Impacts and control of introduced small Indian mongoose on Amami Island, Japan

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Abstract Thirty individuals of the small Indian mongoose (*Herpestes javanicus*) were released on Amami Island, Japan in 1979 to control the venomous habu snake (*Trimeresurus flavoviridis*) and the black rat (*Rattus rattus*). However, the mongoose has had a major negative impact on agriculture and the native animals in mountainous areas instead of controlling snakes. A total of 3886 mongooses were trapped by pest control measures of the local government and an eradication project of the Environment Agency in the first year of the project (fiscal 2000). The population of the mongooses and annual growth rate were estimated at 10,000 individuals and 30% respectively before the eradication project. The project is in its early stages and there are many tasks to be addressed. Further eradication projects should take into consideration the low density and partial distributions of the mongoose population in mountainous areas.

Keywords small Indian mongoose; introduction; native animals; eradication; Amami Island.

INTRODUCTION

Amami Island is 710 km^2 in area and 694 m in maximum elevation, and 70% of the island is covered by forest. The island, one of the small islands of the Ryukyu Archipelago in the most south-western part of Japan, has many endemic and threatened species (Table 1). The habu, (*Trimeresurus flavoviridis*), a dangerously venomous crotalid snake, inhabits the higher elevations of the islands of the Ryukyu Archipelago, including Amami Island. The snake is feared by local residents because of the high frequency of encounters and severe consequences of its bite. The snake is encountered in fields during the day, along roads at night, and around residential areas. During the period from 1954 to 1998, 3600 persons were bitten and 50 persons were killed by the snake on Amami Island (Kagoshima Prefecture Office 1999).

Many measures to reduce incidences of snake bite and fatalities have been successively employed, including trapping, poisoning, alteration of habitat around housing, and serum development. Pest control by biological means was also employed to reduce the snake population and their principal prey, the black rat (*Rattus rattus*). Before releasing the small Indian mongoose (*Herpestes javanicus*), 871 individuals of the Japanese weasel *Mustela itatsi*, were introduced as a snake and rat predator on Amami Island during 1954-1958, but none remain. More than 2000 weasels were released on the other eight small islands of the Amami archipelago in the same period. They did not colonise on six islands (including Amami Island) occupied by snakes, but colonised successfully on three islands where there are no snakes. This is thought to be due to competition for the same prey as snakes and also predation by snakes because they share the same nocturnal activity (Hayashi 1979). In contrast, the small Indian mongoose

Table 1 Threatened native species (assessed using IUCN categories) on Amami Island and other islands that have been recorded in the diet of mongoose. Identified mongoose food items are marked with an asterisk.

Category	Mammals	Birds	Reptiles	Amphibians
Critically Endangered		*Zoothera dauma major*[1,2]		
Endangered	*Crocidura orii* [2] *Diplothrix legatus* [1]* *Tokudaia osimensis* [1]* *Pentalagus furnessi* [1]*	*Scolopax mira** *Dendrocopos leucotos owstoni* [1,2]		*Rana ishikawae* [2?]
Vulnerable		*Dendrocopos kizuki amamii* *Erithacus komadori* [1]* *Garrulus lidthi* [1,2]*	*Japalura polygonata** *Eumeces barbouri**	*Tylototriton andersoni* *Rana amamiensis* *Rana subaspera* [2]
Lower Risk	*Crocidura horsfieldii watasei**	*Columba janthina janthina* [1]	*Achalinus werneri* *Calliophis japonicus japonicus* [2]*	*Cynops ensicauda*
Other native species			*Cyclophiops semicarinatus**	

[1] Japanese Natural Monument. [2] Endemic or main population on Amami Island.
Food species were cited from Environment Agency (1999) and Yamada *et al.* (2000).

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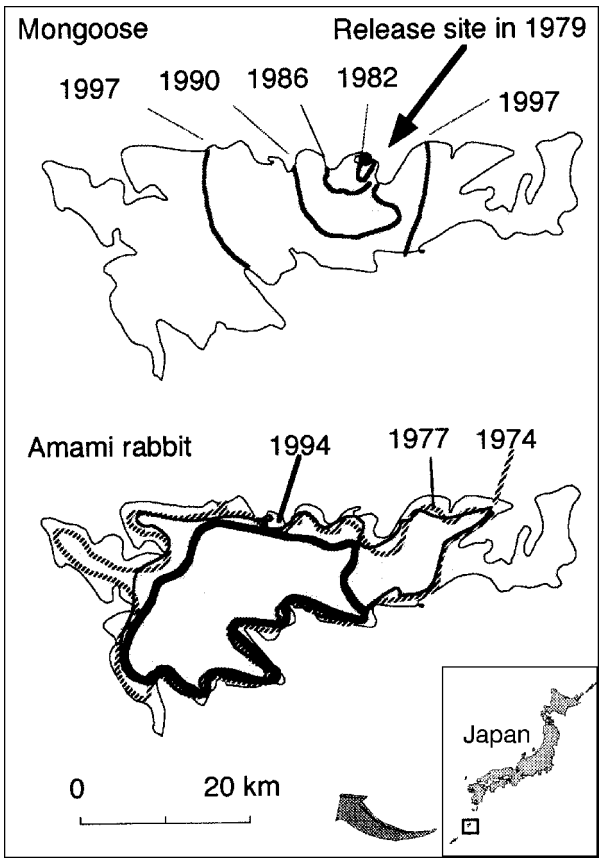

Fig. 1 Release site of the small Indian mongoose (*Herpestes javanicus)* at Naze City in 1979 and current distributions of mongoose (Environment Agency 1999), and Amami rabbit (*Pentalagus furnessi*) (Sugimura *et al.* 2000).

has successfully colonised Amami Island. In Japan, the mongoose had already successfully colonised Okinawa Island from 1910 (Kishida 1931). According to mtDNA analysis, the original individuals of mongooses on Amami Island are thought to have been brought from Okinawa Island (Sekiguchi *et al.* 2001).

This paper reviews and assesses the impacts of the mongoose and control practices on Amami Island.

Release and colonisation

Thirty mongooses are believed to have been released to control snakes around a new public educational facility opened in a forested suburb of Naze City on Amami Island in 1979 (Fig. 1). However, there is no official record of the release. Since then, the mongoose has been expanding its distribution from the release site, covering a 10 km radius by 1989 and a 20 km radius by 1997, covering half of mountainous areas occupied by many threatened species, such as the Amami rabbit (*Pentalagus furnessi*). The rate of range extension was estimated as 1 km per year. After 20 years the population size was estimated at 5000-10,000 mongooses in 1999 (Environment Agency 1999).

Agricultural impacts

The mongoose has a large impact on crops (taro, sweet potato, melon, watermelon, loquat, etc.) and poultry in farmland. The economic cost of the damage rapidly increased in 1994 (USD7000), 1995 (USD32,000), 1996 (USD64,000), 1997 (USD110,000), 1998 (USD100,000) and 1999 (USD80,000). Some farmers trapped mongooses to protect crops on their farmland before 1993 when the local government began to control the mongoose.

Predation damage on endemic animals

Since advancing into mountainous areas in around 1986, the mongoose has had a predatory impact on the native animals in the mountainous areas, as listed in Table 1. However, there was almost no evidence of predation of snake by mongoose (Abe *et al.* 1999; Environment Agency 1999; Yamada *et al*. 2000). According to our findings, insects (40%), other invertebrates (90%), amphibians and reptiles (60%), mammals (20%), and birds (15%) were observed in 89 pellets of mongoose collected in the habitat of the Amami rabbit (Yamada *et al.* 2000). Eight percent of pellets contained the Amami rabbit (Fig. 2). Although the mongoose chiefly preyed on insects and birds in all seasons, it tended to prey more frequently on amphibians and reptiles in summer and on mammals in winter. The distribution and abundance of the Amami rabbit are thought to have been reduced by the mongoose, as well as by habitat reduction due to forest cutting and infrastructure construction (Fig. 1; Sugimura *et al.* 2000).

Mongoose control

In the 1980s local scientists on Amami Island carried out ecological studies of mongoose populations, mostly near the release areas (Abe *et al.* 1999). The local government began to trap the mongoose in order to reduce crop damage in farmlands around the city from 1993 and the Yamato

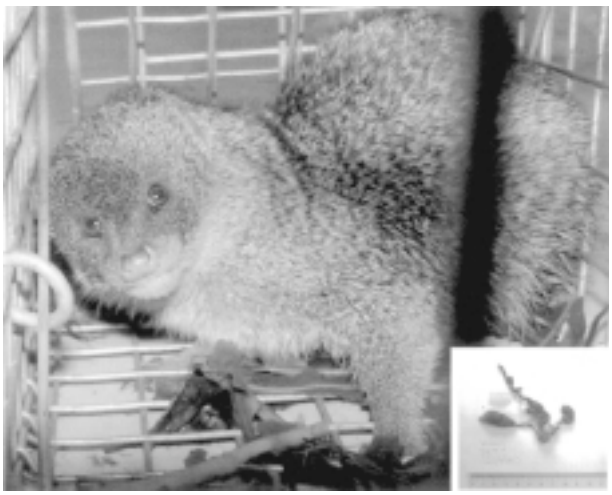

Fig. 2 A small Indian mongoose *(Herpestes javanicus)* and inset a mongoose pellet containing Amami rabbit (*Pentalagus furnessi).*

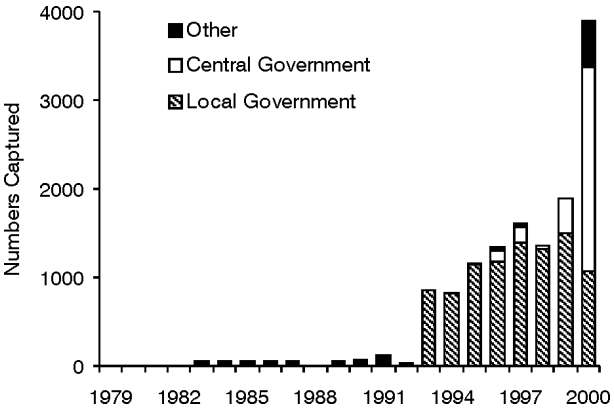

Fig. 3 Annual numbers of the small Indian mongoose (*Herpestes javanicus)* captured by traps on Amami Island (Environment Agency unpublished).

Village Office also began trapping from 1995. As many as 1100-1500 mongooses were captured by 15-20 trappers using 10-30 traps per person for seven to nine months (May-March) in a year (Fig. 3). Approximately 60-80% of those mongooses were captured by four to five skilful trappers.

After recognising the predation impact of the mongoose on threatened animals on the island, the Environment Agency of the Central Government carried out preliminary investigations during 1996-1999 into the possibility of eradicating mongooses from the whole island. The investigations assessed the following: expansion of the distribution, reproduction, food habits, estimation of population size and annual growth rate (5000-10,000 individuals in 1999 and 30%), and techniques for eradication by cage traps and wooden box traps using fish sausage as bait. Following on from the pilot investigations, the Environment Agency decided to begin a full-scale project to eradicate the mongoose from the whole island from 2000 by two methods: (1) great reduction of population using many traps during a short period (3 years) over the whole island (the annual target reduction was 4000-5000, including the number by pest control around farmland by the local governments during May to March, and by trapping in mountainous areas by the Environment Agency during October to March), and (2) long-term eradication until the species becomes extinct.

Results so far

A total of 3886 mongooses were captured by trapping, but the number was lower (87%) than the target number (4500) in the first year (fiscal 2000). The catch comprised 1073 animals by pest control and 2813 by the eradication project of the Environment Agency (Fig. 3). The small drop in numbers was caused by a one-third reduction in the number caught in a normal year by pest control and to the 10% reduction in the target number of the eradication project of the Environment Agency. Twelve to 22 trappers were engaged in the eradication project by the Environment Agency in the first year (October 2000-March 2001). Five of them worked for both the pest control and the eradication project. Most of the capture places and total number of traps they used, and total number of days for trapping were not reported accurately by themselves, because they do not usually record such data. Many of the mongoose captured around farmland were reported to the office as having been captured in mountainous areas. Capturing in farmland is more efficient than in mountainous areas because the density of mongooses in farmland areas is higher than that in mountainous areas.

Trappers were paid USD18 per mongoose by either the pest control or the eradication project upon taking the tail of a mongoose to either office. A total of USD50,000 was spent directly on the island by both agencies in the first year. However, some trappers lost the incentive to trap because of the reduction of capture efficiency as the number of mongoose presumably decreased.

Problems and conclusion

The project is in its early stages and there are many tasks to be addressed. Although there have been a few recent studies on controlling mongooses by chemicals in Hawaii (Smith *et al*. 2000) and on management implications on Mauritius (Roy *et al*. 2002), there are few successful examples of mongoose eradication in the world (Simberloff 2001). This is the first trial of eradicating mongoose. But there are many difficulties, including 70,000 people living mainly along the coast, many endangered animals in the mountain forests, and the venomous snake, Habu, on the large mountainous island. Therefore, even after this trial, it will be necessary to ensure: unified management by both the pest control and the eradication project for establishing year-round trapping and a strategy of eradication; monitoring the efficiency of eradication; introduction and development of more effective techniques; monitoring the effects on recovering the endemic animals and on the ecosystems including rat control; and exchange of information with experts in foreign countries. The continuous supply of more budget, manpower, public information, and research work will also be necessary.

Further projects must consider how to eradicate mongooses of patchy distribution and low density in mountainous areas. Most endemic animals on the island, including the Amami rabbit, seem to be vulnerable to this exotic predator because of their long isolation in an insular environment which lacked such a large active predator as the mongoose. For the conservation of the Amami rabbit and other native animals on Amami Island, more effective measures are needed to eradicate this invasive predator.

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REFERENCES

Abe, S.; Handa, Y.; Abe, Y.; Takatsuki, Y. and Nigi, H. 1999. Food habitats of feral mongoose (*Herpeste*s sp.) on Amamioshima, Japan. In Rodda, G. H.; Sawai, Y.; Chiszar, D. and Tanaka, H. (eds.). Problem Snake Management, pp. 372-383. Cornell University Press.

Environment Agency. 1999. Report on the investigation of the mongoose for eradication on Amami Island. 51p.

Hayashi, Y. 1979. Animals of the Ryukyu Archipelago, with special reference to the Habu and the Amami rabbit. *Kagaku 49*: 616-619.

Kagoshima Prefecture Office. 1999. Annual report of the control of the Habu. 60p.

Kishida, K. 1931. Professor Watase and import of mongoose. *Zoological Science 43*: 70-78.

Roy, S. S.; Jones, C. G. and Harris, S. 2001. An ecological basis for control of the mongoose *Herpestes javanicus* in Mauritius: is eradication possible? In Veitch, C. R. and Clout, M. N. (eds.). *Turning the tide: the eradication of invasive species*, pp. 266-273. IUCN SSC Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Sekiguchi, K.; Inoue F.; Ueda T.; Ogura G. and Kawashima Y. 2001. Geneanalogical relationship between introduced mongooses in Okinawa and Amamiohsima Islands, Ryukyu Archipelago, inferred from sequences of mtDNA cytocrome *b* gene. *Honyurui Kagaku 41*: 65-70.

Simberloff, D. 2001. Eradication of island invasives: practical actions and results achieved. *Trends in Ecology & Evolution 16*: 273-274.

Smith, D. G.; Polhemus, J. T. and VanderWerf, E. A. 2000. Efficacy of fish-flavored Diphacinone bait blocks for controlling small Indian mongoose (*Herpestes auropunctatus*) populations in Hawai'i. *'Elepaio 60*: 47-51.

Sugimura, K.; Sato S.; Yamada F.; Abe, S.; Hirakawa, H. and Handa, Y. 2000. Distribution and abundance of the Amami rabbit *Pentalagus furnessi* in the Amami and Tokuno Islands, Japan. *Oryx 34*: 198-206.

Yamada, F.; Sugimura, K.; Abe, S. and Hanada, Y. 2000. Present status and conservation of the endangered Amami rabbit *Pentalagus furnessi*. *Tropics 10*: 87-92.