Circumstances Leading to Animal Damage of Plantations in Hokkaido

I. An Analysis of Typical Damage Caused by the Red Backed Vole, *Clethrionomys rufocanus*, in an Adult Larch Plantation

By

Kenkichi ISHIGAKI*

北海道の造林地における動物害の発生要因

I．カラマツ壮令林で見られたエゾヤチネズミによる被害の要因分析

石 城 謙 吉*

Abstract

Damage caused by the red backed vole in an adult larch plantation was surveyed in the Nakagawa Experiment Forest of Hokkaido University, northern Hokkaido, and the conditions responsible for the damage were analyzed.

One hundred and forty-three of the 429 larch trees in a quadrat of one hectare (50 × 200 m) were found to be eaten by the voles with various degrees, and the total area of stem bark stripped was 69,205 cm^2.

Although the plantation surveyed included a considerable number of spontaneous broad-leaved trees, estimation of the index of selection (E) confirmed that only larches were eaten selectively by the vole, E being 0.32 for the larch. No significant relationship between the occurrence ratio of damage and the diameter of the larches was observed.

The density of the voles was surveyed by trapping and estimated as 43 individuals per hectare, an abnormally high count for the winter period. The buds and leaves of bamboo grass, which are considered to be an important food resources for the red backed vole throughout the winter, were consumed at high ratio, about 60 % of the buds and 27 % of the leaves.

All the voles captured in the survey area were overwintered individuals, and although the coefficient of their fatness was low compared with that of individuals obtained from another district at the same season, the degree of their sexual maturity was judged to be normal.

Key words: Animal damage, Plantation, Red backed vole, Larch, Scarcity of food.

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*College Experiment Forests, Hokkaido University.

北海道大学演習林

The author discussed two possible reasons for the damage to the plantations by the vole, and, based on the result of this survey, concluded that the damage caused by the red backed vole in winter was led by an insufficiency of food.

Introduction

It is well known that some animals eat trees and sometimes cause significant damage to forests in various parts of the world. In North America, for example, bark stripping and stem girdling by the grey squirrel, *Sciurus carolinensis*, and meadow voles, stem gnawing by rabbits and hares, and browsing by deers have been reported (von ALTHEN, 1983). In Europe, damage caused by the field vole, *Microtus agrestis*, (HANSSON & LARSSON, 1980), the root vole, *M. oeconomus*, (KORHONEN *et al.*, 1983), and the bank vole, *Clethrionomys glareolus*, (HANSSON & ZEJDA, 1977), etc., has become an serious problem.

In Japan, stem girdling caused by the meadow vole, *Microtus montebelli*, in young plantations of the Japanese cedar, the Japanese cypress and the larch in Honshu and Kyushu, and the same by the Smith vole, *Eothenomys smithii*, in Shikoku, are well known. In addition to these, trunk shearing of young trees by the hare, *Lepus brachyurus*, foliage browsing and bark stripping by the sika deer, *Cervus nippon*, and barking by the black bear, *Selenarctos thibetanus*, have also been cited as causes of considerable damage in some areas. And in recent years, browsing of the young cypress by the Japanese selow, *Capricornis crispus*, has become a new problem.

One of the noticeable features of forest damage caused by animals is that most incidences of it have occurred in artificial plantations, and stem girdling by the red backed vole, *Clethrionomys rufocanus*, the mammal which inflicts the most damage to silviculture in Hokkaido, also occurs in plantations, especially in those of the larch, *Larix kaempferi*.

The first record of damage to trees by the voles in Hokkaido was reported in 1904 (HOKKAIDO, 1953), when larch planting was begun in earnest; since then, the destructive action by the voles has increased with the expansion of the area of larch plantations. Furthermore, damage by the voles has recently been found in the young plantations of other tree species, i. e., the todo-fir and the Japanese cedar, accompanied with a decrease of newly planted larch plantations in Hokkaido (NAKATSU, 1985).

There have, however, been few analyses of the circumstances which give rise to such damage. The author observed a remarkable damage caused by the red backed vole in an adult larch plantation. This paper deals with the result of analysis of the circumstances which led to the damage caused by the voles.

Survey area and Methods

Surveys were carried out in an adult larch (*Larix kaempferi*) plantation, planted in 1929, in the Nakagawa Experiment Forest of Hokkaido University, located in northern Hokkaido.

A quadrat measuring one hectare (50×200 m) was plotted in the plantation for the damage survey. Species of trees with a diameter over 5 cm in this quadrat and their diameter class distributions are shown in Table 1. Besides the artificially planted larch

Table 1. Tree species and their diameter class distributions in survey area

Diameter class (cm) / Species	5 – 9	10–14	15–19	20–24	25–29	30–34	35–	Total
Larix kaempferi	20	62	126	142	69	12	1	429
Betula ermanii	57	51	33	13	3	3	0	160
Magnolia obovata	46	21	1	1	0	0	0	69
Phellodendron lavallei	34	8	4	2	1	0	0	49
Kalopanax ricinifolium	30	10	6	1	0	0	0	47
Salix spp.	31	14	1	0	0	0	0	46
Acer pictum	18	1	0	0	0	0	0	19
Quercus mongolica	15	2	1	0	0	0	0	18
Alnus hirsuta	4	11	1	0	0	0	0	16
Hydrangea paniculata	15	0	0	0	0	0	0	15
Sorbus commixta	3	4	1	0	0	0	0	8
Picea abies	5	0	0	0	0	0	0	5
Ulmus davidiana	3	0	0	0	0	0	0	3
Prunus spp.	3	0	0	0	0	0	0	3

1) Surveyed area : 1 ha 2) Age after planting : 42 years

trees, the plantation contained considerable numbers of other spontaneous trees, most of them, except the birches, being under 14 cm in diameter. The floor of the forest was covered with the bamboo grass.

The quantity of damage caused by the voles was measured for all the damaged trees in the quadrat. The part of the stem where the bark had been stripped by the voles was traced on a sheet of paper and its area was measured.

In another experiment, seven small quadrats ($1\ m^2$) were plotted in the same area to examine the density of the bamboo grass and its browsing by the voles. The bamboo grass in these seven quadrats was all cut down and the numbers of leaves and buds browsed by the voles were counted.

Furthermore, two 0.6 hectare plots were settled in this plantation and sixty traps were set in each area at the intervals of 10 meters to examine the density of the voles and their physiological conditions. Trapping was continued for seven days in both plots.

These surveys were carried out from April 16 to 23, 1971, at the end of the snow season in this district. At the beginning of the survey, about 10 cm of snow remained on the surface of the survey area, but by the end of the survey, all the snow had disappeared and bamboo grass had begun to flourish on the forest floor.

Results

1. Damage to trees

The results of the survey of the damage to the trees within the survey area are shown in Table 2. Of the 887 trees, 152 were damaged, and of these 143 were larch trees. Thus the larch was obviously the most damaged species among the trees in the survey area, both in occurrence and in total area of bark stripped. The index of selection by IVLEV (1955)

Table 2. Damage ratio and selection index by voles for each tree species

Species	Number	Trees damaged	Damage ratio (occurrence)	Total area bark stripped	E*
Larix kaempferi	429	143	33.3%	69,204.9 cm²	0.32
Betula ermanii	160	0	0	0	−1
Magnolia obovata	69	2	2.9	63.8	−0.70
Phellodendron lavallei	49	3	6.1	207.9	−0.47
Kalopanax ricinifolium	47	1	2.1	127.5	−0.78
Salix spp.	46	0	0	0	−1
Acer pictum	19	2	10.5	189.6	−0.24
Quercus mongolica	18	0	0	0	−1
Alnus hirsuta	16	1	6.3	145.6	−0.46
Hydrangea paniculata	15	0	0	0	−1
Sorbus commixta	8	0	0	0	−1
Picea abies	5	0	0	0	−1
Ulmus davidiana	3	0	0	0	−1
Prunus spp.	3	0	0	0	−1
Total	887	152	17.1	69,939.3	

* Selection index $E=(ri-Ni)/(ri+Ni)$

ri is the ratio of damaged trees of each species to total damaged trees.

Ni is the ratio of damaged trees of each species to total trees in surveyed area.

gave a plus value for only the larch and minus values for all other species of trees. From this result, it can be confirmed that the larch tree is eaten selectively by the voles.

The damage rate of the larches, which were divided into diameter classes, is shown in Table 3. All diameter classes revealed a high degree of damage and no difference of damage rate was recognized between the classes.

Table 3. Diameter class and damage ratio of the larch in survey area

Diameter class (D. B. H.)	Numbers	Trees damaged	Damage ratio
5— 9 cm	20	6	30.0%
10—14	62	21	33.9
15—19	126	34	27.0
20—24	140	52	37.1
25—29	68	25	36.8
30—34	12	5	41.7
35—	1	0	0
Total	429	143	33.3

2. Browsing of bamboo grass by the voles

In Table 4, the result of calculating the numbers of buds and leaves of bamboo grass browsed by the voles is shown for the seven quadrats.

It appeared that the buds of bamboo grass, which were considered to be an important food item of the red backed vole during the winter season, were extensively consumed, at the rate of 60% in all the quadrats, while 27% of the leaves were to some extent browsed by the voles .

Table 4. Consumption of bamboo grass by the red-backed vole in survey area

No. of quadrat*	Numbers of bamboo grass	Bud		Leaf		
		non-consumed	consumed	non-consumed	consumed	
					(under half)	(over half)
		%	%	%	%	%
I	47	115(39.4)	177(60.6)	37(14.3)	154(59.5)	68(26.3)
II	29	22(31.4)	179(68.6)	167(83.5)	26(13.0)	7(3.5)
III	42	45(18.3)	203(81.8)	123(49.0)	112(44.6)	16(6.4)
IV	47	134(34.0)	260(66.0)	263(68.5)	119(31.0)	2(0.5)
V	35	124(49.4)	127(50.6)	309(94.8)	14(4.3)	3(0.9)
VI	38	158(40.8)	229(59.2)	241(93.8)	15(5.8)	1(0.4)
VII	34	179(41.5)	252(58.5)	321(96.1)	12(3.6)	1(0.3)
Total	272	1,049(42.4)	1,427(57.6)	1,461(72.7)	452(22.5)	98(4.9)

* quadrat area: $1m^2(1\times 1m)$

Table 5. Result of vole trapping

Plot A (area: 0.6ha, trap interval: 10m)

Species	Date captured							Total	no./ha
	Apr. 17	18	19	20	21	22	23		
Clethrionomys rufocanus	1	6	4	5	3	2	4	25	—

Plot B (area: 0.6ha, tap interval: 10m)

Species	Apr. 17	18	19	20	21	22	23	Total	no./ha
Clethrionomys rufocanus	4	6	6	4	1	4	2	27	43
C. rutilus	0	0	0	1	0	0	0	1	—
Sorex unguiculatus	0	0	0	0	0	1	0	1	—

3. Population of the red backed vole in this plantation

a) Population density

The results of trapping for seven days in the two plots are shown in Table 5. All the small mammals captured in the two plots were red backed voles, except for one *Clethrionomys rutilus* and one *Sorex unguicratus* in plot B, *i. e.*, the former was the dominant mammal in this plantation.

To estimate the numbers in plot A the method of ZIPPIN (1958) was not applicable since $R=\Sigma(n-1)Cn/Cn=3.0$, then $1-q=0$ (Cn is the number captured on the nth day, $q=p-1$, and p is catchability). As the total number caught indicates, however, at least 40 red backed voles inhabited per hectare. In plot B, $R=2.44$, $1-q=0.625$, and $\hat{N}=\Sigma Cn/(1-q)=43.2$; when this figure was converted into the number per hectare, the latter was estimated to be 43. Since the usual density of the voles during this season in Hokkaido is less than 20 per hectare, the densities estimated in this plantation were considered to be extremely high for this season.

b) Composition of population

The sex ratio of the voles captured was about 1 : 1 (♂-27, ♀-25). Body weight and body length of the voles are shown in Fig. 1 and in Fig. 2. Mean values of weight and

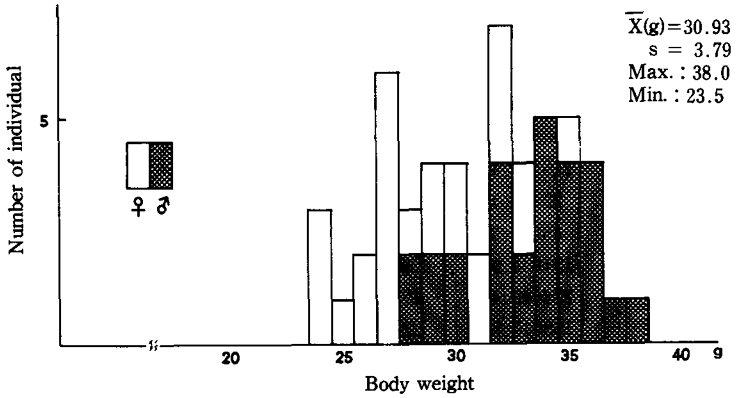

Fig. 1 Body weight of voles captured.

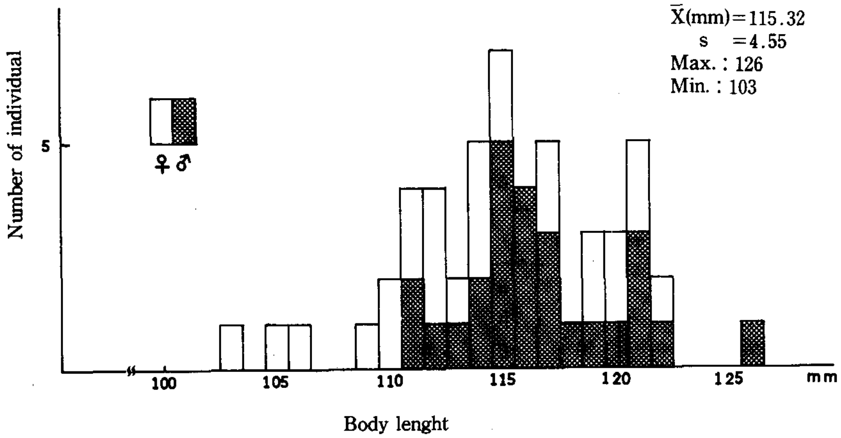

Fig. 2 Body length of voles captured.

length were larger in males than in females, but all the voles captured were recognized as overwintered individuals from the ranges of weight and length, and the colour of their fur.

c) Physiological state of the voles

In Fig. 3, the coefficients of fatness of the voles captured are shown. Comparable data on the coefficient of fatness of the voles are scarce, but MAEDA (1968) reported that the coefficient of fatness of the red backed vole in central Hokkaido was between 2.2 and 2.5 in March and April. The values obtained in this survey are apparently lower than those reported by MAEDA.

On the other hand, as to the sexual maturity of the voles, no abnormalities to mention were found. Over half of the females possessed an opened vagina (Fig. 4-above); approximately one third of the males which were heavier than 30g had scrotal or descending testes while many males less than 30g possessed small, abdominal testes (Fig. 4-below). These results suggest that considerable number of males and females in this population were already in the breeding condition, and the others were in the progressive state of the development of their reproductive organs.

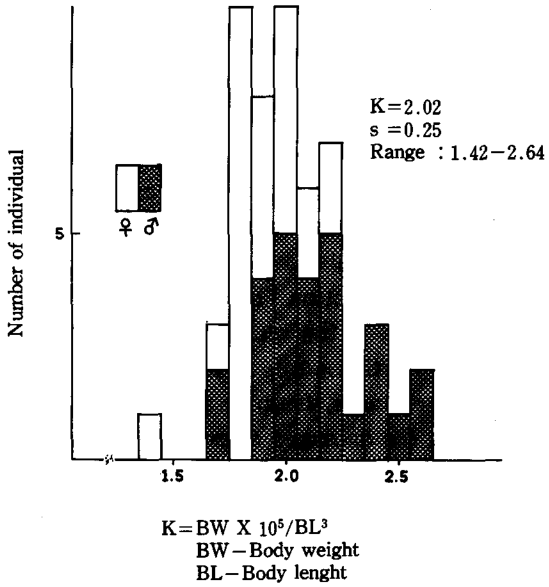

Fig. 3 Coefficient of fatness (K).

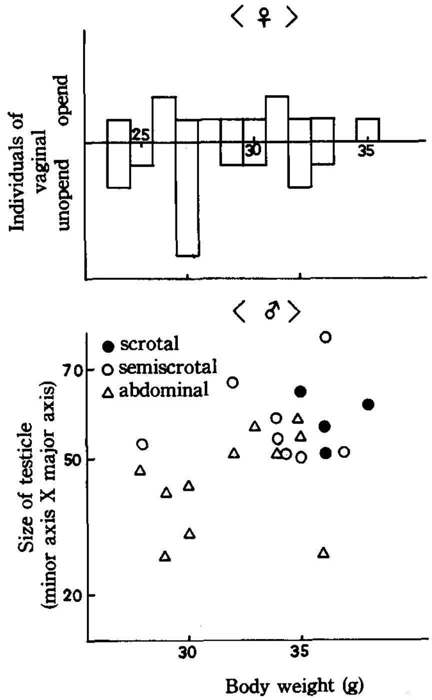

Fig. 4 Sexual maturity of voles sampled.

Discussion

Several theories have been proposed as to what circumstances may encourage stem girdling by the red backed vole in plantations.

KINOSHITA (1928), who was the first to research the damage by the red backed vole in larch plantations of Hokkaido, stated that the eating of tree bark is caused by an insufficient amount of foodstuffs in the late winter period, since the range of activity of the voles below the snow is confined to small areas on the ground. In a later work, INUKAI *et al.* (1963) proposed that exhaustion of body temperature due to the wet environment during the snow thawing period depressed blood sugar values of the voles and accelerates starvation, resulting in barking.

On the other hand, as a result of a comparison of the preference of the red backed vole for the several species of genus *Larix* made by TAKAHASHI *et al.* (1965) the *L. kaempferi* was considered to be the most prefered species among them because of the special nature of the resin contained in the bark.

TANAKA (1957), however, asserted that in the cases where overpopulation resulted in remarkable increase of the voles in limited areas, an increase of social stress accompanied by interference between individuals led to abnormal behaviour which included bark stripping. OTA (1959) observed that when outbreaks occurred, the red backed vole ate tree bark even in summer in spite of an abundant supply of food in the grass, and he considered that stem girdling by the red backed vole in plantations is possibly brought about by social stress caused by a high density of vole population.

In Hokkaido, however, bark stripping and stem girdling by the voles have been found to occur mostly in the late winter period.

MAEDA (1980) clearly showed that there was a small amount of available vegetation for the voles during the winter season in Hokkaido, and, on the basis of his data on the scarcity of food for the voles in this season, he confirmed that bark eating could not be attributed to abnormal behaviour brought about by social stress alone.

In the larch plantation surveyed in this work, there was also a considerable number of broad leaved trees among the larches. But the index of selection (E) estimated for each tree species gives a positive value only for the larch; i. e., the red backed vole clearly selected the bark of the larches in this plantation. Furthermore, at the roots of these damaged trees, beside the shavings of barks, a lot of faces, fresh as well as old, was found, indicating that the voles had remained around the damaged trees and lived on the bark of the trees. These facts suggest that the voles used the bark of the larches for food.

It was also obvious that the outbreak of damage in this plantation was related to the unusual high density of the red backed vole, the estimated number being 43 per hectare. And it is noteworthy that the buds and leaves of bamboo grass, which are known to be important food resources for the voles throughout the winter, were eaten at an extremely high rate, which presumes the scarcity of food for the voles during this season. This is supported by the fact that the coefficient of fatness of the voles captured in this area was lower than that of another district examined in the same season.

Examination of the sexual maturity of the voles in this area, however, revealed normal values, and no abnormal physiological states such as those brought about by social stress were observed.

Based on the results of this investigation, the author conclude that the extensive damage found in this larch plantation was caused by an insufficient food supply for the voles.

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要　　約

北海道北部にある北海道大学中川地方演習林のカラマツ壮齢林（植栽後 42 年）に発生したエゾヤチネズミによる樹皮の食害を 1971 年 4 月に調査した結果をまとめ，被害発生の要因を考察した。

林内に 1 ha（50×200 m）の調査区を設け，調査区内にある 429 本の全てのカラマツについて調べた結果，そのうちの 143 本（33.3%）が被害を受けており，樹皮を食われた部分の総面積は 69,250 m^2 であった。

調査区内のカラマツに混じって自生する落葉広葉樹にも被害が認められたが，全樹種について選択指数を調べた結果はカラマツが選択的に食害されていることがわかった。

一方調査区内に 1 m^2 の方形区 7 個を設けてエゾヤチネズミの冬期間の重要な食物と考えられているササの被食状況を調べた結果，芽，葉，ともに被食率が高く，とくに芽は 50～80%の

高率で食われていることがわかった。

調査区内で行なったワナ掛けの結果からエゾヤチネズミの生息数を推定したところ，ha 当り 43 頭以上となり，冬期間としては異常に高い密度でエゾヤチネズミが生息していたことがわかった。捕獲されたのはすべて越冬個体であったが，肥満度は同じ時期の他地域でのものに比べて低かった。しかし性成熟の進行状況はほぼ正常と認められた。

以上の調査結果をもとに，北海道におけるエゾヤチネズミによるカラマツ樹皮食害に関する二つの説，食物不足説とストレス説を検討し，少なくとも当該調査地で冬期間に積雪下でおこったカラマツの食害は，エゾヤチネズミの食物不足によって引き起こされたものと考察した。