Handling of Acorns by Apodemus Mice.

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Handling of Acorns by *Apodemus* Mice*

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Introduction

Recently, the importance of granivorous and frugivorous animals in regeneration of forests and dynamics of forest ecosystems were stressed and many studies have dealt with the dispersal of seeds by birds and rodents and post-dispersal predation of seedlings by these animals (Gashwiler 1967; Rim and Shidei 1974; Fox 1982; Nilsson 1985; Miyaki and Kikuzawa 1988; Hayashida 1989; Vander Wall 1990).

Two species of field mice, *Apodemus speciosus* and *A. argenteus,* which are widely distributed in forests in Japan, eat and hoard seeds and acorns (Doi and Iwamoto 1982; Miyaki and Kikuzawa 1988). Some granivorous rodents and birds prefer seeds, fruits, and acorns of a particular size, species, and perishability (Reber and Reichman 1983; Nilsson 1985; Jensen 1985; Reichman 1988; Vander Wall 1994). If *Apodemus* mice show a preference for acorns of a particular species and respond differently to acorns of different species, the contribution of the mice to acorn dispersal and the establishment of seedlings will differ greatly among oak species. In this study, we examined the effects of the species and weight of acorns on the handling of acorns by mice.

Study Site

This study was conducted in a mature stand of *Chamaecyparis obtusa* mixed with *Quercus serrata, Q. glauca, Cinnamomum Camohora,* and *Aleurites cordata* at Tama Forest Science Garden, Hachioji, Tokyo, in 1992. A detailed description of the study site has already been given in Soné and Kohno (1996). The stand was about 0.6 ha in area and located on a slope of 12-15° with southern exposure. In the eastern half of the stand, understory vegetation was dominated by deciduous shrubs such as *Callicarpa japonica, C. mollis,* and *Viburnum erosum,* and the forest floor was covered with *Trachelospermum asiaticum* and *Carex* sp. In the western part, *Aucuba japonica* dominated the understory vegetation and *Carex* sp. were distributed only in small patches on the forest floor. There were some *Pasania edulis* trees near the stand and they produced many acorns in 1991 and 1992. In a live-trapping census, we caught two species of *Apodemus* mice, *A. speciosus* (35-50 g) and *A. argenteus* (10-18 g), throughout a year and the shrew-mole, *Urotrichus talpoides,* on a few occasions. The density of *A. speciosus* was three times higher than that of *A. argenteus* (Soné, unpublished data). Some individuals of squirrel, *Sciurus lis,* occasionally visited the stand to collect nest materials.

Materials and Methods

Field experiments were conducted from March to May in 1992. We could collect sufficient acorns of *Q. serrata* and *P. edulis* for the field experiments in and near the stand in Autumn 1991. We attached a lead sinker with polyethylene filler to some acorns, which were classified into four categories in weight for each species; *Q-C, Q-LS, Q-MS,* and *Q-HS* acorns were *Q. serrata* acorns without sinker, those with a light sinker, those with a middle sinker, and those with a heavy sinker, respectively, and *P-C, P-LS, P-MS,* and *P-HS* acorns were *P. edulis* acorns without sinker, those with a light sinker, those with a middle sinker, and those with a heavy sinker, respectively. The mean weights of each catergories of acorns used in the field experiments were given in Table 1.

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* 曽根 晃一・高野 亜紀：**野ネズミによるドングリの採食と運搬**

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Table 1. Mean weights (g) of *Q. serrata* and *P. edulis* acorns used in this study.

	March 2 & 9			April 21 & May 26		
	mean	S.D.	N	mean	S.D.	N
Q. serrata acorns						
without sinker (*Q-C*)	1.2	0.3	50	1.2	0.2	20
with a light sinker (*Q-LS*)				1.7	0.2	22
with a middle sinker (*Q-MS*)	3.2	0.8	100	2.5	0.3	20
with a heavy sinker (*Q-HS*)				4.5	0.3	20
P. edulis acorns						
without sinker (*P-C*)	2.1	0.4	50	2.0	0.3	20
with a light sinker (*P-LS*)	2.6	0.5	34	2.6	0.4	18
with a middle sinker (*P-MS*)	3.1	0.4	33	3.8	0.3	20
with a heavy sinker (*P-HS*)	5.5	0.6	33	6.1	0.5	20

Table 2. Number of acorns used in this study.

Acorns[1]	March 2	March 9	April 21	May 26
Q-C	13	12	10	10
Q-LS			11	11
Q-MS	25	25	10	10
Q-HS			10	10
P-C	12	13	10	10
P-LS	8	9	9	9
P-MS	8	8	10	10
P-HS	9	8	10	10
Total	75	75	80	80

[1] see the text and table 1.

We established a station at the center of the study site, where we placed a feeder of 20x20x2 cm covered with 2.5 cm wire mesh cage of 30x30x20 cm to exclude avian granivores and squirrels. On March 2 and 9, we deployed a total of 75 acorns on the feeder (Table 2). We counted the numbers of acorns which were remaining and eaten on the feeder and calculated the number carried away from the feeder by subtraction every morning until all acorns were eaten or carried away. On April 21 and May 26, we placed a total of 80 acorns (Table 2) at 15:00 and counted the number of acorns eaten or carried away at 1 or 2 hr intervals through the next morning.

The percentages of acorns which were eaten and/or carried away were compared between the acorns of different species and among acorns with different weights for each species with the Fisher's exact test and the chi-square test.

Results

1. Handling of acorns of two species (*Q-C* and *P-C* acorns)

On March 2, field mice began to eat or carry away acorns in the fourth night. They ate or carried away *P-C* acorns more frequently than *Q-C* acorns during that night (Table 3). Mice responded differently to acorns of the two species. More *Q-C* acorns were eaten on the feeder, while all *P-C* acorns were carried away (Table 3). Mice handled all *P-C* acorns quicker than *Q-C* acorns (Fig. 1). On March 9 and April 21, mice ate or carried away all acorns during the first night and on May 26 they handled only a few acorns. On these experiment days, there was no significant difference in the total number of acorns removed and in the relative frequencies of acorns carried away and eaten between acorns of the two species (Table 3). Mice

Table 3. Nmber of *Q. serrata* and *P. edulis* acorns handled by mice during the first night of their response to acorns within the period of field experiments.

	Q. serrata			*P. edulis*			Fisher's exact probability (P) for	
	set	eaten	carried	set	eaten	carried	total handling	eaten vs. carried
March 2	13	5	2	12	0	12	0.010	0.002
March 9	12	3	9	13	0	13	1.000	0.096
April 21	10	0	10	10	0	7	0.105	1.000
May 26	10	0	0	10	0	3	0.105	—

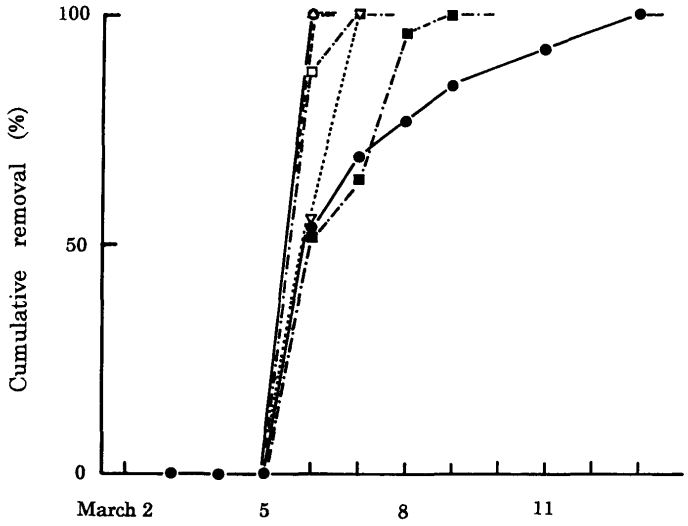

Fig. 1. Cumulative removal of acorns from the feeder placed on March 2.
—●— : *Q-C* acorns, —■— : *Q-MS* acorns, —○— : *P-C* acorns,
—△— : *P-SL* acorns, —□— : *P-MS* acorns, —▽— : *P-HS* acorns.
See the text and table 1 for the explanation about different categories of acorns.

began to handle *P-C* acorns about two hours earlier than *Q-C* acorns, but there was no significant difference in the temporal patterns of cummulative handling intensities of these acorns (Figs. 2 and 3).

2. Handling of acorns of different weights

1) *Q. serrata* acorns

On March 2 and 9, mice not only ate acorns on the feeder but also carried them away from the feeder; they ate more acorns on March 2, and carried away more on March 9. But the relative frequencies of acorns eaten and carried away did not differ significantly between heavy and light acorns (on March 2, 11 *Q-C* and 17 *Q-MS* acorns were eaten, and two *Q-C* and eight *Q-MS* acorns were carried away; Fisher's exact probability $P=0.242$, on March 9, three *Q-C* and seven *Q-MS* acorns were eaten, and nine *Q-C* and 18 *Q-MS* acorns were ccarried away; Fisher's exact probability $P=0.588$). On April 21 and May 26, mice did not eat acorns on the feeder. In all four cases, the weight of an acorn did not affect the handling intensity of acorns by mice (Table 4). An increase in the weight of an acorn did not deter the handling of acorns by mice, but tended to promote the carriage of acorns, especially, on May 26 (Figs. 2 and 3).

2) *P. edulis* acorns

Mice ate few acorns on the feeder but carried them away. On March 2, mice carried away light acorns more frequently than heavy ones during the first night. All heavy acorns that remained were carried away on the second night. However in all four cases, the percentages of carried acorns did not differ significantly among the four catergories (Table 4). Mice tended to handle heavier acorns later than lighter ones (Figs. 1 and 3).

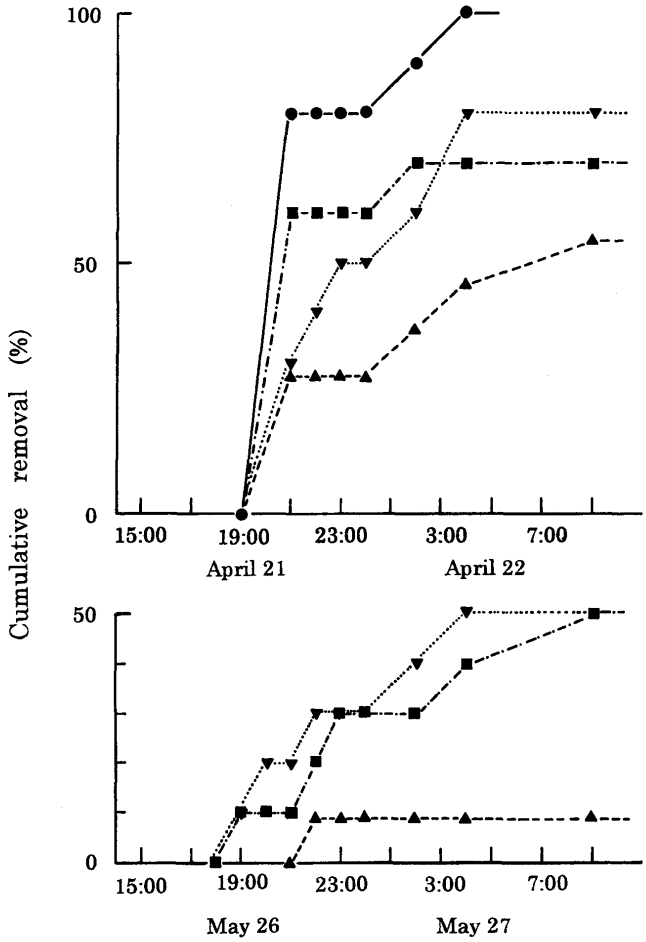

Fig. 2. Cumulative removal of *Q. serrata* acorns during a night.
—●— : *Q-C* acorns, —▲— : *Q-LS* acorns. —■— : *Q-MS* acorns,
—▼— : *Q-HS* acorns.
See the text and table 1 for the explanation about different categories of acorns.

Table 4. Comparison in the number of acorns handled by mice among those with different weights.

Acorns[1]	March 2		March 9		April 21		May 26	
	set	handled	set	handled	set	handled	set	handled
Q-C	13	7	12	12	10	7	10	0
Q-LS					11	7	11	1
Q-MS	25	13	25	25	10	6	10	5
Q-HS					10	4	10	4
χ^2-value	0.007		0.000		1.257		2.067	
P-C	12	12	13	13	10	10	10	3
P-LS	8	8	9	9	9	6	9	2
P-MS	8	7	8	8	10	7	10	2
P-HS	9	5	8	8	10	8	10	2
χ^2-value	1.435		0.000		1.502		0.088	

[1] see the text and table 1.

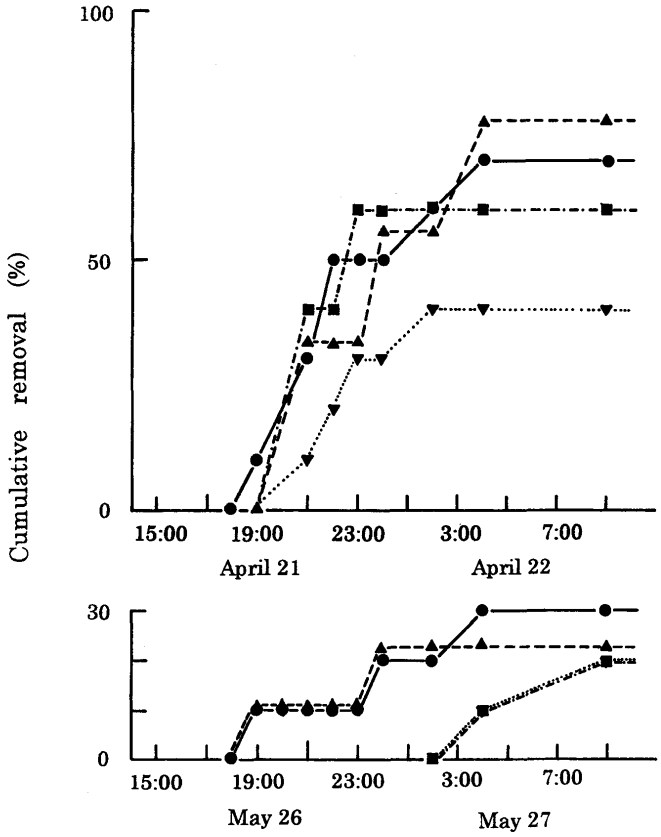

Fig. 3. Cumulative removal of *P. edulis* acorns during a night.
—●— : *P-C* acorns, —▲— : *P-LS* acorns, —■— : *P-MS* acorns,
—▼— : *P-HS* acorns.
See the text and table 1 for the explanation about different categories of acorns.

Disscussion

During the study period, the density of *A. speciosus* was much higher than *A. argenteus*. Interactions between the two *Apodemus* mice was a one-way action from *A. speciosus* to *A. argenteus* (Sekijima & Soné 1994), and *A. argenteus* is much more arboreal than *A. speciosus* (Doi & Iwamoto 1982). *P. edulis* acorns were too large for *A. argenteus* to handle easily. Using a video camera, Soné and Kohno (1996) observed that, in the stand, *A. speciosus* could easily carry an acorns of about 6 g in its mouth but *A. argenteus* could hardly carry them in its mouth. These results suggest that most acorns, especially those with a heavy sinker, set on the feeder were likely to be carried by *A. speciosus* in this study.

Taken as a whole, mice responded to acorns of both species similarly, and the increase of weight of acorns had no significant effect on gathering of acorns by mice in one night in this study. These results suggest that mice may have similar effects on the acorn dispersal and the establishment of seedlings of different oak species in the field. However, *P. edulis* acorns with a heavier sinker seemed to be carried later than those without sinker or those with a lighter sinker. Contrary to *P. edulis acorns, Q. serrata* acorns with a heavier sinker seemed to be removed from the feeder sooner than those without a sinker or those with a light sinker. *P. edulis* acorn is heavier than *Q. serrata* acorn. This difference in the removal patterns between acorns of the two species might be caused by the different mean weights between acorns of the two species, and there can be an optimal range of the weight of acorns for mice to handle. These results were contrary to those reported by Jensen (1985) or Vander Wall (1994), where mice and chipmunks ate and/or carried heavier seeds or acorns more intensively than lighter ones. They used much smaller seeds and acorns than acorns used in this study. If *Apodemus* mice were provided with not only acorns but also small seeds, they may show an apparent preference for large seeds or acorns than small seeds.

Mice handled *Q. serrata* acorns differently among the four experiment days; mice ate and carried away in March but only

carried away in April and May. Mice ate few *P. edulis* acorns on the feeder. The cotyledons of *Q. serrata* acorns are deteriorated soon after they drop to the ground but not for those of *P. edulis* acorns. The quality of acorns may explain parts of the differences in the handling pattern of *Q. serrata* acorns among the experiment days and those between acorns of the two species in March as Reichman (1988) reported. The seasonal changes in the density and social structure of mice and the composition of food items can also affect their handling of acorns and seeds. The effects of these factors are remained to be studied by laboratory and field experiments.

Summary

We examined the behavioral responses of *Apodemus* mice to acorns of two species (*Quercus serrata*a and *Pasania edulis*) of different weights. There seemed to be a tendency that in *Q. serrata,* heavy acorns were removed from the feeder sooner than light ones, and in *P. edulis,* light acorns were taken earlier than heavy ones. However, in general, the mice did not show any significant differences in the handling intensity and the relative frequencies of acorns carried and eaten during one night either between the two species or among acorns of different weights for each species. These results suggest that *Apodemus* mice may have similar effects on the dispersal of acorns of different species and the establishment of their seedlings.

Key words: *Apodemus* mouse, *Quercus serrata, Pasania edulis,* Acorn Handling

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野ネズミによるドングリの採食と運搬

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コナラとマテバシイのドングリを林内の餌場に設置して，アカネズミ属の野ネズミによるドングリの採食や運搬活動を調査した。野ネズミは，コナラのドングリでは重たいものを軽いものより先に餌場から持ち去り，マテバシイのドングリでは，その反対に，軽いものを重たいものより早く持ち去った。しかし，餌場から持ち去ったドングリと餌場で採食したドングリの割合は，コナラとマテバシイの間で有意な差はなかった。これらの結果から，ドングリの分散や稚樹の定着に及ぼす野ネズミの効果は，ドングリを生産する樹種間で差がないことが示唆された。

キーワード：アカネズミ属，野ネズミ，マテバシイ，コナラ，ドングリ，行動的反応