*Exotic rodent species in one South Atlantic Ocean island: House mouse (*Mus musculus*) infestation in Trindade Island, Brazil*

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Summary

An expedition to Trindade Island aiming to identify the prevalent rodent species showed that there is a high infestation of *Mus musculus* in the military base, where a population of 40 military and researchers work. Trindade is a small oceanic island in southern Atlantic, without terrestrial animals, but eight avian, two crustacean and a single sea turtle species. Out of six captured rodents from September 19th to 21st, in 2011, two were positive to PCR analysis to *Leptospira* sp., showing that the human population is exposed to this infectious agent. The control of leptospirosis is important in this island, due to the long distance from the continent and the difficulty of transportation. The human presence is required to allow the exploration of a 200 nautical miles area around the island, called exclusive economic zone. A rodent control program must be difficult to be implemented, and must be based in the results from the present work.

Keywords

Leptospira sp., *Mus musculus*, House Mouse, Oceanic Island, Rodent Control, South Atlantic, Trindade Island.

Una specie di roditori esotici in un'Isola dell'Oceano Atlantico Meridionale: infestazione del topo (*Mus musculus*) all'Isola Trindade, Brasile

Riassunto

Una spedizione all'isola Trindade con l'obiettivo di identificare le specie prevalenti di roditori ha mostrato un'elevata infestazione di *Mus musculus* nella base militare, che ha una popolazione di 40 militari e ricercatori. Trindade è una piccola isola oceanica nell'Atlantico meridionale, senza animali terrestri, ma ha otto specie di uccelli, due di crostacei e una singola specie di tartaruga marina. Su sei animali catturati dal 19 al 21 settembre, nel 2011, due sono risultati positivi alle analisi PCR per *Leptospira* sp., dimostrando che la popolazione umana è esposta a questo agente infettivo. Dunque il controllo della leptospirosi è importante in quest'isola, a causa della lunga distanza dal continente e la difficoltà di trasporto. La presenza umana è necessaria per consentire l'esplorazione di una zona di 200 miglie nautiche intorno all'isola, chiamata zona economica esclusiva. Un programma di derattizzazione sarebbe difficile da attuare, e dovrebbe essere basato nel risultato del presente lavoro.

Parole chiave

Leptospira sp., *Mus musculus*, Topo, Isola Oceanica, Derattizzazione, Sud Altantico, Isola Trindade.

Introduction

Rodents are the largest mammal order, with almost 2,000 of species. Three of them are dependent mainly of human resources, known as commensal synanthropic rodents: *Mus musculus* (house mouse*), Rattus rattus* (black rat) and *Rattus norvegicus* (brown rat, common rat). Given the proximity with human beings, zoonosis transmission from these species occurs and leptospirosis is a very important one. This disease can be transmitted to humans through water, soil and food contamined with urine from infected rodents (1). Besides leptospirosis, a great number of other zoonotic diseases is associated with rodents.

Synanthropic rodent species are not endemic on oceanic islands and their presence is a result from human introduction. Currently, there are only few reports of rodent infestation in Trindade Island (2, 15, 16), although without capture and identification of specimens. These rodents could have been transported along with shipload, without being noticed, probably since the eighteenth century, when the first landing occurred in this island. Once introduced, these animals could reproduce freely, given the absence of natural predators. The introduction of invasive rodents in insulary environments was described as potentially negative for invertebrates (17) and seabirds (4).

A rodent infestation justifies the implementation of control measures aiming to the protection of insulary human populations against zoonotic infections. In Trindade Island, this population is constituted of military and researchers. Because of the long distance from the Brazilian coast as the logistic supply is performed only every two months, the management of zoonosis infection risk is essential to maintenance of human health in the island. Human occupation is necessary to justify the exclusive economic zone of 200 nautical miles around the island.

Currently, the prevalent rodent species in Trindade Island are not known, not even its abundance nor environmental carrying-capacity. Such elements must be obtained for the formulation of a rodent management plan.

Material and methods

Study area

The Trindade Island is located in southern Atlantic, 620 nautical miles away from the Brazilian coast. Controled by the Brazilian Navy, with 9.28 km2 of area, is located between 20°29'-20°32' South latitudes and 29°17'-29°21' West longitudes. It has a mountain-chain in the northwest-southeast, reaching a peak of 620 m. The West side is rugged, with a predominance of walls, making human occupation impossible. The East is less rugged, and the human occupation is limited to a small military base, built in 1957 (14).

The climate is tropical oceanic, with mean temperatures around 24°C, and daily rapid rain precipitations.

The island environment is currently degraded, with low vegetation coverage. The domestic species introduced since the eighteenth century, especially goats, were responsible for the elimination of almost all undergrowth vegetation. All goats were killed in 2005 (16). Through years, several invasive vegetal species have been introduced. Few fauna inventory were produced, reporting insects, molluscs, marine fish, cnidarians, eight avian, two crustaceans and one chelonian species. No amphibian, reptile and mammal native species were reported (2, 15, 16).

Currently, there are only three reports of house mouse in Trindade Island (2, 15, 16), based on visualization, without capture and biometric identification of this specie.

There is no airport in the island, and it is only reached by ship travel. The Brazilian Navy provides transportation of military and researchers every two months. The present investigation was performed during September 19th to 21st, in 2011.

Rodent capture and identification

A total of 12 small Shermann traps were used during rodent capture, installed inside and outside the buildings according to (18). Locations were chosen according to previous rodent visualization (Figure 1).

Two kinds of baits were used: (a) mortadella and (b) mass of mashed bananas, peanut powder and a cereal mix.

The capture effort consisted of traps' installation at three pm on September 19th, 2011 and inspection during the next morning. If a rodent was captured, the trap would be cleaned and washed before re-installation. On September 20th, 2011, traps were re-installed where rodents were previously captured.

Captured animals were desensitized by being put into a bag with a wad of cotton soaked with etilic ether. After immobilization, animals were euthanized receiving a >150 mg/kg of ketamine with >15 mg/kg of xylazine dose of anesthetic (13), through intracranial application.

Animals were photographed and measured, and the following biometric information were obtained (7): body, tail, left ear and feet length, also fur color. Based on these characteristics, the species could be identified.

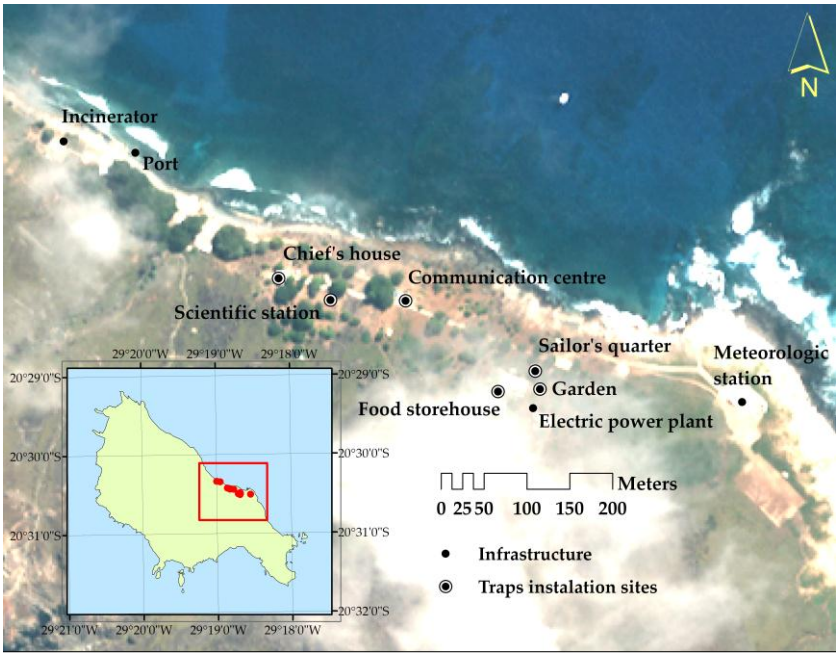

Figure 1. Rodent trap installation locations in Brazilian Navy base of Trindade Island, Brazil.

Sampling and laboratorial analysis

Euthanased animals were fixed with needles in supine position to a paraffine plate. Blood samples were collected directly from the heart, being wrapped in microtubes with BAB + LIT transport medium (Blood Agar-Based + Liver Infusion Tryptose) in room temperature, to *Trypanosoma* sp. direct diagnosis (isolation).

Both kidneys were collected, one of them was destined to direct diagnosis of *Leptospira* sp. DNA through PCR (11) and the other, to microbiologic isolation (5). The first kidney was placed in a microtube with TE solution (10 mM Tris-HCl + 1 mM EDTA pH 8.0), frozen until processing in the lab. The second, in a small Stomacher plastic bag, followed by maceration, and then 500 µL of the resulting product was pipetted and placed in a microtube with Fletcher culture medium, maintained at room temperature during transportation and after reaching the laboratory, at 28 to 30°C.

The laboratory tests were performed at Department of Preventive Veterinary Medicine and Animal Health of Faculty of Veterinary Medicine, University of Sao Paulo, Brazil.

Results

Specimen identification

All of six captured animals were identified as *Mus musculus* (house mouse), since all biometric measures were compatible to this specie (Figure 2).

A single individual was captured inside a building. There was no preference for baits, since three animals (50%) were attracted by mortadella and the other three (50%), by the mass of mashed banana, peanut powder and cereal mix (Table 1).

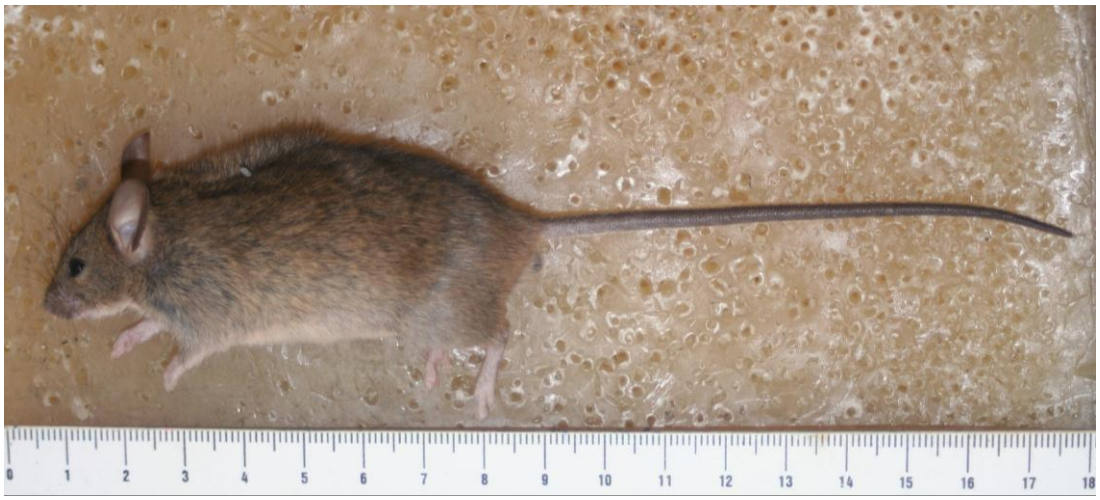

Figure 2. Specimen of *Mus musculus* captured in Trindade Island, Brazil.

Table I. Number and distribution of captured rodents in traps installed inside and ouside buildings of the Brazilian Navy base of Trindade Island, Brazil.

Location	September, 19 (Inside)	September, 19 (outside)	September, 20 (inside)	September, 20 (outside)
Chief's house	0/1	2/2[b]*, [c]*	-	0/2
Scientific base	0/2	-	-	-
Communication centre	1/1[a]*	-	-	-
Sailor's quarter	0/1	-	-	1/1[f]#
Food storehouse	-	1/3[d#]	0/2	-
Garden	-	1/2[e]*	-	0/1
Total	1/5	4/7	0/2	1/4

[a,c]Pregnant female (both PCR-positive for *Leptospira* sp.)
[b]Young female
[d]Young male
[e,f]Adult male
[#]Mortadella bait
*Mashed banana, peanuts powder and cereal mix

Environment carrying-capacity

A large number of trees was observed in the inhabited area, most of them were almond trees (*Terminalia catappa*), an exotic species, as other fruit tree species. Almond seeds and leaves formed an organic matter coverage that provides rodent protection during their movimentation. It was observed an expressive number of almond seeds showing marks of rodent incisors teeth (Figure 3). Another proportion of seeds were cut, apparently by yellow-crab claws (*Gecarcinus lagostoma*), very common in the island.

Figure 3. Almond tree (*Terminalia catappa*) seed with signs compatible with rodent incisors marks from Trindade Island, Brazil.

The yellow-crab has nocturnal behaviour and for that reason, rodents showed an activity peak during a small temporal window, between the late afternoon and early evening. The crabs were also observed preying mice (Figure 4).

Figure 4. Yellow crab (*Gecarcinus lagostoma*) preying a house mouse (*Mus musculus*) in Trindade Island, Brazil.

Sailors reported presence of rodents in areas distant from the military base, after unsuccessful management attempts in the past.

All organic waste was maintained in a large container, and the material trown into the sea. Inorganic waste was incinerated in the island. No litter was observed. Bins without lids were observed inside the buildings.

A single sailor guarded the food storehouse, in order to prevent looting and provide orderly distribution of food to the crew. A large quantity of small (0.5 cm) fusiform faeces compatible to *Mus musculus* faeces were observed spread over the floor and in the shelves where food was stored. Food was stacked in thin plastic packages. Wood mouse traps were incorrectly installed (away from the walls), and no rodent was found captured.

The garden's beds were made of half plastic drums, in order to prevent rodent and crab attacks.

No careful inspection was made inside the buildings in search of possible mice shelters (drawers, kitchen counters, cabinets). Several mice holes were identified in almond tree roots, always located less than five meters away from the buildings.

Laboratorial results

Two animals (33%) presented positive results in PCR to *Leptospira* sp. but there was no isolation of this bacteria. Positive animals were both pregnant females.

No *Trypanosoma* sp. isolation was observed.

Discussion

Even with the capture and identification of *Mus musculus* in Trindade Island, it is not possible to determine when these animals were introduced. Probably, the rodents arrived in the island along with the shipload since its first landing, in the year 1700 (14). Despite the probable date of introduction, no differences between biometric parameters were observed with *Mus musculus* found in the continent (7). This finding does not corroborate the insular syndrome described by (9), since morphological, behavioural, demographic, ecological, physiological and genetic shifts could be exhibited by organisms living in isolation (3, 9). The absence of differences between continent and insular biometric parameters could indicate systematic reintroductions. Domestic mice do not face competition nor aggressive behaviour when introduced in a feral population, which can be a cause of successful adaptation of newcomers to the insulary environment (8). Rodents also exhibit adaptative shifts in degraded or arid insulary environments (10).

The diversity-invasibility theory states that the less diverse the communities, more susceptible to invasion by exotic species (3). Along with this theory, when control measures are unsuccessfully applied in high rodent infestations, the result could be dispersal behaviour (7). This could be proved with a transect capture design in the whole island territory.

Unfortunately, it was not possible to estimate the rodent abundance, because the capture effort lasted only two days. The removal method (in which captured animals are killed) demands a more intense capture effort to adequately estimate the abundance, which can only be achieved with a longer permanence in the island (6, 18).

Nevertheless, through mice holes observation on almond tree roots (*Terminalia catappa*), a large number of mice could be observed before evening. Along with the evidence of rodent presence inside the buildings, especially the great quantity of faeces in the food storehouse, one can conclude that there is a large infestation of *Mus musculus* in the inhabited area of Trindade Island. A total of five animals (out of 6, or 83.3%) were captured within a five meters radius from the buildings, indicating that the preferred shelters are almond tree roots. This could be corroborated with the observations of mice coming out from the mice holes.

The main source of rodent's food is the storehouse, with a large quantity of cereal and other food sources within the reach of mice.

Once shelters are outside and food source inside the buildings, mice had to adapt their natural activity peak to a small temporal window due to the crab activity and predation. This adaptative strategy is a result of micromammal behavior shift living in isolation, especially in oceanic islands (9).

The high level of infestation and the *Leptospira* sp. circulation among mice population justify the implementation of a management program in Trindade Island. This program will have to aim the elimination of *Mus musculus* species and the maintenance of this status, in order to mitigate the risk of transmission of leptospirosis to the researchers and military population.

Considering all these constraints, a rodent control program must be difficult to be implemented and should be well executed. Previous experiences of control programs implementation should be used to improve its effectiveness (12).

A rodent control program should be implemented in the food storehouse of the Brazilian Navy base in Rio de Janeiro, place where all Trindade's food comes from. Rodents should be avoided to get into the ships, using protection devices on ropes ("Chinese hat") and systematic inspections should be made on board. The food stored in the Island should be protected from rodent gnawing and urine, through packing in sturdy plastic containers and installation of metallic mousetraps close to the walls of the storehouse (with daily inspection), in order to improve mouse capture. The organic matter resulting from fallen almond tree seeds and leaves should be removed. An alternative to this fact is the elimination of invasive tree species. Finally, a waste destination program should be implemented by using bin with lids inside the buildings and keeping the organic waste in plastic bags until its final destination. The organic waste could be used in a composting instead of being thrown in the sea. No biologic control measures are indicated, such as predator species introduction (domestic cat, lizards) or infectious agent spread.

A chemical treatment should only be implemented when infestation decreases, using hydroxycoumarin-based products (bradifacoum, bromadiolone, flocoumafen and difethialone), the only ones allowed in Brazil (7).

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