

Rapid range expansion of the feral raccoon (*Procyon lotor*) in Kanagawa Prefecture, Japan, and its impact on native organisms

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Abstract The distribution of feral raccoons (*Procyon lotor*) was surveyed in Kanagawa Prefecture, central Japan. Information was collected mainly through use of a questionnaire to municipal offices, environment NGOs, and hunting specialists. The raccoon occupied 26.5% of the area of the prefecture, and its distribution range doubled over three years (2001 to 2003). The most remarkable change was the range expansion of the major population in the south-eastern part of the prefecture, and several small populations that were found throughout the prefecture. Predation by feral raccoons on various native species probably included endangered Tokyo salamanders (*Hynobius tokyoensis*), a freshwater Asian clam (*Corbicula leana*), and two large crabs (*Helice tridens* and *Holometopus haematocheir*). The impact on native species is likely to be more than negligible.

Keywords: Feral raccoon; *Procyon lotor*; distribution; questionnaire; invasive alien species; native species; Kanagawa Prefecture

INTRODUCTION

The first record of reproduction of the feral raccoon in Kanagawa Prefecture was from July 1990, and it was assumed that the raccoon became naturalised in this prefecture around 1988 (Nakamura 1991). Damage by feral raccoons is increasing and the number of raccoons, captured as part of the wildlife pest control programme, is also rapidly increasing.

The distribution range of feral raccoons in Kanagawa Prefecture was reported, based on information from 1998 to 2000 (Kanagawa Prefecture 2001). However, the more recent distribution range since this survey had not been determined. Distribution and its rate of expansion are essential information required in addressing invasive alien species. We, therefore, decided to investigate the present distribution range through questionnaires and interviews.

There is much information available on the agricultural damage and nuisance to humans caused by feral raccoons in Kanagawa Prefecture, and other prefectures; but, evidence of impact on native species is unclear in Kanagawa Prefecture. Predation on native species was, therefore, determined through questionnaires and interviews.

METHODS

Questionnaires

We collect information through the use of questionnaires. In the main sheet of the questionnaire (Fig. 1), questions were concerned mainly with the

presence of feral raccoons between 2001 and 2003 and the reliability of the information. One of the issues relating to reliability is possible confusion with the native raccoon dog (*Nyctereutes procyonoides*; Canidae), which has a similar facial pattern with a black band around the eyes, and a similar body size to the raccoon. An important external feature characteristic to the raccoon is the stripe on the tail, which is absent in the raccoon dog. The masked palm civet (*Paguma larvata*; Viverridae), another invasive alien mammal, is also sometimes confused with the raccoon. Therefore, we attached a sheet with

Questionnaire on Feral Raccoons

Recording date: 2003/ / /

Area in which you or your group are active.	
Name of group	Your name
Address	
Phone	Fax
E-Mail	
Q. - A. Do you have any information on the presence of raccoons? (e.g., sighting live animals or dead bodies, or reports of damage)	
<input type="checkbox"/> (1) Present <input type="checkbox"/> (2) Present, but not certain <input type="checkbox"/> (3) None	
Check (✓) one number from (1) to (3) during the period from 2001 to present.	
Q. - B. If you checked (1) or (2) on question A, Do you keep the information in the form of document?	
<input type="checkbox"/> (1) Most information is kept <input type="checkbox"/> (2) Partially recorded. <input type="checkbox"/> (3) No document	
Check (✓) one number from (1) to (3).	
<input type="checkbox"/> Person who checked (1) or (2) on question A & B. Please enter another sheet "Raccoon Data". Or you may send a copy of your document. Please make clear the date, location, situation, and reliability, and if possible, the environment, damage, and possibility of breeding.	
Opinion about feral raccoons	
We are collecting feral raccoon information. Please introduce the person with information to us.	

Thanks for your cooperation. We never use personal information for other purposes

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Figure 1 Questionnaire used. Original questions were in Japanese.

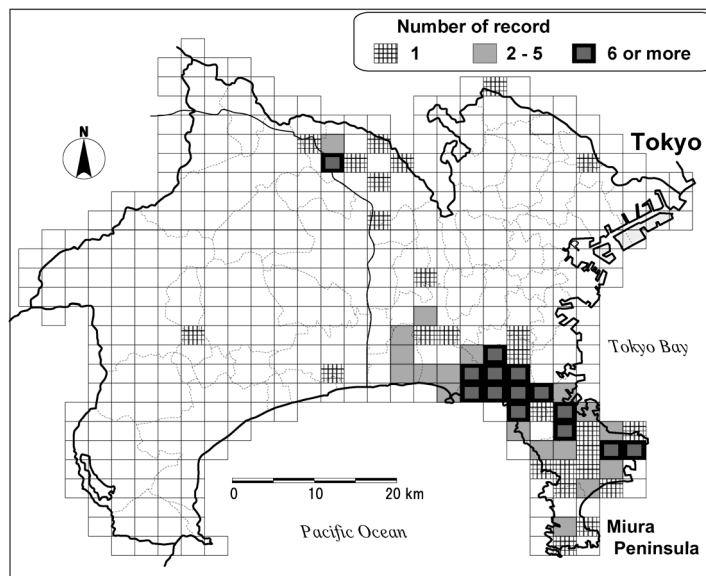


Figure 2 Distribution of feral raccoons by 2001 (based on information in 1998-2000). (From: Kanagawa Prefecture (2001)).

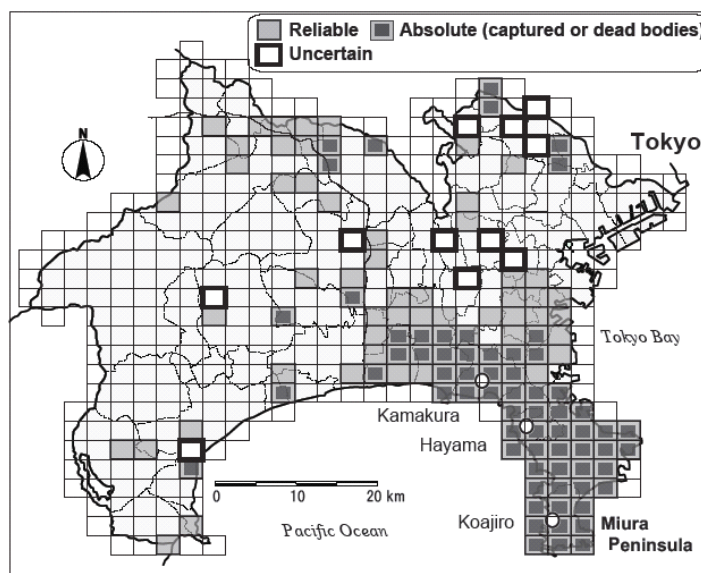


Figure 3 Distribution of feral raccoons by 2004 (based on information in 2001 - 2003). Three circles (Kamakura, Hayama, Koajiro) represent the places where predation on native species was reported.

illustrations of the external features and footprints, and with behavioural characteristics of the four carnivores (raccoons, raccoon dogs, palm civets, and badgers (*Meles meles*; Mustelidae)).

On another sheet, respondents were asked to choose one or several answers, on methods of identification (dead body, captured, sighting, footprints), confidence of identification, habitat, damage and reproduction (sightings of young). When the identification of the raccoon was not certain, we interviewed the respondents. If we could not confirm the identification even after an interview, the information was dealt with as “uncertain”. Finally, we

classified identification reliability into three categories: capture or dead bodies as “absolute”, “reliable” information from sightings and/or footprints, and “uncertain”.

The questionnaire (Fig. 1) was sent to the division of all municipal offices for wildlife conservation and management. It was also sent to staff of wildlife conservation and park management of the municipal government, and the environment NGOs. The questionnaire for municipal offices was sent through the Department of Environment and Agriculture, Kanagawa Prefectural Government.

Distribution range

In the previous distribution survey (Kanagawa Prefecture 2001, Fig. 2), a questionnaire was used to obtain the location of raccoons. These locations were then indicated on a plot map. We followed the same method to show changes in the distribution range of feral raccoons.

All information was plotted on a map drawn to a 1:25,000 topographic map. Each plot was about 2.85 x 2.3km in size, which was 1/16 of the area size of the 1: 25,000 topographic map.

Information on predation of native species

We interviewed environmental NGOs in the Miura Peninsula at the south-eastern part of the prefecture (Hayama Town, and Cities of Kamakura, Zushi, Yokosuka and Miura), and also obtained information from local newspapers and local reports of raccoon feeding on native species.

RESULTS AND DISCUSSION

Distribution pattern

A total of 882 records containing information on feral raccoons were obtained. Reliability of information was variable, but captures under the wildlife pest control programme certified raccoon presence. Figure 3 shows the distribution between 2001 and 2003, with the reliability of information classified into the three categories (“absolute”, “reliable”, and “uncertain”). A concentrated distribution range existed in the south-eastern part of

Table 1 Number of plots showing the presence of raccoons. Each plot was about 2.85 x 2.3km in size. Presence represents the sum of “absolute” and “reliable”. Number in parenthesis represents number of “absolute” plots.

Survey years	Presence	Uncertain	Total	Whole plots
2001–2003	119 (67)	11	130	448
1998–2000 ^a	58	0	58	448

^a Kanagawa Pref. (2001)

the prefecture (Fig. 3). Based on the number of plots (2.85 x 2.3km), this major population occupied 524.4 km², and represented 67.2% (80 of 119 “absolute” and “reliable” plots) of all plots with raccoons. About 2/3 of its population boundary was formed by the coastline. This main population not only extended over a large area, but was estimated to have a high density, based on capture under the wildlife pest control programme, which had been in most of those plots (83.6%; 56 of 67 capture plots; Fig. 3). Small populations were found in other parts of the prefecture, mostly situated inland. Among them, the second largest population was at the north-western part of the prefecture.

Range expansion

Raccoons were found in 12.9% of the area of the prefecture by 2001, and in 26.5% of the area by 2004 (Tab. 1). In other words, their distribution range increased 2.05 times over these three years. Because the effort put into obtaining the distributions was different between these two surveys, this value of 2.05 times is not absolute, but it is sufficient to infer raccoons are expanding rapidly. In comparison with

Table 2 Presumed predation by the feral raccoon on native species on the Miura Peninsula, Kanagawa Prefecture, Japan. (Information from 2001 to 2003, based on interviews and questionnaires).

Location	Observation
Hayama Town, and Yokosuka City	Eleven partially eaten bodies of endangered salamanders (<i>Hinobius tokyoensis</i>) were left at their spawning sites. Many footprints of raccoons were left there simultaneously (observations by M. Kaneda and M. Ohno).
Hayama Town	More than ten egg sacs of endangered salamanders (<i>H. tokyoensis</i>) were eaten or broken, and many footprints of raccoons were left (observations by M. Kaneda).
Chuo Park, Kamakura City	Recent sightings of medium-sized mammals during the night were mostly of feral raccoons, instead of native raccoon dogs (<i>Nyctereutes procyonoides</i>).
Kamakura City	Freshwater Asian clams (<i>Corbicula leana</i>) were eaten. Such predation was not observed before the raccoon invasion.
Koajiro, Miura City	Numbers of the sesarma crab (<i>Holometopus haematocheiri</i>) decreased after footprints of raccoons increased. Footprints of raccoons were found widely. A claw was found in the excrement of a medium-sized mammal on a fallen tree (observation by M. Kaneda).
Koajiro, Miura City	Numbers of the grapsid crab (<i>Helice tridens</i>) decreased after footprints of raccoons increased. Footprints of raccoons were found widely at the habitats of the crab (an article in a local newspaper, Kanagawa Shinbun on 7 July, 2003).

the previous survey (Fig. 2), the biggest increase in distribution range was from the major population, in the north and northwest direction. The range of the major population seems to have joined up with that of the second largest population in the northwest.

It should be noted that several small patchy isolated populations in the north and north-eastern parts of the prefecture in 2001 did not disappear, and seemed to have spread in the present study. New isolated populations were also found at the south-western part of the prefecture. These new small populations suggest that raccoons emigrated from the major population under high population density and/or were released by people. After they settled, they increased in numbers presumably through natural reproduction, resulting in an expanded distribution range.

Impact on native species

Records collected suggest predation by feral raccoons on native salamanders, freshwater clams, and two large crabs (Tab. 2). Almost all of these species live in and around water. The grapsid crab *Helice tridens* and the sesarma crab *Holometopus haematocheir* are semi-terrestrial, but spawn in seawater. Except for the spawning period, adult *H. haematocheir* live in forests, whereas adult *H. tridens* live in mud flats and salt marshes.

In the Miura Peninsula situated on the south-eastern part of the prefecture, it is possible that the increase in feral raccoons was involved in a decrease of native raccoon dogs which may have a similar niche to raccoons. This indicates the possibility of competition, directly through physical contact and/or indirectly, through food sources. Different use of microhabitat between these two sympatric species was reported in northern Japan (Abe *et al.* 2006). Mange epizootics occurred recently among the raccoon dog population in Kanagawa Prefecture (Shibata and Kawamichi 1999), where the number of raccoon dogs infected with mange epizootic has been high since 1992, and the number of raccoon dogs that were hunted or trapped abruptly reduced by 1995, indicating the decline of population density. Because mange epizootics apparently contributed to a decrease of raccoon dogs, the ecological relationship between raccoons and raccoon dogs may be complicated, and this makes any conclusions about competition more difficult.

Although we did not obtain direct observations of predation on native species by raccoons, many footprints of raccoons were left at predation sites

(Tab. 2). Most information indicated a decrease in numbers of native species and a simultaneous increase in the feral raccoon (Tab. 2), based on careful observations over many years by local naturalists. These observations should be given serious consideration, although further research is required to clarify the impact of feral raccoons on native species.

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REFERENCES

- Abe, G., Ikeda, T. and Tatsuzawa, S. 2006. Differences in habitat use of the native raccoon dog (*Nyctereutes procyonoides albus*) and the invasive alien raccoon (*Procyon lotor*) in the Nopporo Natural Forest Park, Hokkaido, Japan. . In Koike, F., Clout, M. N., Kawamichi, M., De Poorter, M. and Iwatsuki, K. (eds). *Assessment and Control of Biological Invasion Risks*. Shoukadoh Book Sellers, Kyoto, Japan and IUCN, Gland, Switzerland, pp 116-121
- Japan Map Centre 1998. Numerical map users guide (2nd ed.). Japan Map Centre, Tokyo.
- Kanagawa Prefecture 2001. Inyu seibutu no seisokubunpu chosa hokokusyo (A report on distribution of alien species), Kanagawa Prefecture Office, Japan.
- Nakamura, K. 1991. A note on the naturalisation of common raccoons in Kanagawa Prefecture. *Natural History Report of Kanagawa* 12: 17-19.
- Shibata, F. and Kawamichi, T. 1999. Decline of raccoon dog populations resulting from sarcoptic mange epizootics. *Mammalia* 63: 281-290.