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Intake rate of captive masked palm civets on large-sized cultivated fruit, Japanese persimmon

Chinatsu Kozakai[*1], Ayaka Hata[*1], Midori Saeki[*1], Masahiko Takeuchi[*1], Hironori Ueda[*2] and Yusuke Eguchi[*2]

I. Introduction

Cultivated crops can be excellent food resources for wildlife because they are usually larger in size and more nutritious than natural foods. However, only few attempts have been made to quantify the nutrient value of cultivated crops for wildlife (Borchet et al. 2008 , Kozakai et al. 2018). Higher birth rate and lower infant mortality were reported in troops of Japanese macaque (*Macaca fuscata*) that were dependent on crops (Hanya et al. 1997). A similar situation can arise for invasive mammal species in Japan such as masked palm civet (*Paguma larvata*) (hereafter civet) and raccoon (*Procyon lotor*). Distributions of civet and raccoon have expanded during the past decade in Japan (Biodiversity Center of Japan 2018). We need to evaluate beneficial effects of cultivated crops for these invasive mammals. This is important for crop damage control and animal population management.

Animals will minimize time and energy expenditures for food gathering while maximizing digestible energy intake (Robbins 1993). Thus, energy efficiency is one of the indices used to assess food value for wildlife. To calculate energy efficiency, a) the energy content of food per unit weight of the food and b) the food intake rate of animals need to be obtained. For the former, we can use data of human food composition for cultivated crops (The Ministry of Education, Culture, Sports, Science and Technology of Japan, 2015). For the latter, several approaches can be taken. The ingestion pattern (i.e., how food is taken into the mouth) depends largely on the condition and size of the food item (Hiiemae et al. 1985). The small-sized fruits and leaves may simply be picked up and plucked by animals. The occurrence rate of certain feeding events such as bite can be a good variable to calculate intake rate for these food items: for example, the intake rate (g/min) can be calculated by multiplying bite size (amount of food intake per bite, g/bite) by bite rate (bites/min). The main foods of civets and raccoons are fruits (Torii 1986, Matsuo et al. 2009, Iwama et al. 2017). We recently researched the energy intake in orchard dump sites of strawberries (*Fragaria* spp.) and found that discarded strawberries have very high energy efficiency for the invasive mammals (Kozakai et al. 2018). For example, civets ate almost 6.0 strawberries per minute, the median feeding efficiency was 144 . 7 kJ/min, and the necessary time to obtain the daily energy requirement was as low as 13 minutes if they consumed 15 g of strawberries (Kozakai et al. 2018). For strawberries, we could obtain both bite size and bite rate using remote video cameras at orchard dump sites because medium-sized mammals usually eat a whole or

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*1 Central Region Agricultural Research Center, NARO
*2 Western Region Agricultural Research Center, NARO

half of a strawberry per bite.

On the other hand, medium-sized mammals would ingest large-sized cultivated fruits, such as kaki/Japanese persimmon (*Diospyros kaki*) (hereafter, kaki), apple (*Malus pumila*) and peach (*Amygdalus persica*), with more complex movements of the jaw (including teeth and muscles) and tongue than those of smaller food items such as strawberries. When the animals do not ingest the fruits with bites only, we need a different parameter of bite size/rate to obtain the intake rate: for example, we can calculate intake rate by using the duration time of ingestion behavior. Even if the animals ingested large-sized fruits by simply biting, the bite size is difficult to measure via remote video cameras in the field. To the best of our knowledge, no previous studies have investigated bite size in medium-sized Carnivora.

The purpose of this study was to evaluate energy value of kaki fruits, a large-sized cultivated fruit, on civets. We first determined standard values of fruit intake rate using captive civets to apply to wild civets. We then calculated realistic intake rate of the captive civets. We conducted feeding experiments assuming a condition that the kaki fruits are on the ground (e.g., fruits at orchard dump site and on the ground under trees). The ingestion pattern of fruits by civets could change according to the flesh hardness, as was the case in a study of frugivorous bats (Dumont 1999). Thus, we conducted experiments with two types of hardness (relatively-hard and relatively-soft kaki fruits) and tested whether the intake rate of civets varied with fruit hardness. We used civets in this study; we have captive civets in the facility, while we do not have raccoons that are suitable for our research. Kaki fruits are eaten by civets (Torii et al. 1986, Iwama et al. 2017) and have a large market (cultivation area of 20,900 ha, annual yield of 232 , 900 t; Ministry of Agriculture, Forestry and Fisheries, Japan, 2016 statistics). In addition, kaki trees are popular for home gardening. The availability of kaki fruits for civets and the other wildlife is probably very high in Japan.

II. Methods

1. Animals and housing conditions

We used 11 (seven females and four males) civets at the Oda Research Center (Oda City, Shimane Prefecture) of the Western Region Agricultural Research Center (Table 1). The animals were caught 7 to 10 years ago in Saitama Prefecture and were regarded as adults. Body weight ranged from 2.85 to 4.15 kg in females and 2.50 to 4 . 35 kg in males. Differences between body weight during the experiment and average body weight over the last 2 years were -0.25 to 0.30 kg (Table 1). There were no individuals that had a large fluctuation (> 10 %) of body weight.

The animals were housed in individual cages (hereafter, home cage) indoors with an air conditioner. The home cages (W 540 ×H 525 ×D 750 mm) were made of metal mesh with a sliding door at the front. Except for during the experimental period, the animals were fed dog food (200 to 300 g) between 09:00 and 10:00 a.m. All animals had access to water ad libitum. The experimental procedures were approved by the institutional ethical animal care and use committee of the Western Region Agricultural Research Center, NARO (Protocol No. 17 Chojugai 05).

2. Fruits for experiments

We purchased kaki fruits that were as uniform in size and volume as possible from a farmer. For fruits (n = 44) that we used in the test session, the mean (±SD) fruit weight, vertical fruit diameter and horizontal fruit diameter were 145 . 5 ± 8 . 0 g, 69 . 9 ± 1 . 6 mm, and 52.2±2.7 mm, respectively. Each morning during the test session, we determined flesh hardness at three positions (one on the top and two on the sides) per fruit using a penetrometer with a 12 -mm-diameter conic cylinder (KM- 5 ; Fujiwara Scientific Co., Tokyo, Japan) and the sugar concentration at two points per fruit using a Brix meter (Pen-J; Atago Co., Tokyo, Japan). The sugar concentration of all fruits was higher than 13 %. We assumed that hard fruits were relatively difficult to eat, and soft fruits were relatively easy to eat. To ensure the soft fruits were easy to eat, we cut 2 cm from the top of

Table 1. Body weight and age of masked palm civets used in this study

Animals	Sex	Body weight (kg)					Age[2)] (years)
		Experiment	The last 2 years			Gain and loss[1)]	
			Mean	SD	Range		
F1	Female	2.85	2.94	0.13	2.70-3.30	-0.09	11
F2	Female	3.00	3.14	0.13	2.95-3.40	-0.14	10
F3	Female	3.05	3.30	0.23	3.05-3.75	-0.25	8
F4	Female	3.75	3.82	0.15	3.60-4.15	-0.07	9
F5	Female	3.80	4.05	0.25	3.60-4.45	-0.25	7
F6	Female	4.05	4.01	0.27	3.50-4.40	0.04	10
F7	Female	4.15	3.92	0.23	3.50-4.30	0.23	10
M1	Male	2.50	2.58	0.15	2.40-2.95	-0.08	10
M2	Male	2.50	2.75	0.24	2.40-3.25	-0.25	Unknown
M3	Male	2.90	2.88	0.25	2.55-3.35	0.02	9
M4	Male	4.35	4.05	0.37	3.20-4.65	0.30	8

[1)] Body weight during the experiment - mean of body weight over the last 2 years

[2)] Estimated age at capture + housing period

soft fruit and exposed the surface of the flesh (Fig. 1) after the hardness measurements. The flesh hardness of the fruits was as follows: the mean hardness of hard fruits (n = 22) was 1.07 kg/cm3 (range = 0.70 to 1.85) and that of soft fruits (n = 22) was 0.24 kg/cm3 (range = 0.22 to 0.55).

3. Procedure

We had a training session to acclimate the animals to eating kaki fruits of similar size and hardness as the hard fruits described above for 7 days between December 7 th and 22 nd, 2018 . During the first 5 days of the training session, we fed the animals one fruit per day without attaching the fruit to the cage. To record feeding behavior of the animals, we needed to keep the fruits in the front of the cage during the latter 2 days of the training session. We used a string to connect the fruit and a loop clutch (Fig. 2). We used a curved needle to put the string under the calyx of the fruit. The length of the string between the fruit and the loop clutch was 10 cm. Furthermore, the trainings during the latter 2 days of the training session were conducted after moving the animals from the home cage to a testing cage (Fig. 3). The size and structure of the testing cage was the same as the home cages. The animals ate most of the provided fruit in the early days of the training session. Because one male (ID: M2) took a long time to start feeding in the testing cage, we conducted the test for this male in the home cage.

We first conducted the test session with hard fruits for 2 days and then with soft fruits for 2 days from December 25th to 28th, 2018, from 09:00 a.m. to 12:00 p.m. every day. We weighed the fruit with the string and loop clutch and set the fruit with the loop clutch and string down on its calyx. The loop clutch can slide ($\leq$ 15 cm) on the grating of the cage, the animals could change the direction of the fruit (Fig. 3). A “test time” was defined as the time after a civet was moved to the testing cage and until the civet finished feeding on all or leaving only its calyx of the provided fruit. After each test, we collected all of the remaining fruit (including flesh, hull and seed), the string and the loop clutch in a plastic bag

Fig. 1 Cutting surface of soft kaki fruits

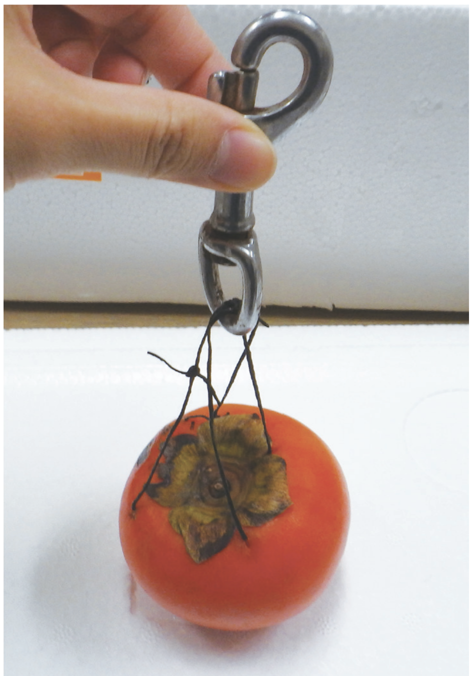

Fig. 2 String and loop clutch to fix kaki fruits to the cage

Fig. 3 Testing cage and an example of the experimental situation

to measure its weight. After each test session, we made sure that there was no fruit left in the testing cage. We conducted the test first with females and then with males. During both the training and test sessions, we fed the animals the usual amount of dog food after each session, regardless of the amount of remaining fruit.

4. Recording of feeding behavior

During the test time, we recorded the feeding behavior of animals using two video cameras (HDR-CX 680 , Sony) on tripods. One camera was placed in front of a sliding door made of transparent acrylic and another camera was placed on the side of the cage. While the side camera was set to record the animal's behavior if the front camera could not record, we were able to confirm the behaviors in all tests just from the front camera. We connected the front camera to a mobile monitor with an HDMI cable and observed feeding to decide the timing of the end of the test from a distance.

Among a series of feeding behaviors (i.e., ingestion, mastication and deglutition), we used the ingestion behaviors in which the animals took the fruits into the mouth to calculate the standard values of intake rate. We had no ethogram information for the ingestion behaviors of civets. Although there are differences in behaviors among species, extent behavioral codes were defined in the ethograms of New Guinea Singing Dog (*Canis hallstromi*), a medium-sized Carnivora, including ingestion behaviors (Koler-Matznick et al. 2005). Referring to the definitions of New Guinea Singing Dog, we observed the ingestion behaviors of civets ingesting kaki fruits as follows: BITE (to bite off a piece of fruit), NIBBLE (using a scissors action of teeth to work at the surface of a fruit) and GNAW (to repeatedly chewing and NIBBLE) with the teeth, and LAP (to lap up the flesh) and LICK (to wipe a fruit before or during ingestion) with the tongue.

5. Measurements of standard intake rate during the ingestion behaviors (SI)

We measured the standard intake rate per second during the time captive civets were performing the ingestion behaviors (hereafter, SI). The civets rarely used single BITE to remove a mouthful of fruit. In addition, many of them fed on kaki fruits with multiple actions such as BITE, NIBBLE, GNAW, LAP and LICK using the teeth and the tongue. Furthermore, we could not determine the amount of fruits ingested into the mouth for each action from the external observations. Therefore, a certain ingestion action such as BITE was not suitable for a common variable among multiple individuals in calculating SI, at least for the kaki fruits used in this study. Based on these reasons, we measured the total duration of ingestion behaviors (hereafter, TDI) by summing up the observation times of BITE, NIBBLE, GNAW, LAP and LICK actions (i.e., time that the civet's mouth was open and either or both the teeth/jaw and the tongue were moving, attaching or keeping some parts of the mouth within 3 cm of the fruits) with a stopwatch. Gross fruit intake (hereafter, GFI) was measured as the sample weight before the test subtracted from that after the test. We calculated the SI as follows:

SI (g/s) = GFT (g) / TDI (s).

6. Statistical analysis and representative values

Because the measurements in this study were replicated multiple times (days) for each individual, we used a linear mixed-effects model (LMM). The analyses were performed by a function "nlme" (Pinheiro et al. 2018) in R 3 . 44 . We checked model quality by visual inspection of the quantile–quantile (QQ) plot of the residuals and the predicted mean versus residual-plot.

First, for each hardness experiment (hard and soft fruits), we evaluated whether the training was effective as follows: lme (SI ~ DAY, random = ~ 1 |ID, method= "ML"). The variable DAY was experimental day (first and second, factor) as fixed effect and ID of civets was treated as random effect. We assumed that SI of the first day was lower than that of the second day (i.e., the variable DAY had significant positive effect on SI) when the feeding training for kaki fruits were not successful.

We then pooled each day's data and tested for effect of fruits hardness on SI as follows: lme (SI ~ HARDNESS, random = ~ 1 |ID, method = "ML"). Because the categorical classification of fruits hardness (hard or soft) was based on subjectively, we used the hardness as presented to each individual (HARDNESS, continuous) in this analysis. When the variable HARDNESS had a significant effect on SI, we determined the representative values for SI based on hardness value. In the contrary case (the variable HARDNESS had no significant effect on SI), we determined the representative values for SI pooling each day's experiments without regard for fruit hardness. In any case, the representative values were calculated as follows. First, the mean value in each individual was defined as "individual data." Then the range between the top 25 th percentile and the bottom 25th percentile for the individual data of SI in 11 civets was defined as the "representative value."

7. Energy intake rate for captive civets

We calculated the realistic intake rate in the captive civets. The nutrient content of kaki fruit per 100 g was cited from the food composition table: protein 0.4 g, lipid 0.1 g and carbohydrate15.9 g (The Ministry of Education, Culture, Sports, Science and Technology of Japan, 2015). Clauss et al. (2010) showed that the estimation of dietary metabolizable energy content in domestic carnivores (protein and carbohydrate = 16.7 kJ/g, lipid = 37.7 kJ/g) by National Research Council (2006) could be applied to wild carnivores as well. Using these findings, the metabolizable energy of kaki fruit (hereafter, ME) was 276.0 kJ/100g (= protein 0.4 g × 16.7kJ/g + lipid 0.1 g × 37.7 kJ/g + carbohydrate 15.9g×16.7kJ/g).

For civets had the lowest and the highest SI, the daily energy requirement was calculated using the field metabolic rate (hereafter, FMR) by Nagy (2005) as follows: FMR (kJ) = $4.82 \times$ body weight (g)$^{0.734}$. Finally, we calculated what percent of FMR did the civet get during the ingestion time (i.e., TDI) as follows: ME (kJ/100g) / 100 (g) × GFI (g) / FMR (kJ) × 100.

III. Results

For 10 civets, we obtained all data for 4 days of experiments (Table 2). For one male civet (ID: M2), we did not obtain 1 day's data in the hard fruit experiment (Table 2). The civets ingested the amount of 101 . 6 to 145 . 5 g in 56 to 364 seconds (range of SI = 0 . 36 to 2.04 g/s) for the hard fruit experiments and ingested the amount of 95.0 to 142.3 g in 56 to 192 seconds (range of SI = 0.55 to 2.17 g/s) for the soft fruit experiments (Table 2).

The variable DAY had no significant effect on the SI for both models of the hard and the soft fruit experiments ($P \geq 0.62$, Table 3). The variable HARDNESS had no significant effect on the SI for the model pooling each day's experiments ($P = 0.31$, Table 4). The individual data when pooling SI data of both hard and soft fruit experiments were from 0.49 to 1.77 g/s (Table 2). The range of the representative value of SI was from 0.91 to 1.37 g/s (Table 2).

Among all experiments (Table 2), M4 on day 1 had the lowest SI and M2 on day 3 had the highest SI. The realistic intake rate of M4 was 356.8 kJ for 364 seconds and that of M2 was 335.3 kJ for 56 seconds. This showed that M2 obtained 22.3% of the daily requirement (1503.6 kJ) only in 56 seconds of ingestion time and M4 obtained 14 . 4 % of the daily requirement (2257 . 9 kJ) in 364 seconds of ingestion time.

IV. Discussion

1. Trainings for feeding kaki fruits and experimental season

Because the standard intake rate during ingestion of fruits (SI, g/s) did not change significantly with the experimental day for the both experiments, the trainings for feeding kaki fruits were successful. But the captive civets somewhat hesitated to eat the fruit especially during the beginning of the test time. If wild civets are more skillful and more motivated to eat kaki fruits, their SI might be larger than that of the captive civets in this study. Civet activity declines during winter in Japan (Seki et al. 2010). Although we conducted the experiments in the winter (December), the experiments were conducted with air-conditioning and we fed each civet only one kaki

Table 2. Standard intake rate during ingestion behaviors for kaki fruits in masked palm civets

Animals	Hard fruit						Soft fruit						Individual data [1)]	Representative value [2)]
	Day 1			Day 2			Day 3			Day 4				
	GFI	TDI	SI	GFI	TDI	SI	GFI	TDI	SI	GFI	TDI	SI		
F1	124.1	184	0.67	123.8	169	0.73	136.1	132	1.03	125.0	105	1.19	0.91	
F2	112.0	76	1.47	120.3	83	1.45	121.7	74	1.64	117.8	83	1.42	1.50	
F3	116.4	80	1.46	121.9	120	1.02	117.3	93	1.26	106.9	100	1.07	1.20	
F4	142.5	150	0.95	142.0	98	1.45	128.8	176	0.73	112.1	112	1.18	1.08	0.91
F5	145.5	197	0.74	116.8	108	1.08	128.9	129	1.00	131.9	112	1.00	0.96	to
F6	123.3	92	1.34	140.1	99	1.42	111.7	98	1.14	135.7	115	1.18	1.27	1.37
F7	114.2	56	2.04	115.6	88	1.31	127.9	120	1.07	119.1	114	1.04	1.37	
M1	101.6	259	0.39	128.0	119	1.08	117.1	122	0.96	123.9	94	1.32	0.94	
M2	NA	NA	NA	135.1	95	1.42	121.5	56	2.17	142.3	83	1.71	1.77	
M3	109.8	183	0.60	110.1	172	0.64	95.0	127	0.75	103.2	143	0.72	0.68	
M4	129.3	364	0.36	119.4	324	0.37	129.2	192	0.67	96.8	176	0.55	0.49	

GFI: gross fruit intake (g), TDI: duration time of all ingestion behaviors (s), SI: standard intake rate during the animals doing ingestion behaviors (GFI/TDI) (g/s), NA: not available

[1)] The mean value between four tests in each animal

[2)] The range between the top 25th percentile and the bottom 25th percentile for the individual data

Table 3. Summary of the linear mixed-effects models for the effects of experimental day on the standard intake rate (SI) of kaki fruits in masked palm civets

Fixed effects	Estimate	SE	DF	t-value	p-value
Hard kaki fruit					
Intercept	1.02	0.14	10	7.07	0.00
DAY(second day)	0.07	0.13	9	0.51	0.62
Soft kaki fruit					
Intercept	1.13	0.12	10	9.78	0.00
DAY(second day)	0.00	0.08	10	-0.05	0.96

SE: standard error, DF: degrees of freedom

We used data during day 1 and day 2 for the hard kaki fruit model and used data during day 3 and day 4 for the soft kaki fruit model.

Table 4. Summary of the linear mixed-effects model for the effect of flesh hardness on the standard intake rate (SI) of kaki fruits in masked palm civets

Fixed effects	Estimate	SE	DF	t-value	p-value
Intercept	1.16	0.12	31	9.63	0.00
HARDNESS	-0.09	0.09	31	-1.03	0.31

SE: standard error, DF: degrees of freedom fruit per day. The amount might be insufficient to fill the civets' stomachs. Therefore, the influences of seasonal variance in the food intake rate appeared to be low in this study.

2. Effects of flesh hardness on SI and application to wild civets

The hardness of kaki fruits presented to each civet did not affect significantly the SI. Even the hard fruits in this study was relatively soft compared to salable fruits. The range of hardness was too small to affect the SI. The ingestion pattern and SI will differ in fruits with very high hardness during the early ripening period, as in a study of frugivorous bats (Dumont 1999). More factors are needed to examine the applicable situation (e.g. hardness) of SI of this study to wild civets. Nevertheless, this is the first study to provide an index to estimate the intake rate of kaki fruits by civets. It is more robust to use the duration of all ingestion behaviors to calculate intake rate than to use bite size/rate for discarded kaki fruits, which are on the ground and relatively soft compared to salable fruits. In addition, we used non-astringent kaki fruits in this study. Japanese monkey, wild boar (*Sus scrofa*) and sika deer (*Cervus nippon*) eat astringent kaki fruits during the early ripening period (H. Ueda personal observation). It is well known that the Asian (common) palm civets (*Paradoxurus hermaphroditus*) eat coffee fruits (Marcone 2004), which contain high level of tannin (Farah and Donangelo 2006). Also, a species of the order Carnivora produced tannin-binding salivary (Robbins et al. 1991). Therefore, wild masked palm civets will eat astringent kaki fruits at least after fully ripening.

We can calculate intake rate of wild civets by multiplying the representative values of SI of captive civets by the duration of ingestion behaviors of wild animals observed from remote cameras. The minimum ingestion time (TDI) was 56 seconds in this study (Table 2). In an extremely shorter observation period than this, for example, when civets bite only two or three times for a few seconds, the estimation would not be accurate. Furthermore, we recommend to use the representative values (i.e., the range between the top 25 th percentile and the bottom 25 th percentile) of SI in estimation of wild civet's intake rate. The reason is that internal factors of animals, such as body size and appetite, also affect feeding efficiency and SI. For example, body weight variety within a species (and sex for species with greater sexual dimorphism) affects intake rate (Wilmers et al. 2002). We usually cannot determine the body weight and sex of animals from the videos of remote cameras in the field. The sex difference in body weight of civets is little (Table 1 and Ohdachi et al. 2015). Thus, we did not test the effect of body weight and sex on SI in this study. But the wild civets have great individual differences with various state affecting feeding behaviors and SI. The representative values of SI include some differences among individuals in ingestion behaviors of kaki fruits, allowing more realistic application than using the mean value.

3. Energy intake rate for captive civets

The SI was calculated while eating a whole or most of kaki fruit. For the captive civets, even the individual with the lowest SI (M4) could obtain 14.4% of the daily requirement in just about six minutes. Therefore, it is clear that even "one" cultivated fruit can be excellent food resource for civets. Regardless of whether the cultivated fruit is salable or not, we need to limit the access of invasive mammals to fruits, and consequently, to decrease crop damage and the animal populations.

V. Summary

We evaluated energy value of kaki fruits (*Diospyros kaki*), a large-sized cultivated fruit, on masked palm civets (*Paguma larvata*), an invasive species in Japan. We determined the standard values of intake rate (SI) for kaki fruits by captive civets to apply to wild civets. We conducted feeding experiments over a total of 4 days with different flesh hardness (i.e., hard and soft conditions) using 11 captive civets. We divided gross fruit intake by duration of ingestion behaviors (biting, nibbling, gnawing, lapping, and licking actions) to obtain the SI (g/s). From linear mixed-effects model analyses, the experimental day and fruit hardness presented to each

individual had no significant effect on the SI. We defined the representative values of SI as ranging from 0 . 91 to 1 . 37 g/s. The captive civet with the greatest efficiency obtained 22 . 3 % of the daily requirement in 1 minuet of ingestion time and even the civet with the lowest efficiency could obtain 14.4% of the daily requirement in just six minutes. This is the first study providing an index to estimate the intake rate of invasive medium-sized Carnivora on large-sized cultivated fruits. It is clear that cultivated fruit is an excellent food resource for civets and efforts are needed to limit the access of invasive species to cultivated fruits, and consequently, to decrease crop damage and the animal populations.

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飼育ハクビシンにおける大型栽培果実カキの摂取効率

小坂井　千夏[*1]・秦　彩夏[*1]・佐伯　緑[*1]・竹内　正彦[*1]・上田　弘則[*2]・江口　祐輔[*2]

摘　要

筆者らは栽培果実の野生動物の餌としての価値評価を行ってきた．本研究では，外来種ハクビシン（*Paguma larvata*）及び大型の栽培果実としてカキ（*Diospyros kaki*）を対象とした．野生個体の単位時間当たりの果実摂取量の推定を目的に，飼育個体における標準摂取率（SI）の算出を行った．飼育個体11頭に硬い果実及び柔らかい果実の２種類の果実を１日１個与える給餌実験を計４日間行った．実験中の採食量（g）を，口内に果実を取り込む摂取行動の持続時間（秒）で割ってSI（g/s）を求めた．線形混合モデルを用いて実験実施日及び各個体に与えた果実の硬度がSIに与える影響を検証したところ，いずれもSIに対する有意な効果は示さなかった．そこで個体毎に４日間のSIの平均値をindividual dataとし，全ての個体のindividual dataの第一及び第三四分位の範囲をSIの代表値（0.91-1.37 g/s）として設定した．さらに，飼育個体における実際の果実摂取効率を計算したところ，最も効率（SI）の高い個体ではわずか１分間で１日の必要エネルギー量の22.3％，最も効率（SI）の低い個体であっても6分間で１日の必要エネルギー量の14.4％を摂取できていた．本研究は大型栽培果実の摂取率及びその算出指標となる数値を中型サイズの食肉目哺乳類で示した初めての研究である．餌資源としての栽培果実の質の高さは明らかで，被害や個体数を減らすためには外来種に栽培果実を利用させない対策が必要である．

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＊[1] 農研機構中央農業研究センター　虫･鳥獣害研究領域
＊[2] 農研機構西日本農業研究センター　畜産･鳥獣害研究領域