Successional Change of Small Mammal Fauna on Kahoku-Gata Reclaimed Land with Agricultural Development

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(Received May 11, 1985)

Small mammals were trapped each year from 1976 to 1984 on Kahoku-gata reclaimed land in Ishikawa Prefecture. This area, which had been covered with grassland, was gradually transformed to cultivated fields. Before cultivation started, 3 species of rodents and 1 species of insectivore were trapped. *Microtus montebelli*, *Rattus norvegicus* and *Mus molossinus* were abundant. After cultivation, *Apodemus speciosus* was added to this fauna. *Microtus* and *Mus* were as dominant as before. Three dominant species were found in all sampling plots of this area. Their level of abundance was roughly equal to that in each plot before cultivation began, but *R. norvegicus* was usually found near a water source. After the start of cultivation, these homogeneous patterns of distribution changed. *Microtus* decreased in the cultivated areas and the level of abundance in the *Mus* population differed. A remarkable change was found in the *Rattus* population in this area: this species increased from 1977 to 1979 and then rapidly disappeared. Such a pattern of fluctuation is supposed to be characteristic of a reclaimed land ecosystem.

INTRODUCTION

Recently, numerous studies on the distribution and ecology of small mammals have been carried out in mountainous parts of Japan; however, except for Hokkaido, little information was obtained on the dynamics of rodents and insectivores in the lowland areas of the country.

Lowland areas near the seacoast of Honshu, Shikoku and Kyushu have been cultivated for agricultural use for many hundreds of years, and those areas have now become rice fields as well as villages and towns. Some of the studies on mammals in lowland districts were performed mainly for the control of agricultural pests or to prevent tsutsugamushi disease, because the Japanese meadow mouse is an important host of the vector.

In this paper, the author shows the species composition and abundance of small mammals in an extensive reclaimed land area near the seaside, along with successional changes that occurred there from the period when the area was covered with natural grassland to its transformation into cultivated fields and pasture. The field survey began in the spring of 1976, when the entire area was covered with tall grasses. By the fall of 1984, most of the land had been transformed into crop and vegetable fields or pasture for cattle.

STUDY AREA AND METHOD

Kahoku-gata, a large area of reclaimed land ($36^{\circ}40'N$, $136^{\circ}42'E$), is situated in the northern suburb of Kanazawa City, Ishikawa Prefecture, in the Hokuriku District of central Japan. The land was created by drainage of a large lagoon near the coast of the Japan Sea. It was completed in 1970, and 1,358 ha of land was reclaimed.

The reclaimed land was at first wet with many bogs. It gradually became dryer, and various kinds of grasses colonized it to form a wide grassy area composed of reeds, cattails, jointweeds and other grasses and herbs.

Cultivation of the reclaimed land began in 1979. By 1984, most of the land was covered with barley and vegetable fields, while about 20 percent was utilized as pasture. Native grassland is now limited only to the southwestern area.

A map of the reclaimed land and trapping plots is shown in Fig. 1; watercourses about 10 to 100 m in width ring the area. Five bridges connect it with the previously existing land mass except in the southwestern part where the land is linked with the sand dunes of the seacoast. These sand dunes are covered with pine forest or orchards and there are some small villages at the foot.

Small mammals were collected by trapping in 7 plots arranged along the unpaved main road running through the land. This road has two lanes and runs parallel with a drain creek. In each plot, 20 traps were set on both sides of the road as shown in Fig. 2. The areas between the road and creek were covered with grasses, but occasionally the vegetation had been stripped off by bulldozer; in such cases, the vegetation recovered within 1 or 2 years. The side of the road away from the creek was the same as the creek side until cultivation started, but since 1980, plots on this side have been converted to cultivated fields or pasture. Successional changes in vegetation in the plots on both sides of the creek are shown in Table 1.

Fig. 1. Map of Kahoku-gata reclaimed land. Numbers in black circles identify the trapping plots. R: main road, W: main watercourse for draining, D: sand dune of seacoast, P: paddy field.

Fig. 2. Schematic illustration of trapping plot. Viewed from above and from the side.

Fig. 3. Fluctuation of abundance in 7 trapping plots of Kahoku-gata study area from 1976 to 1984. Cr: *Crociodura dsinezumi*, Ap: *Apodemus speciosus*, Mu: *Mus molossinus*, Rt: *Rattus norvegicus*, Mi: *Microtus montebelli*.

Table 1. Vegetation types and their successional changes of trapping plots in Kahoku-gata study area

Year	Sampling plot													
	Creek side							Inland side						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
1976	MG	TG	TG	TG	G(D)	G(D)	TG	MG	TG	TG	TG	G(D)	G(D)	TG
1977	TG	TG	TG	MG	TG	SH	TG	MG	MG	TG	MG	MG	MG	TG
1978	TG	TG	TG	MG	TG	SG.H	TG	TG	MG	MG	MG	MG	MG	TG
1979	TG	SG	TG	SH.SG	TG	MG.H	TG	MG	MG.H	TG	SH.SG	MG.H	MG.H	TG
1980	TG	TG	MG	MG	O	O	TG	MG	TG	O	O	TG	O	TG
1981	TG	TG	O	MG	MG	SH	TG	TG	B	O	B	MG	O	TG
1982	TG	TG	O	O	MG	SH	TG	MG	B	P	P	O	SH	TG
1983	TG	O	O	O	MG	MG	TG	B	B	P	P	P	O	TG
1984	TG	O	H	H	O	O	TG	B	B	B	MG	TG	SH	TG

SG: short grass, MG: mid grass, TG: tall grass, G (D): withered grass, SH: short herb, H: herb, O: open striped land, B: barley field, P: pasture.

Trapping started in March or April each year and was repeated 5 or 6 times until winter (except for 1981 when only 3 trappings were done). In winter, these areas were covered with snow.

Twenty traps were set in each plot each night of collection. Four types of traps were used, viz. the cage trap, Sherman trap, snap trap and panchu trap (one kind of snap trap was made of plastic), because each type seemed appropriate for the catching of a specific rodent species. These various traps were set together. Standard composition was 5 cage traps, 10 Sherman traps and 5 snap or panchu traps in one plot. Fried fish or walnuts were used as bait.

RESULTS

1. *Species composition of collected animals*

Five species of small mammals were collected over these 9 years:

<i>Microtus montebelli</i>	(Japanese meadow mouse)
<i>Rattus norvegicus</i>	(Norway rat)
<i>Mus molossinus</i>	(Japanese house mouse)
<i>Apodemus speciosus</i>	(Japanese field mouse)
<i>Crocidura dsinezumi</i>	(Japanese white-toothed shrew)

During this period, 3 more species of wild mammals, the masterless dog, masterless cat and Japanese weasel were also observed in this reclaimed land. Although field surveys on small mammals were performed in other parts of the Kahoku-gata area during these years by my collaborators and myself, we could find no other species of mammals there.

Figure 3 shows the number of trapped individuals of each species per 100 effective trap-nights each year. This figure reflects the fluctuation in relative abundance of species in the area.

In this paper, relative abundance of species is expressed by the effective trap-night index (ETN Index), which is calculated by the following formula.

In the case of the Norway rat:

$$\frac{\text{Total number of trapped individuals}}{\text{Total number of set cages, snap and panchu traps}} \times 100$$

In the case of other species:

$$\frac{\text{Total number of trapped individuals}}{\text{Total number of set Sherman, snap and panchu traps}} \times 100$$

The trapping data obtained in the Kahoku-gata reclaimed land during the 9 years studied showed the following with regard to the population fluctuation of small mammals.

1) Two species of rodents, *Microtus montebelli* and *Mus molossinus* were constantly dominant in this grassland, except for the year of the *Rattus* outbreak.

2) The *Rattus norvegicus* population increased remarkably in 1977 and 1978 and became a dominant species. It then disappeared.

3) After 1982, a small population of *Apodemus speciosus* became established in this area.

4) An insectivore, *Crocidura dsinezumi* was found throughout study period but its population level was usually low.

2. *Distribution of species and their change*

The relative abundance of each species of small mammals in the 7 sampling plots before and after cultivation is shown as the ETN Index in Fig. 4.

Two species of rodents, *Microtus montebelli* and *Mus molossinus*, which were dominant in small mammal fauna in Kahoku-gata were found in all plots throughout these years. Their population level seemed similar among the plots, except for a few cases before cultivation. After cultivation started, some differences were observed among plots. Almost all *Rattus norvegicus* was found only before cultivation. *Apodemus speciosus* was found after cultivation, and in restricted plots. *Crocidura dsinezumi* was found in all

Fig. 4. Distribution of species in the study area and its change related to cultivation. Abbreviations and patterns are as in Fig. 3. 1976-1979: before cultivation, 1982-1984: after cultivation.

Fig. 5. Selective habitat tendencies of species in each plot and the change related to cultivation of the land. W: water (creek) side, L: inland side, Before C: before cultivation, After C: after cultivation. Other abbreviations are as in Fig. 3.

plots, but it was trapped mainly in plots 2 and 7, and was not particularly abundant.

3. Occurrence of species in each plot

In the plots, trapping sites were arranged on both sides of the main road which ran through the land. As described (Fig. 2), one side of the road ran along the bank of a creek, and the other side faced open grassland. Both sides were covered with tall grasses until 1980.

In 1979, the cultivation of Kahoku-gata reclaimed land started. The inland side of each plot was gradually changed to fields of barley or pastures of rye-grass. On both sides plots were in the same condition before cultivation, but after cultivation their conditions varied. The change began in the northern part of the land and extended southward in 1980-1981. By 1984, therefore, native grassland remained only around plot 7.

The changes in species composition and abundance on the creek and inland sides of plots 2-6 (effects of cultivation developed in a typical manner in these areas), are shown in Fig. 5.

In the years 1976-1980, *Microtus* and *Crocidura* were trapped in equal numbers on both sides, but most *Rattus* was trapped on the bank of the creek. On the other hand, *Mus* was found more frequently on the inland side than on the creek side. In that period, the vegetation of both sides was similar; however, the distribution of *Rattus* and *Mus* was rather different. This seemed to depend upon the existence of water or interspecific competition with other species.

After the start of cultivation in 1980, the distribution of *Microtus* did not change but

Mus and *Crocidura* moved in great numbers to the creek side. These two species seemed to avoid the cultivated side.

DISCUSSION

1. Species composition of rodent fauna in reclaimed land

After completion of a drainage system in 1970, Kahoku-gata reclaimed land remained as a large natural grassland for about 10 years until cultivation was started.

In Japan, the development of lowland plains for agriculture and industrial use has been pursued since ancient times so that at present large native grasslands in lowland districts cannot be found. Fauna and flora of native grasslands remain only fragmentally in flood basins around rivers and lakes. Therefore, large reclaimed land areas now seem most representative of a native grassland environment in the lowland plain.

Reclaimed land also seems to represent a newly created environment, and plants and animals which colonize here are invaders following the creation. The areas might have characteristics different from the native environment, and this seems to affect composition of both community structure and species. Recent big social projects have stimulated the creation of large reclaimed land areas in Japan, such as Hachiro-gata, Chu-kai, Kojima-wan and Ariake-kai. Among these, a faunastic survey on small mammals was carried out only in Hachiro-gata (IGARASHI, 1971; OGASAWARA and YONEDA, 1973), where 3 species of rodents, *Microtus montebelli*, *Mus molossinus* and *Rattus norvegicus* were found. The species composition of this fauna is similar to that of Kahoku-gata. These 3 species may thus be representative of rodent fauna for reclaimed land all over Japan.

Some reports have been made on the rodent and insectivore fauna of lowlands. TAKEDA et al. (1979) found 3 species of rodents, *Microtus montebelli*, *Apodemus speciosus* and *Micromys japonicus* and an insectivore, *Crocidura dsinezumi*, in a reed marsh near Inba-numa lake, Chiba Prefecture. TAKADA (1983) reported 3 species of rodents and an insectivore from a fallow field in farmland, and the species composition is the same as in TAKEDA's report. KANEKO (1979) summarized the information on rodent fauna in a lowland plain of northern Shikoku, and showed the distribution of *Apodemus speciosus*, *Mus molossinus*, *Micromys japonicus* and *Crocidura dsinezumi* from this district. In Shikoku, *Microtus montebelli* is not found and *Apodemus speciosus* occupies its lowland habitat.

MOCHIZUKI (1962) reported the distribution of *Microtus*, *Apodemus* and *Crocidura* in lowland farms in Toyama Prefecture. In Shikoku and Toyama, the native vegetation of lowland plains has already been replaced by rice fields or villages and towns. The types of species composition above mentioned are different from those for the reclaimed land represented by Hachiro-gata and Kahoku-gata. In contrast, IZUMI (1979) observed a dense population of the Norway rat in reclaimed land near Osaka City, but his observation was limited to the *Rattus* population. His results do not include information on other species.

In conclusion, the species composition of small mammals in reclaimed land is characterized by the dominancy of the Norway rat and house mouse populations. *Microtus* is found throughout native and cultivated environments. *Apodemus* is found mainly in the forest edge of secondary vegetation. On the other hand, *Mus* and *Rattus* are found mainly in the artificial environment of villages, cities and suburbs, including abandoned fields and certain other fields. According to studies on the habits of the

Japanese rodents described above, the small mammalian fauna in reclaimed land in a wild condition is similar to that in suburbs of cities or abandoned fields that do not have native or primary vegetation.

2. *Ecological distribution of rodent species in the study area*

Three species of rodents were found in all plots, while the distribution of one rodent species and one species of insectivore was limited to only a few plots.

Environmental conditions of the area changed after the start of cultivation; therefore, it is best to consider the pattern of distribution in species composition on, before, and after the periods relating to cultivation, respectively. These conditions were typically represented in 1976–1979 and 1981–1984.

Before cultivation, the Kahoku-gata area was homogeneously covered with reeds and other tall grasses, except for some parts near the water and where the western margin connected directly to the sand dunes of the seacoast. After cultivation began, heterogeneity within the area developed. The northern part of the area was cultivated first, and then, in turn, the fields and pastures, extending gradually southward. In 1984, natural grasslands remained only at the southern end of the area and in a narrow belt along the creek.

Before cultivation, the species composition of small mammals and their abundance did not greatly differ among the sampling plots; this might have correlated with the homogeneity of vegetation. A significant difference was seen only in plot 6 where *M. molossinus* was abundant.

After the start of cultivation, differences in small mammal association among the plots were observed. The inland side of plots 1 to 6 became cultivated field or pasture. At the same time, the abundance of *M. montebelli* was increased in plot 7 and decreased in other plots. And the dominancy of *M. molossinus* differed among the plots, but we could recognize no correlation between the mammal populations and the environmental conditions.

From the viewpoint of species composition, plot 2, where the species composition was most complex, was most interesting. *Apodemus speciosus* and *Crocidura dsinezumi* were abundant in comparison with other species found in the same plot. But we could find no remarkable differences in this plot in vegetation or other contributing conditions such as roads, as was pointed out by ADAMS and GEIS(1983). This seems to indicate the existence of interspecific relations in rodent association which affect the distribution and abundance of small mammals in these grassland communities.

3. *Remarkable population fluctuation in Norway rat*

In the Kahoku-gata grassland, the Norway rat, *Rattus norvegicus*, was found during 1976–1979, and especially in 1977 and 1978. In these two years, this rat increased remarkably and became the most abundant species of rodent found. After the cultivation, it was only rarely found. This fluctuation in population was the most dramatic change in small mammal fauna in Kahoku-gata between 1976 and 1984.

Recently, the outbreak of Norway rat has been recorded by other authors in Japan. Most of the outbreaks have occurred at seaside villages and fields in southwestern Japan, and might have been induced by a decrease in natural enemies (domestic cat, snake) and an increase in food (stock of potatoes) or other unknown factors in the natural community (TANAKA, 1955, 1964, 1965; MIYAGI et al., 1975). On the other hand,

an outbreak of Norway rat was recorded at Hachiro-gata reclaimed land in 1965–1967, and this was 7 to 10 years after completion of the reclaimed land (IGARASHI, 1971; OGASAWARA and YONEDA, 1973). IZUMI(1979) also observed a dense Norway rat population on reclaimed land 5 years after completion. These cases are analogous to the case of Kahoku-gata.

The Norway rat is a rodent which inhabits houses and other buildings in Japan. It is sometimes found living outdoors in rice fields and the dumping grounds of cities. The cases occurring on reclaimed land are examples of the outdoor habitat of this rodent. The increase of Norway rat in wild grassland environments may be one specific aspect of small mammal association on reclaimed land. It seems to be an important key to the analysis of the community structure of these semi-artificial environments.

ACKNOWLEDGEMENTS

The author wishes to express his thanks to the staff and students of Kanazawa University, especially Drs. T. YAZIMA, K. NAKAMURA, Miss N. NAKAHASHI, Miss A. SASA, Messrs. M. NAKAMURA, A. SANO, E. URANO, M. EGUCHI, T. SHIDA, T. YAMAMOTO, D. HASHIGUCHI and Miss M. T. KARIYA for their kind cooperation in the field survey. Thanks are also due to the staff of the Kahoku-gata Water Area Reclamation Project, Hokuriku Regional Agricultural Administration Office, Ministry of Agriculture, Forestry and Fisheries, for their kind permission to conduct our study in this area and for their valuable advice.

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