Status and Range of Introduced Mammals on St. Martin, Lesser Antilles

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ABSTRACT
The introduction of mammals to islands is one of the leading causes of extirpation of native biota worldwide. Data gaps in the introduction of mammals to islands have led to inadequate management practices which do not take into consideration the potential destruction caused by those mammals. Herein, we report the current status of introduced mammals on the island of St. Martin within the Lesser Antilles region of the Caribbean. We surveyed the island for introduced mammals and interviewed residents on their observations, from 2000 - 2007. In addition to recording domesticated mammals (i.e. dogs, *Canis familiaris*), we recorded six species of feral introduced mammals including raccoons (*Procyon lotor*) and African green vervet monkeys (*Cercopithecus aethiops*).

Key words: Introduced mammals, African green vervet monkey, mongoose, raccoon, rat, mouse, St. Martin, Tintamarre, Caribbean, Lesser Antilles.

INTRODUCTION

The invasion of ecosystems by exotic species is currently viewed as one of the main causes of global ecological change, mostly due to biodiversity loss (Vitousek *et al*. 1997). The largest part of this loss has occurred on islands where indigenous species had thrived in the absence of competition. The effect of introduced species on an ecosystem may be simple or very complex, depending on the array of introduced species on the island and the interaction among those introduced species, but the effect is almost always destructive (Courchamp *et al*. 2003). Therefore, there is an urgent need to understand and counteract the processes by which biological invasions threaten biodiversity within insular ecosystems.

Oceanic islands are home to plant and animal communities with relatively little diversification, simplified trophic webs, and high rates of endemism. Therefore, island communities are highly susceptible to disturbances and subsequent high rates of species extinction (Chapuis 1995). The majority of worldwide extinctions have occurred in insular ecosystems, where more than 90% of the recorded extinctions in reptiles and amphibians have been island forms (Honnegger 1981). Furthermore, predation by introduced animals has been a major cause of 42% of island bird extinctions in the past and is a major factor endangering 40% of currently threatened island bird species (King 1985).

Introduced mammals have caused more problems than any other vertebrate group and are responsible for the best documented ecological disturbances resulting from biological invasions (Ebenhard 1988; Lever 1994). This is due in part to a lack of naturally occurring mammals on most remote islands (Atkinson 2001). The introduction of mammals is known to affect native species in many ways, most notably by predating on native species and affecting plant populations and the species that rely on the structure of those plant communities (Ebenhard 1988).

The Caribbean islands are visited annually by migratory birds from both North America and South America (Brown and Collier 2004). These naturally occurring migratory species seasonally visit and inhabit most environments on islands (Brown and Collier 2004). Resident avian species have developed strategies to co-exist within habitats alongside migratory species to ensure adequate food sources as well as safe roost and nesting areas (Johnson *et al*. 2005).

Mammalian biological invasions in the Caribbean are not well documented with the exception of a few species. The Indian mongoose (*Herpestes auropunctatus*) was introduced to Jamaica from India in 1872 to predate on rats in the sugar cane fields and has since been the source of populations on 29 Caribbean islands, including St. Martin (Nellis and Everard 1983). This population of mongoose has been responsible for the eradication of multiple species of invertebrates, reptiles, amphibians, birds, and mammals in the Caribbean (Westermann 1953; Nellis and Everard 1983; Lever 1994). The African green vervet monkey (*Cercopithecus aethiops*) was first introduced from Africa in 1650 to Barbados, St. Kitts, and Nevis (Denham 1987). While not well documented, we assume that rodents such as *Rattus rattus, R. norvegicus,* and *Mus musculus* as well as domesticated animals are found commonly on most inhabited Caribbean islands and less commonly on many uninhabited offshore islands, all presumably having arrived to the Caribbean with European settlers from the 15th century to the present. The recent discovery of the African Giant Rat (*Cricetomys gambianus*) to southern Florida in the United States raises the possibility that the species might also be established in the Caribbean, given the regularity of ship trade between these two regions. It is within this context of gaps in the knowledge base, that we found it vital to document the current status and range of introduced mammals on St. Martin.

MATERIALS AND METHODS

St. Martin is a small island (95 km^2) located in the northern windward islands of the Lesser Antilles (Latitude 18° 02' 295 N and Longitude 063° 07' 207 W). Politically and physically, the island is divided between the French and Dutch. The island was formed during the height of Pleistocene glaciations and the non-volcanic island consists mainly of limestone and igneous diorite. Pic Paradise is the highest point on the island at 425 m. In Philipsburg, the highest mean temperature is recorded in August at 27.9º C and the coolest months are January and February with a mean of 24.7º C (Stoffers 1956). Mean annual rainfall is 1000 - 1125 mm, but precipitation varies annually and long periods of drought occur (Stoffers 1956). The island lies within the Caribbean hurricane zone and the most recent hurricanes making landfall were: Luis, 1995; Bertha, 1996; Georges, 1998; Jose and Lenny, 1999 (Caribbean Hurricane Network 2005).

Primary hardwood forests once covered the majority of the island, but most of these were removed and replaced with sugar cane during the 17th century. However, at the present time there is little sign of agriculture and St. Martin is dominated by scrub habitat with small exceptions of remnant dry forest occurring in a few high mountain valleys on the island. Additionally, wetlands occur along much of the island's lowland areas, covering approximately a fifth of the entire island.

Tintamarre Island is a small (9 km^2) French - owned islet located 3 km northeast of St. Martin. The island itself is managed as a French Reserve Naturelle and is managed locally by staff on St. Martin. The island consists of low scrubby brush. There are scattered rock outcroppings along the island's shorelines, upon which large numbers of seabirds nest throughout the year. There is a popular tourist beach which is visited daily by sailboat tour operations.

Data on mammals was collected during our annual periodic research on the bird communities of St. Martin from January, 2000 – April, 2007. We surveyed birds within all habitats of the island on a weekly basis and therefore had complete geographic coverage of the island. Although mammals were not the focus of our research, we regularly encountered the mammals reported herein. When mammals were encountered, we recorded total number of animals observed as well as the location of the observation. Additionally, we collected data on mammals encountered while surveying the small satellite islet, Tintamarre Island.

An effort was made to quantify the density of rats on Tintamarre Island. During May, 2004, 50 snap traps were placed during the evening in a one km^2 coastal area, directly adjacent to a Red-billed Tropicbird (*Phaethon aethreus*) colony. Traps were checked the following morning. Permission for trapping was given by the Reserve Naturelle land managers.

Information on the presence and distribution of introduced mammals was recorded during interviews with residents of St. Martin. Residents were surveyed at Maho, Lowlands, Marigot, Rambaud, Columbier, Grand Case, French Cul-de-Sac, French Quarter, Philipsburg, and Simpson Bay, the major villages on the island. The inhabitants were asked what mammals they observed near their homes as well as the regularity the mammals were observed.

RESULTS

Introduced mammals were found in all habitats on St. Martin as well as on Tintamarre Island. Domestic animals, specifically cats (*Felis catus*), dogs (*Canis familiaris*), goats (*Capra hircus*), pigs (*Sus scrofa*), and cattle (*Bos taurus*) were regularly encountered on St. Martin as well as goats and cows on Tintamarre. Six species of feral introduced mammals were recorded including two species of rat, one species of mouse, one species of mongoose, one species of raccoon, and one species of monkey (Table 1).

Table 1. Introduced mammals recorded on St. Martin from 2000 - 2007.

Common Name	Scientific Name
Horse	*Equus caballus*
Donkey	*Equus asinus*
Cow	*Bos taurus*
Ox	*Ovibos moschatus*
Sheep	*Ovis aries*
Goat	*Capra hircus*
Pig	*Sus scrofa*
Cat	*Felis catus*
Dog	*Canis familiaris*
House mouse	*Mus musculus*
Brown rat	*Rattus norvegicus*
Black Roof rat	*Rattus rattus*
Indian mongoose	*Herpestes auropunctatus*
Raccoon	*Procyon lotor*
African green vervet monkey	*Cercopithecus aethiops*

Rats (*Rattus* sp.): Two species of rats were found on St. Martin, the Black Roof or Ship rat *Rattus rattus*, and the Brown or Norwegian rat *R. norvegicus*. Both species were observed regularly in all habitats on St. Martin, as well as on Tintamarre Island. During the trapping effort in May, 2004, each of the 50 traps set captured a Norwegian rat.

House mouse (*Mus musculus*): This species was found on both St. Martin and Tintamarre. Tracks and individuals of this species were regularly observed in all habitats on St. Martin, but rarely throughout Tintamarre Island.

Indian mongoose (*Herpestes auropunctatus*): The mongoose was widespread on St. Martin. The species was encountered weekly at all St. Martin survey locations, observing it within all habitats and within all villages. The species was not observed on Tintamarre Island.

African green vervet monkey (*Cercopithecus aethiops*): This monkey was encountered on St. Martin within both

dry forest and scrub habitats. The species, which was previously unreported for St. Martin, was first noted during bird surveys in dry forest within the Rambaud Valley on the northeast side of Pic Paradise during 2001. In 2001, five individuals were noted, but they appear to be increasing annually and in 2007, 50 individuals were noted in Rambaud Valley. Furthermore, during January, 2007, landowners within this valley regularly observed 35-50 individuals. In the coastal hills behind Guana Bay a scrub habitat of 10-15 monkeys were noted during 2001. Recent observations of this troop by residents of Guana Bay show the population to remain at approximately 10-15 individuals.

Raccoon (*Procyon lotor*): This species was not seen during the diurnal bird surveys, but the residents of Columbier report seeing the species regularly at night. Raccoons were first observed on St. Martin in 1957, when an individual was observed around the small village at Guana Bay (pers. comm., E. Millot-Dubois). The current population resides in the village of Columbier, where it was first observed in 1985. Recently, an individual was recorded in the village of French Cul-de-Sac (pers. comm., E. Millot-Dubois). The population in Columbier is estimated at 20 - 30 individuals by residents of the village and is reported to be stable.

DISCUSSION

While recording the current status of introduced mammals on St. Martin, we were able to document the continued presence of multiple species of domesticated animals: one species of mouse, two species of rat, and one species of mongoose. Furthermore, we were able to document two previously unpublished introduced mammal species: raccoon and African green vervet monkey.

Cats and goats are widespread in all habitats on the island and both are incredibly destructive to native biota on island ecosystems. The destruction to bird communities due to the introduction of cats is well documented; where in one extreme case a single pair of introduced cats on an island soon led to the destruction of over a million birds a year due to the introduced cat's offspring (Pascal 1980). Introduced goats, due to the large spectrum of their diet, are generally seen as one of the most destructive feral mammals to native vegetation. They severely reduce vegetation cover by overgrazing and trampling which in turn affects native species of birds and reptiles (Coblentz 1978). While it is unlikely that cats will be removed from St. Martin, it is imperative that they are not introduced to Tintamarre, where they would likely decimate the seabird colonies. The direct and indirect consequences of introduced goats on Tintamarre have been the most evident within the tropicbird colony, where nests have been found trampled in some cases. While eradication of the goat population on Tintamarre would benefit the breeding seabird colonies, the island is currently under private ownership. Securing landowner co-operation to manage or remove the goat population from Tintamarre is necessary.

The widespread range of rodents on St. Martin is not surprising, however, their densities in unpopulated areas is cause for concern. The origin of mice and *Rattus* sp. to St. Martin is unclear; however it is likely that these species were introduced to St. Martin when the first European settlers arrived in 1631. Rats have been implicated in greatest number of extinctions due to predators, 54% (King 1985). We did not observe direct predation events on bird or reptile populations, however it is highly likely that the rats predate on numerous species of both groups on the island. Currently on Tintamarre, the Red-billed Tropicbird colony has little breeding success (Collier *et al*. 2002). While potentially due to oceanographic conditions (i.e. food availability), it is likely that the colony is suffering from rat predation on eggs and chicks. Furthermore, the impact that rats have on the vegetation of the islands they have invaded is extremely important. Rats eat leaves, seeds, fruits, flowers, bark and stems of many plants and trees, therefore hindering regeneration and modifying entire plant communities and affecting associated fauna (Courchamp *et al*. 2003). Eradication of rats on St. Martin would be a difficult goal, due to the large area and population. Conversely, eradication of rats on Tintamarre has great potential due to the small size of the island, the lack of any harbor on the island, and the likely positive and immediate response by local seabird populations to the removal of rats. However, political and financial issues have hindered previous planning efforts at rat eradication on Tintamarre.

Mongoose were introduced to St. Martin in 1888 to combat rat infestation of the sugar cane fields (Nellis and Everard 1983). During mark/re-capture research, Newton (2004) found mongoose densities to be consistent island-wide, with no notable habitat dependencies. During diet analysis, Newton found mongoose to predate on land crabs, multiple species of reptile, as well as bird species, most commonly the Common Ground Dove (*Columbina passerina*) and the Zenaida Dove (*Zenaida aurita*). All of the aforementioned species have not adapted to the presence of a mammalian predator and therefore have been highly affected by the introduction of the mongoose to St. Martin. Sea turtles are well-known prey of mongoose as well (Nellis and Small 1983). Densities of mongoose in coastal areas of St. Martin were found to be at approximately 22 individuals per 2 km^2 (Newton 2004). It is highly likely that mongoose predate on sea turtles on St. Martin due to the high density of animals within close proximity to known sea turtle nesting areas (Debrot *et al*. 2005). While eradication of mongoose from St. Martin is unlikely, it is important to work towards preventing mongoose from becoming established on Tintamarre, where their introduction would be highly detrimental to seabird colonies.

There are 50 forms of the raccoon genus *Procyon* found in the North America, South America, and the Caribbean (Goldman 1950). Three of these forms were historically recorded from the Caribbean; *P. maynardi*

(New Providence), *P. minor* (Gaudeloupe), and *P. gloveralleni* (Barbados) (Goldman 1950). However, recent research has indicated that all three of these forms are likely related to the North American form *P. lotor* (Helgen and Wilson 2003). Raccoons from other populations have been introduced to the Caribbean as well, in Trinidad and Tobago (*P. cancrivorus*) and Grand Bahama (*P. lotor*). The origin of the St. Martin population is unclear and further research into this population is warranted. This species is considered a pest species by the residents in the Columbier Valley and regular culling of the population through hunting and trapping likely keeps the population stable (pers. comm., E. Millot-Dubois).

The introduction of the African green vervet monkey might have some of the costliest implications for wildlife on St. Martin. On St. Kitts, it is widely speculated that the introduction of the green vervet monkey caused the eradication of the endemic St. Kitts Bullfinch (*Loxigilla portoricensus grandis*) (Rafaelle 1977). This species has the potential to cause major declines in bird populations on St. Martin. Although we have not observed any direct predation on birds by monkeys, it is likely that predation has occurred and that recent reductions in dove and thrasher populations in the Rambaud Valley are directly related to the introduction of monkeys to the forest (Brown and Collier 2006). Eradication efforts on Barbados in the past have shown that despite constant removal efforts, where up to 1,000 individuals were trapped annually, the population remained stable. With such a small population of monkeys on St. Martin, there is potential to successfully trap and remove all the monkeys from the island within a short period of time. If such a trapping effort is to take place, it should happen in the near future before the population gets too large for complete eradication.

It is well understood that introduced mammals to island ecosystems are highly disruptive, however, it is difficult to explain to landowners and stakeholders that the removal of those species will be beneficial to the island. Human empathy to protect animals such as monkeys, cats, and goats is strong, despite the ecological destruction that such species can cause on an island. Educating the public about island specific threats from introduced species is a necessary first step. Furthermore, promotion of the benefits resulting from prior eradication programs, even from other islands, would be beneficial. While immediate removal might not be practical for some introduced species, monitoring of their respective populations and ranges will be highly useful in further understanding the effects each species currently has on the native island biota.

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