacts are predation, habitat destruction, habitat perturbation, and space and niche occupation. The invasive species might also be disease and pest vectors or provoke physiological and metabolic perturbations and stresses in native fauna. Some times the impacts are indirect, reducing or affecting, in the long term, an important resource or a biological and natural process. Research, fieldwork, and data collection are difficult and expensive in the case of invasive mammals, and in spite of the high level of speculation in some surveys, yet research must be considered when determining management plans, or eradication and control measurements.

Black rats are distributed in 39 Cuban islands and are the invasive mammals most widely distributed. Dogs (16 Cuban islands), cats (13) and mice (11), are the other species with the most widespread distributions. However, in the case of rats and mice, the information is not complete, and the presence of these species in many other keys is very likely even though there may not be official reports.

Numerous endemic species, non-abundant, with reduced distributions, suffered sudden impacts from introduced species that, along with other human activities, led to species extinction. *Nesophontes* and *Boromys* might have gone extinct very soon after the arrival of Europeans due to competition with introduced species of similar body size (rats and mice) and to depredation by dogs and cats (Morgan and Woods 1986). More recently, *Mesocapromys sanfelipensis* went extinct because of competition. Today, all endemic mammals of the West Indies are threatened by the negative impact of introduced species. By not taking appropriate and immediate actions to perpetuate the endemic patrimony, we will become accomplices to these new extinctions. The negative impact of invasive species in Cuba has reached significant dimensions that justify serious studies and implementation of eradication actions in order to mitigate the problem.

Acknowledgments We thank Angel Arias Barreto from CESAME for additional information about Cayo Las Brujas and Cayo Frances; to colleagues from the Institute of Ecology and Systematic, especially to Carlos A. Mancina for some additional information, revision and suggestions. We also thank Al Roca from the University of Illinois at

Urbana-Champaign, USA, for the help in the English review of manuscript.

References

- Arredondo O (1988) Los perros indígenas de Cuba. In: Prida ER (ed) *El Perro*. Editorial Científico-Técnica. Ciudad de La Habana, pp 16–41, 305 pp
- Boroto-Páez R (1988) Aspectos generales sobre la biología, ecología, daños y control del ratón casero o guayabito (*Mus musculus*). *Boletín de Reseñas. Protección de Plantas* 29:1–69
- Boroto-Páez R, Ramos I (2003) Current status of the carabali hutia from South of Isla de la Juventud, *Mysateles meridionalis*. *ORSIS* 18:7–12
- Boroto-Páez R, Rodríguez MA (1990) Observaciones del subnicho trófico de *Mus musculus* (L) y *Rattus rattus* (L) en el cultivo de la caña de azúcar. *Cienc Biol* 23:59–67
- Boroto-Páez R, Woods CA (2009) Status and impact of introduced mammals of the West Indies. In: Boroto-Páez R, Woods CA, Sergile FE (eds) *Terrestrial mammals of the West Indies: contributions*. Wocahoota Press and University of Vermont (in press)
- Boroto-Páez R, Tejada M, Lewis F, Rodríguez MA (1990) Fluctuación poblacional de *Mus musculus* (L) y *Rattus rattus* (L) en el cultivo de la caña de azúcar. *Rev Biol* 4(2):121–132
- Boroto-Páez R, Labrada M, Mancina CA, Oviedo R (2007) Valoración rápida de la biodiversidad terrestre en algunos cayos al sureste de la Ciénaga de Zapata, Cuba. *ORSIS* 22:9–33
- Coblentz BE (1998) Strangers in paradise: invasive mammals on islands. *World Conservation. Invaders from Planet Earth*. Double issue 4/97–1/98: 7–8
- Courchamp F, Chapuis JL, Pascal M (2003) Mammals invaders on island: impact, control and control impact. *Biol Rev* 78:347–383
- Crosby AW (1986) *Imperialismo ecológico*, crítica. Grijalbo, Barcelona, p 351
- de Vos A, Manville RH, Van Gelder RG (1956) Introduced mammals and their influence on native biota. *Zool N Y Zool Soc* 41:163–194
- Donlan CJ, Tershy BR, Cambell K, Cruz F (2003) Research for requiem: the need for more collaborative action in eradication of invasive species. *Conserv Biol* 17(6):1850–1851
- Ebernhard T (1988) Introduced bird and mammals and the ecological effects. *Viltrevy* 13:1–107
- Escobar TR (1995) Isla de la Juventud. Vertebrados introducidos por causas deliberadas. Editorial Científico Técnico, Pinos Nuevos, Ciudad de la Habana, 96 pp
- Espeut WB (1882) On the acclimatization of the Indian mongoose in Jamaica. *Proc Zool Soc Lond* 1882:712–714
- Frías AI, Berovides V, Fernández C (1988) Situación actual de la jutiita de la tierra *Capromys sanfelipensis* (Rodentia, Mammalia). *Doñana Acta Vertebrata* 15(2):252–254
- González A, Manójjina N, Hernández A (1994) Mamíferos del Archipiélago de Camagüey, Cuba. *Avicennia* 1:51–56
- Hoagland DB, Horst GR, Kilpatrick CW (1989) Biogeography and population biology of the mongoose in the West Indies. In: Woods CA (ed) *Biogeography of the West Indies: past, present and future*. Sandhill Crane Press, Gainesville, pp 611–630
- Horst GR, Hoagland DB, Kilpatrick CW (2001) The mongoose in the West Indies: the biogeography and population biology of an introduced species. In: Woods CA, Sergile FE (eds) *Biogeography of the West Indies. Patterns and perspectives*, 2nd edn. CRC Press, Boca Raton, pp 409–424
- Kairo M, Ali B, Chessman O, Haysom K, Murphy S (2003) Invasive species threats in the Caribbean Region. Unpublished report to the Nature Conservancy. CAB International, 134 pp
- Lever C (1994) *Naturalized animals*. Poyser natural history. University Press, Cambridge 354 pp
- Lowe S, Browne M, Boudjelas S, De Poorter M (2000) 100 of the world's worst invasive alien species a selection from the Global Invasive Species Database. Published by The Invasive Species Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN), 12 pp. First Publisher as special lift-out in *aliens* 12, December 2000. Updated and reprinted version, November 2004
- MacPhee RDE, Flemming C (1999) Requiem aeternum: the last five hundred years of mammalian species extinctions. In: MacPhee RDE (ed) *Extinction in near time: cause, contexts, and consequences*. Kluwer/Plenum, New York, pp 333–372
- MacPhee RDE, Marx PA (1997) The 40,000-year plague: human, hyperdisease, and first contact extinctions. In: Goodman SM, Patterson BD (eds) *Natural change and human impact in Madagascar*. Smithsonian Institution Press, Washington, DC, pp 169–217
- Manójjina N, Abreu RM (2009) Ecology of the eared hutia (*Mesocapromys auritus*). In: Boroto-Páez R, Woods CA, Sergile FE (eds) *Terrestrial mammals of the West Indies: contributions*. Wocahoota Press and University of Vermont (in press)
- Morgan GS, Woods CA (1986) Extinction and zoogeography of the West Indies land mammals. *Biol J Linn Soc* 28:167–203
- Myers N, Mittermeier RA, Mittermeier CG, da Fonseca G, Kent J (2000) Biodiversity hotspots for conservation priorities. *Nature* 403:853–858
- Oliver WLR (1984) Introduced and feral pigs. In: *Feral mammals-problems and potential*. Proceeding of the workshop on feral mammals at the IIIrd International Teriological Congress. Helsinki. 1982; IUCN, Gland, 87–126 pp
- Oliver WLR, Brisbin IL (1993) Introduced and feral pigs: problems, policy, and priorities. In: Oliver WLR (ed) *Pigs, peccaries and hippos. Status survey and conservation action plan of the IUCN World Conservation Union*. Gland, pp 179–191
- Rams A, Abreu RM, de la Cruz J (1989) Almiquí (*Solenodon cubanus*) depredado por perros jíbaros (*Canis familiaris*). *Garciana* 21:1–2
- Rodríguez D, Rodríguez-León R, Fernández I, Martínez M, Cejas F, Martínez M, Ramos I, Bidart L, Llanes A, Mancina CA, Avila A, Pérez A, Rodríguez D, Chamizo A, Rivalta V (1997) Compendio de Resultados sobre Fauna

- Terrestre del Archipiélago Sabana-Camagüey, Informe Técnico, Proyecto GEF/PNUD Cub/92/631. 100 pp
- Valdés A, Garrido OH (1978) Presencia de *Rattus* (Rodentia: Muridae) en cayos de Cuba. *Misc Zool* 7:2–3
- Varona LS (1974) Catálogo de los Mamíferos Vivientes y extinguidos de las Antillas. Editorial Academia de Ciencias de Cuba, 139 pp
- Varona LS (1980) Mamíferos de Cuba. Editorial Gente Nueva, Ciudad de La Habana, p 110
- Varona LS (1983) Remarks on the biology and zoogeography of *Solenodon (Atopogale) cubanus* Peter, 1861 (Mammalia, Insectivora). *Bijdragen tot de Dierkunde* 53(1): 93–98
- Varona LS, Garrido OH (1970) Vertebrados de los cayos de San Felipe, Cuba, incluyendo una nueva especie de jutía. *Poeyana* 75:1–26
- Vitousek PM (1988) Diversity and biological invasions of oceanic islands. In: Wilson EO, Peter FM (eds) *Biodiversity*. National Academic Press, Washington, DC, pp 181–189
- Westermann JH (1953) Nature preservation in the Caribbean: a review of literature on the destruction and preservation of flora and fauna in the Caribbean area. *Publications of the foundation for sciences and research in Surinam and the Netherlands Antilles* 9, pp 1–106