Journal of Environmental Science and Management 17(2): 63-68 (December 2014)
ISSN 0119-1144

Gut Analysis of Small Non-Volant Mammals of Mt. Makiling, Luzon Island, Philippines

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ABSTRACT

Three non-native species (Rattus exulans, R. tanezumi and Mus musculus) of small non-volant mammals were recorded along various elevational gradients of Mount Makiling. Invertebrate remains and plant matter comprised the bulk of their diets based on the food items identified. The identified plant matter were leaves and seeds while invertebrates were easily identifiable through body parts such as legs, head and antennae. Other contents identified including vertebrate remains such as hair/fur, feathers and bones, plastics, rubber, stones, and intestinal worms were noted. Based on the calculated relative abundance of each food type, there is no significant difference in the diets of the three non-native rodent species. Preliminary results suggest that introduced rodents in Mt. Makiling have broad diets and there are no indications that their main diet includes native wildlife species. Traces of vertebrate remains, however, may indicate potential predation on wildlife species and further studies are needed to clarify this.

Key words: *rodents, gut analysis, endemic, non-native, elevational gradient*

INTRODUCTION

The complexity of tropical mountain ecosystems have long provided haven for various Philippine wildlife species. The elevational gradients provide various forest types while vertical stratification of trees offer habitat to species of different niches. It is no wonder then that forest destruction has been identified as the primary threat to Philippine wildlife (*Rickart et al. 2007*). This has also been the leading threat listed for many Philippine wildlife species. However, one of the most overlooked threats is the negative ecological impacts of introduced small non-volant mammals on native and endemic wildlife species. Non-native rats have been reported to cause extinctions on islands and cause severe biodiversity loss (*Amori and Clout 2003*; *Howard et al. 2007*; *Jones et al. 2008*; *Ruffino et al. 2009*).

There are eight introduced small non-volant species in the Philippines: *Suncus murinus* (Asian house shrew), *Mus musculus* (house mouse), *Rattus argentiventer* (ricefield rat), *Rattus exulans* (Polynesian rat), *Rattus nitidus* (Himalayan rat), *Rattus norvegicus* (brown rat), *Rattus tanezumi* (oriental house rat), and *Rattus tiomanicus* (Malaysian field rat) (*Rickart et al. 2007*; *Heaney et al. 2010*). Non-native rodents have been known to cause great economic loss in the lowlands by damaging agricultural crops, (*Stuart et al. 2011*), stored food, and properties, as well as the diseases they carry (*Aplin et al. 2003*). However, information on thepotential impacts on biodiversity is scanty.

In the Philippines, *R. tanezumi*, *R. exulans,* and S. *murinus* are geographically widespread and are known to become established in disturbed forests where there are few endemic species (*Rickart et al. 2007*; *Ong and Rickart 2008*). *R. exulans* and *R. tanezumi* have been recorded at altitudes of 725 – 1450 masl on Mt. Isarog (*Heaney et al. 1998*). *S. murinus*, *R. exulans* and *R. tanezumi* have been recorded as well in Mt. Tapulao, Zambales from 860-1690 masl (*Balete et al. 2009*). In general, non-native species only invade areas where habitat is highly disturbed. Although, on geologically young (such as Negros) and relatively small islands (like Camiguin and Maripipi), *R. exulans*, *R. tanezumi*, and *Suncus murinus* occur in relatively undisturbed habitats (*Heaney et al. 2006*).

Very little is known on the diet of these non-native species in forests. In the Philippines, their ecology is poorly known and relatively little research has been done to determine the effects of introduced small non-volant mammals on the native fauna. Examination of its gut contents will indicate how they survive at higher altitudes and on what food sources they depend on. Mt. Makiling is a good area to sample due to its relatively low peak (~1100 masl) and diverse habitat types such as: secondary growth forest with built-up areas at the UPLB forestry campus, mixed grassland and agro-forest areas, secondary lowland evergreen forest, mid-montane and mossy forest.

Mt. Makiling is home to 21 species of amphibians, 69 species of reptiles, 241 bird species, and 44 species of mammals. Many restricted-range bird species such as the Philippine Cockatoo, Philippine Hawk Eagle, Philippine Dwarf Kingfisher, Green-faced Parrotfinch, Luzon Bleeding Heart Pigeon, and the threatened Philippine Eagle-Owl are

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recorded to occur in Mt. Makiling (*Gonzalez 1997*; *Kennedy et al. 2000*). The Philippine forest rat (*Rattus everetti*), Luzon shrew (*Crocidura grayi*), small Luzon forest mouse (A*pomys microdon*), and a possible new species of *Apomys*, are some of the endemic small non-volant mammals present in Mt. Makiling (*de Guia et al. 2011*). The mountain is also rich in endemic frog and reptile species notably the small forest frogs, *Platymantis corrugatus* and *P. dorsalis* which are abundant from the secondary lowland evergreen forest and up (*Alcala et al. 1997*). Due to Mt. Makiling's proximity to urban centers, some of its areas are inhabited by upland settlers, and the mountain is a popular destination for tourists and campers.

The study aimed to determine the gut contents of non-native rats or shrews at various elevational gradients along Mt. Makiling and to determine whether wildlife species in Mt. Makiling are included in their diet.

METHODOLOGY

Collection

The field collection was conducted from July to September 2011 in Mt. Makiling, Los Banos, Laguna. Gut samples of non-native non-volant small mammals preserved in the Museum of Natural History– University of the Philippines Los Banos, collected from 2009 to May 2011, were also added.

Cage traps, measuring 18”x5”x5”, baited with roasted coconut meat coated with peanut butter were positioned 5 to 10 m apart along possible runways, near burrow entrances, under root tangles, on top of fallen logs, etc.

Processing of specimens

All captured endemic small non-volant mammals were released. Only commensal species were collected for dissection. Prior to dissection, important information such as species, weight, sex, approximate age category (adult, sub-adult or adult), and when applicable, reproductive condition, were noted. Identification of non-native species was based on *Aplin et al. 2003*. All caught individuals were sacrificed by cervical dislocation (*Aplin et al. 2003*) and standard biometric measurements such as total length (TL), tail-vent length (TV), ear length (E), and hind foot length (HF) were noted. Specimens were brought to the Animal Biology Division Research Laboratory for processing.

Dissection and identification of stomach contents

Thirthy-three guts, extending from the cardiac end of the stomach to the anus were excised and their mesenteries carefully stripped off. These were placed in 70 % ethyl alcohol. Stomach content and intestinal contents were washed in a beaker with 50 ml 2 % detergent solution to dissolve gastric juices, stomach oils, and grease. The contents were then filtered through a mesh and washed with distilled water.

Stomach contents were examined in a petri dish under the dissecting microscope. A 1 cm^2 grid under the petri dish was placed to quantify the abundance of food items in each sample. The stomach contents were classified into three major food types: invertebrates (arthropods, earthworms, slugs, and snails), plant matter (fruits, seeds, leaves, stems, roots, rhizomes), and animal matter (fur, feather, bones and flesh). The percentage occurrence of each food type was calculated as the percentage of stomachs in which the food type occurred. The “Points Method” by *Sugihara* (*1997*) was used to estimate the relative abundance of each food type. Based on size and frequency of items in each stomach, a score ranging from 0 to 5 (estimated proportion of individual contributions) was assigned to each food type as follows: 0 (absent), 1 (<0.5 %), 2 (0.5-5 %), 3 (>5 to 25 %), 4 (>25 to 50 %), and 5 (>50 %). The relative abundance of each food type was calculated by dividing the sum of the scores for each food type for all rodents by the sum of scores for all food types.

Presence of parasitic worms in the digestive tract was noted; however, the abundance of these worms was not included in the analysis of the gut contents.

RESULTS AND DISCUSSION

Field collection

Three introduced species (*Mus musculus*, *Rattus exulans* and *R. tanezumi*) of small non-volant mammals were recorded from Mid-montane forest and down. The list of endemic and introduced species recorded in various elevational gradients of Mt. Makiling are found in **Table 1**. The list includes a new record for *Apomys microdon* in Mt. Makiling and a possible new species assigned as *Apomys* sp. (*de Guia et al. 2011*). Record of *Chrotomys mindorensis* at the lowest elevation were based on interviews.

Introduced rodents are highly dependent on human habitats for essential supplies such as food, water, shelter, and space, thus, they are generally found living in close proximity with humans (*Tung et al. 2012*). Presence of households were observed up to the Agila base at ~525 masl covering the secondary lowland evergreen forest. However, the non-native rodents utilize the forest resources up to the mid-montane forest where they have been recorded.

Gut Contents

Gut contents consisted of plant matter (leaves, seeds),

Table 1. List of endemic and introduced small non-volant mammals recorded in Mt. Makiling from 2009-2011.

Forest type	Elevation (masl)	Endemic species	Introduced species
Mossy forest	900-1100	*Crocidura grayi* *Rattus everetti*	None
Mid-montane forest	760-899	*Rattus everetti* *Crocidura grayi* *Apomys sp.*	*Rattus tanezumi* *Rattus exulans* *Mus musculus*
Secondary lowland evergreen forest	443-759	*Rattus everetti* *Crocidura grayi* *Apomys sp.*	*Rattus tanezumi* *Mus musculus*
Mixed grassland and agroforestry	262-442	*Rattus everetti* *Crocidura grayi* *Apomys microdon*	*Rattus tanezumi* *Rattus exulans* *Mus musculus*
Secondary growth forest near built-up areas	148-262	*Apomys microdon* *Chrotomys mindorensis*	*Rattus tanezumi* *Rattus exulans* *Mus musculus*

animal matter (feathers, bones, hair), insect remains (adult and larvae), parasites and other matter (plastics and stones).

While a wide variety of fragments from plants can be identified in dietary samples, seeds that are eaten were often undigested and highly diagnostic (*Jordan 2005*). Seeds identified were *Cucurbita maxima* (squash) from Family Cucurbitaceae, an introduced species widely cultivated in the Philippines. Native species identified were *Solanum nigrum* (*Lubi-lubi* or black night shade, Family Solanaceae), *Antidesma bunius*, (Bignay or currant tree, *F. Phyllanthaceae*) and *Trichosanthes cucumerina*, (*melon-melonan* or snake gourd, *F. Cucurbitaceae*). All species are regularly found in forested areas but are more common along ecotone between *kaingin* and secondary forest. The role of these plant species in the forest ecosystem is not yet certain. However, these plants are economically important as they are widely cultivated and consumed as vegetables, especially by rural farmers (*Edmonds and Chweya 1997*; *Saha et al 2011*). This indicates that non-native rodents feed in or near areas of human habitation. It is unknown whether native small non-volant mammals feed on these plants as well.

All samples contained some hair/fur that were most probably due to self-grooming. Presence of feathers and bones indicate occasional feeding on birds and other vertebrates. Non-native rodents are known to prey on the eggs and chicks of various types of birds.

Invertebrates identified consisted of undigested chitinous insect remains many of which are totally unidentifiable fragments with no diagnostic features. However, key structures, such as mandibles, wings, head capsules, legs, elytra, and Lepidoptera scales, can all be diagnostic. In many cases, identification is only possible to order or family level (*Jordan 2005*). Recorded were mature individuals of Orders Lepidoptera (moths and butterflies), Blattodea (cockroaches) and Coleoptera (beetles) while both mature and larvae of Orders Hymenoptera (ants, bees) and Diptera (true flies) were recorded.

Other contents identified were plastics, rubber, stones, and intestinal worms (39% prevalence). The presence of rubber and plastics are indication of feeding on garbage or household refuse. Stones could have been accidentally ingested. *Rattus tanezumi* had the highest prevalence of intestinal worms. Those collected at 262-442 masl had the most number of intestinal worms. Intestinal worms are mainly transmitted in rodents through scavenging carcasses. Other modes of infection are through predation or transmission by beetles and fly larvae, which are eaten by the rodents (*Paramasvaran et al. 2009*). The saponin in the seeds of *C. maxima*, *S. nigrum* and *T. cucumerina* is believed to have anti-helminthic effect. However, individuals which ate these seeds still had intestinal worms.

Food Preference

Invasive rodent species have very varied feeding habits, consuming vegetable matter, vertebrate animals of several different classes, and invertebrates (*St. Clair 2011*). Invertebrates, plant matter, and animal matter comprised bulk of the diets of *Mus musculus*, *Rattus exulans,* and *Rattus tanezumi*. The calculated relative abundances of each food type (0.3 – 0.375) approximate each other, suggesting that there is no significant difference in the diets of the three non-native rodent species ($H(2) = 0.3527$, $p<0.05$). Similarly, on a per elevation basis, results showed that there is no significant difference on the food items consumed per elevation ($H(2) = 0.1731$, $p<0.05$) (**Tables 2 and 3**).

Table 2. Combined relative abundances of food items per species.

	Animal Matter	Invertebrates	Plant Matter
Mus musculus	0.3214	0.3036	0.375
Rattus exulans	0.3	0.35	0.35
Rattus tanezumi	0.3626	0.3099	0.3275

Table 3. Combined relative abundances of food items per elevation.

	Animal Matter	Invertebrates	Plant Matter
Mid- Montane	0.3061	0.2449	0.489
Secondary Lowland Evergreen Forest	0.3793	0.2414	0.3793
Agroforest	0.3564	0.3564	0.2871
Secondary Growth Forest near Built-up Areas	0.2414	0.3276	0.431

Possible Pathways of Non-native Rodent Impacts

Though the identification of animal remains in the gut of non-native rodents captured in Mt. Makiling does not directly imply predation to native wildlife species in the mountain, other potential causes of declines in the abundance and diversity of vertebrates and invertebrates taxa through direct predation, competition, and transmission of diseases should also be taken into consideration. Understanding the mechanisms and consequences of the spread of an introduced species should focus on impacts on particular species to cumulative impacts on ecosystems (*Simberloff et al. 2012*)

Predation

Similar to *Sugihara's* (*1997*) study, other than few feather fragments, neither birds nor bird eggs were found in the stomach of the rodents examined in this study; however, it does not mean that they did not eat either. As what was concluded in *Sugihara's* (*1997*) study, "examination of rodent stomach contents is not a reliable indicator of the potential threat of rat predation to birds". Rats are fastidious feeders that may consume egg contents without actually ingesting eggshells.

Several studies have shown how invasive non-native rodents affect the population of native wildlife species, especially on islands where losses to predation can be sufficient to decrease breeding success and tip the balance especially against endangered bird species (*Sugihara 1997*). Non-native small non-volant mammals in mountain ecosystems, however, such as those on Luzon Island which is a big island with a more complex history (*Rickart et. al 2011*) are less successful.

In addition to their direct effects on bird predation, these non-native rodent species compete with the native bird species on food and nesting sites. As in the case of Hawaiian forest birds, during the periods when resources are scarce, rats and mice may compete with native birds that rely on invertebrates and plants. These non-native rodents may limit the distribution and number of frugivorous and nectivorous birds by competing with them for preferred fruits, seeds, or nectar resources. They may also compete with insectivorous birds that have restricted diets or substrate foraging capabilities (*Scott et al. 1986*). Declines in insects such as beetles, ants and termites, cockroaches and moths and butterflies may affect prey availability to frogs, lizards, birds and native rodents and other mammals. In the study conducted by *Sugihara* (*1997*), black rat (*Rattus rattus*) and Polynesian rat (*Rattus exulans*) were observed to prefer invertebrates (mostly arthropods) over the other food items.

Transmission of diseases

Non-native rodents which harbour endoparasites especially rats represent potential risk to human health. Abundance of beetles and fleas had led to a wide variety of those parasites utilizing arthropods as vector or intermediate host in their indirect life cycles. *Rodentolepis nana*, also called "dwarf tapeworm", is a cestode that usually occurs in the anterior intestine of rodents and which was commonly observed in rodents collected from Mt. Makiling. This species of cestode is considered a zoonotic parasite, which poses health risks to humans (*Singleton et al. 2008*; *Chaisiri et al. 2012*). The transmission of this worm to humans is frequent in areas with high temperatures and poor sanitation. Seriously infected humans will experience diarrhea and abdominal pain (*Tung et al. 2012*). However, potential risk of transmitting endoparasites to native fauna is still unknown.

CONCLUSION

This study is an initial attempt to investigate whether introduced rodents feed on mountain native fauna. Three non-native rodent species in Mt. Makiling are *Mus musculus*, *Rattus exulans* and *Rattus tanezumi*, recorded from the Secondary Growth Forest near Built-up Areas of the U.P. Los Baños College of Forestry and Natural Resources to the Mid-montane Forest. These rodent species are opportunistic feeders and may have limited access to food, being confined only to disturbed areas of the mountain. There are also no indications of population explosion. There is minimal evidence to support that they feed on native fauna of Mt. Makiling. Competition for forest resources can be further investigated by identifying the food of native rats such as *Rattus everetti* and *Apomys microdon* in Mt. Makiling. Endoparasites present in these rats can also help understand the possible transmission of diseases. Potential positive effects include providing ecological services such as base prey and agents of dispersal for some beneficial plants and fungi. However, this aspect also needs to be further investigated.

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ACKNOWLEDGMENT

The authors would like to thank the staff of the UPLB Museum of Natural History, Phillip A. Alviola, Veverle San Juan, Eduardo Eres and Edison Cosico for their assistance during the field work and analysis of samples. Thanks also to Dr. Gruezo who helped identify the seed samples. This study was funded by the UPLB Basic Research grant.