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Multi-annual variation in the diet composition and frugivory of the Japanese marten (*Martes melampus*) in western Tokyo, central Japan

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19 prey animals and/or fruits. We emphasize the importance of multi-annual studies both on food habits and
20 to monitor food availability in the temperate region where the food environment changes among seasons
21 as well as years.

22

23 **Keywords** Dietary composition • Frequency of occurrence • *Martes melampus* • Multi-annual • Seed
24 dispersal • Yearly variation

25

26 **Introduction**

27
28 Food habit analysis is a basic and important subject in studies on wildlife ecology. The food environment
29 varies both temporally and spatially in accordance with variations in food availability (Herrera et al.
30 1998; McShea 2000). In temperate regions, marked seasonal changes in plant phenology limit the fruiting
31 period of frugivores (Hanya et al. 2013). Such variations in plant availability often affect the population
32 size of prey animals, such as small rodents and sedentary birds, which in turn affect the food
33 environments of omnivorous mammals (Helldin 1999; McShea 2000). As a result, both frugivorous and
34 carnivorous mammals in temperate regions seem to change their food habits according to environmental
35 conditions (O'Donoghue et al. 1998; Naves et al. 2006; Tsuji et al. 2006; Koike 2010), which implies that
36 multi-annual information on the food habits of animals is needed to fully understand temporal variation in
their feeding ecology.

Mustelids (family Mustelidae) are small- to medium-sized mesopredators that have a wide distribution in the Northern Hemisphere (Buskirk et al. 1994). Martens, as generalist predators, switch to alternative prey when their principal foods are not readily available. Several multi-annual studies have shown that martens fed on rodents (voles and mice) during years when their availability was high, while the martens switched to feeding primarily on alternative diets, such as animal carcasses and fruits when the rodent availability was low (Pulliainen and Ollinmäki 1996; Ben-David et al. 1997). These examples imply that information about marten food habits based on short-term studies can lead to erroneous conclusions about their foraging strategies. Mustelids also feed on fruits (Rosalino and Santos-Reis 2009), and therefore potentially disperse intact seeds that pass through their digestive tracts (endozoochory; Wilson 1993; Otani 2002). Thus, multi-annual variation in their food habits can also affect their roles as seed dispersal agents. Despite numerous studies on the food habits of mustelids, few have attempted multi-annual studies on variations in diet composition and its implications.

In this study, we tried to address multi-annual variation in the food habits of wild Japanese martens (*Martes melampus*), an endemic mustelid species in Japan. We especially focused on multi-annual variation in their frugivory. Although several studies have examined the food habits of Japanese martens (Yamagishi 1990; Tatara and Doi 1994; Arai et al. 2003), no study except Arai et al. (2003) documented multi-annual variation. In western Tokyo, the food habits of Japanese marten were previously studied by Nakamura et al. (2001) in 1997–1998 (Period 1 hereafter), and thus we were able to examine

55 multi-annual variation in diets by conducting a follow-up study in 2007–2008 (Period 2) and comparing

56 the results between these two periods.

57

58 **Materials and methods**

59 Our study was conducted at the Bonbori Forest Path (36° N, 139° E) between Hachioji City and Akiruno

60 City, approximately 50 km west of the central part of Tokyo. The path is about 10 km long and about 5 m

61 wide, and it is almost entirely asphalt-paved (Tsuji *et al.* 2011a). Mean annual precipitation and

62 temperature at Hachioji, the nearest weather station to the study site, during Period 1 were 2358 mm and

63 14.8°C, respectively, while in Period 2, they were 2074 mm and 14.6°C, respectively (Japan

64 Meteorological Agency, <http://www.jma.go.jp/jma/index.html>). The area is mostly covered with forest

65 vegetation dominated by deciduous broad-leaved secondary forests on slopes as well as planted

66 coniferous forests of *Cryptomeria japonica* and *Chamaecyparis obtusa* in valleys (Nakamura *et al.* 2001;

67 Tsuji *et al.* 2011a).

68 We surveyed the forest path at least once a month from July 2007 to July 2008 (23 surveys in total),

69 and collected marten feces along/on it. When we found feces in one large pile, we treated it as one sample

70 if the color was the same or as independent samples if the color differed. We could easily distinguish

71 marten feces from that of sympatric mammals, such as Japanese macaques (*Macaca fuscata*) and red fox

72 (*Vulpes vulpes*) by its shape. We could also distinguish marten feces from that of sympatric mustelids,

73 Japanese weasels (*Mustela itatsi*), by its size (mean $\pm$ SD width: 10.1 ± 1.5 mm for martens and 6.5 ± 1.1
74 mm for weasels; Tsuji *et al.* 2011b). When we collected feces, we removed stones and leaves that were
75 present on the surface.

76 In the laboratory, defrosted feces were washed through a 0.5-mm mesh sieve, and remnants on the
77 sieve were identified under a microscope. Based on Nakamura *et al.* (2001), we classified the contents
78 into the following eight categories: mammals (including rodents and insectivores), birds,
79 reptiles/amphibians, insects, arthropods/other animals, fruits/seeds, other plant parts (including leaves,
80 stems, and roots), and others/unidentified items. To examine multi-annual variation in the contribution of
81 fruits, fruits/seeds were sorted to the level of species or genus. Fruits/seeds identification followed
82 Nakayama *et al.* (2000) and our own references. The percent frequency of occurrence in feces ($\%FO =$
83 number of fecal samples containing a specific food item/total number of fecal samples) was used to show
84 seasonal and year-round food habits, as well as multi-annual variation.

85 We separated the study period into four seasons: spring (March–May), summer (June–August), fall
86 (September–November), and winter (December–February). To test effect of season on the $\%FO$ of the
87 given food item in each period, we used chi-square tests for independence. If significant seasonal
88 difference was obtained, we conducted *post-hoc* Bonferroni tests to address when the martens fed on the
89 item more frequently. To test the effect of study period on the $\%FO$ of a given food item in a given
90 season, we used chi-square tests for independence. In these analysis, α was set at 0.05 except for the

91 Bonferroni tests in which we adjusted the significance levels (α) to 0.013 (for 4 seasons) and 0.017 (for 3
92 seasons) to avoid type I error. Data analyses in this study were performed using the statistical software R
93 2.15.1.

94

95 Results

96 During Period 2, we collected 381 fecal samples, among which we analyzed 257 samples ($N = 33$ in
97 spring, 20 in summer, 26 in fall, and 178 in winter). In total, 594 identifiable food items were found in the
98 257 fecal samples, which corresponded to an average of 2.32 food categories per fecal sample ($SD =$
99 0.83, range: 1–5). Fruits/seeds (annual %FO: 94.9), mammals (annual %FO: 69.6), insects (annual %FO:
100 51.0), and other plant parts (annual %FO: 61.5) were the staple food items during Period 2 (Table 1).
101 Birds, reptiles/amphibians, arthropods/other animals, and fungi were supplementary sources, whose
102 annual %FOs were less than 5%.

103 As to seasonal change, the %FO of mammals in Period 2 was significantly higher in spring and
104 summer than winter ($p < 0.017$). The %FO of birds in Period 2 was significantly higher in spring than
105 winter ($p < 0.013$). The %FO of arthropods/other animals in Period 1 was significantly higher in spring
106 than other seasons ($p < 0.013$), while %FO of arthropods/other animals in Period 2 was significantly
107 higher in summer than winter ($p < 0.013$) (Table 1).

108 Significant effects of study period on %FO were detected for mammals in the annual mean ($\chi^2 =$

109 4.7, $df = 1$, $p = 0.031$), for birds in winter ($\chi^2 = 11.8$, $df = 1$, $p < 0.001$), reptiles and amphibians in the
110 annual mean ($\chi^2 = 3.9$, $df = 1$, $p = 0.049$), arthropods/other animals in the annual mean ($\chi^2 = 11.1$, $df = 1$, p
111 < 0.001), and other plant parts in each season (spring: $\chi^2 = 16.3$, $df = 1$, $p < 0.001$; summer: $\chi^2 = 20.0$, $df =$
112 1 , $p < 0.001$; fall: $\chi^2 = 11.4$, $df = 1$, $p < 0.001$; winter: $\chi^2 = 9.3$, $df = 1$, $p = 0.002$; the annual mean: $\chi^2 =$
113 65.1 , $df = 1$, $p < 0.001$). However, no significant difference in %FO was observed for insects and
114 fruits/seeds among the study periods ($p > 0.05$ for each; Table 1).

115 Throughout the study periods, at least 19 species of fruits/seeds were found in the feces. Some
116 fruits appeared in feces during only one period (Table 1): in spring, *Rubus* spp. and *Aspidistra elatior*
117 fruits appeared only in Period 1, while *Actinidia arguta*, *Stachyurus praecox*, *Morus bombycis*, *Hovenia*
118 *dulcis*, *Pyrus pyrifolia*, *Celtis sinensis*, *Aphananthe aspera*, and *Physalis alkekengi* appeared only in
119 Period 2; in summer, *Rubus* spp., *A. arguta*, and *Broussonetia kazinoki* appeared only in Period 1, while
120 *M. bombycis* appeared only in Period 2; in fall, *Rubus* sp., *H. dulcis*, and *Cinnamomum camphora*
121 appeared only in Period 1, while *C. sinensis*, *Viburnum dilatatum*, *Cocculus orbiculatus*, and *Sorbus* sp.
122 appeared only in Period 2; in winter, *Cardiospermum halicacabum*, *Mollugo verticillata*, and *Prunus* sp.
123 appeared only in Period 1, while *S. praecox*, *H. dulcis*, *P. pyrifolia*, *C. sinensis*, *Prunus jamasakura*,
124 *Actinidia polygama*, and *Vitex* spp. appeared only in Period 2 (Table 1).

125 Variation in %FO was also observed in several fruits between the two periods. In fall, the %FO of *A.*
126 *arguta* was significantly higher during Period 2 ($\chi^2 = 3.9$, $df = 1$, $p = 0.049$). In winter, the %FOs of

127 *Rubus* spp. ($\chi^2 = 4.7$, $df = 1$, $p = 0.030$) and *Diospyros kaki* ($\chi^2 = 51.2$, $df = 1$, $p < 0.001$) were
128 significantly higher in Period 1, while the %FO of *A. arguta* ($\chi^2 = 10.1$, $df = 1$, $p = 0.002$) was higher in
129 Period 2. On an annual basis, the %FOs of *Rubus* spp. ($\chi^2 = 14.9$, $df = 1$, $p < 0.001$), *D. kaki* ($\chi^2 = 11.2$, df
130 $= 1$, $p = 0.001$), *Akebia quinata* ($\chi^2 = 14.1$, $df = 1$, $p < 0.001$), and *P. jamasakura* ($\chi^2 = 15.7$, $df = 1$, $p <$
131 0.001) were significantly higher in Period 1, while those of *A. arguta* ($\chi^2 = 45.5$, $df = 1$, $p < 0.001$) and *S.*
132 *praecox* ($\chi^2 = 8.5$, $df = 1$, $p = 0.003$) were significantly higher in Period 2 (Table 1).

134 Discussion

135 Japanese martens in the Bonbori Forest Path fed mainly on animal materials and fruits during both study
136 periods. Their omnivorous diets were similar to what has been reported at other sites (Yamagishi 1990;
137 Tatara and Doi 1994; Arai et al. 2003). In terms of seasonal changes in food habits, the martens fed
138 frequently on fruits/seeds and insects throughout the year in both periods, while other categories, like
139 mammals, showed seasonal variation.

140 We found variation in dietary composition between the two study periods: the annual %FOs of
141 mammals, reptiles/amphibians, and arthropods/other animals were higher, while those of some berry
142 species were lower in Period 1 than in Period 2. Since climatic conditions were similar between the two
143 periods (see Materials and methods), the results strongly suggest three possibilities: fruit production
144 varied annually, prey animal abundance varied annually, or both fruit production and prey animal

145 abundance varied annually. The availability of prey animals (Saito et al. 1998, 2007) and fruit production
146 (Komiya et al. 1991; Suzuki et al. 2005) are known to vary annually in Japan. Thus, the martens at our
147 study site seem to adjust their dependence on animal materials in accordance with the availability of prey
148 animals and/or fruits, as do other mustelids (Buskirk et al. 1994; Pulliainen and Ollinmäki 1996; Zhou et
149 al. 2011; Caryl et al. 2012). In this study we could not quantify the food availability, and our
150 interpretation of the multi-yearly variation in the dietary composition is speculative. Collecting such
151 information would be useful to investigate how dietary preferences change with availability of their staple
152 foods.

153 We also found considerable variation in fruit occupation in the fecal composition between the two
154 study periods. A similar phenomenon was noted by Otani (2002) when studying martens in northern
155 Japan: he found differences in fruit composition among samples during a 2-year study; e.g., seeds of
156 *Taxus cuspidata* var. *nana* and *Prunus nipponica* were only found in feces in 1 year. These results can be
157 attributed to yearly variation in fruit production. In our study, for example, the availability of *A. arguta*
158 and *S. praecox* from fall to the next spring should have been greater in Period 2, while the availability of
159 *Rubus* sp. in all seasons except for fall, *D. kaki* and *A. quinata* in fall, and *Prunus japonica* in summer
160 should have been greater in Period 1. This implies that the role of Japanese martens as seed dispersal
161 agents would also vary annually according to fruit availability.

162 The annual %FO of other plant parts, mainly leaves, was higher in Period 2. Because we removed

163 leaves that were attached to the surface of fecal samples at collection, detected leaves were likely to be
164 food-originated. Folivory by Japanese martens has been reported at other study sites (e.g., Shiratsuki et al.
165 1973; Yamagishi 1990). Whether folivory is a “side effect” of capturing insects on leaves or a separate
166 feeding strategy of the martens is not clear. The amount of leaves in feces, however, was very low
167 (Yamagishi 1990), and the relative importance of leaves for martens seems lower than that of fruits and
168 animal matter.

169 We demonstrated that multi-annual studies are required to fully understand temporal variation in
170 marten diet. Furthermore, monitoring the availability of plant and prey animals is necessary to explain
171 multi-annual variation in the foraging behaviors performed by martens (e.g., Pulliainen and Ollinmäki
172 1996; Ben-David et al. 1997; Caryl et al. 2012) and to confirm their role as a seed dispersal agent (Otani
173 2002; Tsuji et al. 2011a). Accumulating such fundamental data from multiple time points and localities
174 would be useful to meta-analyses investigating large-scale drivers of prey availability and diet.

175

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180

References

- Arai S, Adachi T, Kawahara Y, Yoshida K (2003) Food habit of Japanese marten (*Martes melampus*) at Kuju Highland in Kyushu, Japan. *Mamm Sci* 43:19-28 [in Japanese with English summary]
- Ben-David M, Flynn RW, Schell DM (1997) Annual and seasonal changes in diets of martens: evidence from stable isotope analysis. *Oecologia* 111:280-291
- Buskirk SE, Harestad AS, Raphael MG, Powell RA (1994) Martens, sables and fishers: biology and conservation. Cornell University Press, Ithaca
- Caryl FM, Raynor R, Quine CP, Park KJ (2012) The seasonal diet of British pine marten determined from genetically identified scats. *J Zool Lond* 288: 252-259
- Hanya G, Tsuji Y, Grueter CC (2013) Fruiting and flushing phenology in Asian tropical and temperate forests: implications for primate ecology. *Primates* 54:101-110
- Helldin JO (1999) Diet, body condition, and reproduction of Eurasian pine martens *Martes martes* during cycles in microtine density. *Ecography* 22:324-336
- Herrera CM, Jordano P, Guitian J, Traveset A (1998) Annual variability in seed production by woody plants and the masting concept: reassessment of principles and relationship to pollination and seed dispersal. *Am Nat* 152:576–594
- Koike S (2010) Long-term trends in food habits of Asiatic black bears in the Misaka Mountains on the Pacific coast of central Japan. *Mamm Biol* 75:17–28

- 1
- 2
- 3 199 Komiyama A, Wada K, Kuga H (1991) Annual fluctuation of seed-fall amounts in the basin of Yokoyu
- 4
- 5
- 6 200 River, Shiga Heights. Bull Gifu Univ Exp Forest 56:166-174 [in Japanese with English summary]
- 7
- 8
- 9
- 10 201 McShea WJ (2000) The influence of acorn crops on annual variation in rodent and bird populations.
- 11
- 12
- 13 202 Ecology 81:228-238
- 14
- 15
- 16 203 Nakamura T, Kanzaki N, Maruyama N (2001) Seasonal changes in food habits of Japanese martens in
- 17
- 18
- 19 204 Hinode-cho and Akiruno-shi, Tokyo. Wildl Cons Japan 6:15-24 [in Japanese with English summary]
- 20
- 21
- 22 205 Nakayama S, Inokuchi M, Minamitani T (2000) Encyclopedia of plant seeds of Japan. Tohoku University
- 23
- 24
- 25 206 Press, Sendai [in Japanese]
- 26
- 27
- 28 207 Naves J, Fernández-Gil A, Rodoríguez C, Delibes M (2006) Brown bear food habits at the border of its
- 29
- 30
- 31
- 32 208 range: a long-term study. J Mamm 87:899-908
- 33
- 34
- 35 209 O'Donoghue M, Boutin S, Krebs CJ, Zuleta G, Murray DL, Hofer EJ (1998) Functional responses of
- 36
- 37
- 38 210 coyotes and lynx to the snowshoe hare cycle. Ecology 79:1193-1208
- 39
- 40
- 41 211 Otani T (2002) Seed dispersal by Japanese marten *Martes melampus* in the subalpine shrubland of
- 42
- 43
- 44 212 northern Japan. Ecol Res 17:29-38
- 45
- 46
- 47
- 48 213 Pulliainen E, Ollinmäki P (1996) A long-term study of winter food niche of the pine marten *Martes*
- 49
- 50
- 51 214 *martes* in northern boreal Finland. Acta Theriol 41:337-352
- 52
- 53
- 54 215 Rosalino LM, Santos-Reis M (2009) Fruit consumption by carnivores in Mediterranean Europe. Mamm
- 55
- 56
- 57 216 Rev 39:67-78
- 58
- 59
- 60
- 61
- 62
- 63
- 64
- 65

- 1
- 2
- 3 217 Saitoh T, Stenseth NC, Bjørnstad ON (1998) The population dynamics of the vole *Clethrionomys*
- 4
- 5
- 6 218 *rufocanus* in Hokkaido, Japan. Res Pop Ecol 40:61-76
- 7
- 8
- 9
- 10 219 Saitoh T, Osawa J, Takanishi T, Hayakashi S, Ohmori M, Morita T, Uemura S, Vik JO, Stenseth NC,
- 11
- 12 220 Maekawa K (2007) Effects of acorn masting on population dynamics of three forest-dwelling rodent
- 13
- 14
- 15 221 species in Hokkaido, Japan. Pop Ecol 49:249-256
- 16
- 17
- 18
- 19 222 Shiratsuki N, Asahi M, Yoshida H (1973) Food habit of Japanese marten *Martes melampus*, with
- 20
- 21
- 22 223 consideration on the home range. Bull Mukogawa Women Univ 20/21:45-56 [in Japanese with
- 23
- 24
- 25 224 English summary]
- 26
- 27
- 28
- 29 225 Suzuki W, Osumi K, Masaki T (2005) Mast seeding and its spatial scale in *Fagus crenata* in northern
- 30
- 31
- 32 226 Japan. For Ecol Manage 205:105-116
- 33
- 34
- 35 227 Tataru M, Doi T (1994) Comparative analyses on food habits of Japanese marten, Siberian weasel and
- 36
- 37
- 38 228 leopard cat in the Tsushima islands, Japan. Ecol Res 9:99-107
- 39
- 40
- 41 229 Tsuji Y, Fujita S, Sugiura H, Saito C, Takatsuki S (2006) Long-term variation in fruiting and the food
- 42
- 43
- 44 230 habits of wild Japanese macaques on Kinkazan Island, northern Japan. Am J Primatol 68:1068-1080
- 45
- 46
- 47
- 48 231 Tsuji Y, Tatewaki T, Kanda E (2011a) Endozoochorous seed dispersal by sympatric mustelids, *Martes*
- 49
- 50
- 51 232 *melampus* and *Mustela itatsi*, in western Tokyo, central Japan. Mamm Biol 76:628-633
- 52
- 53
- 54 233 Tsuji Y, Uesugi T, Shiraishi T, Miura S, Yamamoto Y, Kanda E (2011b) Faecal size criteria to discriminate
- 55
- 56
- 57 234 Japanese marten (*Martes melampus*) and Japanese weasel (*Mustela itatsi*). J Zoo and Aquarium
- 58
- 59
- 60
- 61
- 62
- 63
- 64
- 65

235 52:8-15 [in Japanese with English summary]

236 Wilson MF (1993) Mammals as seed-dispersal mutualists in North America. *Oikos* 67:159-176

237 Yamagishi M (1990) Seasonal food habits of the Japanese marten. *Bull Exp Forest Univ Tokyo* 83:9-18

238 [in Japanese with English summary]

239 Zhou YB, Newman C, Xu WT, Buesching CD, Zalewski A, Kaneko Y, Macdonald DW, Xie ZQ (2011)

240 Biogeographical variation in the diet of Holarctic martens (genus *Martes*, Mammalia: Carnivora:

241 Mustelidae): adaptive foraging in generalists *J Biogeogr* 38:137–147

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Table 1. Seasonal change in food habits of Japanese martens in Bouhori Forest Park, western Tokyo, central Japan based on fecal analyses and expressed as frequency of occurrence (%FO) from the feces.												
Food Item	Spring (March-May)		Summer (June-August)		Fall (September-November)		Winter (December-February)		Annual		Seasonal Change	
	Period 1 N = 40	Period 2 N = 33	Period 1 N = 49	Period 2 N = 20	Period 1 N = 48	Period 2 N = 26	Period 1 N = 31	Period 2 N = 178	Period 1 N = 168	Period 2 N = 257	Period 1	Period 2
Animal materials	85.0	72.7 ^{NS}	71.4	90.0 ^{NS}	66.7	46.2 ^{NS}	45.2	50.6 ^{NS}	92.9	69.6 ^{NS}	NS	NS
Mammals	42.5	36.4 ^{NS}	28.6	30.0 ^{NS}	—	—	12.9	6.2 ^{NS}	20.8	11.3 [*]	*** (Sp = Su = Wi)	*** (Su > Wi, Sp > Wi)
Birds	12.5	15.2 ^{NS}	2.0	10.0 ^{NS}	2.1	3.8 ^{NS}	16.1	1.1 ^{***}	6.5	3.9 ^{NS}	* (Sp = Su = Fa = Wi)	** (Sp > Wi)
Reptiles/amphibians	10.0	—	—	—	6.3	—	—	1.1	4.2	0.8 [*]	NS	NS
Insects	37.5	48.5 ^{NS}	51.0	80.0 ^{NS}	64.6	42.3 ^{NS}	32.3	49.4 ^{NS}	48.8	51.0 ^{NS}	NS	NS
Arthropods/other animals	37.5	3.0 ^{NS}	6.1	20.0 ^{NS}	2.1	—	3.2	1.1 ^{NS}	11.9	2.7 ^{***}	*** (Sp > Su, Sp > Fa, Sp > Wi)	*** (Su > Wi)
Plants	55.0	97.0 ^{NS}	65.3	95.0 ^{NS}	97.9	100.0 ^{NS}	96.8	100.0 ^{NS}	80.0	100.0 ^{NS}	NS	NS
Fruits and seeds	52.5	84.8 ^{NS}	63.3	70.0 ^{NS}	97.9	96.2 ^{NS}	96.8	99.4 ^{NS}	77.4	94.9 ^{NS}	NS	NS
<i>Rubus</i> spp.	17.5	—	14.3	—	2.1	—	12.9	2.2 [*]	11.3	1.6 ^{***}		
<i>Diospyros kaki</i>	7.5	3.0 ^{NS}	—	—	2.1	11.5 ^{NS}	83.9	6.2 ^{***}	17.9	5.8 ^{***}		
<i>Akebia quinata</i>	2.5	3.0	—	—	60.4	38.5 ^{NS}	3.2	1.7 ^{NS}	19.0	5.4 ^{***}		
<i>Aspidistra elatior</i>	2.5	—	—	—	—	—	—	—	0.6	—		
<i>Actinidia arguta</i>	—	39.4	8.2	—	33.3	80.8 [*]	19.4	81.5 ^{**}	15.5	69.6 ^{***}		
<i>Stachyurus praecox</i>	—	39.4	—	—	14.6	3.8 ^{NS}	—	12.9	4.2	14.4 ^{**}		
<i>Morus bombycis</i>	—	15.2	—	45.0	—	—	—	—	—	5.4		
<i>Hovenia dulcis</i>	—	6.1	—	—	4.2	—	—	0.6	1.2	1.2 ^{NS}		
<i>Pyrus pyrifolia</i>	—	6.1	—	—	—	—	—	1.1	—	1.6		
<i>Celtis sinensis</i>	—	3.0	—	—	—	3.8	—	3.4	—	3.1		
<i>Aphananthe aspera</i>	—	3.0	—	—	—	—	—	—	—	0.4		
<i>Physalis alkekengi</i>	—	3.0	—	—	—	—	—	—	—	0.4		
<i>Prunus jamasakura</i>	—	—	36.7	10.0 ^{NS}	—	—	—	0.6	10.7	1.2 ^{***}		
<i>Broussonetia kazunoki</i>	—	—	6.1	—	—	—	—	—	1.8	—		
<i>Actinidia polygama</i>	—	—	—	—	6.3	3.8 ^{NS}	—	1.1	1.8	1.2 ^{NS}		
<i>Cinnamomum camphora</i>	—	—	—	—	2.1	—	—	—	0.6	—		
<i>Viburnum dilatatum</i>	—	—	—	—	—	3.8	—	—	—	0.4		
<i>Cocculus orbiculatus</i>	—	—	—	—	—	3.8	—	—	—	0.4		
<i>Sorbus</i> sp.	—	—	—	—	—	3.8	—	—	—	0.4		
<i>Cardiospermum halicacabum</i>	—	—	—	—	—	—	3.2	—	0.6	—		
<i>Mollugo verticillata</i>	—	—	—	—	—	—	3.2	—	0.6	—		
<i>Prunus</i> spp.	—	—	—	—	—	—	3.2	—	0.6	—		
<i>Vitis</i> spp.	—	—	—	—	—	—	—	1.7	—	1.2		
Nuts	10.0	—	—	—	2.1	—	—	—	3.0	—		
Poaceae	—	3.0	—	—	—	—	—	1.7	—	1.6		
Polygonaceae	—	3.0	—	—	—	—	—	—	—	0.4		
Other seeds	25.0	—	—	—	2.1	—	6.5	—	7.7	—		
Other plants	5.0	75.8 ^{***}	4.1	85.0 ^{***}	4.2	50.0 ^{***}	9.7	57.9 ^{**}	5.4	61.5 ^{***}	NS	NS
Fungi	2.5	6.1 ^{NS}	—	—	—	—	—	2.3	0.6	2.5 ^{NS}		
Others/unidentified materials	5.0	6.1 ^{NS}	2.0	5.0 ^{NS}	6.3	—	—	2.3	3.6	2.5 ^{NS}		

Effects of study periods on the %FO are also shown for each season (performed by chi-square tests for independence). ***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$, NS: not significant ($p > 0.05$)
Results of multiple comparison (Bonferroni tests in which significance levels (α) are adjusted to 0.013 (4 comparisons) and 0.017 (3 comparisons)) are shown in parenthesis
Period 1: 1997–1998 (from Nakamura et al. 2001)
Period 2: 2007–2008

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