Zahl von Herkünften untersuchten. Die Interior-Herkünfte liegen am Ende der Skala der hier untersuchten Herkünfte.

Verglichen mit den Baumschulergebnissen hat sich die Rangordnung in den Extremen erhalten, in der Spitzengruppe haben sich aber einige deutliche Verschiebungen ergeben. Die Herkünfte von Vancouver Island und aus den Kaskaden in Oregon sind zurückgefallen, während sich besonders die Küstenherkünfte von Washington weiter nach vorn geschoben haben.

Da die Flächen zum Zeitpunkt der Aufnahme erst 6 Jahre alt waren, können noch Änderungen in der Rangfolge der Höhe eintreten. Die Zahl der Ausfälle, die Wuchsform und die Anpassungsfähigkeit, welche für die praktische Forstwirtschaft nachhaltige Konsequenzen haben, lassen aber bereits jetzt eine differenziertere Betrachtung der Herkünfte für den Anbau in der Bundesrepublik Deutschland geraten erscheinen.

In Zukunft wird besonders der regionalen Differenzierung von Anbauempfehlungen Aufmerksamkeit gewidmet werden müssen.

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Summary of results on European larch (Larix decidua Mill.) height growth in the IUFRO 1944 provenance experiment

By M. GIERTYCH

Institute of Dendrology, 63-120 Kórnik, Poland

(Received July / November 1979)

Summary

Data on height growth published so far from the IUFRO 1944 provenance experiment on European larch (*Larix decidua* MILL.) is evaluated. For each planting site the latest published height measurements were converted to units of standard deviation from the site mean. These deviations are plotted separately for each provenance onto a map of all the experimental sites. It is then possible to see the relative performance of each provenance on all the sites where it was tested. Best growing provenances come from the Sudetan and west Carpathian region. Performance declines in all directions from the optimal region, particularily westwards, so that west Alpine provenances demonstrate poorest growth. Siberian larch is of no use except in Finland and Japanese larch demonstrated average performance, no better than domesticated populations of European larch.*L.* × *eurolepis* has good growth potential even in further generations, and over a variety of sites. Genotype x environment interaction is considerable for many provenances. It is least for the best growing Sudetan provenances indicating a positive correlation of adaptability with mean height. Growth was inversely correlated with stem form. Since qualitative characters are best improved by individual selection an integration of provenance and seed orchard programs is the recommended breeding strategy.

Key words: Larix decidua, provenance, genotype × environment interaction, adaptability.

Zusammenfassung

Die bisher veröffentlichten Ergebnisse von Messungen der Baumhöhe des IUFRO Lärchenprovenienzversuches (Larix decidua MILL.) von 1944 wurden zusammengefaßt. Hierbei wurden die auf den Versuchsflächen zuletzt erhaltenen Werte in Einheiten der Standardabweichung vom Versuchsflächenmittel ausgedrückt und getrennt für jede Provenienz in eine Landkarte eingezeichnet, die alle Versuchsorte umfaßt. Auf diese Weise wurde es möglich, die relative Wuchsleistung jeder Lärchenherkunft auf allen Versuchsflächen, auf denen diese vorkommt, zu beurteilen.

Die am besten wachsenden Herkünfte stammen aus den Sudeten und Westkarpaten. Die Wuchsleistung wird von diesem Optimalgebiet ausgehend, nach allen Richtungen hin geringer, besonders aber nach Westen hin, so daß alpine Provenienzen die niedrigsten Werte für den Höhenwuchs aufweisen.

Die Sibirische Lärche hat sich mit Ausnahme von Finnland als unbrauchbar erwiesen und die Japanische Lärche erreichte nur mittlere Werte, ebenso die eingeführten Populationen von Europäischer Lärche. Die Wuchspotenz der *Larix* × *eurolepis* ist gut, auch in den nächsten Generationen und auf unterschiedlichen Versuchsflächen.

Die Genotyp x Umwelt Interaktion ist für viele Provenienzen auffällig. Sie ist aber am niedrigsten bei den am besten wachsenden Sudetenherkünften, woraus auf eine positive Korrelation der Anpassungsfähigkeit mit mittlerer Baumhöhe geschlossen werden kann. Der Wuchs ist jedoch mit der Stammform negativ korreliert.

Da qualitative Merkmale am besten durch Individual-Selektion verbessert werden können, wird als Züchtungsstrategie eine Integration der Provenienz- und Samenplantagenprogramme vorgeschlagen.

Introduction

Following reviews of the IUFRO *Picea abies* (L.) KARST and *Pinus sylvestris* L. provenance experiments (GIERTYCH 1976, 1979) I now present in a similar format results from the IUFRO 1944 experiment on European larch (*Larix decidua* MILL.). It is surprising how efficiently the International Union of Forest Research Organisations was able to function during the Second World War. During 1942—44 seeds of larch were collected not only in the countries of the Axis and German-occupied territories but also in neutral Switzerland und Sweden and on the other side of the front in the United Kingdom. The seeds were distributed throughout Europe, to the United States and Canada and in the spring of 1944, at the peak of military

Table 1. — Data on European larch provenances from the IUFRO 1944 experiment

IUFRO no.	Provenance	Year collected	Age of mother trees	Lat. N	Long. E	Alt. in m	Notes
1	Blühnbach, Austria	1943	85	47°29′	13°10′	600	
3	Hollenburg, Austria			46°33′	14°18′	900	
4	Innsbruck, Austria			47°14′	11°23′	900	
5	Krumbach, Austria			47°31′	16°12′	600	from 1 tree
6	Lamerau, Austria			48°05′	16°10′	700	
7	Landeck, Austria			47°08′	10°37′	750	edge trees
8	Murau, Austria			47°08′	14°10′	950	
9	Obervellach, Austria	1944	120	46°55′	13°13′	1100	few trees
10	Pitz Thal, Austria			47°05′	10°50′	1100	
11	Ried-Tössens, Austria			47°00′	10°37′	1050	
12	Schottwien - W., Austria			47°40′	15°55′	800	
13	Steinach - M., Austria			47°06′	11°28′	900	
14	Waldstein, Austria			47°14′	15°15′	550	
15	St. Michael i.L., Austria			47°05′	13°39′	1700	
16	Paal, Austria			47°04′	14°06	1700	
17	Ried - Pflunds, Austria			46°55′	10°35′	1900	
18	Steinach - Gries, Austria			47°02′	11°30′	1900	
20	Dorizzo Alto, Italy	1943	80	46°33′	12°00′		
21	Monte Col, Italy			46°32′	12°26′	1350	
22	Monte Zucco, Italy			46°25′	12°14′	1400	
23	Lago /V. Fiemme/, Italy	1942	70-90	46°17′	11°23′	925	few trees
24	Feudo /V. Fiemme/, Italy	1942	100	46°20′	11°27′	1400	
25	Val Venosta, Italy			46°35′	10°40′	1100	
26	Lötschenthal, Switzerland			46°23′	7°47′	1500	
27	Untervaz, Switzerland		80	46°57′	9°32′	550	
28	Meilgaard, Denmark	1942/3		56°31′	10°37′	< 50	L. kaempferi
29	Harbke, W. Germany			52°12′	11°03′	70	
30	Neckargemünd, W. Germany	1942/3	106	49°23′	8°49′	335	
31	Neumünster, W. Germany			54°05′	10°00′	50	ex Danish seed
32	Pruszków, Poland			50°34′	17°48′	175-200	
34	Slobity, Poland			54°08′	19°47′	65	
35	Sobowidze, Poland			54°09′	18°36′	80	
36	Słupsk, Poland			54°28′	17°06′	30	
37	Punkaharju, Finland		16	61°48′	29°20′	85	L.sibirica,origin Urals,few trees
38	Pińczów, Poland			50°30′	20°30′	270	
40	Bochnia, Poland			49°58′	20°27′	300	
41	Lublin, Poland			51°15′	22°34′	200	
42	Nowy Sącz - Toki, Poland			49°38′	20°42′	450	
43	Starachowice-Skarżysko, Poland			51°08′	21°03′	200	
45	Hrotovice, Czechoslovakia			49°16′	16°07′	410	
46	Hubertovo, Czechoslovakia			50°04′	17°18′	700	
47	Hubertovo, Czechoslovakia			50°04′	17°18′	700	
49	Paršovice, Czechoslovakia			49°30′	17°42′	375	
51	Čierny Váh - Liptovsky, Czechoslovakia			49°02′	19°40′	825	
52	Muráň - Liptovsky,Czechoslovakia			49°02′	19°40′	1000	
53	Aldroughty Estate, Scotland	1942	65	57°39′	3°23′W	50	domesticated
54	Visingsö, Sweden			58°02′	14°20′	100	L.sibirica
55	Visingsö, Sweden	1943	120 or 68	58°02′	14°20′	100	L.eurolepis,several trees,ex.Scottish seed
56	W. Germany, Wolfgang			48°15′	12°10′	500	L.kaempferi,ex seed extraction plant at Wolfgang.

activity, seeds were sown and the experiment began. The plantings were formed after the war, in some regions after a considerable delay (for example in Poland in 1949) (CHODZICKI 1967) due to the post-war disorganisation of life. From 15 of the planting sites there are printed reports. Only height growth is available for comparisons, being the sole character that is presented in all the published reports.

In 1958 SCHOBER published a review of all provenance experiments on European larch, including the IUFRO 1944 study. His conclusion from 29 trials, including 7 from the 1944 study, is that best height growth is produced by Japanese larch then by European larch provenances from the Sudetan region, from the Tatras, from Poland and also from the East Alpine northern and eastern foothills. Swiss and other western provenances demonstrated poor growth.

After SCHOBER, to my knowledge only ŠTASTNY (1971) attempted to evaluate jointly data from various plots of this experiment. At 4 to 5 years correlations between the Slovak experiment at Podbanské and those in Scotland, USA and Switzerland were rather low (r = 0.14—0.45). At 9 to 12 years the Slovak results correlated with USA, Scottish, German and Italian ones much better (r = 0.70—0.94). In general, Sudetan provenances appear best (particularily Paršovice no. 49); Čierny Váh no. 51 from west Carpathians is also good and among the Alpine provenances Blühnbach no. 1 is best. The differences were carried over to 5 year old progeny of seed collected in the provenance experiment (ŠTASTNY 1971). These studies showed that early comparisons are misleading but at age 7 or more the relative performance stabilizes (ŠTASTNY 1971, SCHOBER 1958, 1977). Thus the large scatter of ages at which last reported measurements are available (ranging from 6 to 31 years) in the IUFRO 1944 series is not an obstacle to meaningful comparisons.

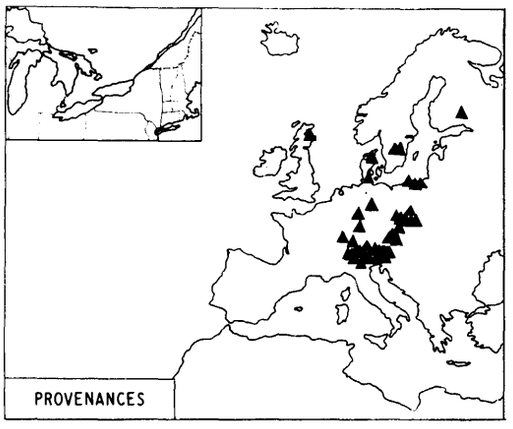

Figure 1. — Location of provenances from the IUFRO 1944 European larch provenance experiment

The growth superiority of Sudetan larch is rather obvious to all students of provenance differentiation in European larch. In all reports coming from the IUFRO 1944 study this basic result is underlined. The presentation given here confirms this general knowledge. It also provides an easy look at the extent of provenance x site interactions and for this reason is worth making.

Materials and Methods

The origin of seed used for the IUFRO 1944 experiment on European larch is shown in *table 1* and *figure 1*. The planting sites from which data on height growth have been published is shown in *table 2* and *figure 2*. The basic data on these experiments were taken from VEEN (1953) with corrected place names and coordinates where information was available from other sources. Planting sites are numbered as given by VEEN (1953) and those not mentioned by him have been assigned further numbers.

The latest available printed data on height measurements for trees per provenance in all these experiments are given in *table 3*. These values are not comparable due to differences in age when last measured. Also some

Table 2. — Location of planting sites of the IUFRO 1944 European larch provenance experiment.

Exp. no.	Locality	Lat. N	Long.	Alt.in m
2	Vilppula, Finland	62°00′	24°30′E	110
4	Arboretum d.l.Sivr.,Nancy,France	48°45′	6°09′E	375
5	Bremervörde, W.Germany	53°30′	9° E	50
7	Drummond Hill, Perthshire,U.K.	56°34′	4°06′W	275-330
8	Savernake, Wiltshire, U.K.	51°24′	1°38′W	145
9	Haugh Forest, Herfordshire, U.K.	52°01′	2°36′W	125
10	Mortimer Forest,Herefordshire,U.K.	52°19′	2°53′W	243
11	Walcot Forest, Shropshire, U.K.	52°25′	3°01′W	260
12	Wyre Forest, Worcestershire, U.K.	52°25′	2°22′W	90
13	Acquerino Forest, Pistoia, Italy	44°01′	11°05′E	950
14	Hjuleberg, Holand, Sweden	56°56′	12°44′E	175
15	Hönggerberg, Zürich, Switzerland	47°25′	8°30′E	535
16	Hillsboro, N.H., USA	43°10	71°55′W	260
18	Podbanské, Czechoslovakia	49°08′	19°55′E	950
19	Kolanów, Poland	49°55′	20°31′E	330

of the measurements concern mean height and others dominant height. To make the data comparable they were converted to units of standard deviation from the mean for each planting site. Each provenance is considered in these units over all the planting sites that include it.

For each provenance a map was prepared with the performance at each planting site plotted as an ideogram showing the deviation from the mean *(Fig. 3—9)*. A black circle indicates a ± deviation of less than 0.3 σ which corresponds to the radius of the circle. The magnitude of + 1 σ and - 1 σ is indicated on the legend in *figure 2*. The place of origin of the provenance is plotted as a triangle. These maps were constructed only for provenances represented on at least three planting sites.

The advantages and disadvantages of this method of presentation have been discussed in the review of the Norway spruce IUFRO 1938 experiment (GIERTYCH 1976) and they are equally pertinent here. The main drawback

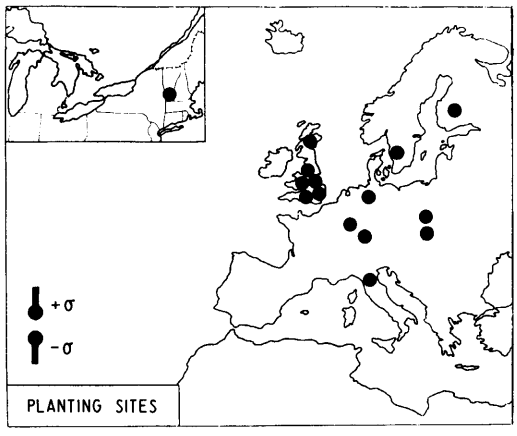

Figure 2. — Location of planting sites from the IUFRO 1944 European larch provenance experiment. Ideograms showing positive and negative deviations in tree height from the site average as used in *figs.* 3-9 are shown here, indicating dimensions corresponding to one standard deviation. The radius of the black spot corresponds to 0,3 σ. On all figures a triangle indicates seed origin and black spots indicate location of planting sites.

is that the point of reference is somewhat different for each planting site, being the average over all the provenances included there. The choice of provenances used, though not necessarily random was effectively so because in 1944 little information was available about racial differentiation in larch. None the less, on some sites a lopsided representation of some regions occurs.

The experiment includes 49 provenances *(Table 1)*. Originally there were 7 more (nos. 2, 19, 33, 39, 44, 48 and 50) but these are not represented on any of the planting sites. The study includes two Japanese larch (*Larix kaempferi* (LAMBERT) CARRIERE) provenances (nos. 28 and 56), two Siberian larch (*Larix sibirica* LEDEB.) provenances (nos. 37 and 54) and one population (no. 55) of the Dunkeld larch (*Larix* × *eurolepis* HENRY).

Of the original 17 planting sites mentioned by VEEN (1953) I have found printed reports from only 13. The Hillsboro New Hampshire USA planting site (no. 16) is apparently not the only American plantation of the species. GENYS (1960) mentions an unreplicated block in Barkersville New York and he pooled the data on height with those obtained in Hillsboro *(Table 3)*. There exist also two very complete experiments unknown to VEEN (1953), in Slovakia and Poland, which are given here as nos. 18 and 19 respectively. Thus data are available from 15 planting sites *(Table 2)*.

The performance of the different provenances on various sites is shown in *table 3* and in *figs.* 3—9. Best growing provenances are those which have the longest upward deviation from the mean on all planting sites as shown in the ideograms. Those that have a consistently and uniformly upward deviation are not only the best growing populations but they are also most adaptable, being able to excel on a variety of site conditions.

Results

The provenances are grouped in *figs. 3—9* and arranged within them on the basis of geography. Starting from the west in *fig. 3* provenances from the western Alps are shown. Their growth performance is very poor on all planting sites. Elevations of origin are all high 550—1900 m, *(Table 1)* while the planting sites are generally much lower (from 50 m). However even at the high elevation planting sites in Slovakia and Italy at 950 m the performance of these western provenances is well below average.

Growth of the central alpine provenances *(Fig. 4)* is average or below average, but noticably better on the high elevation Italian site (prov. 23 and 24) indicating some adaptation to high elevations reflected in a provenance x site interaction for these provenances. This however is not seen on the Tatra (Slovakian) planting site.

The east Alpine provenances *(Fig. 5)* are average or below average. This applies also on the Slovak (950 m) planting site. Lack of sufficient representation on the Italian (950 m) site does not allow any conclusions about elevational adaptations.

The provenances from lower Austria *(Fig. 6)* are somewhat better, usually having a growth performance slightly above average for the whole experiment.

There is little doubt that provenances from the Sudetan region *(Fig. 7)* are the best producers and most adaptable, demonstrating a uniformly superior growth performance on all sites except that in Finland. Even there, two of the provenances (nos. 45 and 49) are among the best. The Hrotovice provenance (no. 45) though from South West Moravia is of Silesian origin (SVOBODA 1947) and therefore belongs to the Sudetan group.

The two easterly provenances (nos. 51 and 52) are west Carpathian, but in terms of performance they belong to the Sudetan group, though perhaps the growth is not quite so spectacular.

The region of occurrence of the Polish larch is represented by five provenances (nos. 38, 40, 41, 42, 43), but none of these are growing on more than two sites *(Table 3)*. Four of these provenances grow well above average, 3 on the US planting site and one in Poland. On the other hand on the Swiss planting site two of these provenances grow poorly.

There is uncertainty whether the larch stands on the Baltic coast are indigenous and the lowland German provenances are definitely considered to be introduced (JALAS and SUOMINEN 1973). The performance of these is shown together with the population domesticated in Scotland *(Fig. 8)*. The Baltic provenances (nos. 34, 35, 36) generally grow slightly above average, except in Sweden

Table 3. — Average tree heights in the IUFRO 1944 European larch provenance experiment

Exp. no. as in table 2	2	4	5	7	8	9	10	11	12	13	14	15	16	18	19
Mean or Dominant height	M	D	D	D	M	M	M	M	M	M	M	M	M+	M	M
Age when measured	14	6	10	16	7	7	7	7	7	31	12	8	12	20	20
IUFRO prov. no. as in Table 1															
1	1.6				2.3	2.1		2.6		16.8		3.0	5.5	10.2	11.4
3					2.2			2.1					5.2	9.3	
4			5.4		2.8			2.5	1.9				5.5	10.1	11.0
5	1.7		6.2	9.8	2.5			2.3	2.2	16.4	4.2	2.3	4.3	10.3	11.6
6					2.7	2.6	2.4	2.8		16.8	4.9		5.5	10.3	12.0
7				8.4	2.2			2.0			4.3		5.2	10.0	12.0
8	1.7			8.8	2.4	2.1	1.8	2.1			3,4	2.1	4.7	9.9	11.8
9	1.6				2.3						3.6	2.1		11.2	11.9
10	1.8				1.9							1.9		9.3	
11					2.3									9.8	
12		7.7		9.7	2.5			2.6		16.7			5.1	10.8	11.9
13			5.4		2.5	2.1	2.3	2.2			4.1		4.6	9.9	
14	1.6	9.1		10.0	2.7	2.5	2.4	2.6	2.1		3.3		5.4	10.5	11.5
15	1.7		5.6		2.0			2.4	1.7			2.0	3.7	10.7	11.4
16			5.6		2.1						3.9		4.9	10.2	11.2
17	1.5				2.5							2.3	5.2		
18				8.9	1.9								4.4	9.9	10.4
20										16.8					
21										16.6			4.2		
22	1.7	8.2								16.2					
23					2.2					16.9			5.2	10.2	
24					2.6					17.9			4.6	9.6	
25					1.7			2.3	1.6	15.7			3.2	8.2	9.6
26	1.5		4.3	7.5	1.8			1.7		14.5			3.5	8.5	
27	2.1	7.1	5.4	8.4	2.6	1.9	2.2	2.3	1.8	16.1	3.0		4.0	8.7	11.4
28	2.2			10.3	2.8	2.3	2.5	2.8	2.5		5.7	2.4		10.8	12.1
29	3.6	9.0	6.6	9.4	3.0	2.3	2.5	3.0	2.4		4.9		4.8	10.7	12.4
30			6.9	9.4	2.9	2.0		2.7		17.1	3.1		5.0	10.4	11.8
31			7.6	9.9	2.7	2.3	2.5	2.5	2.2		4.3		5.4	10.8	12.5
32			6.8	10.0	3.2	2.9	2.7	2.4			5.2			12.2	11.7
34	2.6			9.5	2.6			2.7		16.6	4.2		5.4	11.5	
35			7.2	9.8	2.7			2.7			2.7		5.5	11.2	11.9
36		8.6		9.6	2.8	2.2	2.3	2.4	2.1		3.8		5.2	10.9	12.1
37	5.9						0.1	0.2			1.6			4.6	2.6
38												2.0	6.1		
40															12.7
41												1.6			
42													6.6		
43													5.9		
45	3.9				3.3			2.9		16.3			6.7	12.3	12.1
46	1.6				2.6		2.6					2.8		11.4	
47			6.6		3.1					17.0			6.6	12.3	
49	3.9		6.6	10.1	3.2			2.9			5.4		6.2	12.1	12.5
51	1.6		7.1		2.8	2.4				16.5	5.1	2.7	5.7	11.9	11.7
52	1.6				3.1			2.7	2.5			2.8	5.1	11.7	12.4
53	1.8		5.6	10.0							4.3	1.6	3.9	10.7	11.5
54	5.5		5.0		2.4		2.2	2.2			2.7				7.7
55	1.7		7.0	9.5							7.0	3.1	4.9	11.2	12.2
56			6.2								5.1			9.4	11.9
Exp. mean	2.36	8.28	6.16	9.42	2.53	2.28	2.19	2.39	2.09	16.5	4.16	2.31	5.08	10.4	11.3
Reference	8	12	17	13	2	2	2	2	2	14	11	3	4	21	1

+ includes data from 1 block in Barkersville, N.Y., USA.

where the growth is poorer. The Scottish population (no. 53) grows satisfactorily in Scotland but nowhere else, a clear case of a very local adaptation with strong response to change of environment. Similarly one of the populations in Germany (no. 30) demonstrates a very variable growth, depending on planting site. On the other hand the remaining two populations introduced in lowland Germany (nos. 29 and 31) are very adaptable, growing well on most sites.

Growth of representatives of other species included in the study is shown in *fig. 9*. Japanese larch *(Larix kaempferi)* from a Danish plantation (no. 28) grows very well in the maritime climate of northern Europa, and about average on the continent. The population from a German seed extraction plant (no. 56) is less consistent in its performance. Siberian larch (nos. 37 and 54) is quite unable to grow on any of the planting sites except in Finland where it appears to be very statisfactory. Finally the Dunkeld larch *(Larix* × *eurolepis* HENRY) which is the progeny of trees growing in Denmark after being introduced from Scotland, is demonstrating very satisfactory growth, particularily in Denmark; only in Scotland and Finland it is around the average.

Provenances represented on less than 3 sites were not given separate maps in *fig. 3—9*. Those concerning the Polish larch were already mentioned above. The two east Alpine ones (nos. 20 and 21) had around average growth and the single west Alpine provenance (no. 11) somewhat below average, all in agreement with the results for other provenances from the same regions.

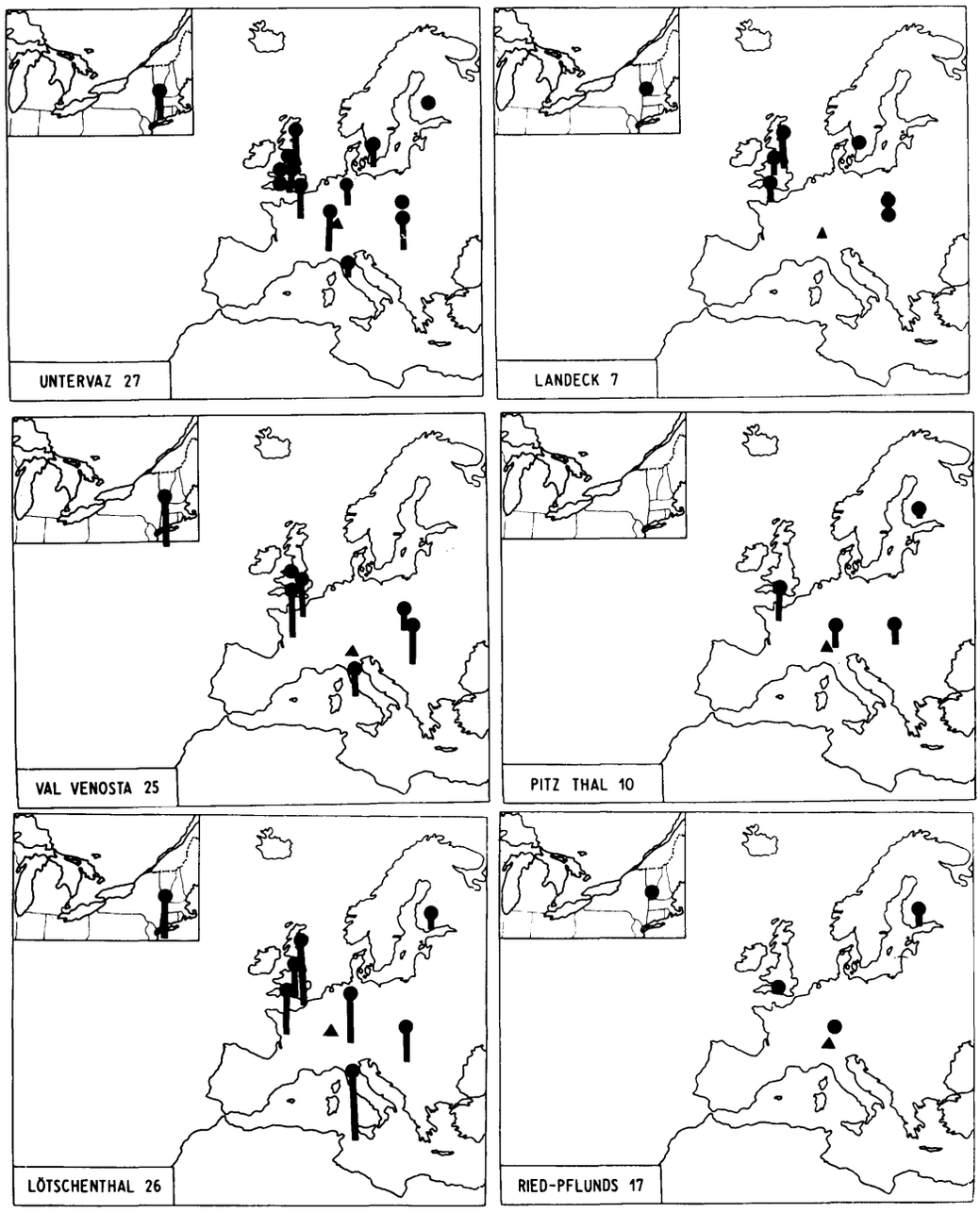

Figure 3. — Height growth performance pattern of 6 west Alpine provenances grown in various locations. (For explanation of ideograms see subscript to *fig. 2*).

Discussion and Conclusions

The main result of this study is obvious. In terms of height growth Sudetan provenances are best. Height is not the only character of interest to growers of larch but it is sufficiently correlated with most other important growth characteristics to be the best indicator of provenance value. Only volume production per unit area would be better but such data are not available for most planting sites. The summary of results presented here indicates that Sudetan populations of larch not only give the tallest trees, but also are most widely adaptable, performing well on all or most sites. Alpine populations are decidedly poorer, the more so the more westerly they are. This agrees with the conclusions of GØHRN (1956) based on Danish provenance experiments and with those of SCHOBER (1958) based on 29 provenance experiments in various parts of Europe. Carpathian populations are slightly less satisfactory than the Sudetan ones. The under represented Polish larch, including the Baltic populations of questionable identity, though generally satisfactory is not as spectacularly superior as the Sudetan larch. European larch populations grown in the USSR are of poorer growth potential, the more so the more eastwards is their origin (NADEZDIN 1971, TIMOFEEV 1972). A provenance from the Romanian Carpathians is slow growing (SCHOBER 1977). Thus while east and north of the optimal Sudetan populations growth potential of larch does not decline as rapidly as west and south of them, the same situation appears to exist as in Scots pine and to some extent Norway spruce (GIERTYCH 1976, 1979), namely that in all di-

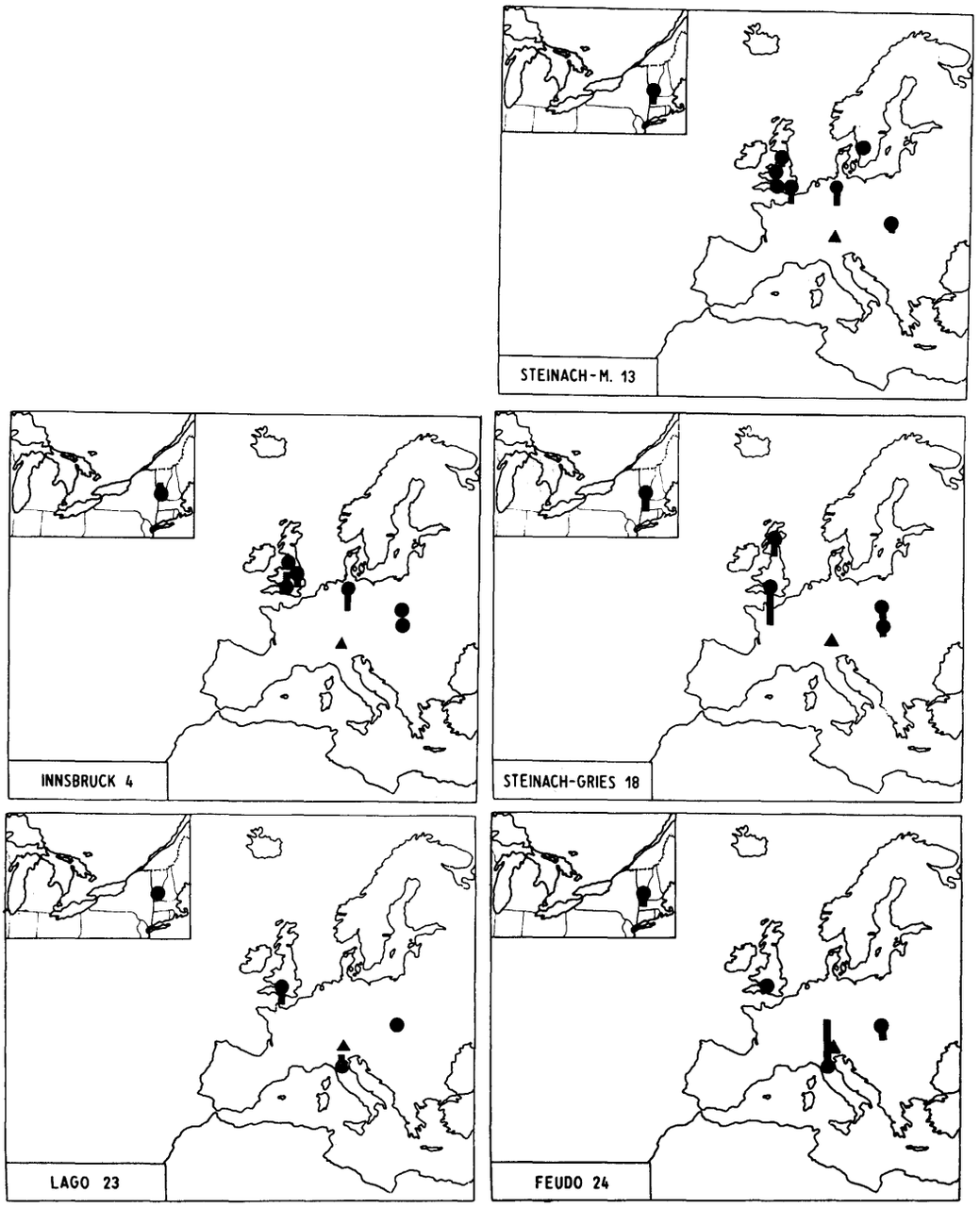

Figure 4. — Height growth performance pattern of 5 central Alpine provenances grown in various locations. (For explanation of ideograms see subscript to *fig. 2*).

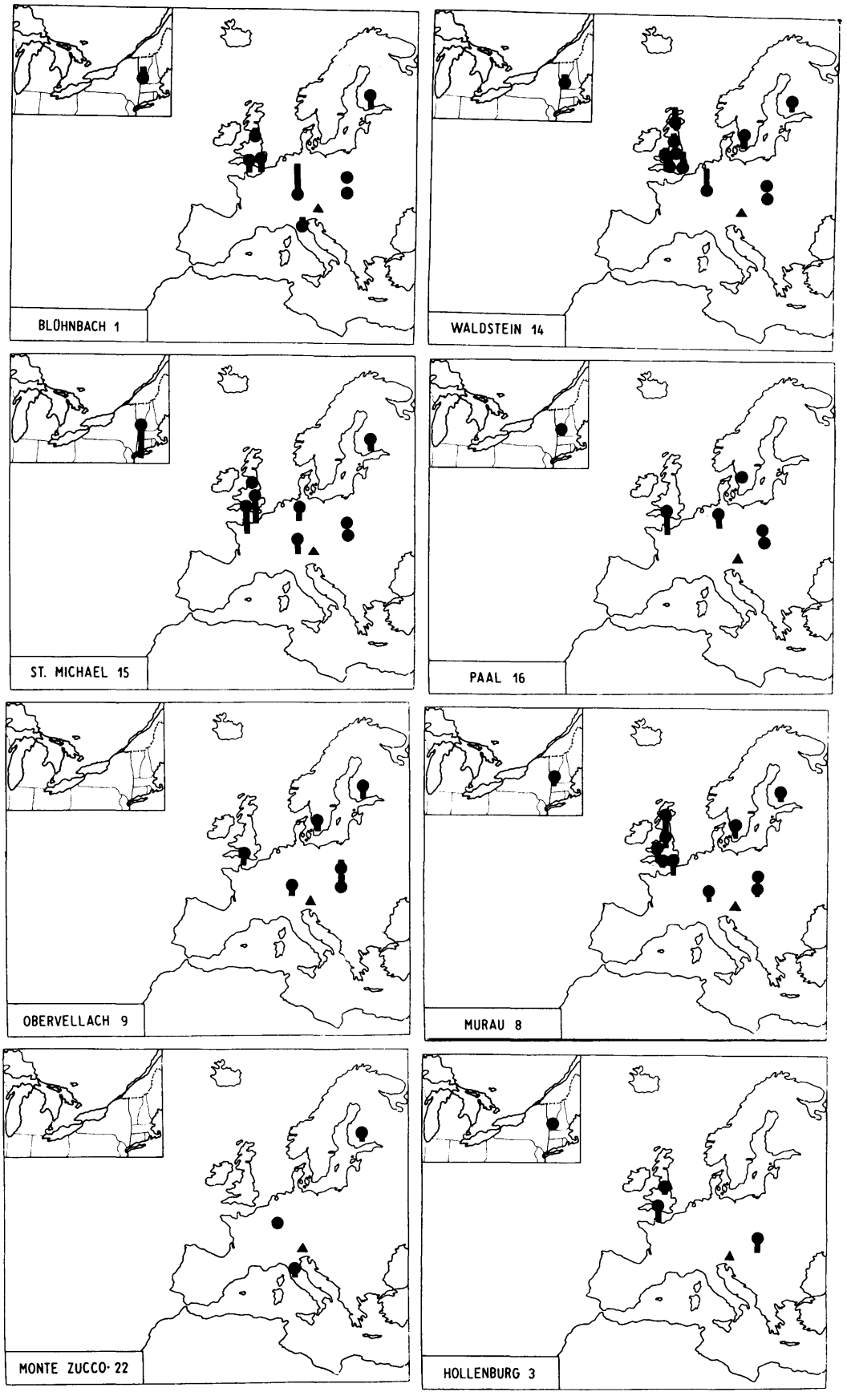

Figure 5. — Height growth performance pattern of 8 east Alpine provenances grown in various locations. (For explanation of ideograms see subscript to *fig. 2*).

rections from the optimal region populations decline in height growth potential.

Elevation does not appear to be a factor in determining potential for height growth. There are representatives of various elevations such as 550—1900 m in *fig. 3*, 900-1900 m in *fig. 4*, 500-1700 m in *fig. 5* and 175—1000 in *fig. 7* and yet the differences between figures are much more obvious than within them, indicating the existence of regional racial differences regardless of altitude. At the most elevated planting sites (Italy and Slovakia) at 950 m the same Sudetan provenances are among top producers. Thus HOLZER's (1967) opinion that altitudinal photoperiodic adaptations will affect seed transfers in larch is not supported by the data compiled here. The altitudinal differentiation of Alpine larch into „races" as described by RUBNER 1954) is probably more environmentally than genetically induced. There have been suggestions that growth is negatively correlated with elevation of the provenances (SCHOBER 1958, 1977) but this is obvious only on a range-wide basis and is a reflection of the fact that the Sudetans and Carpathians are lower mountains than the Alps. Taken within regions the altitudinal correlations are less obvious.

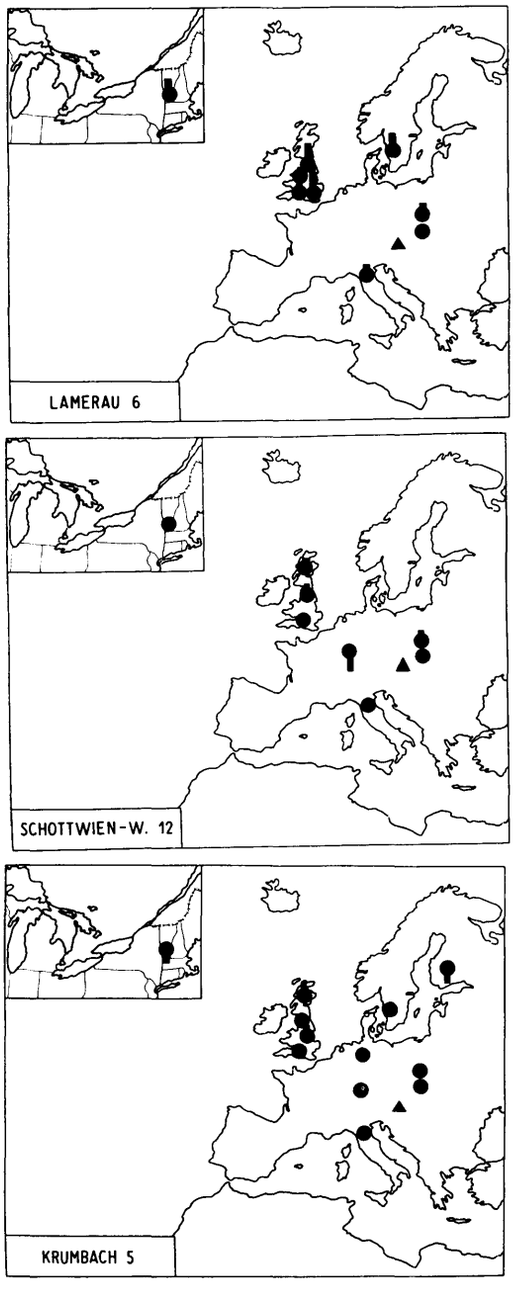

Figure 6. — Height growth performance pattern of 3 Lower Austrian provenances grown in various locations. (For explanation of ideograms see subscript to *fig. 2*).

In Scandinavia European larch has little future. In Finland only the Siberian larch looks promising whereas European larch provenances are of little use, except perhaps for two Sudetan provenances (nos. 45 and 49), but even those are 30% smaller than Siberian larch.

In southern Sweden Siberian larch is as poor growing as at most other sites. KIELLANDER (1958) claims his height data is meaningless because many tops are dead, but the results he published agree with those reported elsewhere, so that in spite of top-dying relative performance remains meaningful. Especially free of top-dying were Japanese (nos. 28 and 56) and Siberian (no. 37) larches and three of the best Sudetan and Carpathian provenances of European larch (nos. 32, 49, 51).

In USA at a lower latitude the same general results hold as in continental Europe, United Kingdom or southern Sweden.

It is concluded therefore that the direction of European larch seed transfer is of no significance. Neither elevational nor latitudinal transfer affect choice of best proveances. The same Sudetan provenances are the best producers wherever tried. The west Alpine ones are worst. Of course Finland is no place for European larch, Siberian larch being more proper there, but if the former must be used, the Sudetan provenances are best.

The two Japanese larch provenances acclimatized in Europe and used in the study give an average or above average performance. In view of the fact that 50% of the European larch provenances used in the study are of Alpine origin, and thus poor growing, the Japanese larch looks relatively good: however it is not as good as the Sudetan populations *(Fig. 7)* nor the introduced and acclimatized populations of European larch *(Fig. 8)* with which the Japanese larches of similar origin should most properly be compared. Thus selections among East European populations appear more justified than introductions of an exotic species.

The opinion that *L.* x *eurolepis* (no. 55) is a good producer is fully justified, even in further generations. This is a clear case of heterosis that is something more than an adaption to an intermediate environment. This could be an explanation in Scotland or Denmark, whence it came, but not on all the sample plots, many of which are typical European larch sites.

Compared with Scots pine and particularily with Norway spruce (GIERTYCH 1976, 1979) European larch appears much more sensitive to interactions with environment. There are populations, Sudetan ones among them *(Fig. 7)*, that are very adaptable showing growth superiority on all or most sites. Others, like provenance Krumbach (no. 5, fig. 6) are uniformly average on all sites. Still others are uniformly inferior (e.g. no. 26, *Fig. 3)*. There are populations however which are very variable in their response. Italian populations nos. 23 and 24 are good example of this *(Fig. 4)*, growing very well in the Italien Alps but be-

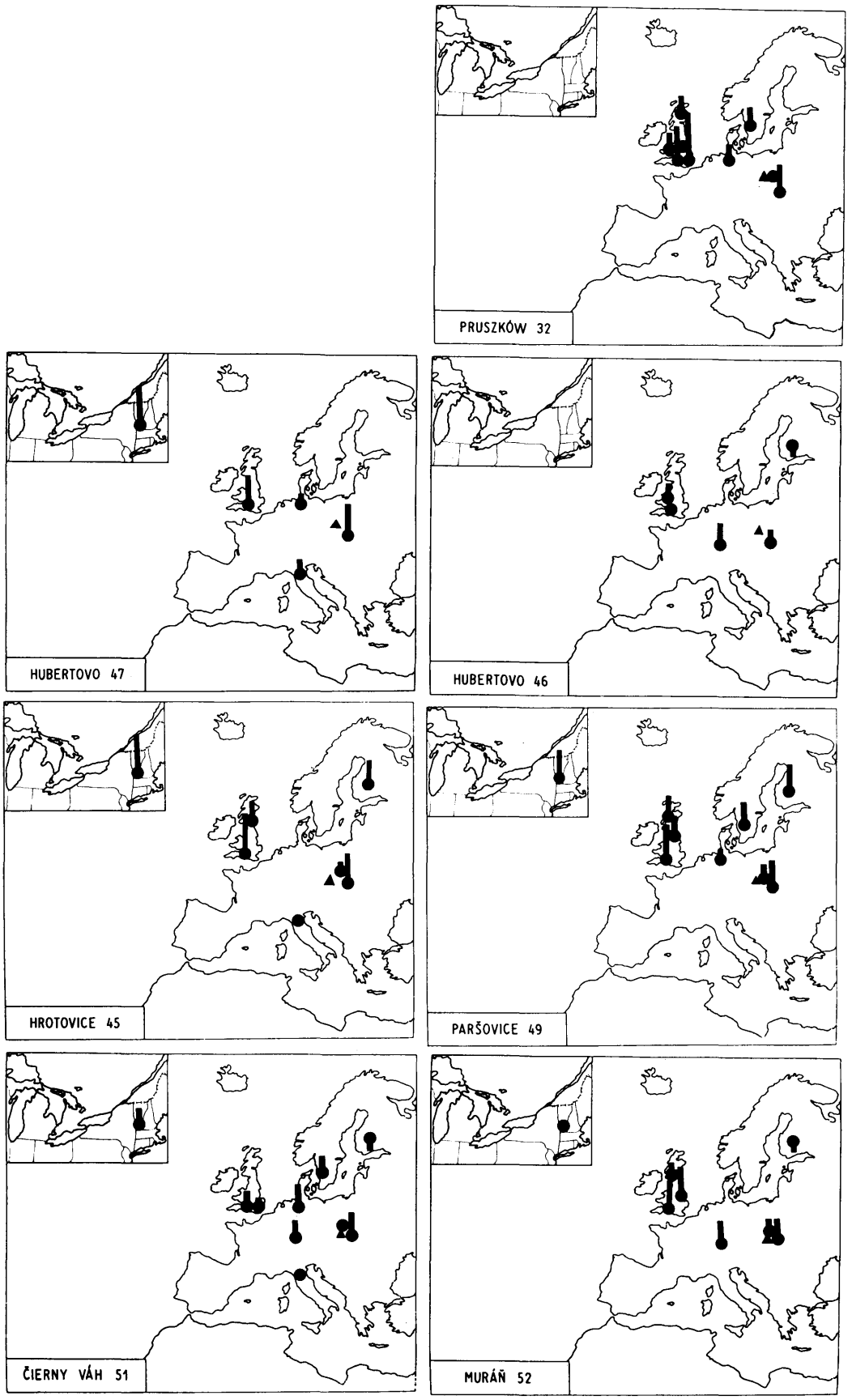

Figure 7. — Height growth performance pattern of 5 Sudetan and 2 west Carpathian provenances grown in various locations. (For explanation of ideograms see subscript to *fig. 2*).

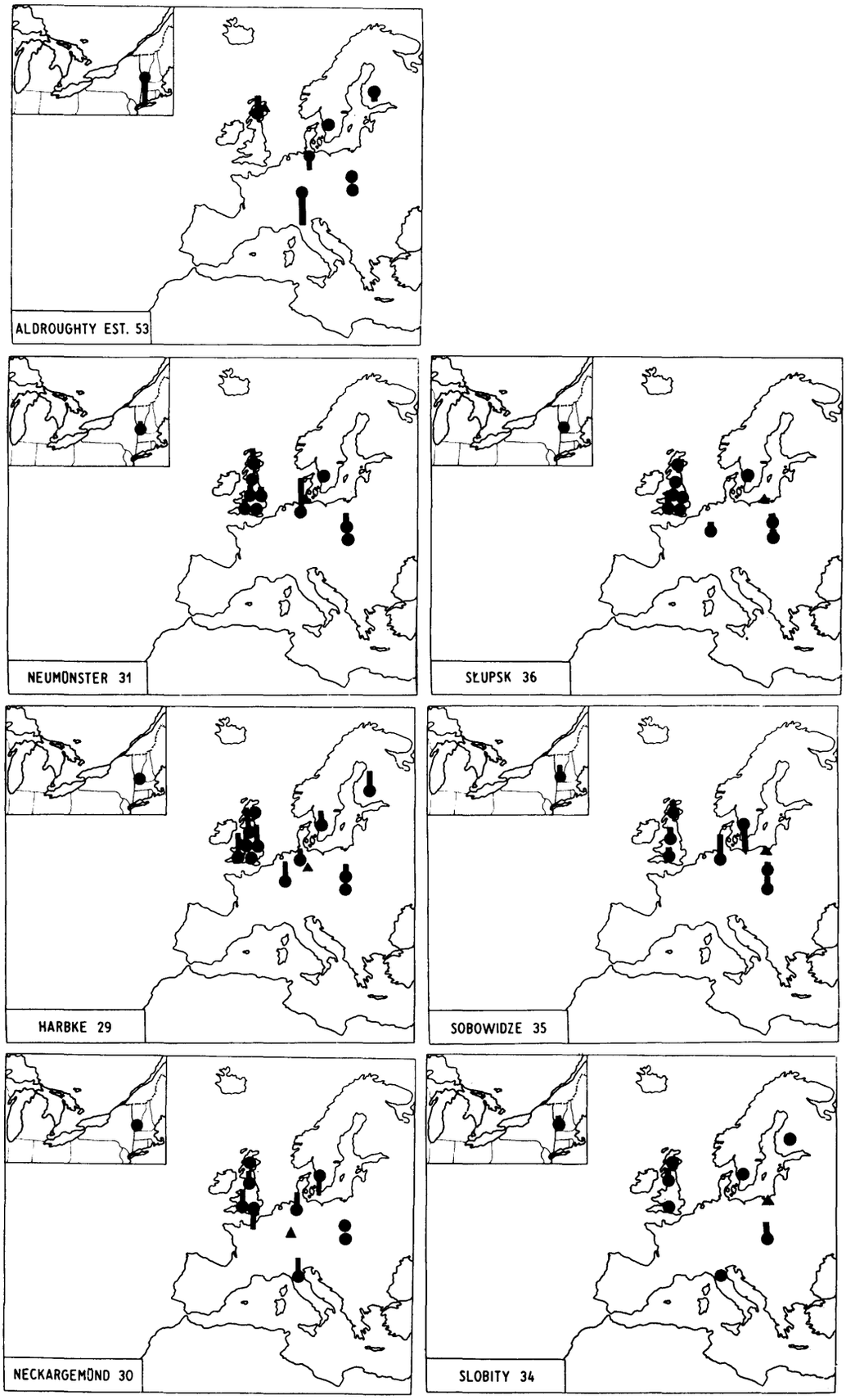

Figure 8. — Height growth performance pattern of 4 non-indigenous and 3 Baltic populations of questionable indigenity, grown in various locations. (For explanation of ideograms see subscript to *fig. 2*).

low average elsewhere. The eastern Alpine provenances nos. 1, 9 and 14 *(Fig. 5)* are another example with widely ranging performances depending on site. The same can be said of some of the introduced populations, *(Fig. 8)* as no. 53 acclimatized only in Scotland and no. 30 with a very inconsistent response akin to that of the Italian provenances nos. 23 and 24.

The introduced populations of European larch can perhaps be identified on the basis of adaptability. The Harbke provenance (no. 29) is believed to be of Sudetan origin (SCHMIDT 1955, LINES 1967, SCHOBER 1969) and its performance *(Fig. 8)* justifies this view. The same may perhaps be true of the Neumünster provenance (no. 31). There is working plan evidence that the Hrotovice larch (no. 45, *Fig. 7)* is of Sudetan origin (SVOBODA 1947) and the performance found in this study fully confirms this. The Scottish population, (no. 53) is probably of west Alpine origin with a local adaptation (compare *figs. 3* and *8)*.

Adaptability is an important characteristic to look for when contemplating seed transfers. The value of Sudetan, Carpathian, and to some extent Polish and lowland Austrian larch is unquestionable. This is indicated not only by the IUFRO 1944 study but also by the younger and much better represented 1958/59 provenance series of SCHOBER (1977).

Adaptability appears associated with best average height growth not only in larch but also in Scots pine and Norway spruce (GIERTYCH 1976, 1979). It appears that this dual property in all these species is not found in outlier or fringe populations, but concerns some central part of

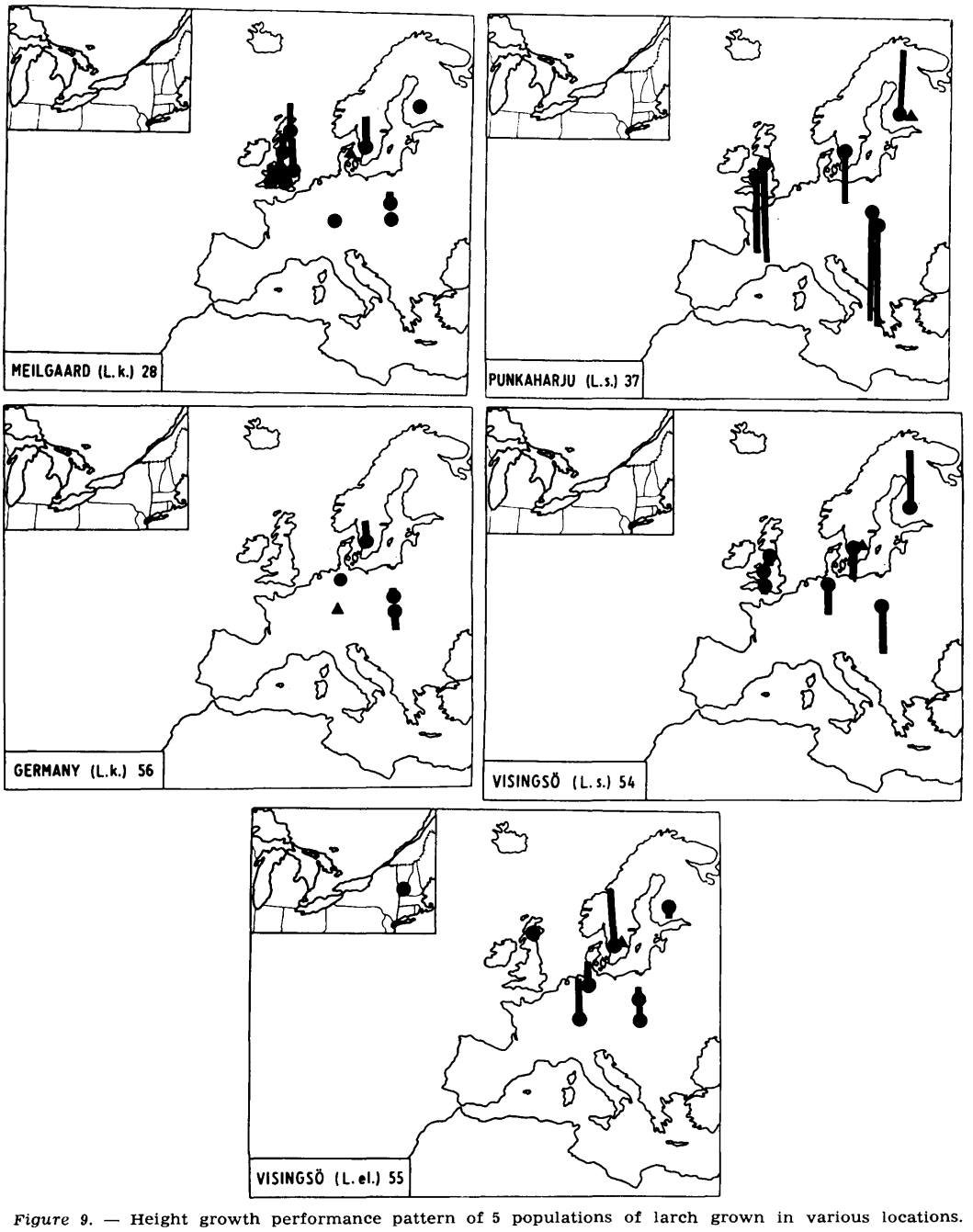

Figure 9. — Height growth performance pattern of 5 populations of larch grown in various locations. L. k. = *Larix kaempferi*, L. s. = *Larix sibirica*, L.el. = *Larix* × *eurolepis*. (For explanation of ideograms see subscript to *fig. 2)*.

the species range, where it grows at its climatic optimum and where a richer gene pool is available.

Unfortunately provenances with fastest growing trees are not the ones with best quality trees. Stem form is almost inversely correlated with growth. The greatest percentage of straight stemmed trees is in the Alpine populations wheras in Polish and Sudetan ones there are less (SCHOBER 1977). In larch, stem quality is very important and in provenance selection that means loss of growth potential. As is well known quality characters can be readily bred for and one generation of a seed orchard program will usually eliminate undesirable traits. Growth intensity and adaptability are better dealt with by appropriate choice of populations. Integration of these two approaches is the obvious breeding strategy to adopt for the future.

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