Endozoochorous seed dispersal by sympatric mustelids, *Martes melampus* and *Mustela itatsi*, in western Tokyo, central Japan

Yamato Tsuji[a,*], Takafumi Tatewaki[b], and Eiji Kanda[c]

[a]Primate Research Institute, Kyoto University, Aichi 484-8506, Japan.

[b]Laboratory of Wildlife Ecology, School of Veterinary Medicine, Azabu University, Kanagawa 229-8501, Japan.

[c]Tokyo Wildlife Research Institute, Tokyo 190－0181, Japan

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*Corresponding author; Tel: +81-568-0539, fax: +81-568-0539

E-mail: ytsuji@pri.kyoto-u.ac.jp (Y. Tsuji)

Abstract

We investigated seed dispersal by two sympatric mustelid species, the Japanese marten (*Martes melampus*) and Japanese weasel (*Mustela itatsi*), along an intercity forest path in western Tokyo, central Japan, from Jul 2007 to Jul 2008. We aimed to investigate the effect of food/habitat preference of these mustelids (martens are semi-arboreal frugivores while weasels are terrestrial carnivores) on their seed dispersal characteristics, which determine their efficacy as seed dispersers. In total, we analyzed 478 fecal samples collected from the two mustelids ($N_{marten} = 381$, $N_{weasel} = 97$). The proportions of feces containing seeds for martens and weasels were 81.4% and 55.7%, respectively. The number of plant species whose seeds were found within the feces were 28 and 17, respectively. Almost all seeds within feces of both mustelids were intact. The number of plant species whose seeds were found within a single fecal sample ranged from one to four, but no significant difference was detected between the two mustelids. However, marten feces contained a significantly greater number of seeds of most plant species as well as total number of seeds than did weasel feces. The numbers of plant species and seeds represented in marten feces varied seasonally, but those represented in weasel feces did not. Our findings suggest the possibility that both mustelids act in some ways as seed dispersers, although martens seem to disperse a greater diversity and total amount of seeds.

Keywords: endozoochory, Japanese marten, Japanese weasel, seed dispersal

Introduction

Differences in the ecological niches of animals are often reflected in their feeding ecology, such as food habits, food handling, and habitat preferences (Begon et al. 1996; Feldhamer et al. 2003). With respect to seed dispersal, sympatric frugivores showing different food habits might vary in their efficacy as seed dispersers, both in terms of quantity (the number of seeds dispersed) and quality (the number of plant species, proportion of intact seeds, and germination rate). Such variation is highly relevant to the structuring of forest ecosystems. To evaluate the contribution of each animal species in the dispersal of seeds of a given plant species, we must conduct inter-specific comparisons regarding the characteristics of seed dispersal. So far, numerous comparative studies have been conducted for avian seed dispersers (Herrera 1984; Fukui 1996), but few have focused on the seed-dispersing roles played by mammals (but see Koike et al. 2008).

Mustelids (family Mustelidae) are small- to medium-sized carnivorous mammals with a wide distribution (Feldhamer et al. 2003). These animals play the roles of middle-level to top predators in boreal and temperate regions (Buskirk et al. 1994). Mustelids feed on animal materials as well as fruits (Rosalino and Santos-Reis 2009), and therefore exhibit the potential to disperse seeds that pass unaffected through their digestive tracts (endozoochory) (Koike and Masaki 2008). However, with the exception of martens (*Martes* spp.) (Wilson 1993; Hickey et al. 1999; Otani 2002; Zhou et al. 2008; Rosalino et al. 2010), little is known about the details of seed dispersal among mustelids, such as the number of seeds contained in fecal samples and the percentage of seeds that are destroyed, both of which serve as quantitative indices of the efficacy of seed dispersal.

We examined seed dispersal in two mustelid species, the Japanese marten *Martes melampus* and the Japanese weasel *Mustela itatsi* (hereafter marten and weasel, respectively). Both are endemic to Japan and live sympatrically in the forests of the eastern part of Honshu Island (Ohdachi et al. 2009), though they differ in many respects, including body weight (ca. 1000–1500 g for martens and 140–470 g for weasels: Ohdachi et al. 2009), home range size (ca. 60–360 ha for martens; Kawauchi et al. 2003: ca. 1–4 ha for the weasels: Sasaki and Ono 1994), and habitat preference (martens are semi-arboreal while weasels are terrestrial: Yasuma 1985). In addition, martens are in part frugivorous (percentages of absolute occurrence of fruit in feces: 5.9-89.9% (Arai et al. 2003); 52.5-97.9% (Nakamura et al. 2001)), whereas weasels are not (percentages of absolute occurrence of fruit in feces: 1.6-22.2% (Yukawa 1968); 3.9-8.9% (Sekiguchi et al. 2002)).

In this study, we aimed to investigate the effect of food/habitat preference of martens and weasels on their seed dispersal characteristics. We predict that the semi-arboreal/frugivorous martens would swallow and excrete a more diverse array and/or greater amount of intact seeds than would the terrestrial/carnivorous weasels.

Materials and methods

Study site

The study was conducted along the Bonbori Forest Path (36º N, 139º E) between Hachioji City and Akiruno City, approximately 50 km west of Tokyo (Fig. 1). The path is ca. 10 km in length and ca. 5 m wide, and is almost entirely asphalt-paved. Much of the land surrounding the study site has been developed over the past few decades (Nakamura et al. 2001). The mean annual precipitation and temperature at Hachioji, the nearest weather station to the study site, is 1581.7 mm and 14.1°C (range: –2.0°C to 30.3°C), respectively (Japan Meteorological Agency, http://www.jma.go.jp/jma/index.html). The study site is seldom covered by snow, although snow does occasionally fall during winter. The area is mostly covered with forest vegetation with flowing streams (Fig. 1). The vegetation at the study site is dominated by deciduous–coniferous mixed natural forest, as well as planted coniferous forest species such as *Cryptomeria japonica* and *Chamaecyparis obtusa* (Nakamura et al. 2001). In addition to martens and weasels, several carnivorous mammal species, such as red foxes (*Vulpes vulpes*) and raccoon dogs (*Nyctereutes procyonoides*), inhabit the study site.

(Fig. 1 should appear here)

Fecal sample collection and size measurement

We collected mustelid feces during walking or cycling (less than 10km·hr^{-1}) surveys along the forest path on clear days. We conducted these surveys at least once a month between Jul 2007 and Jul 2008 (23 surveys in total: two walking and 21 cycling). We did not collect paste-like fecal samples. When we encountered several parts of mustelid feces in one large clump, we treated them as one sample if the color was uniform, or independent samples if the color varied throughout the clump. We measured the maximum diameter (D_{max}) of the collected fecal sample to the nearest 0.05 mm using a vernier caliper (THS-30; Niigata Seiki Co., Sanjo, Japan). Tsuji et al. (in press) demonstrated that mustelid species could be distinguished based on fecal size. Using the parameters outlined therein, we classified fecal samples whose D_{max} ranged from 8.7 mm to 13.1 mm as marten feces, while samples whose D_{max} ranged from 4.3 mm to 7.2 mm were attributed to weasels. We excluded fecal samples whose D_{max} ranged from 7.2 mm to 8.7 mm from the analyses because we could not be confident of their specific origin. All samples were frozen after collection and stored at –20°C until analysis.

Fecal analyses

Defrosted feces were washed through a 0.5-mm-mesh sieve and any seeds remaining in the sieve were identified and counted. Seed identification was based on Nakayama et al. (2000). Using the vernier caliper, we measured the maximum length of five seeds for each plant species to the nearest 0.05 mm. We also weighed five dry seeds for each plant species using an electric balance

(UX4200H; Shimadzu Co., Kyoto, Japan) to the nearest 0.1 mg. Seeds less than1 mm were difficult to count directly, so we removed as much of the non digested remains as possible and subsequently counted the seeds in a 1-g sub-sample to estimate the total number of seeds contained within the whole sample. In order to minimize the risk of over/underestimating the seed number, we homogenized the whole sample before sub-sampling. We were only able to measure the size and weight of *Elaeagnus* sp. (Elaeagnaceae) seeds, and the weight of *Rosa multiflora* (Rosaceae) seeds once, due to their paucity in our samples.

Statistical analyses

In accordance with Nakamura et al. (2001), we separated the study period (13 months) into four seasons: spring (Mar–May 2008), summer (Jul-Aug 2007 and Jun-Jul 2008), fall (Sep–Nov 2007), and winter (Dec–Feb Dec 2007 and Jan-Feb 2008). We employed Mann–Whitney U-tests to test for a difference between mustelids in mean seed size (mean seed length) and mean seed weight. We compared the frequency of seed occurrence (in relation to the number of fecal samples analyzed) between the two mustelids for each season using a chi-square goodness-of-fit test. Finally, we employed the generalized linear models (GLMs) to test for effects of season, mustelids species, and their interaction on the number of seeds of each plant species, the total number of seeds in a single fecal sample, and the mean number of plant species whose seeds were found within the feces. We assumed that a Poisson distribution represented the error structure of these data. For these analyses, significance levels (α) were set at 0.05. All data analyses were carried out using the statistical software R. 2.9.1 (R Development Core Team 2009).

Results

Composition of seeds consumed by the martens

In total, we collected 560 fecal samples over the study period, but excluded 82 samples whose D_{max} ranged from 7.2 mm to 8.7 mm, thus not allowing us to distinguish their specific origin. We analyzed 381 samples that we classified as marten feces (Table 1). The total proportion of fecal samples that contained seeds was 81.4% (310/381). The proportions of seeds in fecal samples were relatively lower in spring (67.2%, 41/61) and summer (57.5%, 23/40), and relatively higher in fall (95.3%, 61/64) and winter (85.6%, 185/216). We identified the seeds of 28 plant species from the feces of martens, including 23 woody species and five herbaceous species (Table 2). The martens ingested seeds of wild species, as well as those of the fruit cultivars *Citrus junos* (Rutaceae) and *Diospyros kaki* (Ebenaceae). The number of plant species whose seeds were found within feces of the martens was greatest in winter (17 species), followed by spring and fall (13 species each), and lowest in summer (five species) (Table 1). The mean (±SD) seed length and seed weight were 4.56±3.74 mm (range: 1.30–11.80) and 44.4±72.7 mg (range: 0.7–336.0), respectively. The total mean number of seeds within a single fecal deposit was 107.9±126.2. We identified only three cases in which marten fecal samples contained destroyed seeds: two *Celtis sinensis* (Ulmaceae) seeds found in the spring and winter, and one *Hovenia dulcis* (Rhamnaceae) seed found in the winter. Thus, almost all seeds found within the fecal samples were intact.

Composition of seeds swallowed by weasels

In total, we analyzed 97 fecal samples attributed to weasels during the study period (Table 1). The total proportion of fecal samples that contained seeds was 55.7% (54/97). These proportions were relatively lower in spring (44.5%, 10/23) and summer (40.0%, 6/15), and relatively higher in the fall (63.6%, 7/11) and winter (64.6%, 31/48). We identified the seeds of 17 plant species, including 16 woody species and one herbaceous species, within the fecal samples of the weasels (Table 2). The weasels ingested the seeds of wild plants as well as those of the cultivar *D. kaki*. With the exception of *Physalis alkekengi* (Solanaceae), the weasels did not ingest seeds of herbaceous plants. The number of plant species whose seeds were found within feces of the weasels was greatest in winter (11 species), followed by fall (six species) and spring (four species), and was lowest in summer (two species) (Table 1). The mean seed length and weight were 3.86±2.22 mm (range: 1.30–9.24) and 47.2±82.3 mg (range: 0.7–336.0), respectively. The total mean number of seeds within a single fecal deposit was 44.6±42.4. We did not identify any destroyed seeds within weasel fecal samples during the study period.

(Fig. 2 and Table 1 should appear here)

Comparison of seeds ingested by martens and weasels

The percentages of seeds recorded in each season did not differ between martens and weasels (chi-square goodness-of-fit tests, spring: χ^2=0.660, *df*=1, *P*=0.417, summer: χ^2=0.158, *df*=1, *P*=0.691, fall: χ^2=0.286, *df*=1, *P*=0.593, winter: χ^2=1.004, *df*=1, *P*=0.316), nor did the total percentage of seeds identified per sample collected (χ^2=1.459, *df*=1, *P*=0.227). Five plant species were identified in the feces of both mustelids in the spring, two in the summer, four in the fall, and nine in the winter (Table 1). No differences were observed in either seed length (Mann–Whitney *U*-tests, df_1=28, df_2=17, *U*=249.5 *P*=0.797) or seed weight (*U*=248.5, *P*=0.815) between the two mustelids.

The GLM shows that mustelid species, season, and their interaction all significantly affect the numbers of seeds represented in the feces from 10, nine, and four out of the 28 plant species observed, respectively (*P*<0.05; Table 1). The GLM also detected the effect of mustelid species (*z*=9.74, *P*<0.001), season (*z*=-7.55, *P*<0.001), and their interaction (*z*=7.04, *P*<0.001) as factors affecting the total number of seeds contained in the feces (Table 1): the feces of martens contained a greater amount of seeds than those of the weasels in spring and winter, but this pattern was not observed in summer and fall (Fig. 2a). However, the GLM did not identify any of these factors as affecting the mean number of plant species whose seeds were found within feces (mustelid species:

z=0.51, *P*=0.611, season: *z*=0.48, *P*=0.630, species×season: *z*=–0.75, *P*=0.452; Fig. 2b).

Discussion

Several studies have examined endozoochorous seed dispersal by Japanese martens (Kusui and Kusui 1998, Otani 2002). The number of plant species we found from the marten fecal samples (28 species from 478 fecal samples) was much greater than previously reported (11 species from 141 fecal samples at Mt. Yumori: Otani 2002; 14–15 species from 305 fecal samples at Mt. Katsuragi: Kusui and Kusui 1998), and was similar to the total identified fruits on which European martens (*Martes foina* and *M. martes*) fed (15-30 species from 940-1739 fecal samples: Rosalino and Santos-Reis, 2009). Conversely, despite several reports describing the frugivory of Japanese weasels (Fujii et al. 1998; Koike and Masaki 2008; Kaneko et al. 2009), a detailed examination of their role in seed dispersal has not been conducted until now. We found that weasels ingested the seeds of 17 different plant species (from 97 fecal samples) during the study period. This is much greater than the number of total identified fruits on which European weasels (*Mustela nivalis* and *M. putoris*) fed (1-2 species from 103 fecal samples: Rosalino and Santos-Reis, 2009). Furthermore, given that almost all seeds within the fecal samples of the two mustelids were intact, they do not appear to be seed destroyers, thus supporting the results of previous studies of other species (Herrera 1989; Zhou et al. 2008).

We predicted that semi-arboreal/frugivorous martens would swallow and excrete a greater amount of intact seeds and/or seeds from a greater diversity of plant species than the more terrestrial/carnivorous weasels. As we predicted, the total number of seeds within a single marten fecal sample contained more seeds (both within each species and in total) than that from a weasel. This difference may be due to differences in the number of *S. praecox* seeds in spring and of *A. arguta* seeds in winter, both of which were more abundant within marten feces. Habitat preference seems to be an important factor affecting this difference: terrestrial weasels can only access fruits found on the ground, while semi-arboreal martens have access to fruits on the ground as well as in the trees, such as those of *S. praecox* during the spring before they drop, as well as *A. arguta* fruits in the winter that did not drop in the fall.

Contrary to our prediction, however, we did not observe a significant difference in the number of seeds contained in the feces (both within each species and in total) between the two mustelids in the summer and fall. This result can be attributed to seasonal changes in the staple foods of the two mustelids. In summer and fall, martens mainly feed on animal matter which is abundant in these seasons (Tatara and Doi 1994; Kusui and Kusui 1998; Nakamura et al. 2001), while weasels feed consistently on animal matter throughout the year (Yukawa 1968; Sasaki and Ono 1994; Sekiguchi et al. 2002). Therefore, the relative value of fruit is reduced for martens in summer and fall, likely causing the absence of a clear difference in fruit feeding between the two mustelids in these seasons.

This implies that dispersal characteristics of martens reported in this study might simply reflect their generalist feeding behavior.

As we predicted, martens ingested seeds from a larger variety of plants (28 species) than did weasels (17 species). Contrary to our prediction, however, no significant difference was observed in the mean number of plant species whose seeds were found within a single fecal deposit between the two mustelids. This discrepancy between the diversity of plant species detected and the lack of diversity of species number found within a single feces can be attributed to the short intestine and consequential short digestion time of the mustelids (4.1-4.6 hrs, Hickey et al. 1999). That is, for both martens and weasels, only the contents of a single fruit feeding bout are likely to be excreted in a single fecal deposit.

To be an effective seed disperser, fruit consumers cannot destroy the seeds they ingest, but also they are expected to enhance (or at least have a neutral effect on) seed germination during its transit through the gut (Pollux et al. 2007, Rosalino et al. 2010). As for mustelids, several studies have shown that gut transit significantly enhanced the germination of seeds of many plant species (Hickey et al, 1999; Zhou et al., 2008), while other studies have shown deleterious effects (Rosalino et al. 2010). This implies that whether subject mustelid species are truly effective seed dispersers for a given plant species should be judged based on seed viability (Rosalino et al. 2010). For example, the martens in our study apparently engage in opportunistic fruit consumption, and there is a possibility that they could be less efficient (less specialized) dispersers. An evaluation of the impact of fruit consumption on seed survival is necessary in the future. By confirming the effects of passage through the mustelid gut on seed viability, we can gain a clearer understanding of how each mustelid species varies in its dispersion of viable seeds from various plant species, which will ultimately determine differences in their contribution to the structuring of forest ecosystems

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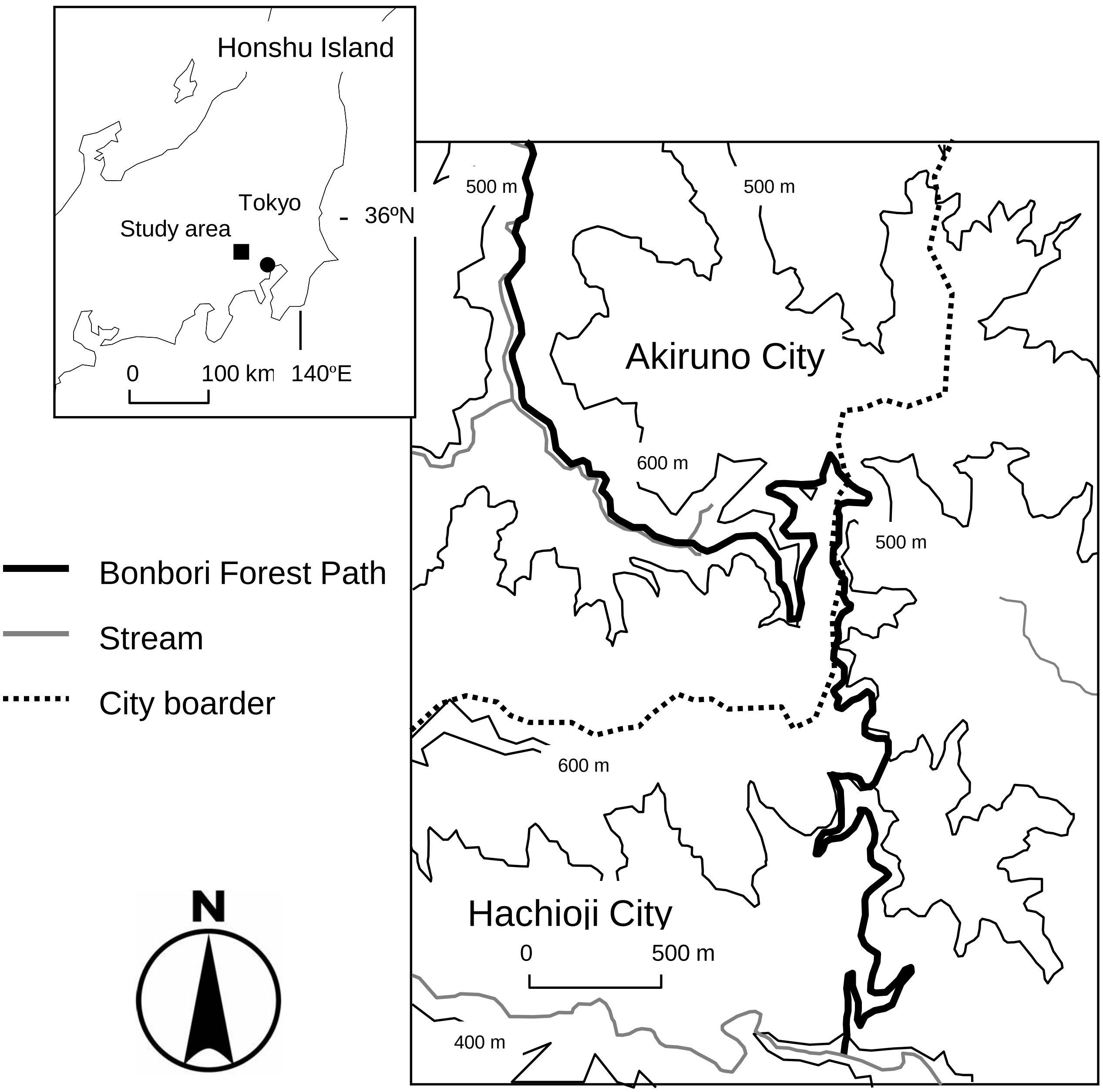
Figure Legends

Figure 1. Map of the study site. Contours show 100-m intervals.

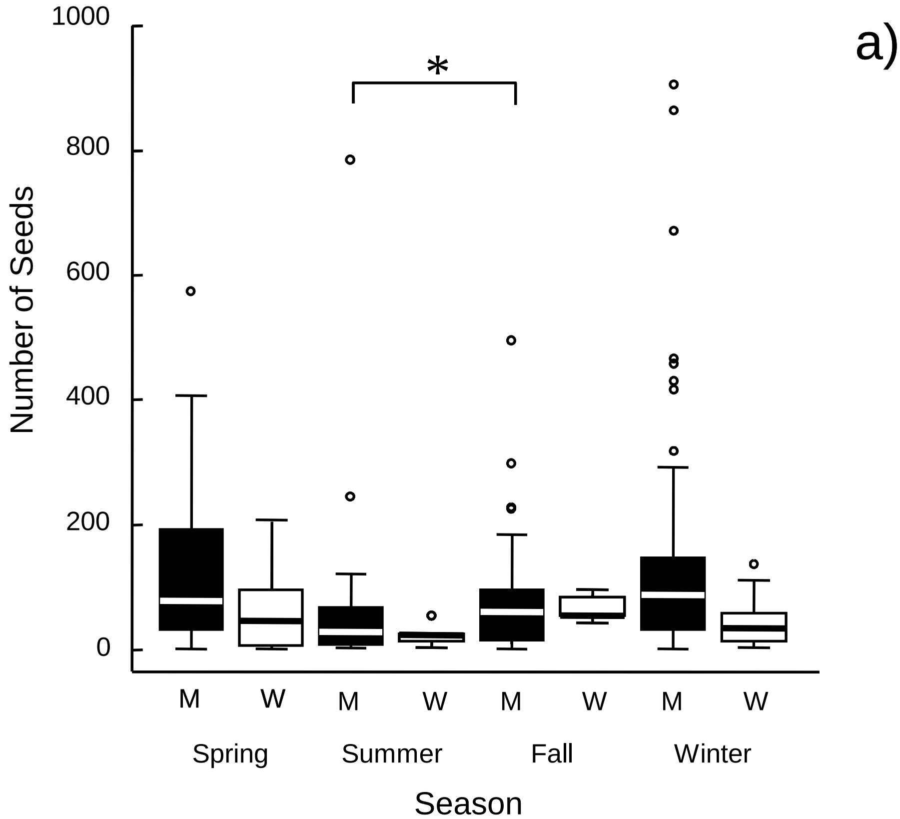
Figure 2. Boxplots for seasonal changes in the (a) total number of seeds within a single fecal deposit, and the (b) mean number of plant species whose seeds were found within a single fecal sample.■: marten (M), □: weasel (W). Spring: Mar–May, summer: Jun–Aug, fall: Sep-Nov, winter: Dec-Feb. Bold lines represent medians. Open circles show outliers. Samples without seeds were excluded from the analyses. *: $P<0.05$.

Figure

Tsuji et al. Figure 1



Tsuji et al. Figure 2



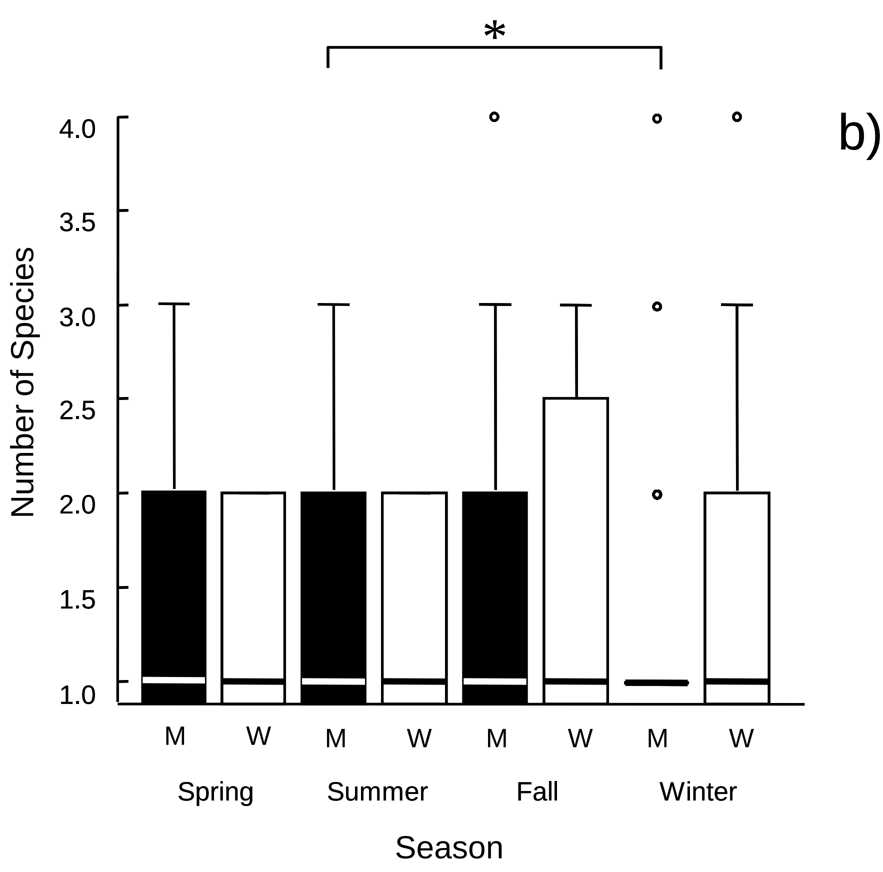


Table 1. Seasonal changes in mean±SD number of seeds within fecal samples of the martens and the weasels at Bonbori Forest Path, central Japan from 2007 to 2008.
N means number of collected fecal samples. Figures in parenthesis mean number of fecal samples containing seeds of given species.

Species	Spring (Mar - May)				Summer (Jun - Aug)				Fall (Sep - Nov)				Winter (Dec - Feb)				
	Marten (N=61)		Weasel (N=23)		Marten (N=40)		Weasel (N=15)		Marten (N=64)		Weasel (N=11)		Marten (N=216)		Weasel (N=48)		Species (Sp)
Woody Plant																	
Stachyurus praecox	134.1 ± 171.8	(15)	9.5 ± 12.0	(2)	—		—		1.7 ± 1.2	(3)	—		9.5 ± 12.5	(31)	3.7 ± 1.5	(3)	-10.99 ***
Morus bombycis	95.9 ± 113.0	(16)	11.3 ± 10.7	(3)	76.2 ± 24.8	(6)	37.1 ± 26.6	(2)	—		—		—		—		-10.88 ***
Actinidia arguta	73.3 ± 59.1	(15)	95.8 ± 75.9	(6)	3.0	(1)	—		61.5 ± 60.4	(38)	160.7 ± 271.8	(7)	121.7 ± 114.4	(160)	45.1 ± 36.4	(21)	17.89 ***
Aphananthe aspera	9.0	(1)	—		—		—		—		—		—		—		n.a.
Prunus jamasakura	8.0 ± 6.1	(11)	4.5 ± 4.7	(4)	—		—		—		—		—		—		-2.22 *
Hovenia dulcis	2.0 ± 1.4	(2)	—		—		—		—		—		1.0	(1)	4.0 ± 3.5	(3)	1.33 $^{n.s.}$
Pyrus pyrifolia	1.5 ± 0.7	(2)	1.0	(1)	—		—		—		—		4.5 ± 0.7	(2)	1.0	(1)	-0.03 $^{n.s.}$
Celtis sinensis	1.0	(1)	—		—		—		12.2 ± 4.8	(5)	4.0	(1)	7.6 ± 7.9	(8)	15.0	(1)	-2.05 *
Diospyros kaki	1.0	(1)	—		—		—		8.3 ± 6.8	(3)	—		3.9 ± 3.3	(11)	1.5 ± 1.0	(4)	-2.60 **
Citrus junos	1.0	(1)	—		—		—		—		—		—		—		n.a.
Cinnamonum camphora	—		4.0	(1)	—		—		—		—		59.0	(1)	—		n.a.
Ilex macropoda	—		—		240.0	(1)	—		179.3 ± 273.2	(3)	—		—		—		n.a.
Rubus sp.	—		—		170.6 ± 343.5	(5)	19.0 ± 7.1	(2)	—		—		104.0 ± 185.4	(4)	—		-13.24 ***
Akebia sp.	—		—		—		—		57.8 ± 57.4	(30)	2.0 ± 1.4	(2)	15.5 ± 20.7	(4)	—		-6.50 ***
Actinidia polygama	—		—		—		—		29.0	(1)	21.0	(1)	12.0	(1)	—		-1.13 $^{n.s.}$
Sorbus sp.	—		—		—		—		7.0	(1)	—		1.0	(1)	14.5 ± 15.2	(6)	2.66 **
Viburnum dilatatum	—		—		—		—		2.0	(1)	—		—		7.5 ± 9.2	(2)	n.a.
Cocculus trilobus	—		—		—		—		1.0	(1)	—		—		10.0	(1)	n.a.
Elaeagnus sp.	—		—		—		—		1.0	(1)	—		—		—		n.a.
Rosa multiflora	—		—		—		—		—		—		41.0	(1)	—		n.a.
Eurya japonica	—		—		—		—		—		—		13.0	(1)	23.5 ± 23.3	(2)	1.89 $^{n.s.}$
Vitis sp.	—		—		—		—		—		—		2.0 ± 1.0	(3)	—		n.a.
Ilex pedunculosa	—		—		—		—		—		—		2.0	(1)	—		n.a.
Herbaceous Plant																	
Amphicarpaea sp.	10.0	(1)	—		—		—		—		—		—		—		n.a.
Poaceae species A	4.0	(1)	—		—		—		—		—		—		—		n.a.
Polygonaceae sp.	1.0	(1)	—		—		—		—		—		—		—		n.a.
Physalis alkekengi	—		—		—		—		202.0 ± 256.0	(2)	—		800.0	(1)	26.0	(1)	-17.20 ***
Poaceae species B	—		—		3.5 ± 2.1	(2)	—		8.5 ± 6.2	(3)	—		1.0	(1)	—		-1.90 $^{+}$
Total number of seeds	92.0 ± 128.8	(41)	28.0 ± 54.8	(10)	44.1 ± 127.1	(23)	8.7 ± 14.7	(6)	74.6 ± 82.1	(61)	41.4 ± 34.7	(7)	99.0 ± 125.3	(185)	24.5 ± 32.3	(31)	9.74 ***
# Species detected	13		6		5		2		13		4		17		11		

Statistical tests were conducted by GLM (general linear model, erroe structure: Poisson distribution). ***: $P < 0.001$, **: $P < 0.01$, *: $P < 0.05$, +: $P < 0.1$, n.a.: not available, n.s.: not significant ($P > 0.05$).

Table

Table 2. Physical characteristics of seeds included within the feces of martens and weasels at Bonbori Forest Path, central Japan from 2007 to 2008.
[a]Y: appeared within feces, N: not appeared within feces. [b]Measured only once. *: planted species.

Species	Family	Marten[a]	Weasel	Seed Length (mm, Mean±SD)			Seed Weight (mg, Mean±SD)		
Woody Plant									
Aphananthe aspera	Ulmaceae	Y	N	3.47	±	0.62	19.0	±	10.1
Celtis sinensis	Ulmaceae	Y	Y	6.14	±	0.50	102.5	±	88.7
Morus bombycis	Moraceae	Y	Y	1.43	±	0.27	10.6	±	7.6
Akebia sp.	Lardizabalaceae	Y	Y	5.59	±	0.23	30.2	±	29.3
Cocculus trilobus	Menispermaceae	Y	Y	4.82	±	0.53	22.5	±	3.5
Actinidia arguta	Actinidaceae	Y	Y	2.64	±	0.24	4.8	±	6.6
Actinidia polygama	Actinidaceae	Y	Y	1.61	±	0.19	4.6	±	4.8
Eurya japonica	Theaceae	Y	Y	1.94	±	0.22	0.7	±	0.8
Rubus sp.	Rosaceae	Y	Y	1.60	±	0.07	14.0	±	25.7
Sorbus sp.	Rosaceae	Y	Y	4.40	±	0.15	4.5	±	2.6
Cinnamonum camphora	Rosaceae	Y	Y	3.31	±	0.31	64.5	±	74.2
Rosa multiflora	Rosaceae	Y	N	2.38	±	0.40	1.0[b]		
Pyrus pyrifolia	Rosaceae	Y	Y	5.47	±	0.71	336.0	±	634.6
Prunus jamasakura	Rosaceae	Y	Y	5.80	±	0.22	81.7	±	19.4
*Citrus junos**	Rutaceae	Y	N	11.83	±	1.60	88.6	±	45.3
Ilex macropoda	Aquifoliaceae	Y	N	4.64	±	0.28	7.9	±	1.2
Ilex pedunculosa	Aquifoliaceae	Y	N	4.22	±	0.08	15.8	±	13.0
Hovenia dulcis	Rhamnaceae	Y	Y	3.65	±	0.50	8.8	±	9.8
Vitis sp.	Vitaceae	Y	N	3.98	±	0.24	34.7	±	50.8
Elaeagnus spp.	Elaeagnaceae	Y	N	19.4[b]			200.0[b]		
Stachyurus praecox	Stachturaceae	Y	Y	1.64	±	0.11	1.5	±	1.1
*Diospyros kaki**	Ebenaceae	Y	Y	9.24	±	0.36	98.7	±	19.8
Viburnum dilatatum	Caprifoliaceae	Y	Y	5.05	±	0.29	14.7	±	12.8
Herbaceous Plant									
Poaceae sp. A	Gramineae	Y	N	3.17	±	0.27	8.3	±	12.5
Poaceae sp. B	Gramineae	Y	N	2.75	±	0.35	35.7	±	55.6
Polygonaceae sp.	Polygonaceae	Y	N	2.49	±	0.27	7.3	±	9.8
Amphicarpaea sp.	Leguminisae	Y	N	3.77	±	0.36	24.1	±	20.4
Physalis alkekengi	Solanaceae	Y	Y	1.30	±	0.17	1.4	±	0.4