Ecology of Field Mice in Forest Lands in Hokkaido
Report 4

Food habit and nutrition of the red-backed vole, *Clethrionomys rufocanus bedfordiae* (THOMAS)

By

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Summary: In this report the writer has dealt with the influence of feeding habits and nutrition on the population fluctuation of red-backed voles (*Clethrionomys rufocanus bedfordiae*), based on studies made from 1969 through 1971 in the forest lands of Nopporo, Hokkaido. The aim of the study was to ascertain the vegetation available to voles and its nutritional properties in the forest ecosystem.

Voles were found to be typically herbivorous. The stomach contents consisted mainly of green fibers. Voles also showed a greater preference for young shoots of Sasa-bamboo than for any other species of plants in forest land, and the species of grass and herbs eaten by voles were limited to only a few varieties. Availability of food plants depends on the difference of vegetation and its composition. Although it is difficult to estimate the potential food resources available to small mammals, and the task requires a thorough knowledge of a particular plant species in a vegetation foraged by voles in different ecosystems and the feeding habits of voles, a study along this line is important from an ecological point of view, because the nutritional source which has a vital influence on the vole population depends largely on the forest ecosystem in a given area.

Since an analysis of the stomach content of the digestive tract is a direct means of investigating feeding habits of a vole, it is necessary to make an accurate assessment of the vegetation and their nutritive values.

A group of captive voles fed on a low protein diet showed a significant decrease in serum protein as compared with that of a high protein group.

The plasma protein level of voles was remarkably reduced in the presence of food deficiency (e. g. winter). In spring the level was the highest and in autumn the values were slightly higher than in summer. Measurements of plasma-protein were made by means of thin layer chromatography and the results reflected nutritional ingestion.

Introduction

This is the 4th report in a series of investigations and deals with the population fluctuation of red-backed vole, *Clethrionomys rufocanus bedfordiae* (THOMAS). As reported in our previous papers (1–3), the investigations were carried out in areas with different type of vegetation in the forest land of Nopporo, Hokkaido. Bedford red-backed voles prefer lowlying grassland with a high moisture level and tend to concentrate in young plantations which provide them with an optimum habitat[5]. It was revealed that red-backed voles are herbivorous and their stomach contents was mainly composed of green fibers probably originating from leaves. The population fluctuation of the vole seems to depend on the mortality rate, sexual maturation, and growth index of young individuals[8]. As may be seen from the survival and mortality curves, a sharp reduction in a given population was noted when the vegetation differed in type. It must be emphasized that the habitat conditions in various types of forest land determine the population fluctuation. Therefore, it is necessary to make an accurate evaluation of

Received September 5, 1972

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the standing vegetarian, feeding habits of voles and its nutritional influence on the vole's diet[9].

The aim of this study was to ascertain the vegetation available to voles and its nutritional properties in the forest ecosystem.

Materials and Methods

1. **Plant structure and standing crops**

In each survey area, five permanent plots were selected at random in natural Todo-fir forest. A wooden frame (100×100 cm) was constructed around each plot. The plants were cut once a month throughout the year according to the experimental procedures. Individuals plants of each species were cut after counting the number of clumps.

The clumps were weighed and identified after which they were dried. Plant samples for yield and estimation by chemical analysis were taken from the duplicated plots, with an area of 100×100 cm.

2. **Stomach contents of voles**

The stomachs were removed from the voles captured by means of monthly snap-trapping in the forest. The content was spread out on a petri dish (10 cm in diameter), and separated into three components i. e., seed, animal, and vegetable materials. The petri dish was then placed on section paper and the relative proportion of animal and vegetable material in the content was measured under gross inspection. Representative plants were collected from the study area, and finely ground plant fragments were mounted on microscopic slides. These slides were used as reference material for the identification of the stomach contents of voles. The stomach contents were weighed and approximately 10 per cent of each item of the main food (i. e., green, berries, animal food) was removed for the volumetrical estimation. Later these items were identified by a higher microscopic observation. The permanent slides of the epidermal layers of stems and leaves were prepared by the method previously described by Maeda (1968)[9]. The plant fragments on the slide were identified by the aid of a microscope, and by comparing them with the material of the reference collection.

3. **Nutrient components of plant**

a. Protein—Nitrogen determination was performed after the Kjeldahl-method.

b. Fat—Quantitative analysis of fat was made by ether extraction, using a Soxhlet apparatus. The samples were extracted continuously in a Soxhlet apparatus for 5 hours using anhydrous ethyl ether.

c. Fiber—Crude fiber was determined by ignition loss of dried residue remaining after digestion of sample with a 1.25% H_2SO_4 and 1.25% NaOH solution under specific conditions. Sample (1 g) was boiled for 30 min. successively after which it was filtrated and washed thoroughly with H_2O. This treatment was repeated three times. The dried residue was completly burned for 5 hr at 600°C in a furance.

d. Ash—Ash content in the sample was determined using combustion analysis.

e. Calory—The gross energy value of the plant and diet was obtained by burning the weighed sample in oxygen gas in a calorimeter (OGAWA 100-3).

4. **Analysis of amino acids**

a. Amino acids in the sample of plants and stomach content of voles were determined.

The samples were hydrolyzed with 6N-HCl at 110°C for 20 hr. Because of the simplicity of operation and equipment, thin layer chromatography was applied for amino acid determination. The sample was processed on a silica-gel (WAKO-B-10) layer activated previously at 110°C for 15 min and developed with a solvent system of n-butanol/acetic acid/water (6 : 2 : 2). After drying at 110°C for 15 min, the amino acids were determined using a ninehydrin solution.

b. Sampling of blood and preparation of sera for analysis.

The voles were jugulated with a heparinized syringe. Samples of blood (3～5 m*l*) were drawn into vacuum blood collecting tubes with specific needles, and were deposited at 38°C for 30 minutes, then stored at 2°C for one or two days. The samples were centrifuged at 2,500 r. p. m. for 10 minutes to collect serum. The serum (about 0.1 m*l*) was decanted into a small tube. The serum was quantitatively analyzed by a two-dimensional ascending thin layer chromatography method. Serum proteins precipitated with 3 volumes of ethyl alcohol were centrifuged off. The whole transparent supernatant was spotted on a corner of the silica-gel layer for free amino acids analysis. The running solvents were n-butanol, acetic acid, water (6 : 2 : 2). Secondary solvents were phenol and water (4 : 1). 0.1 per cent ninehydrin (W/V) in n-butanol was sprayed on to locate the free amino acids. The density of the color spots were read with a recording densitometer (TOYO-DMU-2) and the volume was estimated by comparing with a standard. The position of the substance on a chromatogram is specified by its "RF" value which can be defined as follows;

$$\text{RF. value} : \frac{\text{Distance of the substance from the base line.}}{\text{Distance of the solvent front from the base line.}}$$

Results

1. Seasonal changes of quantity of plants in study areas

Although the total amount of plant biomass fluctuated considerably, the seasonal variations in green mass were far greater. The average amount of above-ground parts of plants is always greatest in summer, but decreases considerably, though gradually, with the change of the seasons in succession. Maximum values were obtained in summer, but in winter a yearly

Table 1. Changes in standing crop of the ground flora of study area (in grams of dry matter per m²)

Abundance of plants in natural Todo-fir forest					Abundance of plants in Todo-fir seedling forest			
Species	Stem number	Green weight	Cover-degree(%)	Month	Species	Stem number	Green weight	Cover-degree(%)
1	17	483	—	Jan.	5	52	708	—
2	13	413	—	Feb.	2	84	743	—
5	21	412	—	Mar.	4	74	1400	—
6	25	326	58	Apr.	5	81	1123	64
6	24	372	35	May	22	171	1415	85
8	22	789	44	June	26	234	2013	98
5	26	759	55	July	20	105	1921	94
8	38	402	25	Aug.	22	138	1965	92
8	31	461	59	Sep.	19	108	1530	96
4	29	469	56	Oct.	11	149	1754	100
5	25	381	18	Nov.	15	166	1464	94
3	28	645	—	Dec.	3	51	840	—
(5)	(25)	(492)	(29)		(13)	(109)	(1406)	(60)

( ) : Mean

Table 2. Relative abundance of plant species, of possible importance to the diets of voles in May～November on forest land Todo-fir seedling (per m^2)

Month	Average number		Average weight (g)		Sasa-bamboo (g)	Weight proportion (%)	Palatable plants (g)	Weight proportion (%)
	Height		Height					
	～30 cm	31 cm～	～30 cm	31 cm～				
May	89.6	32.0	280.4	86.8	231	61	37	10
June	68.4	50.6	195.8	90.2	240	83	166	58
July	94.2	10.0	188.8	65.0	140	55	96	38
Aug.	133.2	38.8	352.8	142.0	142	29	73	15
Sept.	136.4	31.0	310.2	152.8	390	84	6	1
Oct.	106.0	14.4	187.8	128.0	143	45	13	4
Nov.	49.8	1.2	94.7	12.0	170	76	28	12
(Mean)	(96)	(25)	(230)	(96)	(208)	(65)	(59)	(19)

Table 3. Seasonal changes of food; frequency of occurrences in percentage of feeding pattern stomach content of the red-backed vole

	Population size	Green matter	Roots	Fruit	Seed	Animal	Other
Jan.	1	6.6			93.3		
	27	62.5		12.5	25.0		
Feb.	3	25.0			60.0	15.0	
	16	86.2	6.2		3.7	2.5	1.4
Mar.	5	80.0			6.7	10.0	3.3
	16	70.0		3.8	15.0	8.7	2.5
Apr.	5	37.5			57.5	5.0	
	25	65.7	2.8	5.6	22.8		3.1
May	3	55.0			45.0		
	8	90.0				5.0	5.0
June	5	6.6			93.3		
	2	70.0	10.0		5.0		15.0
July	10	19.1		77.5			3.4
	9	80.0		20.0			
Aug.	8	45.0			25.0	30.0	
	12	6.6		36.6	56.6		
Sept.	8	24.0	23.0	14.0	24.0	15.0	
	18	61.3	2.5	18.0	10.0	8.2	
Oct.	3	100.0					
	21	25.0		6.3	68.7		
Nov.	6	30.0			66.6		3.3
	18	55.5		2.7	35.5	5.5	0.8
Dec.	3	67.5			32.5		
	6	6.7			93.3		
(Mean)		(41.4)	(1.9)	(7.6)	(41.0)	(6.3)	(0.8)
		(56.6)	(1.8)	(7.8)	(28.0)	(2.5)	(2.3)

The upper values indicate natural Todo-fir forest.

The lower values indicate forest land with Todo-fir seedling.

reduction of about 25 per cent was found in the amount of biomass per 1 m^2, varying in both experimental areas. The greatest difference in the amount of plant mass between the two habitats is shown in Table 1. Green vegetation occurs most frequently in a period from May through November when the annual vegetation is green in the seedling land.

The measurement of fresh weight of different plant species at the height of the middle of spring and at the end of winter, when the green plant mass reached its lowest were made. With the advance of growth, therefore, protein contained in plants decreases and the structure of plants becomes tougher. This process becomes most conspicuous in grasses with tall, dense growth forms. For perennial plants, the difference in a net plant production between the biomasses at the period of seed formation and in the process of growth prior to was measured. The biomass of plants at the period of seed formation is taken as the peak biomass of plants. Apparent green growth in the forest land begins in May and late June. However, some green vegetation is present, though quite sparse, during all months of the year.

2. **Monthly utilization of important food**

Food items of the voles were shown in Table 2 and 3.

Summer and winter saw a different amount of plant eaten while very large and distinctive seasonal variations occurred, from a minimum in February and March to a maximum in late July through to early August. The most common food of voles was Sasa-bamboo, occupying 19 per cent of the volume for voles (Table 2). Sasa-bamboo is the most dominant plant in such areas, amounting to 44.3 per cent or more of the total vegetation. The diet of voles is influenced by changes in the amount of different food items available in its habitat.

3. **Stomach content of voles**

In this experiment the stomach contents of 367 voles captured during 1967～1968 were analyzed and the results were summarized in Table 3. The table reveals the important types of food, gives seasonal trends, and suggests differences in feeding habits.

These habits vary within a very wide range in species, seasons, and habitats. The quantitative proportions of different types of natural food eaten by voles may be established with the aid of quantitative analysis of stomach contents. The constituent percentage in the volume of main food categories in the diet of the voles is shown in the results. The results of analyzing stomach contents of red-backed voles indicate that these rodents consume greens in greater quantity and lesser amount of seeds. On an average greens amounted to 41～56% of their food (by volume), seeds to 28～42% and animal protein 2～6%. The most important constituent by bulk, measured on an annual basis, was green matter.

Seeds were second in importance and accounted for only 35～49% of the diet, with fruit included. Other items of volumetric importance were green leaves in the early spring, fruit matter in late summer. Insect materials were important only in early spring. Other food mixed in occurred sporadically and only in small amounts throughout the year. Red-backed voles were found to eat buds or young shoots, stems and leaves of green plants during the summer, and roots during the winter. The most obvious and important change involved Sasa-bamboo grasses. These accounted for about 60%, by weight, of the total food taken during the period from April through October. The relative amount of the different foods eaten by voles in the two different areas, is shown in Table 3. In both areas the importance of green matter in the diet at this time is obvious. Various plants occupied 56% of the annual diet of voles in the afforested land and over 41% in the natural forest land. A significant difference was observed in some of the areas between the composition of plants and the age levels of voles. The food habits of young and adults were similar. Adult voles displayed a general tendency to eat less ground vegetation than young voles. Only two plants were taken in significantly different amounts by the two age levels.

Most of the stomach content was limited to certain types of fragments, hence, identification was not too difficult if they had not been destroyed in the digestion process; not only the frequency of occurrence but also the relative amounts of each food item present could be obtained from this examination.

4. Nutritional substance of ground vegetation and stomach contents

The chemical compositions of green parts and dead parts of ground vegetation were shown in Table 4. The underground parts of plant were not examined because such an examination was not practical. It is shown that among the grazed field vegetations, grasses containing over 4.1% ether extract and over 12.2% protein were selected by the vole feeding in a forest land. The amount of protein increased gradually in spring and a saturation deficiency was not noticed until the middle of July. In August, however, the deficiency was conspicuous. The protein in the stomach content of voles increased in April. Protein occupies a markedly lower level in natural forest land and it is markedly inferior to seedling land (brush and grass) range, for it fell below maintenance levels in late fall and early winter and attained optimal levels only for a brief period in late April and early May. In the seeding land range, however, protein levels never fall below maintenance value and are optimal for six months of the year. Fat reserves declined throughout the winter, but during the breeding season (May~July), the reserves accumulated rapidly. During the summer, fat reserves declined again. These voles maintain a constant fat index of 6 mg throughout the summer (Table 5); the slightly higher figures for June reflects higher body fat of breeding voles. In September it jumps to even 7 mg which is higher than it is in other months. The caloric value of vole stomach contents closely correspounds with caloric content in plants, the food taken by voles. Young voles preferred higher protein and lower fat containing food as compared with adults. It is also known that voles are capable of selecting the most nutritions plants among the same species, as well as the portion with the highest quality.

5. Amino acid composition of plant, diet and plasma

Amino acid composition of plant and diet in the forest land, as expressed in grams per 100 g of dry matter, was given in Tables 7 and 8.

There were remarkable changes in the amino acid composition of grass, although samples decreased in amino acid content with the lapse of time in the growing season. It seemed that the content of such essential amino acids as lysin, methionin and threonin might change with the growth of plants. Amino acid ratio for all seasons ranged from 1.9 up to 4.0. In Table 7, the amino acid composition of serum in the vole is compared with that of the plants on which they had been feeding. Also presented in Table 8 are the average amino acid ratios for voles feeding under the differental dietary protein level. The serum protein level of the vole was higher in spring than in autumm. The protein level was remarkably reduced in the season of food deficiency (winter) and in autumm slightly over that of other seasons. Emphasis was placed upon the importance of the relationship between protein utilization and the amino acid composition in the protein. On the basis of this thinking the protein quality will be greatest when the dietary protein provides the amino acids in a pattern optimum to the amino

Table 4. Nutritional substance of the diets of voles found in stomach contents during the period from August to November 1969 (% of dry matter 100 g in stomach contents)

	Crude protein	Crude fat	Crude fiber	Crude ash	N-free extract	Calory
Aug.	13.25	4.20	54.26	9.61	18.62	480
Sep.	19.46	4.06	54.30	9.64	12.54	418
Oct.	12.19	5.34	40.80	9.67	32.00	428
Nov.	13.87	4.58	62.00	9.70	9.85	464

Table 5. Relation of the nutritional substance and nutritive values of ground vegetations on forest lands (% of dry matter 100 g)

	Sample number	Crude protein	Crude fat	Crude fiber	Crude ash	N-free extract	Caloric value	Nutritive value	Protein-calorie ratio
Apr.	20	10.86	4.43	53.61	8.92	22.18	332.4	4.86	11
May	31	10.58	4.68	43.79	11.48	29.77	330.8	8.74	12
June	30	9.62	6.91	43.39	11.12	29.96	314.0	9.50	11
July	38	7.71	6.05	52.63	8.79	24.86	330.6	18.50	17
Aug.	21	8.55	4.71	54.38	9.80	22.56	302.0	14.42	13
Sep.	53	9.78	7.56	47.37	8.62	26.66	299.8	16.68	17
Oct.	59	8.48	4.14	45.86	9.51	32.02	324.6	14.18	12
Nov.	20	9.82	3.88	49.65	9.80	26.85	318.8	15.22	12

Table 6. Nutritional substance of plants (% of dry matter 100 g)

Species	Sample	Crude protein	Crude fat	Crude fiber	Crude ash	N-free extract	Calorie
Cirsium pectinellum	F	9.6	9.8	37.8	8.6	34.2	302
	S	5.9	7.0	43.0	9.8	37.3	280
	D	4.1	4.4	50.7	11.0	29.8	292
Sonchus arvensis var. *ulginosus*	F	10.1	6.8	39.3	8.7	35.1	328
	S	13.7	4.4	43.4	8.6	29.9	294
	D	5.5	4.5	43.6	7.0	39.4	234
Disporum smilacinum	F	8.7	7.4	48.5	8.1	27.3	290
	S	7.9	6.1	54.6	9.3	22.2	306
	D	2.9	4.8	58.4	8.7	25.2	308
Oenothera biennis	F	8.6	3.3	35.6	9.2	43.3	278
	S	4.2	2.0	65.6	9.1	19.1	338
	D	1.4	3.0	33.8	9.7	52.1	176
Taraxacum hondoense	F	11.3	5.0	37.8	8.6	37.3	294
	S	8.1	2.7	30.6	8.7	49.9	296
	D	5.0	3.8	50.8	8.7	31.7	300
Picris hieracoides	F	11.8	5.1	29.5	8.2	45.4	440
	S	4.3	5.2	31.9	9.2	49.4	296
	D	8.8	5.7	35.2	8.8	41.5	318
Erigeron annuus	F	9.2	2.3	33.6	8.4	46.5	476
	S	9.1	1.9	41.4	8.6	39.0	366
	D	6.7	4.9	33.5	8.6	46.3	494
Artemisia gigantea	F	5.5	2.6	57.5	9.5	24.9	344
Sasa paniculata	B	14.9	6.3	39.3	7.7	31.9	350
	F	8.7	6.3	35.2	12.2	37.8	308
	Sh	9.0	6.1	31.2	10.6	43.2	382

F : fresh leaf, S : stem & root, D : dead leaf, B : brows, Sh : shoots

Table 7. The amino acid composition of food in

Experiment forest land \ Amino acid	Month	Lys.	His.	Arg.	Cys.
1. Ground vegetation of Todo-fir forest.	Apr.	++			++
2. The stomach content of vole in Todo-fir forest.	Apr.	+++			+
3. Ground vegetation in Larch forest.	Aug.	+			+
4. The stomach content of vole in Larch forest.	Aug.	+++			+++
5. Ground vegetation of Todo-fir forest.	Oct.	++	+	++	
6. The stomach content of vole in Todo-fir forest.	Oct.	+	++	+	+

+ : 0.05 g　++ : 0.10 g　+++ : 0.15 g

Table 8. The amino acid composition in plasma of voles

Experimental zone	Season	Sample	Lys.	His.	Arg.	Cys.	Pro.	Asp.
Animals bred on synthetic diets.	spring	blood	++					
Animals fed on alfalfa.	spring	blood			+	++		
Ground vegetation of Todo-fir forest.	spring	plant	++			++	+	+++
	autumn	plant	++	+	++		++	+
Captured animals in Todo-fir forest.	spring	stomach content	+++			+		+
	autumn	stomach content	+	++	+	+		++
	spring	blood	+					
	summer	blood	+	+	+	++		
	autumn	blood				++		

+ : 0.05 g amino acid ratio : essential a. a./nonessential a. a.

acid requirements of the vole. It reaches highest values during spring, while in winter its values drop, and in summer it is maintained on the same low level.

Discussion and Conclusion

In order to determine the feeding habits of small mammals, it is necessary to use two methods; stomach content analysis and the test of choice. Both methods are qualitative and they supplement each other; they also give fairly similar results. The former method enables the food available to mammals in a given ecosystem to be estimated; in the latter, it can be calculated fairly precisely as to how much of that food is to be consumed by animals. In addition, numerous experiments with food preferences, both under laboratory and field conditions, have been carried out recently. Earlier, largely qualitative studies were summarized by Hoshino (1960)[3] which mostly consisted of lists of plants preferred by various animals. Only a minimal amount of forage crops in a particular region is available to one vole. Thus, the study by Igarashi (1972)[4] in the Nopporo forest land showed that Todo-fir seedling community yielded 4,020 kg per ha in contrast to 1,931 kg produced per ha in natural forest land. In short, Igarashi[4] concluded that preference of plants by voles depended more on growth the stomach of vole (g/100 g, dry weight)

Pro.	Asp.	Gly.	Thr.	Ala.	Glu.	Val.	Met.	Iso.	Leu.	Tyr.	Phe.
	+++	+++	+++		+++	++		++			++
	+	+		++	++			+			++
		+							+		+
+				++		++	++	++	+		
++	+	++	++			+		++		+	
+	++	+++								+	

under various feeding condition (g/100 g, dry weight)

Gly.	Ser.	Thr.	Alo.	Glu.	Val.	Met.	I. Le	Leu.	Tyr.	Phe.	Try.	Amino acid ratio
					+	+++		++		+		3.8
		++	+		+			+	+	+	++	3.2
+++		+++		+++	++		++		+	++		4.0
++		++					++					2.2
+			++	++			++					2.6
+++							++		+			2.3
++					+	++				+	++	3.4
							+			+		1.9
+					++							2.8

stage and succulence than on plant species.

According to Maeda & Igarashi (1972)[10], a vole feeds on 15 species of plants in the Nopporo forest land. Examining the degree of browsing among various plant species and analyzing the stomach contents, the author has roughly determined the number of forage species as food of voles (Table 2). Recent work (Maeda 1969)[9] has been centered on the quantitative assessment of food plants and the seasonal changes in plant growth, chemical content and palatability. A study of feeding habits is important in the understanding of the rodent factor in forest ecology. But a mere list of foods does not indicate the complexity of the interrelations between animals and food supplies, which differ remarkably in kind and amount from place to place and varies enormously among seasons and years. A study along this line can be made between the areas, or comparisons can be run in the same area at different times, especially when a change in the quality of available food has occurred. When the quality of vole food deteriorates because of continued high population pressure, successive changes of plants, or some other reasons, one of the most commonly observed results is a lowering in birthrate and survival rate of young animals.

Variation in the nutritive value of plants available to wild herbivore has been investigated, through physical studies of plants and a general review of the subject by ecologists. Kuwahata

(1971)[6] determined that the vole requires a 7% protein diet merely for maintenance, 9.5% for moderate growth, and 13% for optimal growth and reproductive performance. The serum plasma protein patterns of rats have been studied by several workers in recent years. Under normal conditions ingested proteins are broken down into free amino acids and are absorbed as such into the blood (ALBANSE 1963)[1]. Approximately twenty essential amino acids are known to be required for growth and maintenance of cellular tissue and also for other metabolic functions. From this fact, we can understand readily the importance of amino acids in the composition of the dietary protein. Various reports have indicated that post diet changes in the plasma amino acid concentrations may be dependent upon the amino acid composition of the protein injected. From our experiment with voles, it was shown that the order of abundance of a free amino acid in the blood varies directly with the relative concentration of the amino acid in a dietary protein. It was suggested that the concentration of amino acid in the blood plasma increased after ingestion of a protein diet. These results indicate that some factors creating the concentration of amino acids in the protein are affected by the plasma amino acids level.

TAMURA (1967)[11] recently proposed an interesting theory concerning the evaluation of the efficiency of protein utilization based upon the fasting profile of essential amino acids. He has suggested and demonstrated the use of the fasting level concentrations of essential amino acids as a possible index of protein nutritional status. Also, TAMURA (1968)[12] suggested the use of blood amino acid concentrations as an indicator of protein or amino acid requirements. Protein metabolism is extremely complex, thus the utilization of dietary proteins in a phase of this metabolism is susceptible to many dietary and physiological factors. The fatness of an animal is a good indicator of its physiological condition and accordingly both methods can be recommended in studies. Measurement of protein efficency in body weight gain is one of the simplest and most frequently used procedures.

TAMURA (1967)[11] was instrumental in developing this technique, which revealed a striking correlation between body weight gain in young rat and dietary protein quality. Many authors[1)7] have reported evidence which suggests the nutritional necessity and importance of essential amino acids in the diets. The caloric value of an animal is connected with its gross body composition. It depends, to a considerable degree, on the fat content and, to a smaller degree, on the mineral content. Therefore, even a small change in weight may be responsible for some serious changes in the caloric value of the bodies.

In the study of the energy flow through a mammal population some questions concerning feeding ecology must be answered. The most important is (1) which part of the primary net production of a given ecosystem is available as mammal food; (2) which part of the energy consumed by mammals is assimilated and which is returned to the cycle via excrements. As a rule the food available to rodents is only a part of the plant production and the total primary production cannot be regarded as available in its total bulk. The energy available to rodents was defined by GRDOZINSKI (1968)[2] as "That food which is easy to find is being chosen and eaten by these animals". Consequently, the estimation of the food availability is usually based on some knowledge of mammalian food habits.

The population dynamics in the productivity of terrestrial communities is determined by the transformation by the animals of matter and energy according to trophic level and by their influence on other components of the "ecosystem". Application of the results of this study in the field will require additional work on diet quality and nutritional physiology for red backed vole (*Clethrionomys rufocanus bedfordiae*).

Acknowledgements

The writer wishes to express his gratitude to Dr. K. Ito, Director of Forest Protection Division and Dr. T. Udagawa, Head of Section of Wild Life of Government Forest Experiment Station and Dr. M. Ueda, Chief of Division of Forest Protection and members of Laboratory of Wild Mice, Hokkaido Branch of Government Forest Experiment Station, for their help and cooperation throughout the studies. Thanks are due to Professor M. Ishimoto of the Faculty of Pharmacology, Hokkaido University, for his invaluable advice during this work. He wishes to acknowledge considerable assistance from Dr. J. Kawabata of Hokkaido Institute of Public Health, for his advice in chemical techniques.

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北海道の森林における野ネズミの生態に関する研究（第4報）

エゾヤチネズミの食性と栄養について

前　田　　満[1]

摘　要

この研究は，エゾヤチネズミの個体群変動論に関するシリーズの第4報であり，とくに，森林生態系内でエゾヤチネズミが何を食べ，それがネズミの栄養条件として，どんな役割りをもつのかという点を主眼にして解析したものである。

エゾヤチネズミは他種にくらべ典型的な草食動物であり，胃内容物には緑色繊維が多くみられた。この食物のうちササのしめる割合は天然林よりも人工林において高かった。これら食性の季節変化をみると，胃内容物の構成は，林床植物の種類と量に依存していることが判明した。しかし，草本現存量のなかで"ネズミが好んで食べる草"は，それほど多いものではなかった。

消化管内の内容物をしらべて食性を直接判定する方法のほかに，食物の栄養率（蛋白質とカロリー比）およびアミノ酸比（必須・不必須アミノ酸構成）をもとめ，これとネズミの血漿遊離アミノ酸の構成とを比較した。この結果，天然林においては人工林よりも，また，冬期間と夏期は春期よりも，必須アミノ酸の欠乏がみられた。

森林ごとにネズミの食物資源がどれだけあり，そこでのネズミの栄養状態を知ることは，生息数（土地収容力）および個体群動態（成長・繁殖）を予測するために有効な方法である。

1972年9月5日受理

(1) 北海道支場