ON EATING OF PINE-BUDS BY THE SQUIRREL
(Sciurus vulgaris)

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SELOSTUS:

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Preface

This study was begun at the request of a farmer, Mr. HEIKKI AHO, who had noticed considerable eating of pine-buds by squirrels (*Sciurus vulgaris* L.) in his forest. This work would never have been performed without the continuous assistance and generosity of Mr. AHO. We are deeply indebted to him for all his help. We also wish to express our gratitude to the Nokia Co. Ltd, which offered the use of its forests for the field studies.

We are also deeply indebted to Prof. ESKO KANGAS, Head of the Agricultural and Forest Zoological Institute, whose expert advice, helpful criticisms, and constant encouragement have been of invaluable aid to us during all phases of this work.

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Erkki Pulliainen and *Kalervo Salonen*

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1. Introduction

There are only two detailed accounts (VARTIO 1946 and RAJALA & LAMPIO 1963) of the food biology of the squirrel *(Sciurus vulgaris)* in Finland. In addition to these, there are studies concerning damage caused by squirrels to trees (see e.g. LAMPIO 1948, JUUTINEN 1952, KOSKIMIES 1961, PULLIAINEN & SALONEN 1963, PULLIAINEN 1963, SALONEN 1963). All these studies have shown that in autumn pine (*Pinus silvestris* L.) and spruce (*Picea excelsa* L.) seeds comprise the main food items of the squirrel. The utilization of spruce buds is also comparatively common. In winter, too, seeds of pine and spruce are the chief food items. But eating of spruce and pine buds is much more frequent than in autumn. Thus pine buds are secondary food items in relation to pine and spruce seeds, and spruce buds. They are especially eaten by squirrels when the major food items are not available.

The purpose of the present paper is to provide records of our investigations concerning the eating of pine buds by the squirrel from the standpoints of the food biology of the species and of forestry.

2. Material and methods

The studies here described were performed at Pinsiö, in the northern part of the market town of Nokia, South Finland. The total area of the two seedling stands (I and II) studied was about 20 hectares. The stands were about 10—15 years old and their mean frequencies were 1875 and 2620 seedlings per hectare. There were spruce-pine mixed forests in the surroundings of the seedling stands studied.

The basic work of this study was performed by Mr. HEIKKI AHO, who recorded the feeding activities of squirrels in the seedling stands of the study area in the late winter of 1962 and 1963. Mr. AHO made observations on the buds on which the squirrels were feeding. All the seedlings in which buds were eaten by squirrels were marked. Thus reliable data on the phenomenon were obtained. Because many different agents (see e.g. JUUTINEN 1962, KANGAS 1962, 1963, EIDMANN & INGESTAD 1963) may destroy pine buds, the method used was regarded as the only one possible. In every case we could be sure of the pest responsible for the damage.

In order to obtain a general picture of the extent of bud-eating in the study areas estimates were made of the damage in circular sample plots. The number of these permanent sample plots (each 2 ares) was 15. They were checked in 1962 and 1963. There was a total of 637 seedlings in these plots.

To study the recovery of the seedlings damaged by squirrels, 200 seedlings were individually selected and marked on 8.—9. I. 1963. Buds of these seedlings had been eaten by squirrels a few days earlier. On 3. XII. 1963, these seedlings were checked. However, only 173 seedlings could be studied, because 27 marks had disappeared.

There were a number of spruce seedlings in the sample plots. The damage caused by squirrels to these seedlings was recorded, too.

A rust fungus species, *Melampsora pinitorqua* (A. Br.) Rostr., occurred in these seedling stands. The abundance of this species was also recorded.

Small rodents had damaged a number of seedlings in the study areas. These cases were recorded.

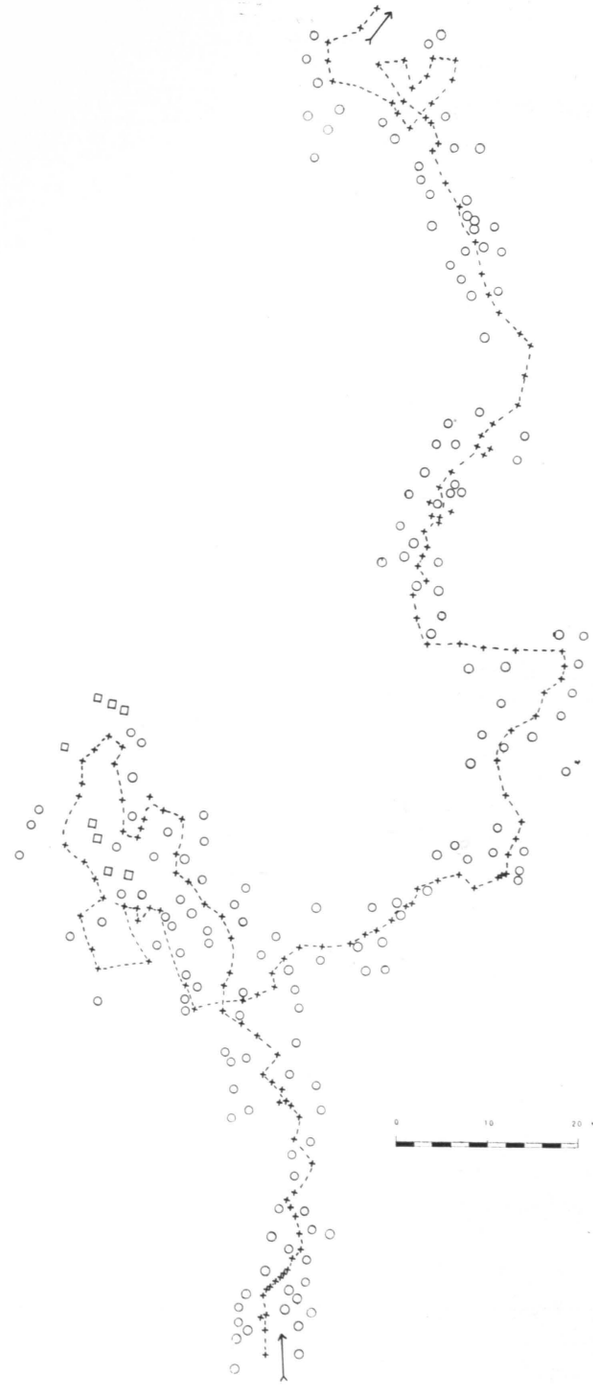

Fig. 1. Records of tracking a squirrel on 13. I. 1963 at Pinsiö (for explanations, see text).

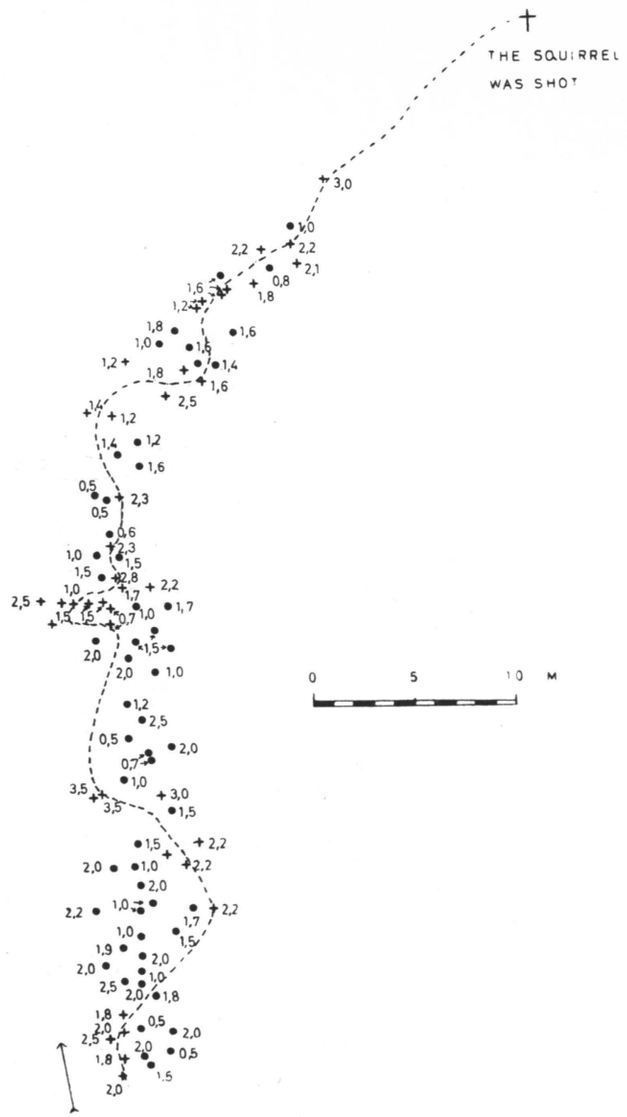

Fig. 2. Records of tracking a squirrel on 12. I. 1963 at Pinsiö (for explanations, see text).

3. Results

3.1. Observations on the feeding behaviour of the squirrel

Mr. Aho made the following observations on the bud-eating behaviour of the squirrel. In the seedling stands squirrels moved on the ground between the seedlings. They climbed to the top of the seedlings, where they fed on the buds of the terminal shoot. The squirrels bent the lateral branches with their fore-legs, so that they could eat buds from them. When the preferred buds had been eaten, the squirrels ran off to another seedling. It is to be noted that they did not feed on every seedling near their track.

In Figs. 1 and 2 the records of two trackings performed on 12. and 13. I. 1963 by Mr. Aho are presented. In Fig. 1 crosses indicate seedlings in which the buds were eaten by the squirrel tracked. Other seedlings in the immeadiate vicinity of the track of the squirrel are shown with circles (height under 4 m) and squares (height over 4 m). This squirrel was seen feeding on buds. In Fig. 2 crosses indicate seedlings in which the squirrel was seen feeding. Other seedlings are shown with black spots. Numbers indicate heights of seedlings. This squirrel was shot in the place marked in Fig. 2. The mean height of the seedlings damaged was 1.9 m and the corresponding value for the other seedlings near the track was 1.4 m. Thus this individual preferred the taller seedlings available.

In area I (7 sample plots) the height classes of the seedlings damaged by squirrels were recorded. The results can be seen in the following tabulation.

	Height classes, m			
	< 0.5	0.5—1.5	1.6—3.0	> 3.0
No. of seedlings damaged	0	63	52	21
Percentage	0	32	74	78

The results are very clear. The tallest trees available are greatly preferred by squirrels.

In Table 1 it can be seen that in areas I and II a total of 637 seedlings was studied. In Table 2 it is shown which buds of these seedlings were eaten by squirrels. The squirrels preferred the buds of terminal shoots. In 54 per cent of the seedlings only the buds of the terminal shoots were eaten. In another 44 per cents the squirrels fed on buds of both terminal shoots and lateral branches. In very few cases was the damage confined to the buds of lateral branches.

The height classes of spruce seedlings damaged by squirrels in area I were recorded, too. Squirrels snapped off both the tops and the lateral branches of these seedlings (cf. also Linder 1924). Table 3 shows the results. The height class 0.5—1.5 m was the most preferred. It is seen from Table 3 that here, too, it was mainly tops of seedlings that were snapped off by squirrels.

Table 1. Densities of the pine seedling stands of areas I and II, and numbers of seedlings damaged by squirrels in these areas in 1962 and 1963.

Area	Seedlings in plots		Seedlings damaged			
	Total no.	Mean no./ha	1962		1963	
			no.	%	no.	%
I	375	1 875	191	51	15	4
II	262	2 620	136	52	94	38

Table 2. Analysis of bud-eating by squirrels in areas I and II.

Buds eaten by squirrels	Area				Total Seedlings	
	I Seedlings		II Seedlings			
	no.	%	no.	%	no.	%
Terminal shoot only	94	56	71	52	165	54
Terminal shoot and lateral branches	73	43	62	46	135	44
Lateral branches only	2	1	3	2	5	2
Total	169	100	136	100	305	100

Table 3. Number and height classes of spruce seedlings snapped off by squirrels in area I (7 sample plots).

Condition of the seedling	Height classes								Total	
	< 0.5		0.5—1.5		1.6—3.0		> 3.0			
	no.	%	no.	%	no.	%	no.	%	no.	%
Top snapped	0	0	17	16	1	9	0	0	18	13
Lateral branch snapped	0	0	2	2	0	0	0	0	2	1
Healthy seedlings .	0	0	86	82	10	91	3	100	121	86
Total	0	0	105	100	11	100	3	100	141	100

3.2. Extent of bud-eating in the study areas

The numbers of seedlings damaged by squirrels in the areas of the permanent sample plots are presented in Table 1. It can be seen that in 1962 about half the seedlings were damaged in both areas. There was no difference between the two areas, whereas in 1963 the difference was clear. In area I only 4 per cent of the seedlings were damaged. In area II the proportion (38 per cent) of

seedlings damaged was also lower than during the previous year. It is to be noted that squirrels were shot in these areas during the winter of 1962—63.

In area I squirrels damaged spruce seedlings, too. A total of 203 spruce seedlings grew in this area, 5 per cent of which were damaged.

3.3. Influence of bud-eating on the growth of seedlings

The influence of bud-eating on the growth of pine seedlings was studied both in the permanent sample plots and with the individually selected seedlings.

Table 4. Data showing recovery of pine seedlings after bud damage caused by squirrels in areas I and II.

New top originates from	Area				Total	
	I		II			
	no.	%	no.	%	no.	%
Terminal bud	23	14	35	26	58	19
Side bud of the terminal shoot	93	55	55	40	148	49
Lateral branch	53	31	46	34	99	32
Total	169	100	136	100	305	100

The results from areas I and II are presented in Table 4. In most cases (49 per cent) a new top originated from a side bud of the terminal shoot. It is to be noted that in 32 per cent of cases a lateral branch formed a new top. Only 19 per cent of the new tops originated from the terminal bud of the terminal shoot. The data of the two areas gave similar results.

In Table 5 the growth patterns of 173 individually selected pine seedlings are presented. There was no case in which only the terminal bud of the terminal shoot had been damaged. In Table 6 a summary of the records presented in Table 5 is shown. It can be seen that only in a very few cases (3 per cent) did the terminal bud of the terminal shoot continue the growth of the seedling. In most cases (60 per cent) a side bud of the terminal shoot formed a new top. It is to be noted that in 38 per cent of cases the new top originated from a lateral branch. In one case the terminal bud of the terminal shoot had been partly damaged, but was able to form a new top.

In general it can be said that the two groups of data presented above gave similar results.

In Figs. 3—7 typical growth patterns of damaged pine seedlings are presented.

Table 5. Growth patterns of 173 pine seedlings after bud-eating by squirrels.

No.	Height of seedling, dm	Annual shoot in 1962, cm	Buds eaten by squirrels			New top originates from		
			Terminal shoot		Lateral branch	Terminal bud	Side bud of the terminal shoot	Lateral branch
			Terminal bud and side buds	Side buds only				
1	11	33	x		x			x
2	20	42		x	x		x	
3	20	27	x		x		x	
4	21	9	x		x		x	
5	21	40		x		x		
6	24	35	x		x		x	
7	21	22	x		x		x	
8	26	37	x				x	
11	20	40	x		x			x
12	20	47	x		x		x	
13	18	50		x			x	
14	19	48	x		x		x	
15	23	51	x		x		x	
16	19	47	x		x		x	
17	21	62	x		x			x
18	18	46	x		x		x	
19	21	52	x		x			x
20	22	59	x		x		x	
21	31	55	x		x		x	
22	40	40	x		x		x	
23	45	56	x		x		x	
24	18	46			x		x	
25	15	44	x		x		x	
26	15	37	x		x			x
27	16	45	x		x			x
28	22	43	x		x		x	
29	16	43	x		x			x
30	17	38	x					x
31	28	60	x		x		x	
32	21	46	x		x		x	
33	22	51	x		x		x	
34	22	49		x	x	x		
35	15	36	x		x		x	
36	16	48	x		x			x
37	15	40	x		x			x
38	25	47	x		x			x
39	18	47	x		x		x	
40	16	46	x		x			x
41	12	41	x					x
42	13	37	x					x
43	12	35	x				x	
44	15	32	x					x
45	15	42	x				x	

No.	Height of seedling, dm	Annual shoot in 1962, cm	Buds eaten by squirrels			New top originates from		
			Terminal shoot		Lateral branch	Terminal bud	Side bud of the terminal shoot	Lateral branch
			Terminal bud and side buds	Side buds only				
46	15	43	x		x		x	
47	20	51	x		x		x	
48	20	53	x		x		x	
49	21	41	x		x		x	
50	25	55	x		x			x
51	15	36	x		x			x
52	15	30	x		x		x	
53	17	43	x		x		x	
54	19	47	x		x			x
55	13	41	x					x
56	21	49	x				x	
57	17	38	x					x
58	16	34	x				x	
59	20	50	x				x	
60	18	48	x				x	
61	17	49	x		x		x	
62	19	46	x				x	
63	14	43	x		x		x	
64	22	46	x		x		x	
65	14	27	x		x			x
66	17	41	x		x			x
67	14	31	x					x
68	24	45	x		x		x	
69	17	34	x		x		x	
70	24	35	x		x		x	
71	18	36	x		x			x
72	23	28	x		x	x		
73	17	20	x		x			x
74	25	36	x		x		x	
75	18	42	x		x		x	
76	22	31	x		x			x
77	11	36	x				x	
78	19	25	x		x		x	
79	17	20	x		x		x	
80	24	40	x		x		x	
81	17	12	x		x		x	
82	24	34	x		x			x
83	25	47	x		x		x	
84	23	38	x		x			x
85	23	45	x		x		x	
86	21	40	x				x	
87	22	30	x		x			x
88	17	36	x		x			x
89	16	39	x					x

No.	Height of seedling, dm	Annual shoot in 1962, cm	Buds eaten by squirrels			New top originates from		
			Terminal shoot		Lateral branch	Terminal bud	Side bud of the terminal shoot	Lateral branch
			Terminal bud and side buds	Side buds only				
90	20	30	x		x		x	
91	14	7	x		x			x
92	16	28	x		x			x
93	17	41	x		x			x
94	17	42	x		x		x	
95	14	43	x		x		x	
96	16	43	x		x		x	
97	16	47	x					x
98	19	48	x		x		x	
99	26	54	x		x		x	
100	16	48	x		x		x	
101	24	51	x		x		x	
102	21	50	x		x		x	
103	23	56	x		x			x
104	21	47	x		x			x
105	17	23	x		x			x
106	13	34	x					x
107	23	62	x		x		x	
109	19	45	x		x			x
110	12	41	x		x		x	
111	16	43	x		x		x	
112	18	45	x		x			x
113	17	55	x		x		x	
114	21	48	x		x		x	
115	20	55	x		x		x	
116	17	45	x		x		x	
117	22	49	x		x			x
118	23	65	x		x		x	
119	21	53	x		x		x	
120	20	50	x		x		x	
121	19	48	x		x		x	
122	17	47	x		x			x
123	16	50	x		x			x
124	17	51	x		x		x	
125	25	48	x		x		x	
126	16	46	x			x		
127	15	40		x			x	
128	17	47	x				x	
129	17	30	x					x
130	21	45	x				x	
137	22	43	x		x		x	
140	22	43	x		x		x	
141	21	45	x		x			x
143	19	43	x		x		x	

No.	Height of seedling, dm	Annual shoot in 1962, cm	Buds eaten by squirrels			New top originates from		
			Terminal shoot		Lateral branch	Terminal bud	Side bud of the terminal shoot	Lateral branch
			Terminal bud and side buds	Side buds only				
144	22	55	x		x		x	
145	20	56	x		x			x
146	24	50	x		x		x	
147	21	45	x		x		x	
148	17	42	x		x			x
149	20	39	x		x		x	
150	23	44	x		x			x
151	17	45	x		x		x	
155	22	56	x		x		x	
156	22	45	x		x			x
158	21	50	x		x		x	
165	19	42	x		x			x
171	25	52	x		x			x
172	14	36	x					x
173	14	34	x					x
174	25	43	x				x	
175	23	48	x				x	
176	32	56	x		x		x	
177	25	50	x		x			x
178	25	50	x					x
179	30	61	x		x			x
180	25	43	x		x			x
181	23	51		x			x	
182	24	46	x		x			x
183	20	49	x				x	
184	19	45	x		x			x
185	27	58	x		x		x	
186	27	52	x		x			x
187	20	41	x		x	x		
188	16	39	x					x
189	21	52	x		x			x
190	22	50	x		x		x	
191	20	50	x		x		x	
192	19	46	x		x		x	
193	19	47	x		x			x
194	20	43	x		x			x
195	19	43	x		x		x	
196	22	48	x		x		x	
197	19	41	x		x		x	
198	20	38	x		x		x	
199	18	40	x				x	
200	19	41	x		x			x

Table 6. Summary of the recovery of the pine seedlings presented in Table 5.

Way in which seedling was damaged	No. of seedlings damaged	New top originates from		
		Terminal shoot		Lateral branch
		Terminal bud	Side bud	
Terminal bud and side buds of terminal shoot ..	32	1	16	15
Terminal bud and side buds of terminal shoot + lateral branches	134	2	82	50
Side buds of terminal shoot only	4	1	3	0
Side buds of terminal shoot only + lateral branches	2	1	1	0
Lateral branches only	1	0	1	0

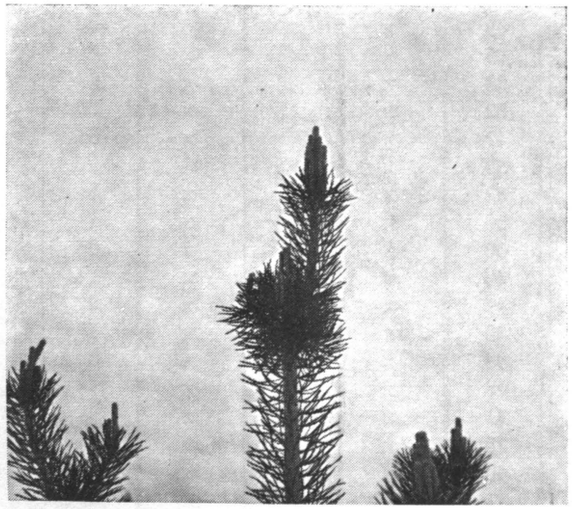

Fig. 3. A case in which the terminal bud and some of the side buds of the terminal shoot were eaten by squirrels. A side bud continues the growth of the pine seedling. — Photo K. Salonen.

Fig. 4. A case like that in Fig. 3. However, the same damage had been inflicted again the following year. — Photo K. Salonen.

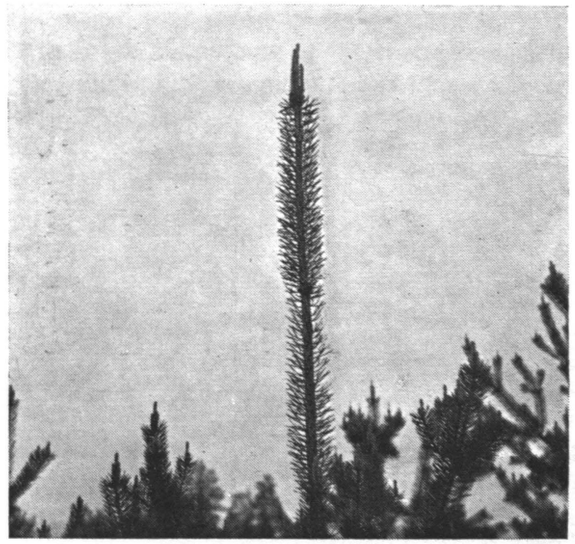

Fig. 5. A case in which all the side buds of the terminal shoot were eaten by squirrels. The terminal bud continued growth. — Photo K. Salonen.

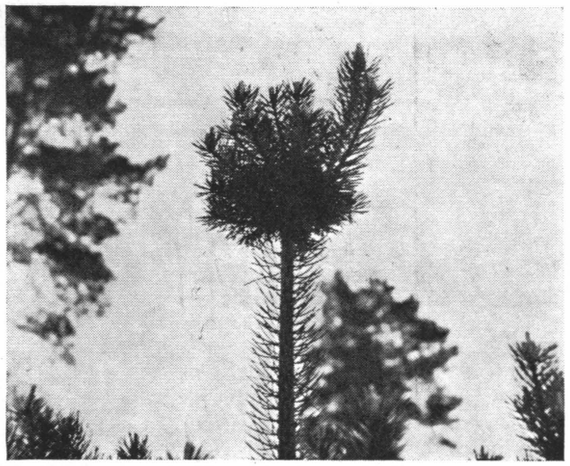

Fig. 6. A case in which all the buds of the terminal shoot were eaten by squirrels. Adventitious buds began growing. A tuft-like crown formed. — Photo K. Salonen.

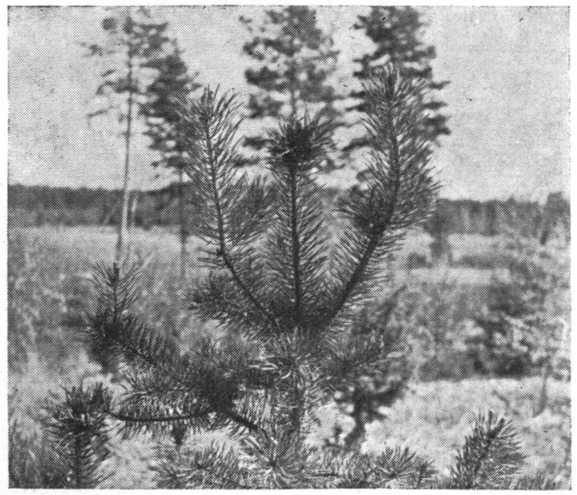

Fig. 7. A case like that in Fig. 6. A lateral branch continued growth. — Photo K. Salonen.

3.4. Other pests of pine seedlings in the study areas

In order to obtain a good picture of the seedling stands studied, other pests were recorded, too. Small rodents (probably *Microtus agrestis* L.; see descriptions of damage by KANGAS 1935, SAALAS 1949) and a rust fungus species *(Melampsora pinitorqua)* were the most notable pests of these stands, besides the squirrel.

Melampsora pinitorqua occurred in area II (5 permanent sample plots; see Table 7). This fungus occurred in 41 per cent of the pine seedlings of these plots. In most cases (59 per cent) it occurred in both terminal shoots and lateral branches.

Table 7. Occurrence of the rust fungus *Melampsora pinitorqua* in area II.

Sample plot no.	No. of healthy seedlings	Seedlings damaged				
		Terminal shoot and lateral branches	Terminal shoot	Lateral branches	Total	
					No.	%
1	34	24	9	8	55	41
2	18	23	5	5	65	33
3	19	2	1	1	17	4
4	37	9	3	3	29	15
5	46	6	1	8	25	15
Total	154	64	19	25	41	21

Small rodents damaged pine seedlings (height class 0.5—1.5 m) in area I. They had gnawed the bark at the base of the stems (under the snow surfice). 30 per cent of the seedlings in 7 sample plots had been damaged.

4. Discussion

The supplies of the main food items — seeds of spruce and pine — of the squirrel fluctuate from year to year (see the review by RAJALA & LAMPIO 1963). When the seed harvests of spruce and pine are poor, squirrels use secondary food items (including pine buds). RAJALA & LAMPIO (op. cit). reported that the eating of pine buds was most frequent either in the years characterized by abundant use of spruce buds, or in the preceding years. Generally, the buds were eaten in greatest amounts at the time when the use of spruce seeds was slight, and pine seeds were the chief food item. In our study areas spruce and pine produced very little seed during the years 1962—63 (see also HELENIUS 1963). The squirrels then mainly inhabited pine stands. In general it can be said that our observations support the results of RAJALA & LAMPIO (op.cit.).

The results of the present study show that squirrels very clearly selected the largest buds of the best seedlings of the stands studied. This means that squirrels showed a good adaptation to the lack of their main food items, for they could select the best secondary food items available.

EIDMANN & INGESTAD (1963) and EIDMANN (1963) reported that *Evetria buoliana* DEN. & SCHIFF. attacked host trees in optimum condition. Thus this moth species, like the squirrel, shows a preference for luxuriant pines. From the standpoint of forestry this means that pine seedling stands in very good condition may attract pests like *Sciurus* and *Evetria*. In Finland, forest cultivation has increased greatly during recent years (see e.g. VALLIVAARA 1964, SIRÉN 1964). One of the main goals has been to grow seedlings in good condition. The present investigation shows that as a result their susceptibility to damage by squirrels, for instance, increases. Naturally at the same time the food resources of the squirrel improve.

KANGAS (1963) has recently reviewed the injuries caused by various agents that result in crooks and forks in the pine stem. The following moths are the most noteworthy in this respect: *Evetria buoliana*, *E. pinicolana* DBLD., *E. resinella* L. and *E. turionana* HB. A rust fungus, *Melampsora pinitorqua*, belongs to this group, too. In our study areas this fungus occurred, but the damage caused by it was recorded separately from that due to the squirrel. In many respects the damage caused by the insects mentioned above resembles that caused by the squirrel when eating pine buds. KANGAS (1963) emphasized that the situation after the damage may be very complicated. He discussed different cases. According to the data presented by KANGAS (op.cit.) and our experiences during this study, the following conclusions can be drawn about the influence of the squirrel's bud-eating on the growth of pine seedlings (see also Figs. 3—7).

If one of the side buds of the terminal shoot continues the growth of the seedling, little, if any, crookedness of the stem is likely to develop.

If a lateral branch continues the growth of the seedling, a considerable crookedness of the stem is probable.

Especially in the latter case the damage is of great economic importance. In our study areas a new top grew in this way in 35 per cent of the cases. Thus, at least in our case, the squirrel could be regarded as a severe pest of pine seedlings.

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SELOSTUS:

ORAVA MÄNNYN SILMUTUHOLAISENA

Käsillä oleva tutkimus suoritettiin vuosina 1962—63 Nokian kauppalan Pinsiön kylässä. Tutkimuksen kohteena oli kaksi 10—15 vuoden ikäistä mäntytaimistoa, joiden yhteinen pinta-ala oli noin 20 hehtaaria. Taimistoissa oli keskimäärin 1875 ja 2620 tainta hehtaaria kohden.

Taimistoissa seurattiin kevättalvella 1962 ja 1963 oravien ruokailua mäntytaimien silmuilla. Näköhavainnointiin perustuen voitiin olla varmoja tuhonaiheuttajasta. Tutkimuksilla pyrittiin selvittämään tätä ilmiötä sekä oravan että taimistojen kannalta. Oravien ohella pikkujyrsijät ja *Melampsora pinitorqua*-ruostesieni olivat vahingoittaneet osaa taimista.

Oravat valikoivat selvästi rehevimmät (usein pisimmät) taimet, joista ne söivät rehevimmät silmut. Yli 50 prosentissa tapauksia oravat söivät vain latvakasvaimen silmuja ja erikoisesti päätesilmut (pituuskasvupisteet!). Ravintotaloudellisesti oravien toiminta oli siis varsin tarkoituksenmukaista.

Vuonna 1962 oravat vahingoittivat tällä tavoin yli 50 prosenttia taimistojen taimista. Vuonna 1963 ilmiö oli harvinaisempi johtuen ilmeisesti siitä, että osa oravista ehdittiin ampua.

Noin 50 prosentissa tapauksia taimen pituuskasvu jatkui jostakin latvakasvaimen sivusilmusta. Tällöin taimeen ei jää yleensä pahoja muotovikoja. Noin 35 prosentissa tapauksia uusi latva muodostui sivukasvaimesta, jolloin seuraa ranganvaihdos ja usein pahojakin muotovikoja. Juuri tämä seikka tekee mainitut tuhot huomionarvoisiksi ja taloudellisesti merkittäviksi.

Kirjoituksessa kiinnitetään huomio siihen seikkaan, että hyväkasvuiset männyn viljelytaimistot saattavat houkutella oravia ja muita tuholaisia niihin, koska niiden tarjoama ravintomäärä on suurempi kuin huonokasvuisten taimistojen.