

# Direct and indirect effects of an alien mongoose (*Herpestes javanicus*) on the native animal community on Amami-Oshima Island, southern Japan, as inferred from distribution patterns of animals

Yuya Watari<sup>1</sup> Fumio Yamada<sup>2</sup>, Ken Sugimura<sup>3</sup> and Seiki Takatsuki<sup>4</sup>

<sup>1</sup>Laboratory of Biodiversity Science, Graduate School of Agricultural and Life Sciences, The University of Tokyo;

<sup>2</sup>Department of Wildlife Biology, Forestry and Forest Products Research Institute;

<sup>3</sup>Department of Forest Management, Forestry and Forest Products Research Institute;

<sup>4</sup>The University Museum, The University of Tokyo

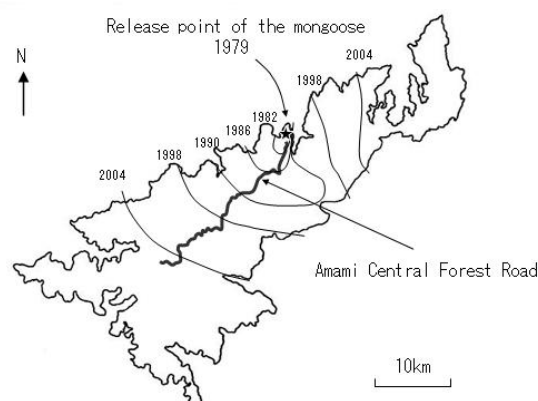
## INTRODUCTION

The small Indian mongoose (*Herpestes javanicus*) is native to the area from the Middle East to the Malay Peninsula. It has been deliberately introduced to many tropical areas, mainly as an attempted biological control agent for rats or pit vipers. For example, it was introduced to the Hawaiian Islands, West Indies and Fijian Islands. The introduced mongoose preys on non-target native vertebrates, and it is now largely blamed for the historical declines and extirpations of many native species on islands (Gorman, 1975, Roots, 1976, Honegger, 1981, Nellis and Small, 1983, Nellis *et al.*, 1984, Cheke, 1987, Case and Bolger, 1991, Henderson, 1992). The mongoose has also been introduced to Japan: to the southwestern islands of Amami-Oshima Island and Okinawa Island.

Amami-Oshima Island (712km<sup>2</sup>) is the second largest of the southwestern islands. It has a subtropical wet climate and 85% of the land area is forest. The forest of Amami-Oshima Island is home to a large number of endemic species of the southwestern islands. In 1979, 30 mongooses were

released to control the poisonous snake; habu (*Trimeresurus flavoviridis*). Since then, the mongoose has rapidly expanded its distribution, causing impacts on native animals. For example, the Amami rabbit (*Pentalagus furnessi*), a natural monument in Japan and regarded as a flagship species, inhabited almost all of the forested area in 1976, before the introduction of the mongoose. After the introduction, the area of distribution of the Amami rabbit has gradually decreased, corresponding to the range expansion of the mongoose (Sugimura *et al.* 2000, 2003, Yamada *et al.* 2000, 2002).

It is thought that, in addition to the Amami rabbit, other native species have also been reduced in abundance in areas where the mongoose has invaded. Such responses, however, are rarely quantified. The objective of our study was to determine the present distribution patterns of native animals along an historical gradient of mongoose establishment, to detect effects of the mongoose on a wide range of animals, including insects and vertebrates.



**Figure 1** Expansion of the mongoose distribution and the location of the study sites

## METHODS

Our survey was conducted along the Amami central forest road (Total 41.1km). This forest road starts near the original release point of the mongoose and leads to areas where it is still absent (Fig. 1).

To assess the present distributions of native animals, we combined the following two methods: night-time driving censuses for native vertebrates and adhesive traps for insects. Night-time driving censuses were started more than 1 hour after sunset. We searched for vertebrates occurring on or around the road from a car at a constant speed of about 10km h<sup>-1</sup>. We recorded species and location when we encountered vertebrates. We also recorded the call of the Amami rabbit, which is distinguishable from those of other animals. To assess relative insect abundance, two adhesive traps (Earth Chemical Co., Ltd., Gokiburi-Hoihoi) were placed on the ground at each of the 27 plots that were established on the forest floor 20-80m from ACFRoad. The distance between adjacent plots was 1.5km.

## RESULTS

Most of the native mammal, bird, amphibians, reptile vertebrates observed in this survey showed an inverse distribution pattern to that of the mongoose: Amami rabbit, Amami woodcock (*Scolopax mira*), Amami tip-nose frog (*Rana amaminensis*), Otton frog (*Rana (Babina) subaspera*), Ishikawa frog (*Rana ishikawae*) and the Akamata snake (*Dinodon semicarinatus*), were all scarce in areas where the mongoose invaded long ago.

On the other hand, two insect species that were captured in sufficient numbers, showed positive density patterns in relation to the mongoose distribution. For example, higher densities of the forest cricket (*Cardiodactylus novaeguineae*) and the small cockroach (*Margattea satsumana*) were found in areas where the mongoose invaded long ago.

## DISCUSSION

Our results showed that the mongoose appears to cause a reduction in, or even local extinction of, many native vertebrates through a strong top-down effect. Forest crickets and small cockroaches are prey of the Amami tip-nose frog and the Otton frog (Watari, unpublished data). It is therefore likely that the increase in these insects is due to indirect effects of increased mongoose predation on the native predators. This trophic cascade may only be one of many wider and unpredicted community effects. It is, therefore, important to carefully monitor the

dynamics of these interactions and to consider not only the direct effects but also the indirect effects of mongoose predation.

It seems clear that many native vertebrate species will continue to decline if the mongoose is allowed to spread and establish over the whole island. Thus, to protect the remaining native animals, it is essential to prevent further expansion of the mongoose's distribution.

## ACKNOWLEDGEMENTS

We thank Shintaro Abe, Tadashi Miyashita and Richard Walters for constructive comments. Our study was funded by WWF-Nikko Green Investors Fund and WWF Japan Fund Grant Program.

## REFERENCES

- Case, T.J., Bolger, D.T., 1991. The role of introduced species in shaping the distribution and abundance of island reptiles. *Evolutionary Ecology* 5:272-290.
- Cheke, A.S., 1987. An ecological history of the Mascarene Islands, with particular reference to extinctions and introductions of land vertebrates. In: *Studies of Mascarene Island birds* (Diamond AW, ed.). pp 5-89. Cambridge University Press, Cambridge.
- Gorman, M.L., 1975. The diet of feral *Herpestes auro-punctatus* (Carnivora: Viverridae) in the Fijian Islands. *Journal of Zoology* 175:273-278.
- Henderson, R.W., 1992. Consequences of predator introductions and habitat destruction on amphibians and reptiles in the post-Columbus West Indies. *Caribbean journal of science* 28:1-10.
- Honegger, R.E., 1981. List of amphibians and reptiles either known or thought to have become extinct since 1600. *Biological Conservation* 19:141-158.
- Nellis, D.W., Dewey, R.A., Hewitt M.A., Imsand, S., Philibosian, R., Yntema, J.A., 1984. Population status of zenaida doves and other Columbids in the Virgin Islands. *Journal of Wildlife Management* 48: 889-894.
- Nellis, D.W., Small, V., 1983. Mongoose predation on sea turtle eggs and nests. *Biotropica* 15:159-160.
- Roots, C., 1976. Animal Invaders. *Universe Books*, New York.
- 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.
- Sugimura, K., Yamada, F. and Miyamoto, A. 2003. Population trend, habitat change and conservation of the unique wildlife species on Amami Island, Japan. *Global environmental research* 7:79-89.
- Yamada, F., Sugimura, K., Abe, S. and Handa, Y. 2000. Present status and conservation of the endangered Amami rabbit, *Pentalagus furnessi*. *Tropics* 10: 87-92.
- Yamada, F. 2002. Impacts and control of introduced small Indian mongoose on Amami Island, Japan. In: Veitch, C.R. and Clout, M.N. (eds.). *Turning the tide: the eradication of invasive species*. pp. 389-392. IUCN, SSC, Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.