Variability in the occurrence of some insect pests on various provenances of European larch Larix decidua Mill.

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Introduction

The realization of integrated insect pest control in forestry requires to solve the problem of resistance and tolerance of host plants to the attack of injurious insects, so that this fact leads to a very close co-operation of entomologists and geneticists. The basic task consists here in the research of the resistance of individual species, partial populations of host plant, and separate individuals within partial population. This work may result either in a direct application of resistant or sufficiently tolerant species or their partial populations into the practice, or in their utilization as initial genetic material in further work in genetics.

The variability in the resistance against the infestation inside of host plant species is proved best in the cases of the discrepancy in such development stages of pest and host plant, the coincidence of which forms a basic prerequisite for the maintenance of high pest population density and for the injuries resulting from this situation. This may be demonstrated by the resistance of lately flushing forms of oaks to the attack of green oak leafroller Tortrix viridana L. (SCHÜTTE 1957) and by the resistance of Norway spruce infested by Zeiraphera diniana (PFEFFER 1930) and *Pristiphora abietina* CHRIST. (OHNESORGE 1958). In other cases, this feature may be documented by the variability in the disposition towards the attack caused by a different content of chemical matters in a plant or by some physiological factors, as it is the case in the variability of infestation induced to Norway spruce by larvae of Lymantria monacha L. (PRELL 1924), to Douglas fir by Gilleteella cooleyi GILL. (PETERSEN — SOEGAARD 1958) and to Scotch pine Pinus *silvestris* L. by Rhyacionia buoliana SCHIFF. (DENGLER 1937), etc.

We dealt in our study with the problems of the variation in the resistance of larch against the attack caused by various insect pests. This paper is devoted to the occurrence of larch-mining moth Coleophora laricella HBN. and larch gall-midge Dasyneura laricis (F. LOEW.) on various provenances of European larch Larix decidua MILL. and Japanese larch Larix leptolepis GORD.

Larch-mining moth is a monovoltinous species and its bionomy, ecology and harmfulness have been described in many papers. In the first place it is necessary to mention the monographic study of EIDMANN (1965) summarizing in detail the knowledge obtained up to now on the mode of life of this pest and evaluating its harmfulness (SCHWERDTFEGER, SCHINDLER 1957). This moth flies in May and June, when the females lay the eggs, mostly one egg on a needle. Its larva, hatching some days afterwards, bores into the needle, where it feeds and forms a gallery. From the eaten part of needle it forms in autumn a whitish bag, which it spins to a twig and overwinters inside. In spring, at the time of flushing of larch needles, the larvae renew their activity and continue in feeding inside of needles. EIDMANN (1965) reports that one or several larvae feeding on 2 brachyblasts bring yet about a danger of heavy injury. In a heavy outbreak the new shoots and needles become shorter and, consequently, the increment decreases too. The spring feeding, which is much more intensive than the summer and autumn ones, is relatively short and its period does not exceed 2–3 weeks. After finishing this activity, the larvae pupate in the bag. This development stage lasts 1–2 weeks.

Larch-mining moth belongs to a group of injurious insects, the occurrence of which or the mass outbreak may be affected by the coincidence of needle flushing and renewal of the activity of larvae in spring period. Despite the fact that this moment may appear in the different intensity grades of attack induced to individual larch species or their provenances, EIDMANN (1965) reports that such apparent differences have not been found. On the other hand, SCHOBER and FRÖHLICH (1967) found outstanding differences relating to the term and rhythm of flushing of various species and provenances of larch.

A further injurious insect under study — larch gall-midge — Dasyneura laricis (F. LOEW.) is also a monovoltinous species. Its images swarm at the end of April or at the beginning of May, i. e. at the time when the larch buds start to unfold. The optimum moment for the oviposition is the phase of bud unfolding, when the needle bases and the enveloping scales are still adjacent and the needle length does not exceed 5 mm (SKUHRAVÁ, SKUHRAVÝ, 1960). The larvae hatching from the eggs laid singly into a bud within a period of 6–9 days suck themselves into the medium part of the bud. After a period of about one month a characteristic hemispherical gall begins to develop here, embedded with resin, around of which the needles radially stick out. The orange-coloured larva sucks in the gall up to the late autumn, when it forms a witish cocoon for overwintering there. Pupation occurs as late as in the spring, about 14 day prior to hatching of insect adults. The mode of life of this insect is described in detail by KOLOMIEC (1955), SKUHRAVÁ, SKUHRAVÝ (1960), SKUHRAVÁ (1966).

The harmfulness of this pest consists in the fact that the infested buds (bases of brachyblasts) will not more flush in the next year. The attack is concentrated prevailingly to the buds of the last year or sometimes to older shoots. With regard to the photophilous character of this species, the attack in the older stands is concentrated to the top parts of the crowns, i. e. to their circumference (HOCHMUT, SKUHRAVÝ 1968). The attack intensity varies very much in the individual years. HOCHMUT, SKUHRAVÝ (1968) found in five stands

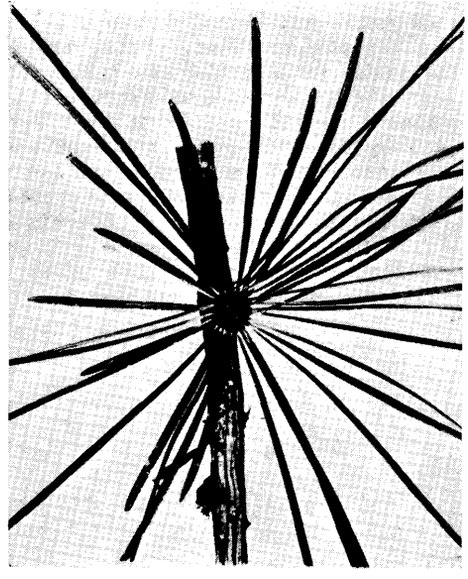

Fig. 1. — *Dasyneura laricis* — a detail of bud (brachyblast basis) recently attacked by midge.

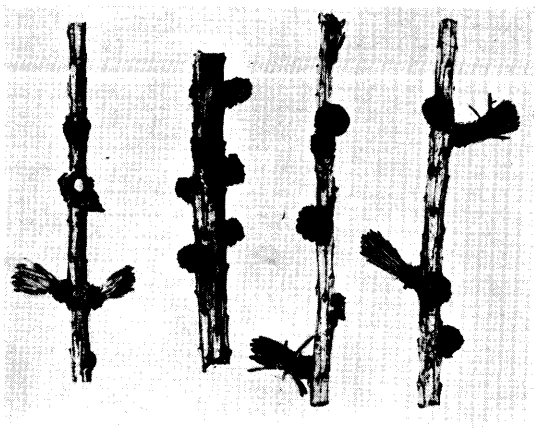

Fig. 2. — Dasyneura laricis — larch buds injured by larvae (changed into galls).

the average infestation rates varying from 2.4% to 10.1%, Kolomiec (1965) reports the rate of infestigation being as high as 98%. Nunberg (1947) reports that beside attacked trees of European larch, the species *Larix leptolepis, Larix kurilensis* and *Larix polonica* remained unattacked and that this fact may be explained by the uneven flushing periods of the mentioned species or races.

Materials and methodology

The objectives of the research work were set down as follows:

a) To find whether within the scope of the species *Larix decidua* Mill. exist among the partial populations (provenances) some differences in the resistance against the attack of the mentioned pests (chermes, moth and midge).

b) To find the differences in the attack induced to the provenance populations which may be involved into the scope of the Carpathian provenance range (subspecies *L. decidua carpatica* Dom.) and into the scope of the Alpine provenance range (subspecies *L. europaea alpica* Šim.).

c) To find the differences in the attack induced to European larch (*Larix decidua* Mill.) and Japanese larch (*Larix leptolepis* Gord.).

d) To try to elucidate, at least partially, the reasons of the differences in the resistance by investigating the relationship of the attack intensity to some growth, phenological, ecological and biochemical characteristics of provenances under study.

This study was based on the material which served for the establishment of the international larch provenance plots in the year 1961. A part of 2—3 years old plants was planted out in spacing 0.5 × 0.5 m in the forest nursery Baně (forest district Jíloviště of the Forestry and Game Management Research Institute Zbraslav-Strnady). The nursery is situated at the altitude of 380 m a.s.l., the soil is deep, clay-loamy, sufficiently supplied with the fundamental mineral nutrients pH exchange value cca 7.0, annual precipitation 480 mm, during vegetation period 295 mm, mean annual temperature 9.3° C, mean temperature during vegetation period (May—September) 16.8° C, mean annual amplitude of month temperatures 19.2 C (the meteorological station Praha-Klementinum, altitude 197 m a.s.l.). The nursery forms a forest semienclave and is surrounded on three sides by forest stands of different age (from the young stand up to the mature stands), in which Norway spruce prevails.

A survey of provenances under study, i. e. 16 provenances of European larch *Larix decidua* Mill. and one provenance of Japanese larch *Larix leptolepis* Gord. may be seen from *table 1.*

As an observation unit for larch-mining moth was chosen in each plant (in total 16 plants of each provenance) the number of bags with overwintering larvae on 1—3 year-old twigs with a total number of 400 buds. This procedure was chosen for the reason that the equal number of buds represents approximately the equal potential basis of future assimilation organs (needles) jeopardized by this pest. In this way, it is possible to obtain a comparability of the attack degrees to a great extent. The plants were chosen randomly and the twigs were taken from the upper part of the crown fully exposed to light. The samples were taken in winter (December, January) and the material was transported to the laboratory for being worked out. The observations was made in the years 1964/65 and 1965/66,

Table 1. — Survey of provenances.

Name	Longitude	Latitude	Altitude a.s.l.	Mean annual temp. °C	Precipitations annual total in mm
38 - Valdeblore, France	7°11′	44°14′	1700-1800	6-7	1100
12 - Sterzing/Fl., Italy	11°26′	46°54′	1100	9.5-10	788
17 - Pegine - Lar. "	11°00′	46°00′	600-800	9.5-10	1289
19 - Pergine - Selv. "	11°23′	46°06′	1300-1400	9.0	1085
47 - Blühnbachtal, Austria	13°06′	47°28′	800-850	7.3	1154
54 - Bischofswiesen, "	13°01′	47°40′	875	6.5	1714
37/78 - Krnov-Hošť., ČSSR	17°34′	50°10′	450-550	7.7	740
49/77 - Krnov-Loučky, "	35°13′Ferr.	50°03′	500-600	6.8	648
50/76 - Krnov-Radim, "	35°13′Ferr.	50°05′	400-500	7.8	684
53/89 - Smokovec, ČSSR	37°51′Ferr.	49°09′	1150-1250	4.7	944
51/88 - Černý Váh, "	37°37′Ferr.	49°01′	780-820	5.9	744
67/93 - Staré Hory, "	36°48′Ferr.	48°52′	850	6.6	1048
69/91 - Lipt.Teplička, ČSSR	37°45′Ferr.	48°55′	1350-1420	5.9	744
59/94 - Brezovička , "	38°29′Ferr.	49°08′	820-840	7.5	591
43 - Blizyn, Poland	20°44′	51°04′	320-340		811
71/87 -Piatra Arsa, Rumania	43°25′Ferr.	45°20′	1160-1260		
36 - Ina- Japan (L.lept.)	135°05′	35°32′	1200		

Table 2. — *Coleophora laricella* Hbn. — occurrence differences inside of species *L. decidua* Mill. in 1964/65.

Variability	Sum of squares	N	Variance	F	$F_{0,05}$	$F_{0,01}$
Provenance ranges	0,01461834	1	0,01461834	$7,94^{++}$	3,89	6,76
Provenance	0,05123453	14	0,00365961	$1,99^{+}$	1,74	2,17
residual	0,42156459	229	0,00184089	.	.	.
total	0,48741746	244	.	.	.	.

Table 3. — *Coleophora laricella* Hbn. — occurrence differences inside of species *L. decidua* Mill. in 1965/66.

Variability	Sum of squares	N	Variance	F	$F_{0,05}$	$F_{0,01}$
Provenance ranges	0,07954129	1	0,07954129	$9,89^{++}$	3,89	6,76
provenance	0,12543902	14	0,00895922	1.11^{-}	1,74	2,17
residual	1,83334831	228	0,00804100	.	.	.
total	2,08381862	243	.	.	.	.

i. e. at the time, when the plants were 5—6 and 6—7 years old, respectively.

An analogous method was applied in the investigation of the attack extent induced by *Dasyneura laricis*. As a basic observation unit was chosen again the number of galls occurring on 400 buds of 1—3 year-old twigs. This procedure is methodologically evident because the buds are directly attacked by this pest. In finding the number of galls, a differentiation was made between the buds (galls) which were recently attacked and the older galls, from which the images yet flew out. The attack induced by gall-midge was also studied on the samples taken up in the winter periods of the years 1964/65 and 1965/66.

Outline of results obtained

a) Variability in the occurrence of Coleophora laricella Hbn.

A basis for the evaluation of the variability in the attack induced to individual larch provenances by larch-mining moth was the number of bags with overwintering larvae on 400 buds of 1—3 year-old twigs. With regard to the fact that the quantities are of proportionate character, it was decided to apply for the analysis the transformation of observed values by the relation $x'' = \arcsin \sqrt{x}$ (Weber 1967).

The results of the analysis of variance for the years 1964/65 and 1965/66 may be seen from the *tables 2 and 3*. Both in the year 1964/65 and in the second year of observation the statistically highly significant differences were found between the Carpathian and Alpine provenance ranges. However, it must be pointed out that in the first year of observation the provenances of the Alpine range and in 1965 the provenances of the Carpathian range were more heavily attacked. Despite the fact that the statistical significance of differences has been found, the differences in the average infestation of the provenance ranges are relatively small.

The differences in the provenances within the ranges are statistically significant only in the first year of observation. Basing on the Duncan's test, it was therefore possible to divide all European larch provenances into following two groups:

group 1 — severely infested provenances: 17, 19, 47, 37/78, 12, 71/87, 54, 53/89, 68/91, 43;

group 2 — less infested provenances: 50/76, 51/88, 49/77, 67/93, 38, 59/94.

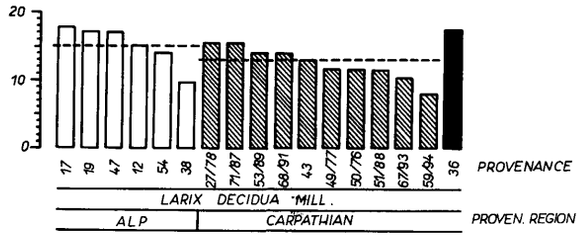

Fig. 3. — Average number of bags of larch-mining moth — 1964/65.

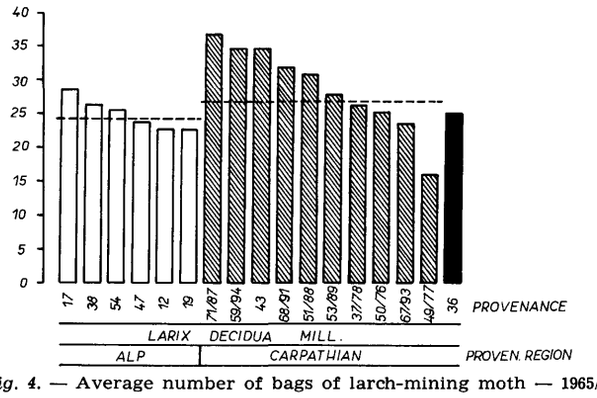

Fig. 4. — Average number of bags of larch-mining moth — 1965/66.

It is interesting that of 6 members included in the less infested group 5 provenances belong to the Carpathian provenance range and only 1 to the Alpine provenance (38 — Valdeblore).

Considering the both two years of observation together, the Alpine provenances show that the provenance 17 was in both years severely attacked, whereas the provenance 12 possessed a relatively small number of bags with wintering larvae. Of course, the absolute differences in the number of bags per 400 buds are very small for the Alpine provenances, namely in 1965/66, when the most heavily infested provenance showed 27 bags and the least infested one 24.

On the other hand, the variation width of average infestation values for individual provenances of the Carpathian provenance range was smaller in 1964/65 than in 1965/66. A heavy attack in the both years of observation showed the provenances 71/87 and 68/91, whereas the provenances 67/93 and 49/77 showed a relatively lower number of bags per 100 or 400 buds.

Despite the fact that some provenances show distinct tendencies in the attack degree, the total trend in the both years of observation is not analogous. This fact is documented by the coefficient of correlation calculated by order for 2 parallel series of both years of observation. The coefficient of correlation $r_{(14)} = 0.33$ is statistically insignificant (the critical value of the corresponding $r_{0,05}$ (for 14 degrees of freedom) = 0.50). Moreover, this result was checked by another calculation method, viz. by means of χ^2 test. The calculation by a known formula (see e. g. Weber 1967) led to the following result:

χ^2 (for 14 degree of freedom) = 156, 842, whereas the corresponding critical values for the probability $p = 0.05$ and $p = 0.01$ are 23.685 and 29.141, respectively. Therefore, the difference found in the course of sequences is highly significant and gives evidence that the trend of infestation of the larch provenances in the both years of observation is variable. Thus, the both mentioned methods of calculation led to quite equal conclusions.

Table 4. — *Coleophora laricella* Hbn. — occurrence differences between *L. decidua* Mill. and *L. leptolepis* Gord. spp. in 1964/65.

Variability	Sum of squares	N	Variance	F	$F_{0,05}$	$F_{0,01}$
Species	0,06749518	1	0,06749518	34,52^{++}	3,89	6,76
Residual	0,50635302	259	0,00195503	.	.	.
Total	0,57384820	260	.	.	.	.

Table 5. — *Coleophora laricella* — occurrence differences between *L. decidua* Mill. and *L. leptolepis* Gord. spp. in 1965/66.

Variability	Sum of squares	N	Various	F	$F_{0,05}$	$F_{0,01}$
Species	0,20524779	1	0,20524779	27,40^{++}	3,89	6,76
Residual	1,93266252	258	0,00749094	.	.	.
Total	2,13791031	259	.	.	.	.

As regards Japanese larch *Larix leptolepis* Gord., represented in our case by a single provenance 36- Ina, the differences in infestation were studied, contrary to the European larch provenances, by means of the analysis of variance *(tab. 4 and 5)*. The differences in the both years of observation are statistically highly significant. In 1964/65, Japanese larch belonged to the most severely attacked populations and the infestation value of this species (number of bags with wintering larvae per the length of twigs containing 400 bags) is higher than the average values for larch trees of both the Alpine and Carpathian provenance ranges. In 1965/66, the average number of bags with overwintering larvae on Japanese larch represents a value approaching to the average value of all European larch provenances. Therefore, it may be concluded that Japanese larch in our case was attacked by larch-mining moth to a rather great degree and, in the year 1964/65, more heavily than a majority of European larch provenances.

The infestation of larch-mining moth was investigated in detail by Schober and Fröhlich (1967), in connection with the evaluation of provenance sample plot Gahrenberg (F. Germany). Of course, the confrontation with our results may be done only conditionally, because the provenances represented on the mentioned plot are other ones than those in our case. Besides, the mentioned authors applied quite another method than we did. They found that the most resistant variant was *Larix Gmelini correnis,* which is not represented in our experiment. Schober and Fröhlich (1967) stated nearly conformable results to our findings for the Sudeten provenance (the authenticity is however not fully proved in this case) and for Japanese larch. Similarly to our experiment, the both mentioned variants on the sample plot Gahrenberg were attacked with a more or less average intensity, too.

Of course, the degree of pest occurrence on the sample plot Gahrenberg was higher than in our case. Basing on the dendrometric evaluation, the authors concluded that the attack may bring about during the current year a reduction of volume increment up to 50%. This investigation was technically possible due to the fact that the larch trees on the provenance sample plot Gahrenberg are yet of higher age (at the time of evaluation 33 years).

b) *Variability in the occurrence of Dasyneura laricis (F. Loew.)*

With regard to the fact that the basic value applied in the evaluation was a relative number, i. e. a ratio of changed buds (galls) of the total constant number of buds, the observation results were transformed for the purposes of the mathematical-statistical analysis analogously as in processing the data on the occurrence of larch-mining moth by the formula $x' = \arcsin \sqrt{x}$.

The extent of infestation was not very different in the both years of observation. The maximum number of galls per 400 buds was found (new and old galls being considered all together) in the year 1965/66 for the provenance 17 — Pergine — Laresotti, i. e. in total 43 galls. This means that nearly the each tenth bud of this provenance was changed to gall. The minimum number of galls in the year 1964/65 showed the provenance 59/94 — Březovička, in total 9 galls. Both in the first and the second year of observation some plants (individuals) were found, on which not a single gall of this pest might be observed. Similarly as in investigating the variability in the occurrence of larch-mining moth, in this case the reason of this fact cannot be also safely discovered, i. e. whether these phenomena are of accidental character or have concrete causes of ecological, physiological or genetical character.

For comparing the degree of infestation, the arithmetic means of galls found for individual provenances were applied, viz. in the form of column histograms. For making this evaluation possible, the new galls were taken into account, i. e. the buds with wintering midge larvae, as well as the old buds and/or old galls, from which the midge images had already flown out. Besides, both the new and the old galls as a total were analysed.

The analysis of variance *(tab. 6)* shows that, in the year 1964/65, the highly significant differences in infestation exist between the provenance ranges, as well as between the provenances within the ranges both in the populations of new and old galls and in the total population of new and old galls together.

In the year 1965/66 the provenance ranges showed highly statistically significant differences only in the new galls and, further, in the new and old galls in total. The differences in the old galls are statistically insignificant. As the provenances within the ranges are concerned, the differences in all three cases of the analysis are statistically significant or highly significant.

In all cases, i. e. in the first year of investigation (1964/65) and in the second year (1965/66), the Alpine range provenances were on the average clearly more severely attacked than those of the Carpathian provenance range. Of

Table 6. — *Dasyneura laricis* (F. Loew.) — occurrence differences inside of species *L. decidua* Mill. in 1964/65 (new and old galls in total).

Variability	Sum of squares	N	Variance	F	$F_{0,05}$	$F_{0,01}$
Provenance ranges	0,12648590	1	0,12648590	32,04^{++}	3,89	6,76
Provenance	0,63725934	14	0,04551852	11,53^{++}	1,74	2,17
residual	0,90390108	229	0,00394716	.	.	.
total	1,66764632	244	.	.	.	.

Table 7. — *Dasyneura laricis* (F. Loew.) — occurrence differences inside of species *L. decidua* Mill. in 1965/66 (new and old galls).

Variability	Sum of squares	N	Variance	F	$F_{0,05}$	$F_{0,01}$
Provenance ranges	0,09362107	1	0,09362107	6,67^{+}	3,89	6,76
Provence	0,39651685	14	0,02832263	2,02^{+}	1,74	2,17
residual	3,20150746	228	0,01404170	.	.	.
total	3,69264538	243	.	.	.	.

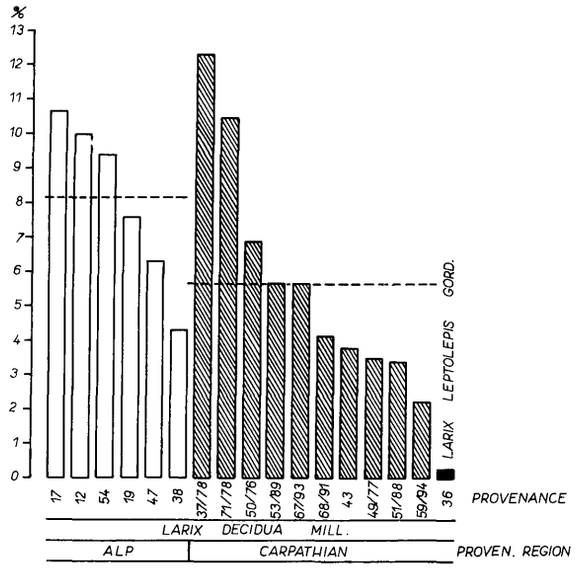

Fig. 5. — Ratio of all buds infestated by larch gall-midge — observation 1964/65.

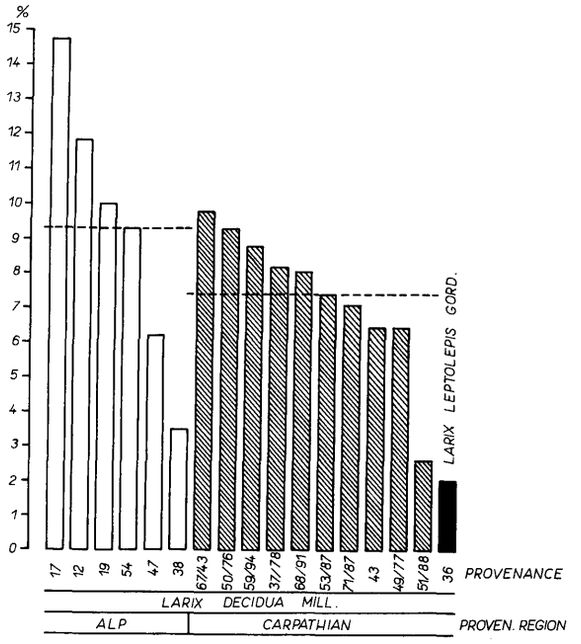

Fig. 6. — Ratio of all buds infestated by larch gall-midge — observation 1965/66.

course, the differences in the absolute values are not too great, being cca 1—2% of galls if related to a total number of buds under study. If we consider (taking into account new and old galls as a total) the average infestation degree for the Carpathian range equal to 100, then the average infestation degree for the provenances of the Alpine provenance range is 140% in the year 1964/65 and 126% in the year 1965/66.

Basing on the DUNCAN's test (for the populations of all galls), it was possible to order the individual provenances by the infestation degrees into the following groups:

1964/65

1. group — the most severely infested provenances: 37/78, 71/87, 17, 12;
2. group — 54, 19, 50/76;
3. group — 47, 53/89, 67/93, 38, 68/91;
4. group — the least infested provenances: 49/77, 43, 51/88, 59/94.

1965/66

1. group — the most severely infested provenances: 17, 12, 19, 59/94, 50/76, 67/93, 54, 37/78;
2. group — 71/87, 68/91, 53/89, 47, 49/77, 43, 38;
3. group — the least infested provenances: 51/88.

The least infested group includes in the both years of observation the provenance 51/88 Černý Váh. The most severely infested group involves both in the first and the second year of observation the following provenances: 37/78 — Krnov-Hoštálkovy, 17 — Pergine Laresotti, 12 — Sterzing, 54 — Bischofswiesen, 19 — Pergine-Selvot, 50/76 — Krnov-Radim.

Both in the year 1964/65 and 1965/66 the least infested group includes exclusively the provenances of the Carpathian provenance range. The group of the most severely attacked provenances involves in the first year of observation 4 provenances of the Alpine and 3 provenances of the Carpathian provenance ranges, whereas in the second year of observation the mentioned group embraces 4 provenances of the Alpine and 4 provenances of the Carpathian provenances ranges.

In general, the provenances heavily attacked in the first year of observation were afflicted to a great degree in the year 1965/66, too. The provenance 68/91 — Liptovská Teplička forms an exception, because larch gall-midge occurred here relatively rarely in 1964/65, whereas the infestation caused by this pest in the second year of observation was relatively heavy. This phenomenon found in the provenance 68/91 caused also that the mathematical comparison of sequences characterizing the infestation of provenances in the both years of observation by means of χ^2 test led to a statistically significant result and that it is necessary to refuse on the basis of this result the null hypothesis on the conformity of the both sequences. The calculated $\chi^2 = 38.90$, whereas the critical χ^2 for the probability $p = 0.01$ is 30.56.

The mathematical comparison of the sequences of the occurrence of new and old galls did not lead to uniform results.

Year of observation	Calculated χ^2	N	$\chi^2_{0.05}$	$\chi^2_{0.01}$
1964/65	6.75	15	25.00	30.56
1965/66	84.38	15	25.00	30.56

While in the first year of observation no statistically significant differences in the sequences were found, they

Table 8. — *Dasyneura laricis* (F. LOEW.) — occurrence differences between *L. decidua* MILL. and *L. leptolepis* GORD. spp. in 1964/65 (new and old galls in total).

Variability	Sum of squares	N	Variance	F	$F_{0,05}$	$F_{0,01}$
Species	0,39909070	1	0,39909070	61,98++	3,89	6,76
residual	1,66768938	259	0,00643896	.	.	.
total	2,06678008	260	.	.	.	.

Table 9. — *Dasyneura laricis* (F. LOEW.) — occurrence differences between *L. decidua* MILL. and *L. leptolepis* GORD. spp. in 1965/66 (old and new galls).

Variability	Sum of squares	N	Variance	F	$F_{0,05}$	$F_{0,01}$
species	0,24846708	1	0,24846708	16,97++	3,89	6,76
residual	3,77833567	258	0,01464471	.	.	.
total	4,02681275	259	.	.	.	.

were statistically highly significant in the year 1965/66. This fact may be evidently elucidated by the population dynamics of this pest or by some other uncontrolled factors.

As regards the attack of Japanese larch by midge, it was the weakest one from among all provenances in the first year of observation, 1964/65. Taking into account both the new and old galls, it was found that one gall fell on about 800 buds in this year. If compared with the average value of all provenances of European larch *Larix decidua* MILL., the infestation of Japanese larch provenance 36 — Ina was nearly 30 times lower.

A somewhat different situation was found in the second year of observation, when the infestation of Japanese larch (considering both the old and new gall as a total) was also the least one of all provenances. But the infestation of the 36 — Ina provenance was only 4 times lower in this year of observation than the average infestation of all European larch provenances.

The differences in the infestation of European and Japanese larch are in all compared cases (the both years of observation, the new and the old galls or buds, separately, the new and the old galls as a total) statistically highly significant.

c) The problem of the reasons of variability in European larch infestation

The explanation of infestation variability reasons, i. e. why a certain provenance is attacked more heavily than the other one, is a very intricate problem. It is evident that several factors play here a role, especially hereditary disposition of plants, initial population density, population dynamics of insects, ecological factors of investigated locality, namely influence of weather etc.

The hereditary disposition of plants, which is the most interesting factor for us from the genetic point of view, may sometimes represent an intricate complex of reasons and, another time, it may be caused by a single property of a plant (e. g. quantity or composition of terpenes in plants) (SALMAN-BONGBERG 1942, KEEN-SALMAN 1942 etc.).

In investigating the material under study, we draw attention to some its further characteristics, which were either subject of the research or were recorded as an accompanying observation. Apart from this, we had at disposal within the scope of documentation activity a series of data on individual provenances. Some data obtained from this documentation activity and some other characteristics were utilized in order that we might study the relations of these data to the degree of infestation. They were especially the following data: altitude above sea level of the mother stand locality, geographic latitude of the mother stand locality, mean height of the provenance in the year of observation, mean height increment for the last year, earliness of flushing, flushing rapidity, average dry-matter content in one year old shoots, content of essential oils in dry-matter % of one-year old shoots.

The earliness of flushing is characterized by a time difference between the most early flushing provenance and a concrete provenance under study. This time difference is expressed in days. Under the term begin of flushing is understood the phenological phase when the needle tips on the shortened twigs are already apparent as little green targets.

The flushing rapidity means a number of days necessary for a provenance to pass over from the average state of phenological phase nr. 2 (buds with begun flushing) to the average state of phenological phase nr. 5 (needle fully flushed and unfolded). The phenological phases have been chosen by the proposal of V. CHALUPA — 1963 — (oral communication).

The relations were studied by calculating the determination coefficients and the correlation coefficients. The calculation results are given in *tables 10 and 11*.

As regards larch gall-midge, somewhat higher values of positive correlation coefficients have been found in studying the relationship between the infestation degree and the content of essential oils in one-year old shoots and needles. In 1965/66 the calculated correlation coefficient got to a great degree near to a lower limit of statistical significance. The disposition to infestation caused by various contents of

Table 10. — Value relations — *Dasyneura laricis* (F. LOEW.).

Relation of values	Observation 1964/65		Observation 1965/66		N	$r_{0,05}$	$r_{0,01}$
	r^2	r	r^2	r			
x - altitude a.s.l.	0,0088	-0,09	0,0357	-0,19	14	0,50	0,62
x - geogr. latitude	0,1082	-0,33	0,0072	-0,08	14	0,50	0,62
x - mean plant height	0,0210	0,15	0,1310	0,36	14	0,50	0,62
x - mean height increment for the last year	0,0350	0,19	0,1616	0,40	14	0,50	0,62
x - flushing earliness	0,2809	-0,53	0,1260	-0,36	14	0,50	0,62
x - flushing rapidity	0,0729	-0,27	0,4552	-0,60	14	0,50	0,62
x - dry-matter content	0,1176	0,34	0,0115	-0,11	9	0,60	0,74
x - essential oils content	0,0272	0,17	0,3700	0,61	9	0,60	0,74

x - average number of galls per 400 buds
r^2 - coefficient of determination
r - coefficient of correlation
N - number of degrees of freedom
$r_{0,05}$, $r_{0,01}$ - critical r values for probability p = 0,05, 0,01

Table 11. — Value relations — *Coleophora laricella* Hbn.

Relation of values	Observation 1964/65		Observation 1965/66		N	$r_{0,05}$	$r_{0,01}$
	r^2	r	r^2	r			
x - altitude a.s.l.	0,0001	-0,01	0,0092	0,10	14	0,50	0,62
x - geogr.latitude	0,0888	-0,30	0,0015	-0,04	14	0,50	0,62
x - mean plant height	0,0943	0,31	0,1300	-0,36	14	0,50	0,62
x - mean height increment for the last year	0,0607	0,28	0,0012	-0,03	14	0,50	0,62
x - flushing earliness	0,2078	-0,47	0,0022	-0,05	14	0,50	0,62
x - flushing rapidity	0,1640	-0,41	0,1697	0,41	14	0,50	0,62
x - dry-matter content	0,0012	-0,03	0,0077	0,09	9	0,60	0,74
x - essential oils content	0,0713	0,27	0,3136	0,56	9	0,60	0,74

x - average number of galls per 400 buds
r^2 - coefficient of determination
r - coefficient of correlation
N - number of degrees of freedom
$r_{0,05}$, $r_{0,01}$ - critical r values for probability p = 0,05 , 0,01

chemical matters in the host plant is known in many cases (see the introduction to this paper). Our results indicate that the eventual further research made on a more extensive material may lead in the future to the interesting results both from the viewpoint of forest entomology and genetics.

The relatively close relations to the phenological characteristics of larch flushing have been found even in the connection with the infestation degree of individual provenance induced by larch gall-midge. In the both years of observation the relation of infestation degree to the earliness and rapidity of flushing is negative, and two of four calculated coefficients of correlation are statistically significant. These results confirm the known fact that for egg-laying a certain development stage of larch flushing is necessary. It was such a situation in the years of observation that the later flushing larches had more suitable conditions for egg-laying than the earlier flushing ones. The early flushing larches in those years showed at the swarming period of midge so advanced stage of flushing that they were less suitable for egg-laying.

It is interesting that, even as regards the content of essential oils in needles and shoots, the positive correlation ratios have been found for this pest. Of course, in the first year of observation this ratio is very free, statistically insignificant, but in the year 1965/66 it becomes statistically significant. Thus, the results indicate that the content or the composition of essential oils in the needles or shoots may play a certain role in connection with the danger caused to larch by some insect pests.

Summary and Conclusions

The variation width of infestation induced to individual provenances by larch-mining moth *Coleophora laricella* Hbn. is relatively small. Likewise, the differences in the average infestation of provenance populations of the Alpine and Carpathian provenance ranges is inexpressive.

Japanese larch, represented in our case by one provenance only, shows in the resistance to larch-mining moth no preference if compared with European larch.

The variability in the occurrence of galls made by midge *Dasyneura laricis* (F. Loew.) is relatively great, whereby the average infestation extent in the both years of observation was not too different. In all cases, i. e. in the both years of observation, the evaluation of new galls, old galls and both of new and old galls together showed quite distinctly that the provenances of the Alpine range were on the average attacked more severely than the provenances of the Carpathian provenance range. The infestation of Japanese larch by larch-mining moth in the first year of observation 1964/65 was the least one among all variants under comparison. In this year, the infestation of Japanese larch *Larix leptolepis* Gord. represented by the provenance 36 — Ina was 30 times smaller than the average value of all European larch provenances. In the subsequent year this difference was not so conspicuous, but the infestation of Japanese larch in this year was still about 4 times smaller than the average occurrence of midge on European larch.

In studying some relations of the infestation degree of individual European larch provenances to some ecological and other factors, some tendencies have been found both for larch-mining moth and larch-midge indicating a dependence of infestation degree on the earliness and rapidity of larch flushing. The correlation calculation led to the conclusion that the connections between the degree of infestation induced by the both mentioned insect species and the content of essential oils in needles and shoots are not excluded. However, the results obtained must be considered as preliminary. In the main, it is necessary to consider them as an impulse to specific and detailed studies of this problem.

Zusammenfassung

Die Variation der Befallsstärke der Lärchen-Miniermotte war bei den untersuchten Lärchen-Provenienzen nicht groß. Es gab auch keine erheblichen Unterschiede zwischen den Alpen- und Karpaten-Herkünften. Auch eine Japan-Lärchenherkunft verhielt sich nicht anders. — Dagegen war das Auftreten der Gallen relativ variabel, die von der Gallmücke hervorgerufen werden. Es änderte sich in den beiden Untersuchungsjahren nicht nennenswert. Die Alpenherkünfte wurden durchschnittlich stärker befallen als die Karpatenherkünfte. Der Befall der Japan-Lärche war geringer als der der Europa-Lärchen. — Der Befall mit beiden Schädlingen scheint von der Schnelligkeit des Lär-

chen-Austriebs abhängig zu sein. Der Ölgehalt der Nadeln und Triebe spielt dabei offenbar eine Rolle.

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Screening of Haploxylon Pines for Resistance to the White Pine Weevil

I. Pinus peuce and P. strobus grafted on Scots pine[1])

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To be fully acceptable for planting in eastern North America, white pine, *Pinus strobus* L., should be resistant to the blister rust, *Cronartium ribicola* FISCHER, and the white pine weevil, *Pissodes strobi* PECK. In this regard, several exotic white pine species easily crossable with native white pine are of interest. Among these, *Pinus peuce* GRISEB. carries a considerable degree of resistance to blister rust, is hardy in central Ontario, and grafts show more weevil resistance than *P. strobus* at Maple, Ontario. Therefore, a cooperative research project was initiated in 1958 with the Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario, to study the weevil resistance of selected *P. strobus* and *P. peuce* field-grafted on Scots pine, *P. sylvestris* L., in a small plantation subjected to weevil attack in Kirkwood Township, Ontario. This paper reports the results of the study. In 1961, further field-grafting of several white pine species and hybrids on *P. strobus* was initiated and the results will be presented in the second paper of this series.

Materials and Methods

In spring, 1947, Scots pine to be used for grafting were planted in ploughed furrows oriented north-south and spaced 6 × 6 feet. Scots pine is suitable for rootstock because of its adaptability to varied sites, its immunity to blister rust, and its rapid growth. Scions of *P. peuce* and *P. strobus*, collected from trees of known reaction to weevil attack, were top-grafted on the Scots pine during the spring of 1957. The field-grafting technique used has been previously determined for *P. strobus* (HEIMBURGER, 1948). Scions from the following sources were used:

1) Ten *P. peuce* from single-row windbreaks along Highway Nr. 7, east of Havelock, Ontario, containing admixtures of red pine, *P. resinosa* AIT., and mugho pine, *P. mugo* TURRA, adjacent to numerous open-growing, heavily weeviled *P. strobus* and growing in shallow sandy soil over limestone. The degree of weevil attack on *P. peuce* ranged widely. The selected trees, mostly dominants about 10 feet tall, represented two reaction types contrasting in apparent resistance to weevil attack.
2) Five unweeviled *P. strobus* plus trees representing the slender-leader type of white pine, selected in plantation 20a, Provincial Forest Nursery Station, Midhurst, Ontario. The plantation was established in 1924 on fine sandy soil and contains trees of above-average growth form and low incidence of weevil attack.
3) Five thick-leader type *P. strobus*, with heavier than average weevil attack, growing immediately north of the grafted Scots pine. The young trees are open-growing, coarse-branched with poor growth form, and represent the natural old-field white pine growing in mixture with scattered aspen *(Populus tremuloides* MICHX.), white birch *(Betula papyrifera* MARSH.), and pin cherry *(Prunus pennsylvanica* L.), characteristic of the area.

Scion sources representing the two contrasting reaction types to weevil attack will hereafter be designated resistant and susceptible, respectively. The grafts consisted of 20 scions each of five clones of the resistant and susceptible

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