Food Habits of Japanese Serow (*Capricornis crispus*) and Japanese Deer (*Cervus nippon*) in a Co-habitat*

By

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Summary : Food habits of the serow (*Capricornis crispus*) and the deer (*Cervus nippon*) were studied by means of fecal content analysis in a co-habitat in the Odaigahara range, Mie prefecture. Their main food consisted of Gramineae (including Cyperaceae), mostly Suzu bamboo grass (*Sasamorpha borealis*) which is dominant in the study area. They also ate needles of Hinoki cypress (*Chamaecyparis obtusa*) all the year round.

The food habits of the two species differed in two aspects, i. e. the percentage of arboreal plants in the serow diets was greater than that in the deer diets, and the percentage of Gramineae in the serow dites was smaller than that in the deer diets. This observation is consistent with the current understanding that the serow is a browser while the deer is a grazer. The other difference is that the deer food habits were more stable than those of the serows.

In many reports it was suggested that the damage to cypress by the serow and the deer was caused by the shortage of foods other than cypress. In this study, however, such a hypothesis was not verified because the amount of cypress eaten did not increase with the corresponding decrease in other food plants. It is suggested that these animals eat cypress as one of their regular foods in the study area.

Plant Consumption Share was defined as the contribution of each animal species to the amount of a certain plant eaten by both species. As for cypress, the index was about 60% for serows and about 40% for deer.

I Introduction

Recently, the damage caused to young coniferous plantations by the Japanese serow (*Capricornis crispus* TEMMINCK) and the Japanese deer (*Cervus nippon* TEMMINCK) has become a serious problem. At present, however, no rational and effective method to prevent the damage has been established, due to the limited information available on the food habits of these animals. Previous studies were carried out only in the habitats where either serows or deer lived, but not in those where the two species coexist. Also cutting marks on plants were used as indicators of food habits in most of the studies, for they are easy to observe. They are, however, less reliable for quantitative analysis than the fecal or stomach contents. The purpose of this study is to investigate the food habits of the serow and the deer in a co-habitat by means of fecal content analysis with reference to the food conditions of the study area. Emphasis was placed on the differences between the food habits of the two species. Plant Consumption Share was defined as a new index to assess the relative amount of plant eaten by each species.

Received May 20, 1986 保 護—45 Forest Protection—45

(1) (2) Forest Protection Division

* この研究は，環境庁国立機関公害防止等試験研究「森林食害発生機構の解明および被害抑止技術に関する研究」の一部として行われたものである。

II　Study area

The study area involved the eastern midslope of Mt. Hidegatake (1695 m), the highest peak of the Odaigahara range, in Miyagawa mura, Taki gun, Mie prefecture. These are very steep slopes, landslides and rocky areas in the vicinity of the study area, the elevation of which is approximately 1200 m(Fig. 1). The mean inclination in the study area is about 25°, which is rather gentler than that in the vicinity. The annual rainfall is about 4000 mm

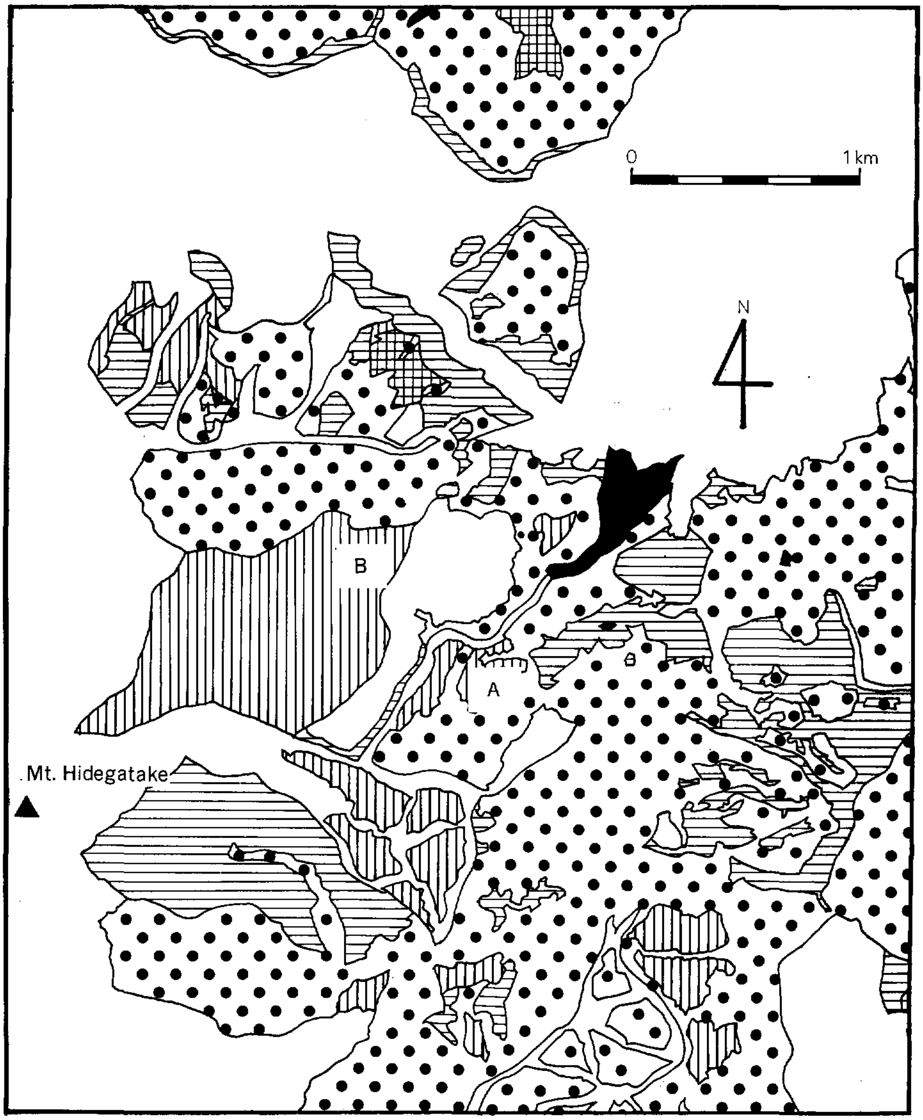

Fig. 1. Location of the study area

dots : artificial coniferous forest, horizontal-lines : natural broad-leaved forest, black : natural coniferous forest, white : natural mixed forest, vertical-lines : cleared land or newly planted stand, mesh : rocky area, A : study area, B : neighbouring young plantation

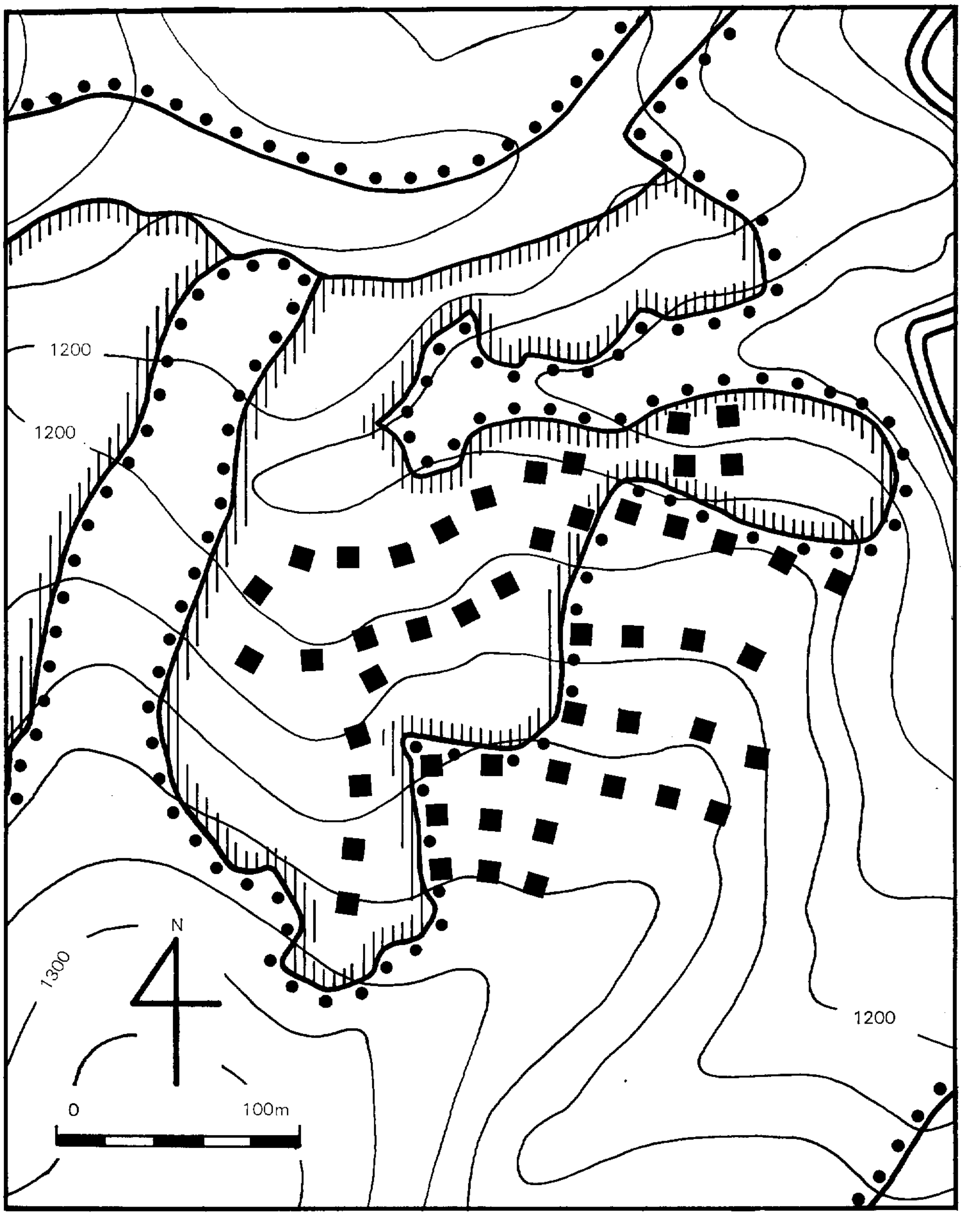

Fig. 2. Location of the plots
lines : young plantation of *Chamaecyparis obtusa*, dots : old plantation of *Chamaecyparis obtusa* ; Contour interval is 20 m.

in this district which is one of the rainiest districts in Japan. The soil consists of moderately moist brown forest soil (drier subtype : BD(d)), and the surface is dotted with stones and boulders.

The study area consisted of a young plantation of Hinoki cypress, (*Chamaecyparis obtusa* (Sieb. et Zucc.) Endlicher) planted in 1979, surrounded by forests of cypress and Japanese red cedar (*Cryptomeria japonica* (L. f.) D. Don) planted in 1929 (Fig. 2).

Ⅲ Methods

1. Standing crop

In order to estimate the food conditions, the standing crop was measured as the average dry weight of grasses and herbaceous plants in each ten plots (1 m× 1 m) in the young and the old plantations in May and October, 1983. The stems were treated separately from the leaves and needles, because the serow and the deer mainly eat leaves and needles, and the stem is not an important source of food. In addition, the leaves and needles located at a height of more than 1 m were treated separately from those located at a height of less than 1 m because these animals can not easily reach leaves and needles above 1 m. In June, 1982, the herbicide (FRENOCK) was used to kill Suzu bamboo grass (*Sasamorpha borealis* (HACK.) NAKAI) in the young plantation. To evaluate its effect on the vegetation, the standing crop was measured also in a neighbouring young plantation of cypress where the herbicide was not used.

2. Collection and dry weight of feces

Twenty five permanent plots(10 m×10 m) were set up in the young plantation, and other 25 in the old plantation (Fig. 2).

Feces were collected three times a year, namely in May, July and October. The first collection was made in October, 1981 and the last in October, 1983. But, the collection of July, 1983 did not take place. The feces in October, 1983 were classified into new and old groups by visual observation, and the old feces were tentatively used as materials for July, 1983.

All the feces in each plot were collected. The serow feces could be distinguished from those of the deer because the former were heaped up, while the latter were scattered.

Mean dry fecal weight per plot per month was calculated. In case of the first collection in October, 1981, there was no preceding collection, and the number of months by which the fecal weight should be divided was not determined. Therefore, the number of months was assumed to be 6, for the feces might have remained in the field for about 6 months[12].

3. Analysis of fecal contents

Microscope slides were prepared from the feces according to HORINO and KUWAHATA's[4] (1984) method that was used for the analysis of the stomach contents of the Japanese hare (*Lepus brachyurus* TEMMINCK). The sequence of the treatments was as follows ;

1) One or two fecal droppings were sampled at random from each fecal heap for the serow, and from each plot for the deer.

2) Each sample was put in a 50 m*l* beaker with 10% nitric acid. The sample was heated at a slightly lower temperature than the boiling point for about 1 hour, then kept at about 60°C until the acid dissolved the viscous matrix that would have interfered with the identification of the plant fragments in the feces. The time needed for this treatment ranged from several hours to one day, depending on the conditions of the feces.

3) The material was washed twice by filling with water, stirring, centrifuging at 3000 rpm for 5 min and decanting. Then it was suspended in F.A.A. which contains 5% formalin, 5% acetic acid and 60% ethyl alcohol.

4) The material was mounted on microscope slides with APATHY's Gum Syrup. Dyeing was omitted.

The slides were observed under the NOMALSKY's differential interference contrast microscope at 200 power magnification. By comparison with the reference slides[3], all the plant fragments in microscope fields were identified.

The quantitative estimation should be made by measuring the dry weight of the material. It was, however, very difficult to measure minute plant fragments on a slide. As a substitute the area occupied by the fragments was measured with a microscope micrometer.

4. **Percentage Similarity between the fecal composition**

WHITTAKER's[15] (1952) Percentage Similarity (PS) was used to compare the composition of fecal samples. This index is derived by the equation

$$PS=\sum_{i} \min(P_{ia}, P_{ib}) \quad \cdots\cdots(1)$$

where P_{ia} and P_{ib} are the percentages for the i th plant item in the two samples A and B, respectively. The higher the value of PS, the higher the similarity between A and B is.

5. **Plant Consumption Share**

Plant Consumption Share (PCS) was defined as the contribution of each animal species to the amount of a certain plant eaten by both species in a certain area during a certain period. If the fecal weight is directly proportional to the amount of plant eaten, PCS of a certain plant item is obtained by the formula

$$PCS_1=r_1\cdot F_1/(r_1\cdot F_1+r_2\cdot F_2)\cdot 100(\%),$$
$$PCS_2=r_2\cdot F_2/(r_1\cdot F_1+r_2\cdot F_2)\cdot 100(\%) \quad \cdots\cdots(2)$$

whese r stands for the percentage of the plant item to the whole fecal weight, F the fecal weight, and the subscripts 1 and 2 indicate serow and deer, respectively.

As a variation of PCS, the Cumulative Plant Consumption Share (CPCS) was also defined to estimate the long-term share of plant consumption. This index of a certain plant item is obtained by the formula

$$CPCS_1=\sum r_1\cdot F_1/(\sum r_1\cdot F_1+\sum r_2\cdot F_2)\cdot 100(\%),$$
$$CPCS_2=\sum r_2\cdot F_2/(\sum r_1\cdot F_1+\sum r_2\cdot F_2)\cdot 100(\%) \quad \cdots\cdots(3)$$

where $\sum$ is defined as the sum from October, 1981 through October, 1983.

IV Results

1. **Standing crop**

The standing crop in May, 1983 is shown in Fig. 3. In all the locations, bamboo grass was dominant. Among the dicotyledons in the young plantation, ciliate-calix menziesia (*Menziesia ciliicalyx* (MIQ.) MAXIM.), hairy-nerved clethra (*Clethra barbinervis* SIEB. et ZUCC.) and palmate bramble (*Rubus palmatus* THUNB.) occurred abundantly. In the old plantation, there was a large amount of menziesia plants.

Differences between the two young plantations were found in the leaf amount of bamboo grass, and the number of species and the amount of the dicotyledons. In the undergrowth of the old plantation, the number of species was small, and the leaf amount of bamboo grass under 1 m was almost zero.

In the neighbouring young plantation, the seasonal changes in the amount of dicotyledons appeared to be considerable, presumably due to the insufficient number of plots.

2. **Fecal weight**

The mean dry weight of feces per plot and per month excreted by the serows and the

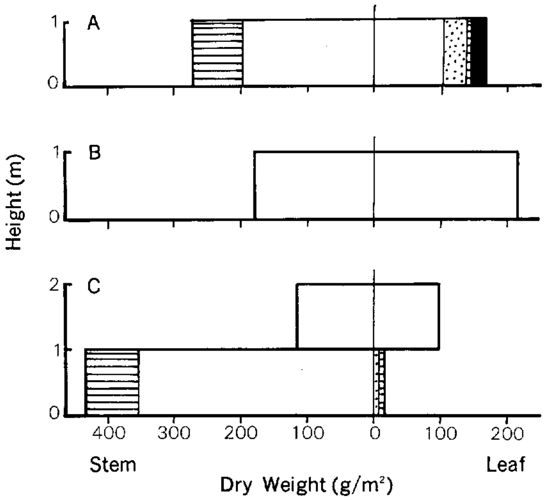

Fig. 3. Standing crop
A : young plantation, B : neighbouring young plantation, C : undergrowth of the old plantation, white : Gramineae, dots : Cyperaceae, line : dicotyledons, black : ferns

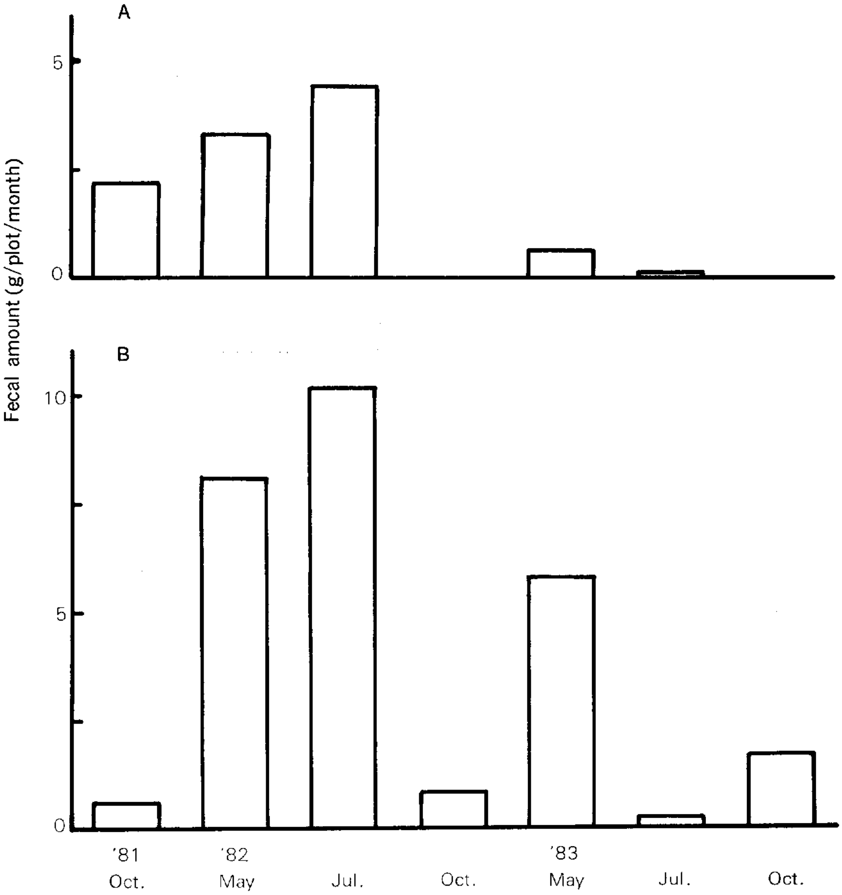

Fig. 4. Fecal weight
A : *Capricornis crispus*, B : *Cervus nippon*

Table 1. Fecal contents

	class	item	1981	1982			1983		
			Oct.	May	Jul.	Oct.	May	Jul.	Oct.
Capricornis crispus	*Chamaeyparis obtusa*		9.06	20.40	17.01	—	15.20	21.89	—
	Cryptomeria japonica		1.06	0	0	—	1.36	0	—
	Pinus parviflora		0	3.09	0	—	8.48	16.11	—
	Gramineae	*Sasamorpha borealis*	4.17	16.57	21.33	—	13.31	23.72	—
		epidermis	0.31	0.06	0.15	—	1.97	0.49	—
		fiber bundle	29.85	23.65	29.16	—	20.49	15.27	—
		parenchyma	4.64	1.32	2.43	—	1.95	1.18	—
		total	38.96	41.60	53.08	—	37.72	40.65	—
	dicotyledons	*Clethra barbinervis*	2.90	0.02	0	—	0.11	0	—
		Callicarpa japonica	1.32	0	0	—	0	0	—
		〔YC〕	0	8.38	11.56	—	0	0	—
		〔GCC〕	0.42	0.33	1.25	—	1.08	0	—
		total	4.65	8.73	12.81	—	1.19	0	—
	unidentified	epidermis	20.38	7.36	5.15	—	8.96	5.94	—
		fiber bundle	2.84	4.15	3.18	—	2.42	3.13	—
		parenchyma	9.77	4.70	1.98	—	7.77	4.42	—
		separate fiber	13.28	9.97	6.79	—	16.89	7.86	—
		total	46.27	26.19	17.10	—	36.06	21.35	—
Cervus nippon	*Chamaeyparis obtusa*		4.95	3.25	7.05	4.86	4.50	2.53	2.89
	Cryptomeria japonica		0	0	1.29	0.57	0.21	0	0
	Pinus parviflora		0	0	0	0.20	0.84	0.23	0
	Gramineae	*Sasamorpha borealis*	28.69	35.88	38.93	31.69	31.08	47.66	29.11
		epidermis	1.60	0.47	0.17	6.71	6.27	1.73	7.09
		fiber bundle	26.01	34.76	25.75	25.83	21.86	13.45	17.93
		parenchyma	12.57	3.43	1.61	2.79	2.52	2.14	1.23
		total	68.88	74.54	66.47	67.03	61.73	64.99	55.37
	dicotyledons	*Clethra barbinervis*	0.91	0	0	0	0.05	0	0.13
		Callicarpa japonica	0	0	0	0	0	0	7.16
		〔YC〕	0	0	0	1.49	0.54	0	0.91
		〔GCC〕	0	0	0.88	0.17	0.69	0	0.34
		total	0.91	0	0.88	1.67	1.28	0	8.54
	unidentified	epidermis	9.51	3.50	6.40	7.48	7.47	6.72	8.85
		fiber bundle	0.95	0.38	0.16	1.37	1.91	1.21	2.60
		parenchyma	4.04	1.59	0.99	3.42	5.22	4.49	7.99
		separate fiber	10.77	16.74	16.77	13.41	16.85	19.84	13.77
		total	25.27	22.21	24.31	25.68	31.45	32.25	33.21

deer are shown in Fig. 4-A, B. The weight of feces excreted by the serows increased from October, 1981 through July, 1982, and decreased afterwards. Especially in October, 1982 and October, 1983 no feces were found at all. The weight of feces excreted by the deer increased from October, 1981 through July, 1982, but was small afterwards, except in May, 1983.

3. **Fecal contents**

In total, 40,789 fragments of materials contained in the feces accounting for a total area of approximately 490 mm², were observed. They were classified into 15 items, some of which were combined into classes (Table 1). The items included the taxon of the plant whenever the identification was possible. The major items recovered were as follows:

Cypress (Plate A, B) was easily identified by the shape and size of its epidermal cells. However, cedar was not easily distinguished from cypress, when no stoma was found.

Japanese white pine (*Pinus parviflora* Sieb. et Zucc.) (Plate C) was identified by the linear arrangement of its epidermal cells and the distinctive structure of the stomata.

The class "Gramineae" includes Gramineae and Cyperaceae plants which are similar to Gramineae in their microscopic structure. They were distinguished from the other plants by the shape and arrangement of the cells. Among them, however, the identification of the species was possible only for bamboo grass (Plate D, E). The other fragments of Gramineae were counted as three items in this class, namely, epidermis, fiber bundle and parenchyma.

Among the dicotyledons, clethra and Japanese beautyberry (*Callicarpa japonica* Thunb.) were segregated. Two other kinds of dicotyledonous epidermis with unique characteristics, whose species names were unknown, were counted as independent items with assumed names, 〔YC〕 and 〔GCC〕.

The unidentifiable fragments were included in the class,"Unidentified" that was separated into four items, namely epidermis, fiber bundle, parenchyma and separate fiber.

Table 1 shows the fecal contents of the serows. Cypress was always detected in great amounts, whereas the amounts of cedar and pine were negligible. Gramineae always accounted for the main part of the fecal contents. The percentage of the class, "Unidentified" was great due to the imperfection of the identification techniques.

The fecal contents of the deer are shown in Table 1. Cypress was always present, though in lesser amounts than in the serow feces. A low percentage of cedar and pine was occasionally found. Gramineae always accunted for the greatest part.

4. **Percentage Similarity for the fecal composition**

Interspecific and intraspecific values of PS for the fecal composition are shown in the histograms in Fig. 5-A, B, C. For the deer, the values ranged from 70.9% to 88.1% with a mean of 79.2%. For the serows, the values ranged from 51.1% to 84.4% with a mean of 70.2%. The interspecific values were generally smaller than the intraspecific ones, ranging from 48.3% to 71.6% with a mean of 63.8%.

5. **Plant Consumption Share**

Values of PCS for cypress, Gramineae and the sum of dicotyledons and "Unidentified" are shown in Fig. 6-A, B, C. In all the three cases, the PCS values for the deer were 100% in October, 1982 and October, 1983 when no feces of serow were found. No consistent seasonal changes were observed.

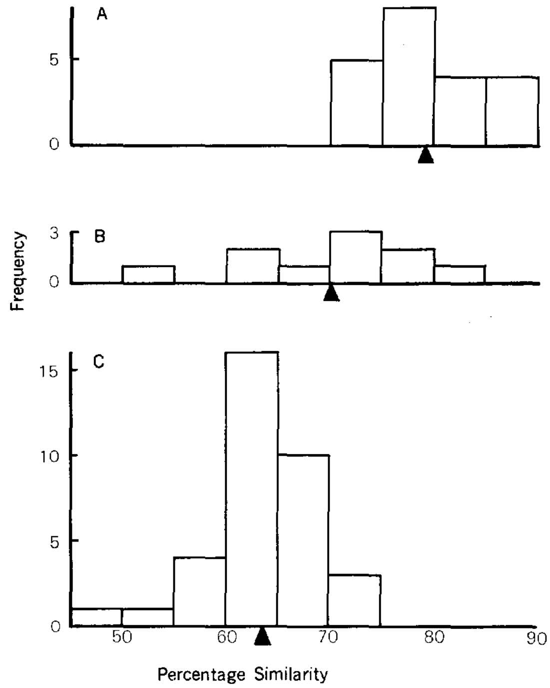

Fig. 5. Percentage Similarity for fecal contents
A : *Cervus nippon*, B : *Capricornis crispus*, C : both species,
Solid triangles indicate the mean values.

V Discussion

1. Fecal weight

The information on the fecal amount is important to estimate the animal population and to consider other ecological aspects. However, it is difficult to determine the exact fecal amount in the field, because the feces are easily lost before being collected. The causes of loss include running down the slope, or being washed away by rain. These losses are sometimes so large that they cannot be underestimated, especially when the interval between collections is long. Moreover, the loss of feces may be significant where a large number of dung beetles live and are active, even if the interval between collections is very short[18]. In such a case, the fecal amount will be underestimated or, in the worst case, no feces will be found. In the present study, serow feces were not detected in October, 1982 and October, 1983, suggesting that dung beetle may have contributed to the disappearance of the feces.

2. Food habits

It is well-known that bamboo grasses are important sources of food for the serow and the deer[7][9][10]. In the study area, Suzu bamboo grass was dominant and many cutting marks made by the animals on this plant were found. These facts suggest that the main food of the serow and the deer was bamboo grass. In fact, Gramineae, mostly bamboo grass, made up the largest part of the diet of both species.

On the other hand, the serow and the deer are similar in many ecological aspects, for example, body size, feeding habits. When two species live in the same habitat like serows

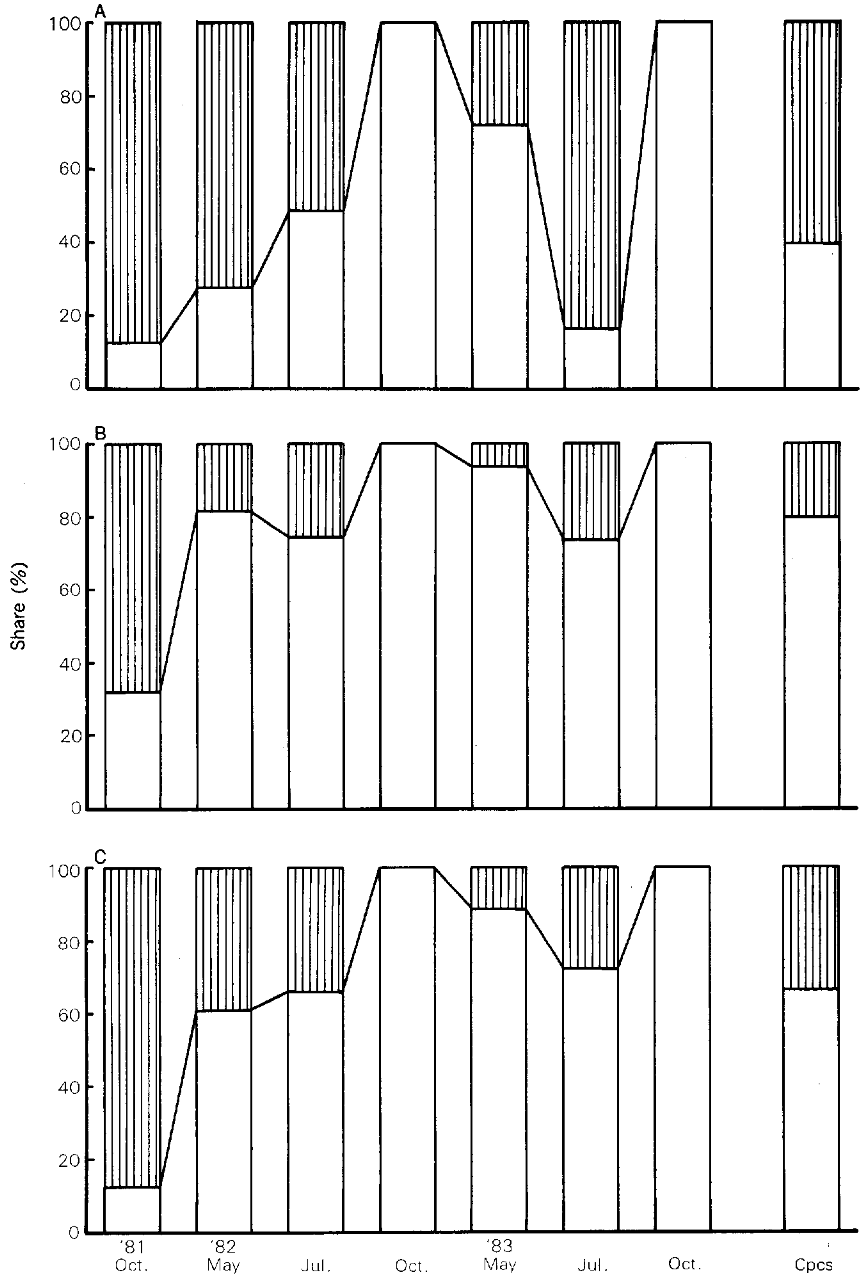

Fig. 6. Plant Consumption Share

A : *Chamaecyparis obtusa*, B : Gramineae, C : dicotyledons and Unidentified, line : *Capricornis crispus*, white : *Cervus nippon*, CPCS : Cumulative Plant Consumption Share through the period of this study and deer in this study area, there may be some ecological differences between the two species. From this point of view, the values of PS revealed two important aspects.

One was the difference in the diets between the two species. The interspecific values of PS were smaller than the intraspecific values, suggesting that there were some differences between the diets of the two species. In particular, there was a difference in the percentage of Gramineae, which was always smaller in the serow than in the deer. In October, 1981 when the difference was greatest, it was 39.0% for the serow and 68.9% for the deer. In July, 1982 when the difference was smallest, it was 53.1% and 66.5% for the serow and the deer, respectively. On the other hand, the percentages of cypress and the material of the class, "Unidentified" were greater in the serow. The items in the "Unidentified" class seemed to consist largely of a mixture of fragments of dicotyledonous shrubs and trees, judging from the vegetation of the study area. The difference between the two species was, therefore, that the serows ate the arboreal plants in a greater percentage than the deer did, and Gramineae in a smaller percentage than the deer did. The serow has been considered to be a browser, and the deer a grazer[8)14)]. However it has been suggested that the deer can be alternatively a browser or a grazer depending on the environment[9)]. The results obtained in the present study tend to support the former concept on the basis of the comparison of the two species in the co-habitat.

The other difference was the variability of the diets. That is, the percentage of each item in the diets showed a greater variation in the serow than in the deer. Fig. 5 shows that the intraspecific values of PS were generally smaller in the serow than in the deer. The minimum value in the deer was 70.9%, which was greater than the mean in the serow. The difference in the values of PS between these animals seems to be related to the difference of food habits mentioned above, namely, the browser or grazer behaviour patterns.

3. **Why is cypress eaten?**

Many researchers reported that the damage caused by the serow and the deer to cypress occurs in the winter and the early spring, i. e. the snow season[1)7)10)~12)]. It was also stated by many researchers that the food plants for these animals are less available due to the snow and are present in smaller amounts in the snow season than in the other seasons[1)2)7)11)13)]. These reports have led to the hypothesis that food shortage in the snow season is responsible for the damage to cypress[6)11)]. Iimura[6)] (1984) attempted to generalize this hypothesis using the concept of "carrying capacity". He argued that the damage occurs in the snow season only when the carrying capacity in the snow season is considerably lower than in the summer.

In this study area, it is considered that both serows and deer ate cypress all the year round. This fact is markedly different from the results in the reports cited above, especially, the typical example of winter and early-spring use of cypress by serows presented by Mori et al.[10)] (1981), who also used fecal content analysis. On the other hand, is it possible to consider that the food shortage due to the year-round overpopulation beyond the carrying capacity caused the damage?

At first, if it is assumed that the degree of food shortage is directly proportional to the intensity of foraging, then the relationship between the food shortage and the damage can be replaced by the relationship between the intensity of foraging and the amount of cypress eaten. If it is further assumed that the fecal amount and the percentage of cypress in the feces reflect the intensity of foraging and the amount of cypress eaten, respectively, then the hypothesis indicated previously can not account for the results of this study, namely, the relationship between the intensity of foraging and the amount of cypress eaten. For example, the total weight of feces excreted by the two species was 11.4 g/plot/month and the percentage of cypress in the deer feces was 3.25% in May, 1982, while the total weight of feces was 6.47 g/plot/month and the percentage of cypress was 4.50% in May, 1983. These figures imply that the amount of cypress eaten was greater in May, 1983 when the intensity of foraging was smaller than in May, 1982. Discrepancies between the intensity of foraging and the amount of plant eaten were also found for the deer in October, 1981, 1982 and 1983, and for the serow in July, 1982 and 1983. Therefore, it seems that the serows and the deer in this study area ate cypress as one of their regular foods, irrespective of the amount of food available.

Also in the case of other districts the amount of data is too limited to determine whether the hypothesis indicated previously can account for the causes of the damage. In order to determine what causes the damage, the food selectivity and the amount of food plants based on the selectivity, as well as the quantitative relationship between the food habits of the animals and the amount of food available should be studied.

4. The importance of the fecal analysis

In a habitat where serows and deer coexist it ts very difficult to differentiate between the damage caused to trees by deer from that by serows, because these animals have similar feeding habits and leave strikingly similar cutting marks on the plants. This difficulty may often lead to an erroneous identification of the animal species responsible for the damage. Consequently, estimations of the damage caused by each animal species may not be accurate. In this investigation, the new index (PCS) revealed that about 60% of the damage to cypress was caused by the serow and about 40% by the deer in the study area during the experimental period.

PCS can not be calculated if quantitative data derived from the analyses of the fecal weight and contents are not available. Generally speaking, these data are very important for considerations on the ecology of the animals and the damage caused to the planted trees. The determinations of PCS suggests that fecal analyses are very important and useful.

VI Acknowledgement

The authors are grateful to Drs. F. YAMADA (former Chief of the Division of Forest Protection, Forestry and Forest Products Research Institute), M. UEDA (former Chief of the Section of Wildlife, Division of Forest Protection, Forestry and Forest Products Research Institute), S. HIGUCHI, H. SAHO, T. IKEDA and Mr. K. KOBAYASHI (Division of Forest Protection, Forestry and Forest Products Research Institute) for their guidance and encouragement. They also thank the staff members of the Osaka Regional Forestry Office and Owase District Forestry Office for their valuable assistance.

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混生地におけるニホンカモシカ（*Capricornis crispus*）とニホンジカ（*Cervus nippon*）の食性

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摘　　要

造林木に対するニホンカモシカとニホンジカ（以下，カモシカとシカ）の食害防除法を確立するためには，基礎的研究として両種の食性を明らかにしなければならない。これまで，一方の種のみを対象とした研究はかなり行われてきたが，混生地で両種を対象にした研究はほとんどみられない。また，両種の食性と食害を定量的に把握するためには，これまで慣習的に用いられてきた食痕調査法よりも，糞量と糞内容分析とを結びつけた調査法の方がはるかに優れている。本研究は，糞量調査と糞内容分析を行うことにより，混生地での両種の食性を明らかにするとともに，ヒノキ幼齢造林地で発生する食害のうち，カモシカとシカのそれぞれによる食害がどれだけの比率であるかを計算した。

調査は1981年10月から1983年10月まで，三重県大台ケ原山中腹の1979年植えヒノキ幼齢林を中心に行った。

糞内容分析の方法は次のとおりである。まず，糞を10%硝酸とともに50 m*l* ビーカーに入れる。これを1時間湯煎した後，糞中の粘性物質が分解するまで約60°Cで保温する。上澄みを捨て，2回水洗してから APATHY のガムシロップでスライドに封入する。スライドは NOMALSKY の微分干渉顕微鏡を用いて200倍で観察する。

結果は次のとおりである。

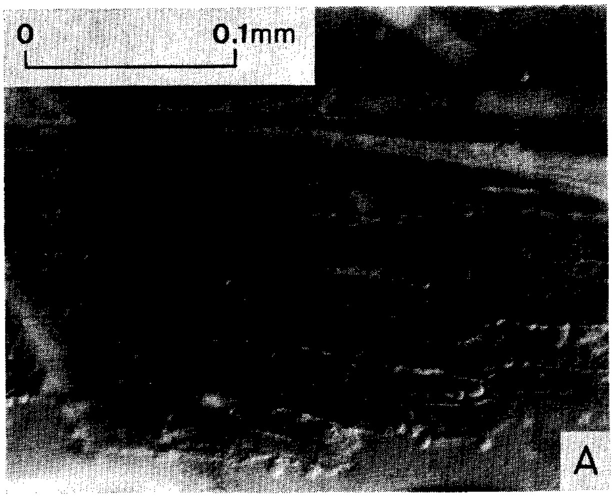
1.　カモシカとシカ両種の主食はイネ科植物であった。その中でも特に，本調査地の優占種であるスズダケの占める割合が非常に高かった（Table 1）。

2.　両種の食性には次の相異点が認められた。第1に，カモシカの食性に占める木本植物の比率がシカのそれより高く，イネ科植物は逆にシカのそれより低かった。このことは，カモシカを木本食い，シカを草本食いとする従来の見解と一致している。第2に，シカの食性はカモシカのそれより経時的に安定していた。

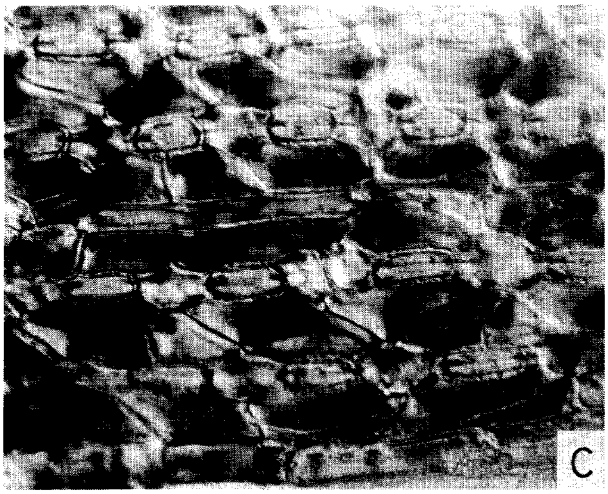
3.　カモシカおよびシカによるヒノキ食害は，積雪期の食物不足が原因で起こるという仮説を採用している報告が多い。しかし，本調査地では，ヒノキが周年摂食されていただけでなく，採食可能な植物の減少にともなってヒノキの摂食量が増大する負の相関関係が認められなかった。したがって，本調査地で発生した食害にこの仮説を適用することはできず，むしろ，両種がヒノキを常食のひとつとしている可能性の方が強い。

1986年5月20日受理
(1) (2) 保　護　部

4.　ある地域において，カモシカとシカの両種が一定期間にある植物を摂食した合計量に対する，カモシカとシカのそれぞれの摂食量の比率を「植物摂食分担率」と定義した。ヒノキの「摂食分担率」をカモシカとシカについてそれぞれ計算すると，本調査地で，調査期間中にヒノキの受けた食害の60%がカモシカ，残る40%がシカによるものであった（Fig. 6)。

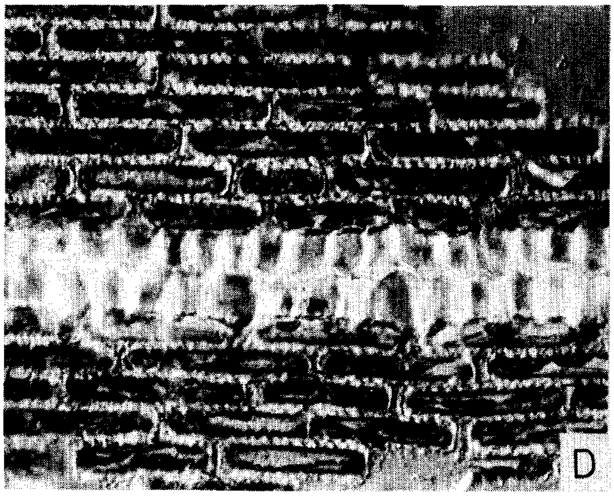


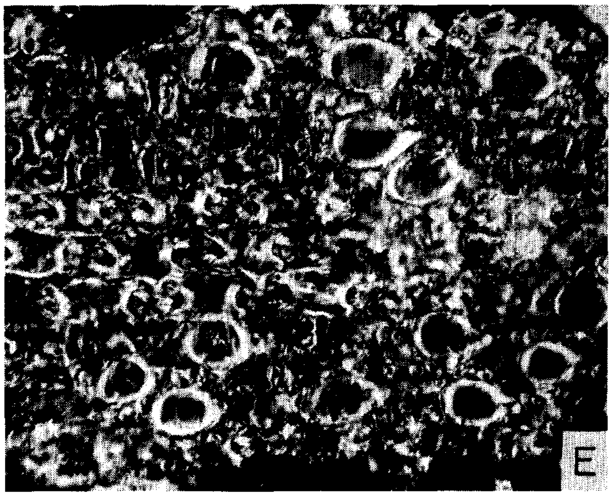
A, B : *Chamaecyparis obtusa,*



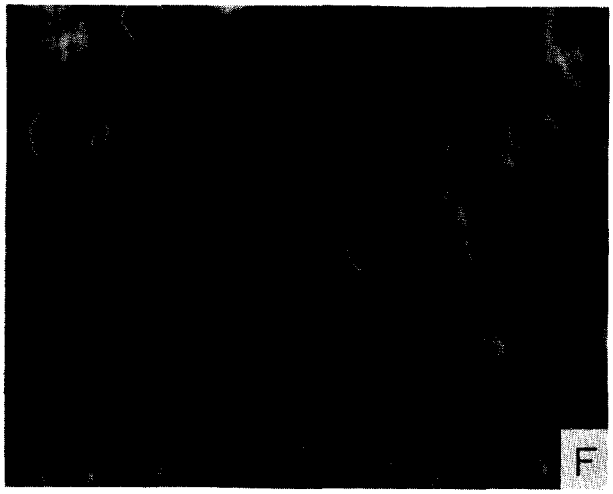
C : *Pinus parviflora,*

Plate 1. 2. Plant fragments in the feces of *Capricornis crispus* and *Cervus nippon*





D, E : *Sasamorpha borealis*,



F : *Callicarpa japonica*