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Relationships Between the Fruiting Phenology of *Prunus jamasakura* and Timing of Visits by Mammals – Estimation of the Feeding Period Using Camera Traps

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1. Introduction

Fleshy fruits have an endozoochory seed dispersal system. Fleshy fruits provide food to dispersal agents in the form of nutritious accessory structures closely associated with the seeds. The exact percentage of tree species dispersed by endozoochory varies from place to place, but can exceed 50% in some temperate deciduous forests (Howe & Smallwood, 1982). So, fruits support a high percentage of a forest's frugivore biomass and the majority of woody plant species are dispersed by frugivores. Seed dispersal by frugivores in temperate deciduous forests has received considerable attention over time, and this interaction is considered an important force shaping the ecology and evolution of frugivore and tree populations (Estrada & Fleming, 1986). Also, many studies report endozoochory generally coevolved as a mutualistic relationship (e.g., Estrada & Fleming, 1986; Howe, 1986; Fleming & Estrada, 1993; Levey et al., 2001; Dennis et al., 2007).

Birds and mammals are the most important seed dispersers, but a wide variety of other animals, including lizards and fish can transport viable seeds (e.g., Corlett, 1998; Willson, 1993; Jordano, 1995; Castilla, 2000; Howe & Westley, 1988; Gottsberger, 1978). However, seed dispersal by birds has been examined most frequently (e.g., Herrera, 2002). Monkeys (e.g., Howe, 1980; Estrada & Coates-Estrada, 1994; Yumoto et al., 1998) and bats (e.g., Fleming, 1981; Gribel, 1988; Izhaki et al., 1995) have long been recognized as important seed dispersers and have been studied intensively, because they can observed directly. Some recent studies have documented the importance of carnivorous mammals in seed dispersal (Willson, 1993; Traveset & Willson, 1997; Hickey et al., 1999). However, the relationship between carnivorous mammals as seed dispersal agents and fleshy-fruit producing plants

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has been somewhat understated, compared with the role of other frugivorous mammals (Herrera, 1989). There are few reports of seed dispersal by other orders of mammals, especially for forest inhabitants, because they are mostly nocturnal or difficult to observe directly.

In Japan, seed dispersal by **Japanese macaque (*Macaca fuscata*)** has been studied intensively among the mammals and shows macaques are important seed dispersers (e.g., Otani, 2003, 2004; Tsuji et al., 2011a). However, the importance of carnivorous mammals in seed dispersal is poorly documented in Japan (e.g., Otani, 2002). Some studies have shown carnivores have features which make them effective seed dispersers. For instance, the sectorial or bunodont cheek teeth of carnivores minimize the damage to seeds (Koike et al., 2008a, 2008b). Also, carnivores disperse seeds longer distances than other animals (Koike et al., 2011). This characteristic would allow carnivores to disperse large numbers of seeds throughout a large area.

Basic data on the number of seeds per fecal sample, which serves as an index of the quantitative effectiveness of seed dispersal (Schupp, 1993), as well as basic information on the physical damage to seeds that pass through a mammal's gastrointestinal tract, which is an index of qualitative effectiveness of seed disperal, are known in Japan for carnivores (Koike et al., 2008b) and macaques (Tsuji et al., 2011a). Koike et al., (2008b) studied five carnivores in the Okutama Mountains (Asiatic black bear (*Ursus thibetanus*), Japanese marten (*Martes melampus*), Japanese badger (*Meles meles*), red fox (*Vulpes vulpes*), and raccoon dog (*Nyctereutes procyonoides*)) and recovered seeds from 17 plant species, representing about 50% of the fleshy-fruited plants occurring in the same study forest, from the carnivore fecal samples. Large numbers (nine to 10,256) of seeds were present in those fecal samples. Almost all the seeds of fleshy fruits retrieved from the fecal samples were undamaged, while no intact acorns or nuts were recovered. These findings suggest all five carnivores can act as seed dispersers for some fleshy-fruited plants in cool-temperate deciduous forests. On the Kinkazan Island in northern Japan, Tsuji et al., (2011a) suggest macaque acts as s seed dispersers in summer and fall. The percentage of intact seeds found in macaques fecal samples was significantly negatively correlated with the seed's mean diameter, and this relationship was strengthened for non-fleshy fruits. This suggests the composition of seeds dispersed by macaques is not rigid, but is determined instead by the vegetation found in a given habitat.

To understand systems of endozoochory, it is also important to consider the feeding period in terms of fruiting phenology. For example, previous studies found a close relationship between the maturation periods of many fleshy-fruited plants and the movement of frugivorous birds in several forest ecosystems (e.g., Thompson & Willson, 1979; Stiles, 1980; Stapanian, 1982; Hererra, 1984; Noma & Yumoto, 1997). Also, some carnivores such as bears, martens, and masked palm civet (*Paguma larvata*) can climb trees to feed on fruits before the fruits drop to the ground. If fruits are ingested after seed maturation, dispersed seeds could germinate. Therefore, whether or not these frugivores are effective seed dispersers can be judged by examining the relationship between the fruit-feeding period of frugivores and the phenology of fruits.

Previous studies indicate bears fed only on mature fruits based on the claw marks left on the stems and the presence of a "bear shelf" (Koike et al., 2008a; Koike, 2009). However, other mammals do not necessary clearly create feeding sign when they consume the ripe fruit. Recently, camera traps have proved useful in the study wildlife ecology. Camera traps are a

non-invasive method of monitoring wildlife which generally cause minimal disturbance to the target species. We can observe nocturnal mammals or mammals sensitive to disturbance by using camera traps.

We chose the fruit of *Prunus jamasakura* Siebold ex Koidz. to answer the questions posed below for three reasons. First, *P. jamasakura* is a common species in the deciduous forest in central Japan (Oba, 1989). Second, *Prunus* is one of the rare woody species bearing fleshy fruits during June–July (Koike, 2009) and, so is probably a common food item for mammals during that time (e.g., Koike, 2010; Tsuji et al., 2011b). Third, the fruiting phenology of *P. jamasakura* is well known (Koike et al., 2008a).

Our objective was to evaluate the effectiveness of temperate zone mammals as potential seed dispersers by estimating the timing of their feeding on the fleshy fruit of *P. jamasakura*. We intended to answer three questions with camera trapping: (1) When do mammals visit *P. jamasakura* trees in relation to the tree's fruiting phenology? (2) Does fruiting phenology influence the mammal's behavior? (3) Which mammals potentially disperse the *P. jamasakura* seeds? We discuss the significance of the mammals as potential seed dispersers for *P. jamasakura* based on our results. We also discuss the relationship between mammalian behavior and fruiting phenology.

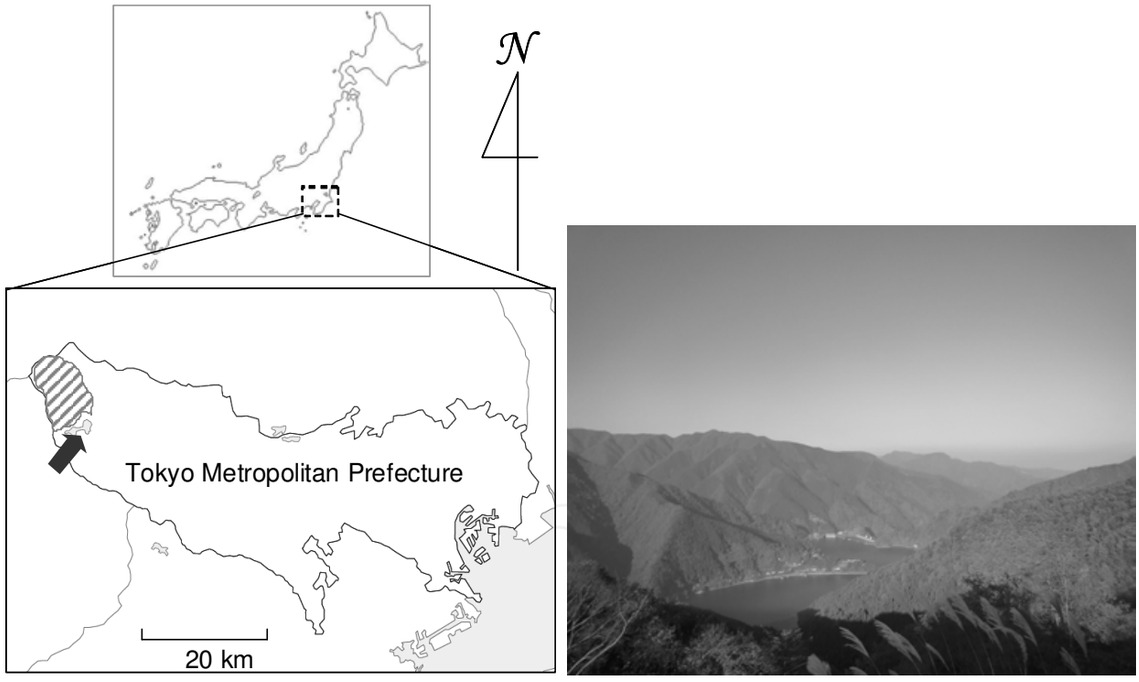


Fig. 1. The study area in an inset map taken from an outline map of Japan (left).
A photograph taken at the position of the arrow in the map (right).

2. Method

2.1 Study area

The study was conducted in the Mine area of the Okutama Mountains, approximately 100 km west of Tokyo central (Fig. 1). The climate of the study area is the coastal Pacific Ocean

type, with heavy rainfall in summer and little snow in winter. The mean annual precipitation is 1,586 mm; mean snowfall ranges from 2 to 4 cm; the mean annual temperature is 11.8 °C, and mean temperatures range from 0.6 °C in January to 24.2 °C in August (Tokyo Environmental Office, 2000).

Forest vegetation covers most of the study area. Natural forests cover 41.3% of the area, and conifer plantations (*Cryptomeria japonica* D. Don or *Chamaecyparis obtusa* (Zieb. et Zucc.) Endlicher) cover 50.3% (Koike, unpubl. data). Natural forests in the lower mountain zone (400–500 m a.s.l.) are dominated by *Castanea crenata* Zieb. et Zucc. and *Quercus serrata* Thunb.; in the middle zone (500–1,500 m a.s.l.) by *Quercus crispula* Blume, *C. crenata*, and *Fagus crenata* Blume; and in the upper zone (1,500–1,800 m a.s.l.) by *Abies homolepis* Zieb. et Zucc. and *Tsuga diversifolia* Masters. The study area was located in a *Q. crispula–C. crenata* community that ranged from 800 to 1,000 m a.s.l. in the middle zone.

2.2 General information

We summarized the information about *P. jamasakura* from Oba, (1989), Mogi et al., (2000), Takeuchi et al., (2005), and Koike, (unpublished data). Known in Japanese as *Yama-zakura*, *P. jamasakura* is a species of cherry native to Japan and Korea, occurring at medium altitudes of up to about 1,000 m in the temperate zone. It prefers sunshine and well-drained soil. This deciduous tree reaches a height of 20–25 m, with a trunk up to 1 m diameter. Its crown spreads to a width of 10–20 m. The flowers are produced in early spring and pollinated by bees.



Fig. 2. The matured fruit of *Prunus jamasakura*. Photo by Motoki Kato.

The fruit is a small drupe, about 10-15 mm in diameter, green at first, then red and finally ripening to black in early summer (Fig. 2). The edible fruit is variably sweet to somewhat astringent and bitter to eat fresh. It contains a single hard-shelled stone 5–12 mm in diameter and 4–8 mm thick with a seed (kernel) inside the stone about 5–8 mm long. The fruits are readily eaten by numerous birds and mammals (Koike & Masaki, 2008; Yoshikawa et al., 2009; Tsuji et al., 2011b), which digest the fruit flesh and disperse the seeds in their droppings. Some rodents and a few birds (notably the *Streptopelia orienta,* Eastern turtle dove) also crack open the stones to eat the kernel (Yagihashi, 2001; Koike, unpublished data).

About 30 species of terrestrial mammals inhabit the Okutama Mountains. The larger ones include Asiatic black bear, Sika deer (*Cervus nippon*), Japanese serow (*Capricornis crispus*), wild boar (*Sus scrofa*), Japanese macaque, red fox, Japanese marten, Japanese badger, masked palm civet, and raccoon dog (Tokyo Environmental Office, 2010). Most of these mammals are carnivores (bears, martens, badgers, foxes, and raccoon dogs); macaques have been recognized as seed dispersers and have been studied in Tokyo (e.g., Koike et al., 2008b; Tsuji 2011).

2.3 Fruiting phenology and defining the flowering date

The fruiting phenology of *P. jamasakura* is known in detail (Ishii, 1991; Koike et al., 2008a) including fruit color, the number of fruits persisting, the fruit and seed size, seed maturation, and the sugar concentration. Ishii, (1991) calculated the *P. jamasakura* fruit maturation period from the flowering date. Below, 'day *n*' represents the date *n* days after the flowering date.

We summarized the information about the fruiting phenology of *P. jamasakura* from Ishii, (1991) and Koike et al., (2008a). All fruits were recorded as green until day 38 for fruit color and bearing number. Red-green fruit then appeared on day 40, followed by red on day 46 and black on day 54. The proportion of persisting fruit decreased gradually until day 60, and then it decreased rapidly. For fruit size and seed size, means of fruit size were not different among fruits of different colors. Fruit size increased from day 10 to 20, from day 34 to 36, and from day 50 to 58. No change in diameter was seen after day 58. Fruit diameter increased in a double sigmoid growth curve and showed three phenological stages. Seed size became measurable beyond day 28, when the endocarp hardened. There was no distinct variation in diameter among fruit colors at the same stage. Seed size was almost constant at all stages. Sugar concentration varied by fruit color and increased as the fruit matured. For seed maturation, no germination was observed until day 44. The percentage rose rapidly on day 50 to 46.1%, and then gradually until day 66. Germination percentages were not different between the differently colored fruit.

We used the method described by Koike et al., (2008a) to determine the flowering day of *P. jamasakura* trees where we set up the camera traps to clarify the fruiting phenology.

In the study area, we chose six *P. jamasakura* trees (DBH > 30 cm) to monitor for flowering once every two days in April 2003 and 2004. We sampled ten branches at random from each sample tree and counted the flowering buds from the tip of each 50 cm long branch while measuring 20 cm wide, 10cm on each side of the branch. The flowering ratio was defined as the

number of flowering buds divided by the total number of buds. When the average flowering ratio reached 80%, that day was designated as the "date of flowering" for each tree. After flowering we checked the fruit color ratio of bearing fruit once every ten days to compare this data with existing data on fruiting phenology (Koike et al., 2008a).

2.4 Estimate of fruit production

In our study area, few suitable trees were available for observing fruit production in detail, because *P. jamasakura* trees form part of the upper tree layer in the forest and the trees grow on steep slopes. Therefore, we used the simpler method of estimating fruit production in the study areas even though it was only an indicator of fruit production. We used the methods described by Mizui, (1993). We used binoculars to sample five randomly selected branches from each sample tree and counted the fruits on each branch within a range of about 50 cm length and about 20 cm width (10cm each side of the branch) from the tip of the branch. We counted the fruits once between day 40 and day 50.

2.5 Camera trap survey

While investigating fruiting phenology, we recorded the frequency of visits by mammals under the crown of each target tree. An automatic camera trap (Fieldnote, Marifu Co. Iwakuni City, Japan) was set up 1.5 m above the ground (Fig. 3). One camera was set up next to each tree using the tree as a target in as flat an area as possible. We set five cameras in total. Cameras operated 24 hr per day. To avoid running out of film, we checked the film twice a week from late April to the middle of August 2003 and 2004. To avoid duplicate counts, we defined conspecific animals recorded within a 30 minute period as the same individual (O'Brien et al., 2003).

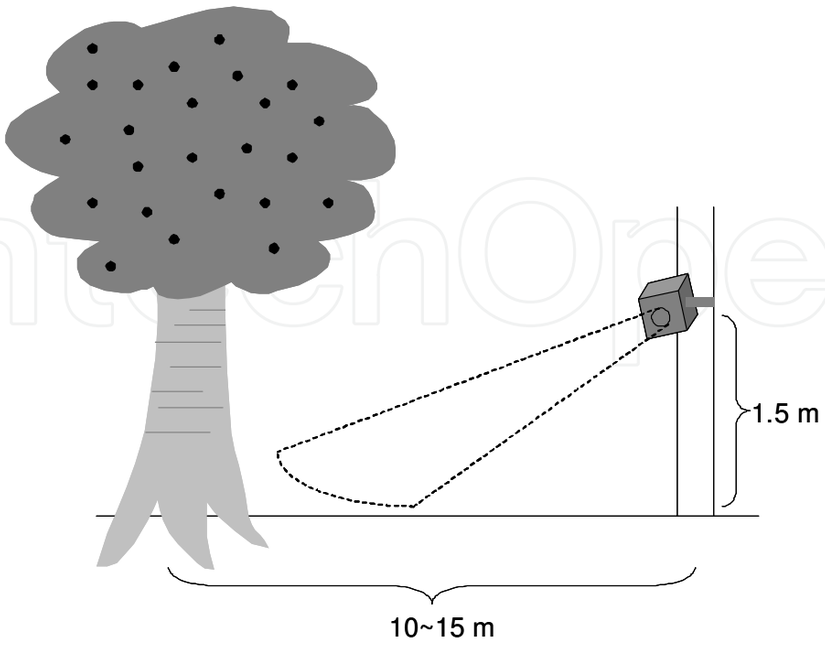


Fig. 3. The setup of an automatic camera trap.

3. Result

3.1 Fruiting phenology and estimate of fruit production

The flowering dates of the sample trees were 24 to 30 April, 2003, and were 27 to 30 April, 2004. There were no differences in the fruit color ratio of bearing fruit after the day of flowering between this study and a previous study (Koike et al., 2008a). We used the date starting at the flowering day to count to the fruit maturation date. The period of fruit maturation was between day 50 and day 66 was after 14 June in 2003 and after 17 June in 2004.

Year	Tree Number	*Fruit production		Number of photographs					
		2003	2004	Bear	Marten	Badger	Fox	Raccoon dog	Civet
2003 - 2004	1	30.0 ± 7.9	3.0 ± 2.0	0,0	3,1	0,0	0,0	0,0	1,0
	2	75.6 ± 9.1	31.2 ± 19.2	2,2	5,1	1,0	1,0	0,0	2,1
	3	70.8 ± 13.8	11.8 ± 3.8	2,1	4,1	0,0	2,0	0,0	2,0
	4	69.6 ± 18.3	2.6 ± 0.8	2,0	4,0	0,0	1,1	0,0	2,0
	5	53.6 ± 18.6	21.4 ± 12.7	1,2	5,1	0,0	0,0	0,0	3,2
	6	46.2 ± 18.9	1.4 ± 0.8	0,0	1,0	0,0	0,0	0,0	1,0
	Total			7,5	22,4	1,0	3,2	0,0	11,3

Number of photographs					
Boar	Deer	Serow	Macaque	Squirrel	Rodent
0,0	5,4	0,1	0,0	7,0	5,2
1,1	4,4	1,0	1,0	7,0	3,4
0,0	4,5	0,1	0,0	11,0	3,1
1,0	4,5	0,2	1,0	8,0	5,3
1,0	3,4	0,0	0,0	12,0	4,4
0,0	1,3	0,0	0,0	8,0	5,4
3,1	21,25	1,4	2,0	53,0	25,18

Number of photographs					
Pheasant	Jay	Thrush	Unknown	Total: 2003	Total: 2004
1,0	1,0	2,0	0,0	25	8
0,0	2,0	2,0	0,0	29	14
0,0	0,0	3,0	1,0	30	9
1,0	1,0	3,0	0,0	31	11
0,0	0,0	1,0	1,0	30	13
0,0	1,0	1,0	0,0	18	7
2,0	4,0	12,0	2,0	169	62

Bear, *Ursus thibetanus;* marten, *Martes melampus*; badger, *Meles meles:* fox, *Vulpes vulpes*; raccoon dog, *Nyctereutes procyonoides*; civet, *Paguma larvata*; boar, *Sus scrofa*; deer, *Cervus nippon*; serow, *Capricornis crispus*; squirrel, *Sciurus lis*; macaque, *Macaca fuscata*; rodent, *Apodemus speciosus*; pheasant, *Syrmaticus soemmerringii*; jay, *Garrulus glandarius*; and thrush, *Turdus cardis*.

Table 1. Estimated fruit production of each target tree and the number of photographs of each vertebrate species photographed by automatic cameras under the crown of each target tree, 2003 and 2004. *See text for fruit production calculation.

The average fruit production (number of fruits per tip of the branch) of target trees were 57.6±17.6 (SD) in 2003, and 11.9±12.2 (SD) in 2004 (Table 1).

3.2 Camera trap survey

During two year study, the camera traps took the total of 915 photographs. We could identify mammals in 204 photographs and birds in 18 photographs during the four-month period after the flowering. Table 1 provides a summary of the species seen each year (Fig. 4).

The cameras captured a smaller number of photographs in 2004 than in 2003. We calculated the correlations between fruit production of each tree and number of photographs for some mammal species at each tree, and we can recognize the correlation between fruit production and number of photographs for some species: values are R^2; bears, 0.40 (P=0.02); martens, 0.75 (P<0.01); civets, 0.65 (P=0.01): boars, 0.36 (P=0.03); squirrels (*Sciurus lis*), 0.75 (P<0.01), and macaques, 0.40 (P=0.02). A poor correlation exists between fruit production and number of photographs for some species: values are R^2: foxes, 0.12 (P=0.26); deer, 0.05 (P=0.46); and rodents (*Apodemus* spp), 0.11 (P=0.27). Also a poor correlation exists between fruit production and number of the photographs of deer after day 50 (R^2 = 0.10, P=0.29).

Next, we compared the timing of the sightings of bears, martens, civets, foxes, boars, and deer with the number of days after the initiation of flowering (Fig. 5). Over 90% of the photographs of bears, martens, and civets were taken between day 50 and day 66 (Fig. 5). For foxes and boars, most photographs were taken after day 60 (Fig. 5).

Deer sightings peaked between day 70 and day 80. However, deer were documented immediately after flowering and were recorded periodically throughout the study (Fig. 5). We could not confirm whether each vertebrate species was photographed with fruits in its mouth.

4. Discussion

In this study, the photographs did not necessarily confirm the mammals actually ate fruits. However, because there are correlations between fruit production and the number of photographs for some mammal species, we can conclude these mammals visited the trees to eat the *P. jamasakura* fruit.

In this study, the cameras captured a smaller number of photographs in 2004 than in 2003. One reason for this may be the difference of fruit production. In 2004, the target trees produced a smaller amount of fruit than in 2003. Also, a correlation exists between fruit production and number of photographs for bears, martens, civets, squirrels, and macaques. These results indicate these mammal species moved and selected trees depending on the fruit production of each tree. For pine martens (*Martes martes*) in Mediterranean area, crop size was correlated with the frequency of occurrence and the proportion of fruits by volume in feces. Pine martens feed on fallen fruit and appeared to choose trees with a higher density of fruits under the canopy, that is, trees that produced larger crops (Guitian & Munilla, 2010). Tsuji, (2010) reported Japanese macaques change their home range, move, or select trees

depending on the availability of food generally and on the fruit production of each tree. There are no reports on the feeding behavior of bears that indicating bears select trees depending on the food availability of each tree. However, it is known bears can change their diet and movement behavior frequently depending on fruit production (Hashimoto, 2002; Hashimoto et al., 2003; Koike, 2010; Kozakai et al., 2011; Arimoto et al., in press).Thus bears may select trees based on the difference in fruit production for each individual tree. Our results indicate for the first time that the amount of fruit production of each tree may

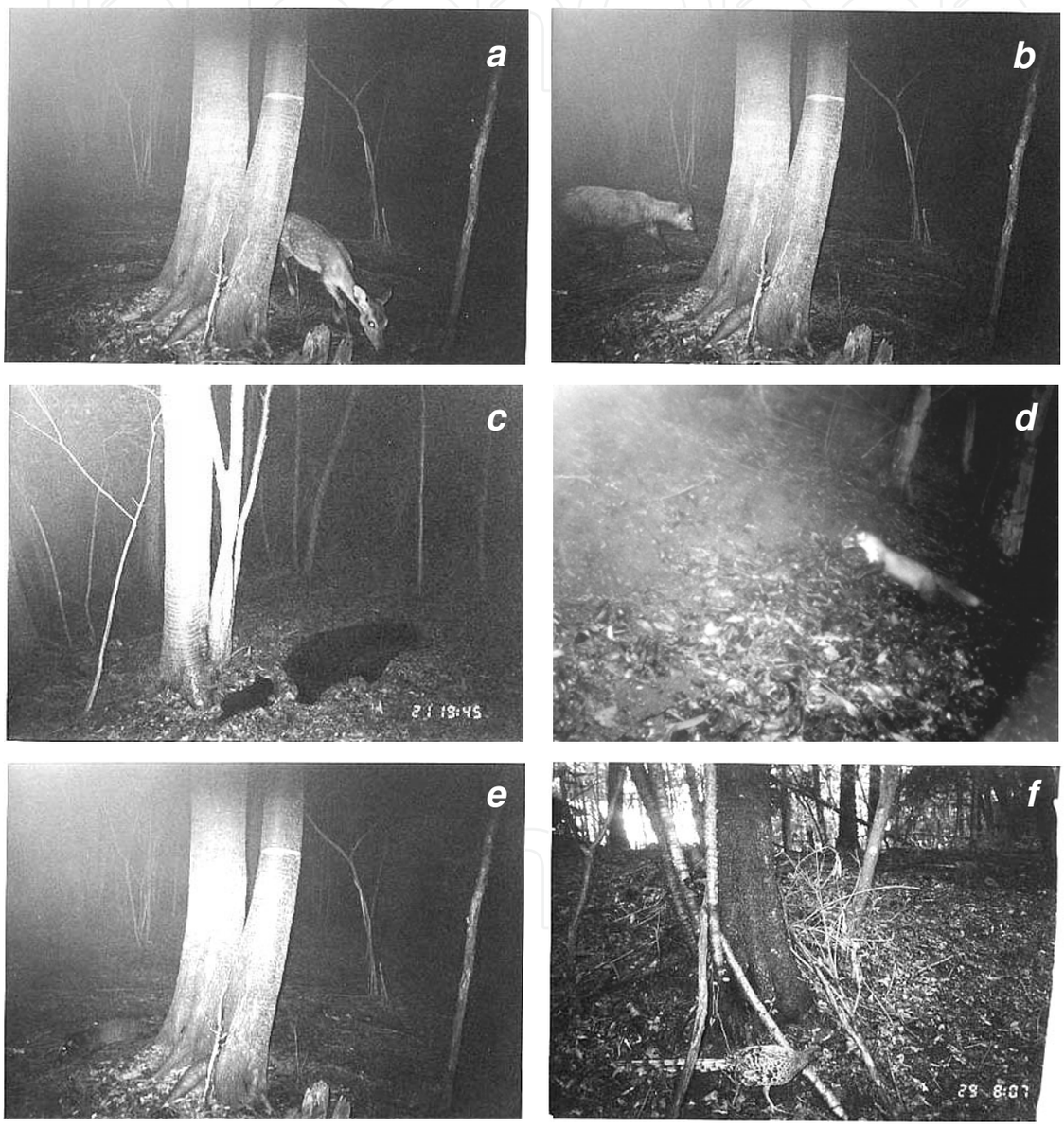


Fig. 4. Sample camera trap photographs of verteblates as they visit under the crowns of *Prunus jamasakura* trees.(a) deer (*Cervus nippon*); (b) serow (*Capricornis crispus*); (c) bear with cub (*Ursus thibetanus*); (d) marten (*Martes melampus*); (e) is civet (*Paguma larvata*); (f) pheasant (*Syrmaticus soemmerringii*).

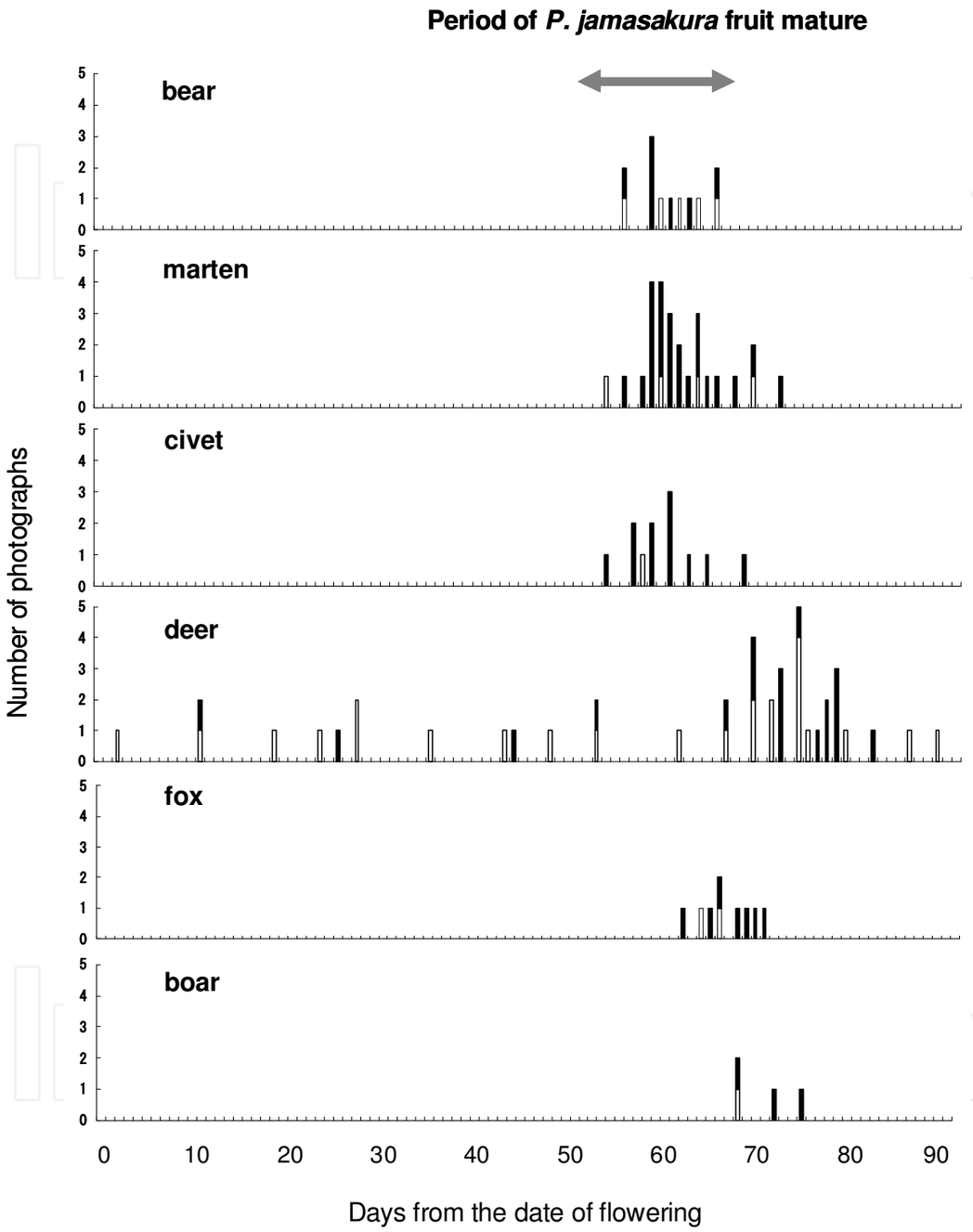


Fig. 5. Relationships between the number of days after the initiation flowering and number of photographs of major mammals under the crowns of *Prunus jamasakura* trees. The period of *P. jamasakura* fruit maturation (maximum of fruit size, sugar concentration, and seed germination) is based on Koike et al., (2008a). Black bar is data of 2003, white bar is data of 2004.

influence individual tree selection by bears; although this result doesn't necessarily clearly demonstrate bears have selective feeding behavior. The ecology of civets in Japan is poorly known (Ohdachi et al., 2009). However, in Southeast Asia, civets are also known to change food items frequently depending on fruit production (Zhou et al., 2008) although the level of fruit production may influence the feeding behavior of civets in Japan. Because some reports indicate squirrels consume the seeds (Ohdachi et al., 2009), squirrels may feed on the fruit of *P. jamasakura*, especially seeds, although documentation of food selection habits of squirrels is lacking. In this study, we recorded many squirrel photographs in 2003, but none in 2004. Because there are no other factors of environmental change such as increases in logging in the study area, fluctuations in the availability of mast may seriously influence the behavior of squirrels.

A poor correlation exists between fruit production and number of photographs for foxes, deer, and rodents. In general, foxes do not inhabit only forest, and they depend strongly on animal food sources (Ohdachi et al., 2009). Also, foxes were not frequently photographed, so the amount of fruit might not affect their behavior much. It is unknown whether deer eat the fruit of *P. jamasakura* or not. Because deer primarily fed on herbaceous plants (Ohdachi et al., 2009), and the presence of deer was recorded before the fruit matured, the fluctuation of fruit production might not affect their behavior. There was also poor correlation between rodent sightings and fruit production. Because rodents eat a variety of foods (Ohdachi et al., 2009), fluctuations in fruit production in one tree species might not affect their behavior. Future research is needed to document the importance of fleshy fruit such as *P. jamasakura* fruit as a food resource for deer and rodents.

Most mammals except deer were photographed after day 50. Koike et al., (2008a) indicated bears consume fruit with high energy content around day 60. The peak for photographs of bears, martens, and civets was between day 50 and day 70. This was earlier than photographs of deer, boars, and foxes. Previous studies indicated the proportion of persisting fruit decreased gradually until day 60, then decreased rapidly by 64.7% in the next 10 days (Koike et al., 2008a). Because bears, martens, and civets can climb tall trees (Hosoda & Tatara, 1996; Huygens et al., 2003; Ohdachi et al., 2009), they can feed on the fruit before it falls. On the other hand, because deer, boars, and foxes cannot climb trees well they feed mainly on fallen fruit. These results indicate the frequency or the peak of photographs of mammalian species reflects their ecological characteristics such as climbing ability and habitat preference.

We show mammals, aside from deer, were recorded after day 50 and they have potential to feed on fruit including mature seed. Previous studies indicate carnivores such as bears, martens foxes, and civets can act as seed disperses for some fleshy-fruited plants (Koike et al., 2008b; Nakashima et al., 2010). This paper clarifies these mammals are not seed eaters in that they don't eat fruit with immature seeds. Although few studies of seed dispersal by ungulates (endozoochory) have been made in Britain, deer have been shown to be effective seed dispersers for a number of plant species. Recent research shows deer do function as seed dispersal agents (Malo et al., 2000; 2001; Myers et al., 2004; Brathen et al., 2007).

5. Conclusions

We investigated the relationship between the fruit phenology of *Prunus jamasakura* and the fruit feeding period of mammals. Our research cannot confirm actual feeding behavior.

However, because the most of photographs for some mammal species were recorded during fruit mature period, we can conclude these mammals visited the trees to eat the *P. jamasakura* fruit. And, these results indicate that some mammal species are potentially effective seed dispersers. We suggest the combination of information gained from camera trap data with information related to fruiting phenology and fruit production will make more intelligent discussion of these relationships possible. Future similar research on other tree species and in other regions will facilitate research related to vertebrate forest ecology by obtaining data that is difficult to observe directly.

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7. References

Arimoto, I., Goto, Y., Nagai, C., & Furubayashi, K. (in press). Autumn food habits and home-range elevations of Japanese black bears in relation to hard mast production in the beech family in Toyama Prefecture. *Mammal study*

Brathen, KA., Gonzalez, VT., Iversen, M., Killengreen, S., Ravolainen, VT., Ims, RA., & Yoccoz, NG. (2007). Endozoochory varies with ecological scale and context. *Ecography,* 30, 308–320.

Castilla, AM. (2000). Does passage time through the lizard *Podarcis lilfordi*'s gut affect germination performance in the plant *Withania frutescens*?. *Acta Oecologia,* 21, 119–124.

Corlett, RT. (1998). Frugivory and seed dispersal by vertebrates in the Oriental (Indomalayan) Region. *Biological Reviews*, 73, 413-448.

Dennis, A., Schupp, E., Green, R., & Westcott, D. (eds) (2007). *Seed dispersal: theory and its application in a changing world.* CAB International Publishing, UK, Wallingford.

Estrada, A., & Coates-Estrada, R. (1984). Fruit eating and seed dispersal by howling monkeys (*Alouatta palliata*) in the tropical rain forest of Los Tuxtlas, Mexico. *American Journal of Primatology,* 6, 77–91.

Estrada, A., & Fleming, T. (eds) (1986). *Frugivores seed dispersal.* Dr. W. Junk Publishers, The Netherlands, Dordrecht.

Fleming, TH. (1981). Fecundity, fruiting pattern, and seed dispersal in *Piper amalago*, a bat-dispersed tropical shrub. *Oecologia*, 16, 42–46.

Fleming, T., & Estrada, A. (eds) (1993). *Frugivory and seed dispersal: ecological and evolutionary aspects.* Kluwer Academic Publishers, The Netherlands, Dordrecht.

Gottsberger, G. (1978). Seed dispersal by fish in the inundated regions of Humaita, Amazonia. *Biotropica*, 10, 170–183.

Guitián, J., & Munilla, I. (2010). Responses of mammal dispersers to fruit availability: Rowan (*Sorbus aucuparia*) and carnivores in mountain habitats of northern Spain. *Acta Oecologia,* 36, 242–247.

Gribel, R. (1988). The shape of bird- and bat-generated seed shadows around a tropical fruiting tree. *Biotropica*, 20, 347–348.

Hashimoto, Y. (2002). Seasonal food habits of the Asiatic black bear (*Ursus thibetanus*) in the Chichibu Mountains, Japan. *Mammal Study*, 27, 65–72.

Hashimoto, Y., Kaji, M., Sawada, H., & Takatsuki, S. (2003). A five year study on fall food habits of the Asiatic black bear in relation to nut production. *Ecological Research*, 18, 485-492.

Herrera, CM. (1984). A study of avian frugivores, birddispersed plants, and their interaction in Mediterranean scrublands. *Ecological Monograph*, 54, 1–23.

Herrera, CM. (1989). Frugivory and seed dispersal by carnivorous mammals, and associated fruit characteristics, in undisturbed Mediterranean habitats. *Oikos*, 55, 250–262.

Herrera, CM. (2002). Seed dispersal by vertebrates. In: *Plant-animal interactions: an evolutionary approach,* Herrera, CM., & Pellmyr, O. (eds), pp. 185–208, Blackwell Science, Oxford.

Hickey, JR., Flynn, RW., Buskirk, SW., Gerow, KG., & Willson, MF. (1999). An evaluation of mammalian predator, *Martes americana*, as a disperser of seed. *Oikos*, 87, 499–508.

Hosoda, T., & Tatara, M. (1996). Japanese marten and sable. In: *The encyclopaedia of animals in Japan, Vol. 2 Mammals, Part 1,* Izawa, K., Kasuya, T., & Kawamichi, T. (eds), pp. 136–139, Heibonsya, Tokyo. (In Japanese)

Howe, HF. (1980). Monkey dispersal and waste of a Neotropical fruit. *Ecology*, 61, 944–959.

Howe, HF., & Smallwood, J. (1982). Ecology of seed dispersal. *Annual Review of Ecology and Systematics*, 13, 201-228.

Howe, HF. (1986). Seed dispersal by fruit-eating birds and mammals. In: *Seed Dispersal*, Murray, DR. (ed), pp. 123–189, Academic Press, New York.

Howe, HF., & Westley, LC. (1988). Ecological relationships of plants and animals. Oxford University Press, New York.

Huygens, OC., Miyashita, T., Dahle, B., Carr, M., Izumiyama, S., Sugawara., T., & Hayashi, T. (2003). Diet and feeding habits of Asiatic black bears in the Northern Japanese Alps. *Ursus,* 14, 236–245.

Ishii, Y. (1991). Methods of seed handling in cherry trees, *Prunus* species. *Forest Tree Breeding*, 161, 7–12. (In Japanese)

Izhaki, I., Korine, C., & Arad, Z. (1995). The effect of bat (*Rousettus aegyptiacus*) dispersal on seed germination in eastern Mediterranean habitats. *Oecologia*, 101, 335–342.

Jordano, P. (1995). Angiosperm fleshy fruits and seed dispersers: a comparative analysis of adaptation and constraints in plant-animal interactions. *American Naturalist*, 145, 163–191.

Koike, S., & Masaki, T. (2008). Frugivory of Carnivora in central and Southern parts of Japan analyzed by literature search. *Journal of Japanese Forest Socience*, 90, 27–36. (In Japanese with English abstract)

Koike, S., Kasai, S., Yamazaki, K., & Furubayashi, K. (2008a). Fruit phenology of *Prunus jamasakura* and the feeding habit of Asiatic black bear as a seed disperser. *Ecological Research*, 23, 385-392.

Koike, S., Morimoto, H., Goto, Y., Kozakai, C., & Yamazaki, K. (2008b). Frugivory of carnivores and seed dispersal of fleshy fruits in cool-temperate deciduous forests. *Journal of Forest Research,* 13, 215-222.

Koike, S. (2009). Fruiting phenology and its effect on fruit feeding behavior of Asiatic black bears. *Mammal Study,* 34, 47-52.

Koike, S. (2010) Long-term trends in food habits of the Asiatic black bear in the Misaka mountains, Japan. *Mammalian Biology,* 75, 17-28.

Koike, S., Masaki, T., Nemoto, Y., Kozakai, C., Yamazaki, K., Kasai, S., Nakajima, A., & Kaji, K. (2011). Estimate of the seed shadow created by the Asiatic black bear (*Ursus thibetanus*) and its characteristics as a seed disperser in Japanese cool-temperate forest. *Oikos,* 120, 280-290.

Kozakai, C., Yamazaki, K., Nemoto, Y., Nakajima, A., Koike, S., Abe, S., Masaki, T., & Kaji, K. (2011). Effect of mast production on home range use of Japanese black bears. *Journal of Wildlife Management,* 75, 867-875.

Levey, D., Silva, W., & Galetti, M. (eds) (2001). *Frugivores and seed dispersal: ecological, evolutionary, and conservation issues*. CAB International, UK, Wallingford.

Malo, JE., Jimenez, B., & Suarez, F. (2000). Herbivore dunging and endozoochorous seed deposition in a Mediterranean dehesa. *Journal of Range Management,* 53, 322–328.

Mizui, N. (1993). Ecological studies on reproduction in deciduous broadleaved tree species. *Bulletin of Hokkaido Forestry Research Institute*, 30, 1–67. (In Japanese)

Mogi, T., Katsuyama, T., Ota, K., Sakio, H.,Takahashi, H.,Ishii, H., Kigawa, S., & Nakagawa, S. (2000). *Flowers bloom in woody plants 1*. Yamatokeikoku-sya, Tokyo, Japan. (In Japanese)

Myers, JA., Vellend, M., Gardescu, S., & Marks, PL. (2004). Seed dispersal by white-tailed deer: implications for long-distance dispersal, invasion, and migration of plants in eastern North America. *Oecologia,* 139, 35–44.

Nakashima, Y., Inoue, E., Inoue-Murayama, M., Rafiah, J., & Sukor, A. (2010). Functional uniqueness of a small carnivore as seed dispersal agents: a case study of the common palm civets in the Tabin Wildlife Reserve, Sabah, Malaysia. *Oecologia*, 164, 721-730.

Noma, N., & Yumoto, T. (1997). Fruiting phenology of animal-dispersed plants in response to winter migration of frugivores in a warm temperate forest on Yakushima Island, Japan. *Ecological Research*, 12, 119–129.

Oba, H. (1989). *Prunus*. In: *Wild Flowers of Japan – Woody Plants*, Satake, Y., Hara, H., Watari, S., & Tominari, T. (eds), pp. 186–198, Heibonsya, Tokyo. (In Japanese)

O'Brien, TG., Kinnaird, MF., & Wibisono, HT. (2003). Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. *Animal Conservation*, 6, 131-139.

Ohdachi, SD., Ishibashi, Y., Iwasa, MA., & Saitoh, T. (eds) (2009) *The Wild Mammals of Japan*. Shoukadoh, Kyoto, Japan.

Otani, T. (2002). Seed dispersal by Japanese marten, *Martes melampus*, in the subalpine shrubland of northern Japan. *Ecological Research,* 17, 29-38.

Otani, T. (2003). Seed dispersal and predation of fleshy-fruited plants by Japanese macaques in the cool temperate zone of northern Japan. *Mammal Study,* 28, 153-156.

Otani, T. (2004). Effects of macaque ingestion on seed destruction and germination of a fleshy-fruited tree, *Eurya emarginata*. *Ecological Research,* 19, 495-501.

Schupp, EW. (1993). Quantity, quality and the effectiveness of seed dispersal by animals. *Vegetatio*, 107/108, 15–29.

Stapanian, MA. (1982) Evolution of fruiting strategies among fleshy-fruited plant species of eastern Kansas. *Ecology*, 63, 1422–1431.

Stiles, EW. (1980). Patterns of fruit presentation and seed dispersal in bird-disseminated woody plants in the eastern deciduous forest. American Naturalist, 116, 670–688.

Takeuchi, M., Iijima, K., & Tamura, M. (2005). *Organisms around the cherry*.Tokyo Agriculture University Press, Tokyo, Japan. (In Japanese)

Tokyo Environmental Office. (2000) *The environment in Tokyo*, 2000. Tokyo Metropolitan Government, Tokyo. (In Japanese)

Tokyo Environmental Office. (2010). *The Reddata book in Tokyo*, 2010. Tokyo Metropolitan Government, Tokyo. (In Japanese)

Thompson, JN., & Willson, MF. (1979). Evolution of temperate fruit/bird interactions: phenological strategies. *Evolution*, 33, 973–982.

Traveset, A., & Willson, MF. (1997). Effect of birds and bears on seed germination of fleshy-fruited plants in temperate rainforests of southeast Alaska. *Oikos*, 80, 89–95.

Tsuji, Y. (2010). Regional, temporal, and inter-individual variation in the feeding ecology of Japanese macaques. In: *Japanese Macaques*, Nakagawa, N., Nakamichi, M., & Sugiura, H. (eds.), pp. 95-123, Springer, Tokyo.

Tsuji, Y. (2011). Seed dispersal by Japanese macaques *(Macaca fuscata)* in western Tokyo, Japan: a preliminary report. *Mammal Study,* 36, 165-168.

Tsuji, Y., Sato, K., & Sato, Y. (2011a). The role of Japanese macaques *(Macaca fuscata)* as endozoochorous seed dispersers on Kinkazan Island, northern Japan. *Mammilian Biolology*, 76, 525-533.

Tsuji, Y., Wada, K., & Watanabe, K. (2011b). Woody Plants Eaten by Wild Japanese Macaques. *Primate Research*, 27, 27-49. (In Japanese)

Willson, MF. (1993). Mammals as seed-dispersal mutualists in North America. *Oikos*, 67, 159–176.

Yagihashi, T. (2001). Effect of bird ingestion on seed germination of arboreal plants in Hokkaido, Japan. *Research Bulletin of the Hokkaido University Forest*, 58, 37–59. (In Japanese with English abstract)

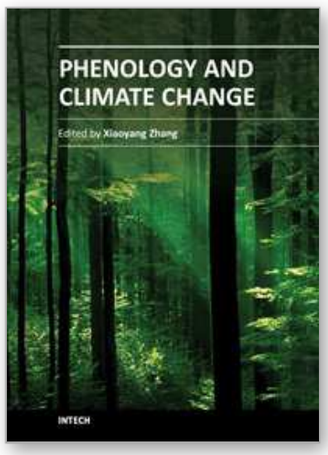
Yoshikawa, T., Isagi, Y., & Kikuzawa, K. (2009). Relationships between bird-dispersed plants and avian fruit consumers with different feeding strategies in Japan. *Ecological Research*, 24, 1301-1311.

Yumoto, T., Noma, N., & Maruhashi, T. (1998). Cheek-pouch dispersal of seeds by Japanese monkeys (*Macaca fuscata yakui*) on Yakushima Island, Japan. *Primates,* 39, 325–338.

Zhou, YB., Zhang, JS., Slade, E., Zhang, LB., Palomares, F., Chen, J., Wang, XM., & Zhang, SY. (2008). Dietary shifts in relation to fruit availability among masked palm civets *(Paguma larvata)* in central China. *Journal of Mammalogy*, 89, 435–447.

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Phenology, a study of animal and plant life cycle, is one of the most obvious and direct phenomena on our planet. The timing of phenological events provides vital information for climate change investigation, natural resource management, carbon sequence analysis, and crop and forest growth monitoring. This book summarizes recent progresses in the understanding of seasonal variation in animals and plants and its correlations to climate variables. With the contributions of phenological scientists worldwide, this book is subdivided into sixteen chapters and sorted in four parts: animal life cycle, plant seasonality, phenology in fruit plants, and remote sensing phenology. The chapters of this book offer a broad overview of phenology observations and climate impacts. Hopefully this book will stimulate further developments in relation to phenology monitoring, modeling and predicting.

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