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Occasional Paper 19

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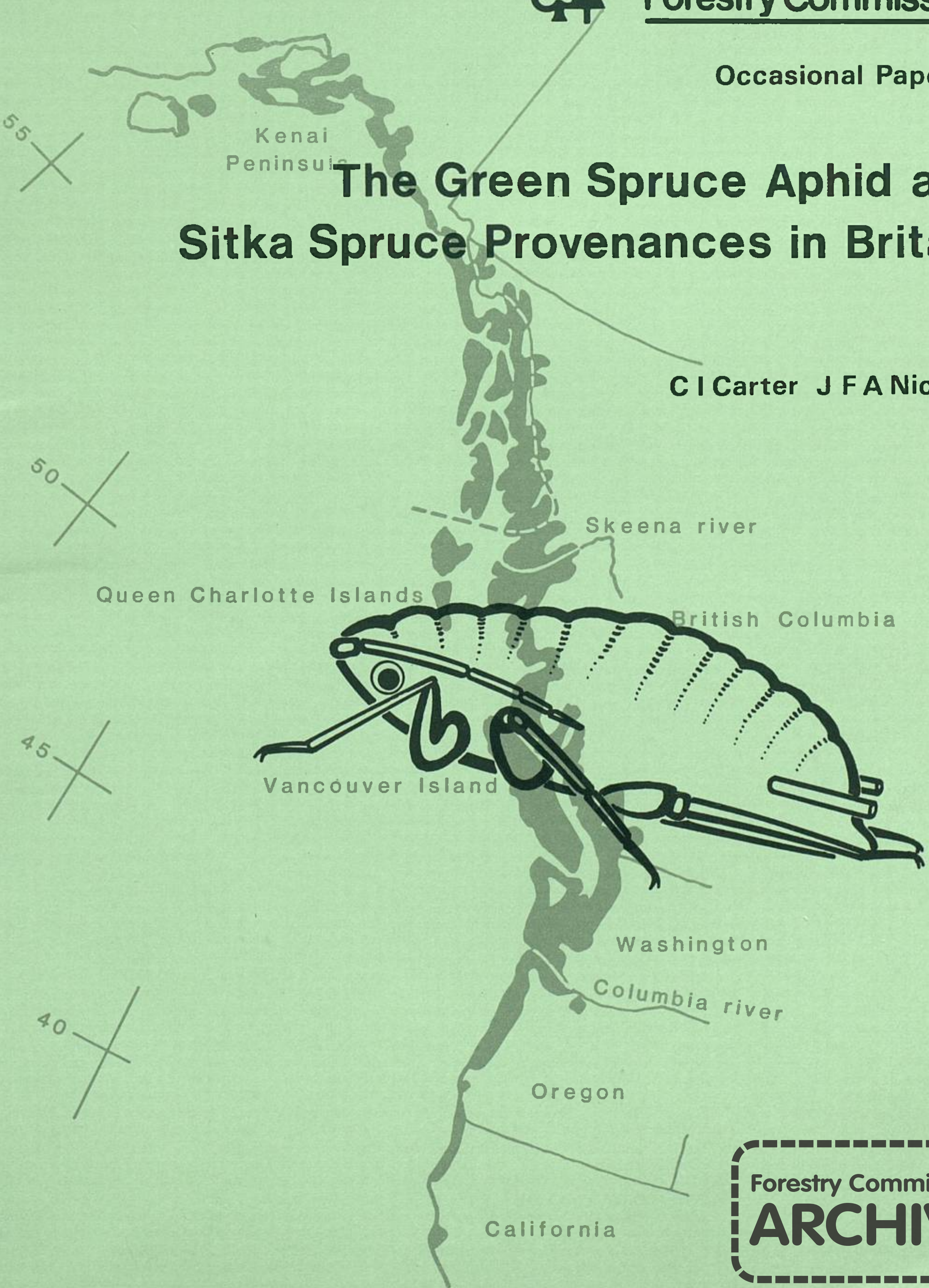

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THE GREEN SPRUCE APHID AND SITKA SPRUCE PROVENANCES IN BRITAIN

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Forestry Commission*

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ODC 453:145.7 *Elatobium abietinum*:174.7 *Picea sitchensis*:(410)

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SUMMARY

1. The damage caused by the green spruce aphid, *Elatobium abietinum,* to Sitka spruce growing in Britain is described.

2. Following an outbreak of this aphid in South Wales in 1980, it was possible to compare the impact and recovery of shoot growth in experimental plots at Rhondda Forest of a IUFRO provenance collection of Sitka spruce from a wide range of North American origins.

3. In all those provenances measured, the mean height growth was less than half that of the previous years and all plots showed a continuous depression of shoot growth for at least two seasons after attack, except those from California.

4. Data on the phenological displacement of plant dormancy and bud break and the associated changes in foliar amino-acid concentration of old needles is presented and the influence this has on aphid population increase is discussed.

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FRONT COVER: The green spruce aphid superimposed over map of the west coast of North America showing the natural range of Sitka spruce.

The Green Spruce Aphid and Sitka Spruce Provenances in Britain

By C.I. Carter and J.F.A. Nichols

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Introduction

The green spruce aphid (*Elatobium abietinum*) has for many years been recognised as a defoliating pest (Theobald, 1914). It particularly thrives on needles of dormant spruce trees in the mild winter weather conditions that prevail in the British Isles (Carter, 1972). It has also caused serious defoliation from time to time elsewhere in Europe (Bejer-Petersen, 1962; Ohnesorge, 1961) and also more recently in British Columbia (J. McLean and W. Stanek, personal communication). This aphid species was first described from *Picea abies* growing in Britain over 100 years ago by Walker (1849). Distribution records suggest that it was originally associated with Norway spruce which is supported by the fact that this tree shows less reaction to its presence than does Sitka spruce (*P. sitchensis*) or the majority of the North American species. Although severe defoliations alone will seldom, if ever, completely kill established Sitka spruce, the loss in potential growth and the frequency of attack makes *E. abietinum* the major background insect pest of Sitka spruce crops in Britain (Carter, 1977).

Life Cycle

The large numbers of aphids that can occur during the autumn to spring damaging-period are all viviparous females. As the population increases to a maximum in late spring a winged viviparous female form is produced. Flight of *E. abietinum* is a regular event and occurs more or less simultaneously all over Britain from late May to early June (Carter and Cole, 1977). Unlike several aphids that are pests of arable crops, this species has no host plant other than *Picea* spp. on which to feed. Indeed, the annual dispersal flight means that spruce trees are exposed to a continual invasion pressure each year. Studies on the nutritional quality of the old needles where the aphids feed on phloem sap suggest that the immigrant winged aphids can acquire only a poor quality food supply during the summer months (Carter, unpublished). It is not until late summer to early autumn when the tree is producing hard terminal buds and is in or near a dormant shoot growth condition that aphids start to increase in numbers and are readily found.

Damage

E. abietinum always feeds on old needles and it is at these sites that chlorotic bands develop; on Sitka spruce these needles rapidly senesce and are abscissed. Adjacent needles that have not been fed upon remain healthy and are not necessarily shed. The leader and upper crown are less often attacked, but in plantations the whole live tree crown may become completely defoliated in outbreak years. Young trees of up to 4 years old that have been heavily defoliated during the winter often have terminal buds that fail to break the following spring (Carter, 1977).

Footnote: This paper was originally presented at the IUFRO Sitka spruce provenance meeting held at Edinburgh in September 1984.

Factors Influencing Aphid Attack

Mild winter weather has been shown to be associated with attacks by *E. abietinum* (Bejer-Petersen, 1962; Ohnesorge, 1961). The air temperature threshold that will cause significant aphid mortality is -8°C, below which only a small proportion of aphids in the most sheltered situations will be able to survive, and as a result severe spring outbreaks are checked (Carter, 1972). Mild winters, on the other hand, are not necessarily followed by outbreaks. It seems likely that a particular host plant condition has to be achieved before the winter to enable the aphid to take advantage of the mild winter weather that may follow (Bevan and Carter, 1975). Periods of insect-increase correspond to an increase in the nutritive quality of the needles, especially the concentration of free soluble amino-acids. Since aphid development appears to increase in this way, the observed phenological differences in bud break, shoot growth and bud set between the various provenances (Lines and Mitchell, 1966; Kraus and Lines, 1976) may result in different rates of aphid development through the differences in physiological condition of the trees. It therefore follows that trees with a longer growing season would have a shorter susceptible period.

Phenology and Amino-acid Content of Needles

Although seed lots of *P. sitchensis* show little variation in the time of bud burst, those of *P. abies* when grown in Britain show considerable variation. In 1984 old needles of *P. abies* were analysed for amino-acid composition over the period from dormancy to shoot extension at Bedgebury Forest in Kent. From 23rd May to 11th July individual trees were sampled at two-weekly intervals and the amino-acid concentration tested against time and bud development. There was no significant relationship with time; a relationship between amino-acid concentration and bud development is suggested by the fitted line in Figure 1 but falls short of being significant at the 5 per cent level.

Provenance, Aphid Attack and Growth Loss

In the spring of 1980 many of the Sitka spruce trees in the replicated provenance plots at Rhondda (South Wales Experiment 3 planted in 1974) were so heavily attacked by *E. abietinum* that many trees were completely defoliated. Some trees escaped serious attack the first year presumably because of the lack of immigrant arrivals the previous year and because they had no contact with adjacent infested trees. Complete defoliation occurred before bud burst and the subsequent height growth of these trees was measured after two growing seasons. Only those trees that had full needle retention in the subsequent two years (i.e. no evidence of further aphid attack) were included in the final sample. The mean height increments were calculated for each plot and these were analysed to compare the performances of provenances (see Table 1).

Table 1.
Annual leader growth increments of five provenances of Sitka spruce at Rhondda Forest, South Wales before and after complete defoliation by the green spruce aphid (*Elatobium abietinum*) in spring 1980.

FC No	IUFRO No	Location	1978		1979		1980		1981		No of trees observed
			mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	
2	2024	Alaska	28.7	9.8	34.1	10.5	18.1	5.5	20.1	5.7	21
11	-	Masset QCI	41.9	13.3	39.4	10.8	20.3	3.9	25.4	7.1	17
13	3066	Vancouver Is	43.1	8.8	48.6	12.5	20.1	5.9	27.6	5.8	16
19	3012	N Oregon	41.1	13.5	35.2	11.2	14.8	4.8	21.5	7.2	17
27	3020	California	41.2	10.4	50.4	9.0	21.7	5.9	35.8	11.5	19

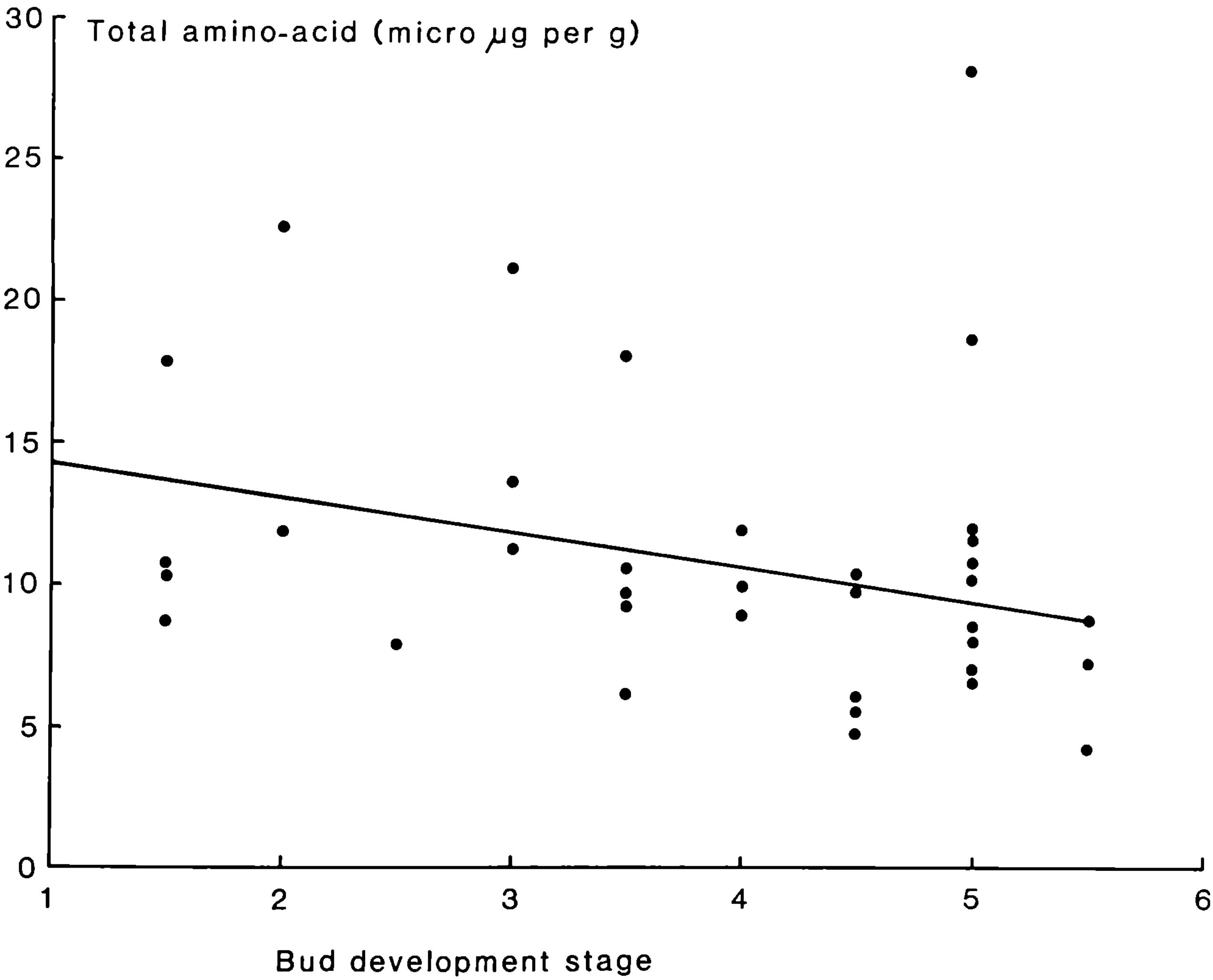

Figure 1. Phenology of selected Norway spruce trees at Bedgebury Forest, Kent, varying in date of bud-break. The amino-acid content of their mature needles suggests a relationship by the fitted line but does not achieve significance. (Bud development classification according to Krutzch, 1973.)

The analyses show that provenances differed significantly before and after attack, the Alaskan provenance having very small increments before attack, the North Oregon provenance being badly affected in the first year after attack, while the Californian provenance recovered exceptionally well in the second year after attack.

The mean annual leader growth measurements for 2 years before and 2 years after attack were converted into percentages of average pre-attack increment of the 2 years before attack so as to compare patterns of response (see Figure 2). All the provenances except the Californian one show a continued depression of growth for two seasons after attack. There was a slight decline in height growth from 1978 to 1979 (i.e. before recorded year of defoliation) in Masset (Queen Charlotte Island) and North Oregon provenances. It is quite possible that this decline could have been brought about by a patchy distribution of *E. abietinum* in the study area the year before the main outbreak of 1980. As there were no trees completely free of aphid attack there were no controls available. The depression of leader growth after attack was greater than that measured previously in an identically aged crop at Thornthwaite Forest (Carter, 1977).

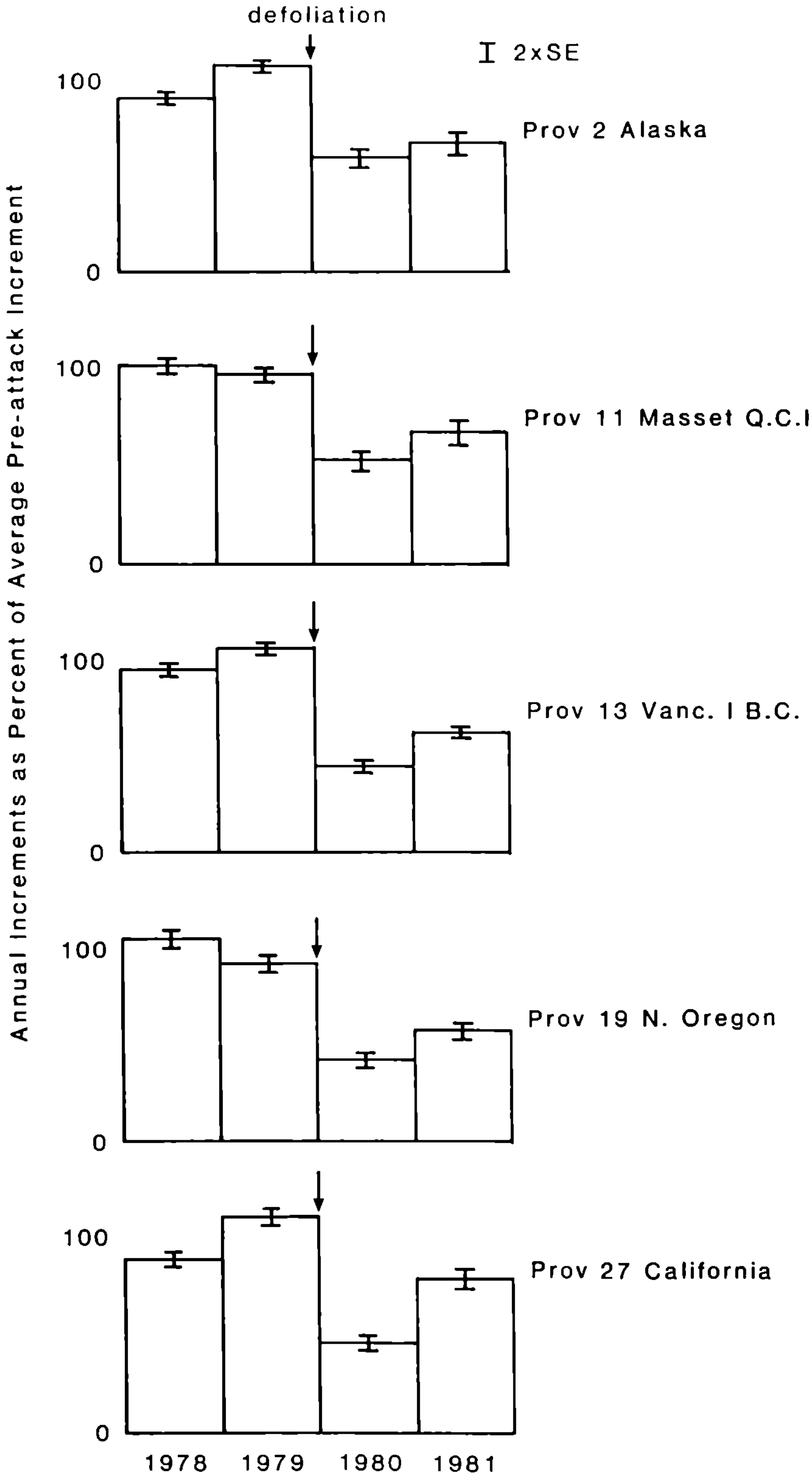

Figure 2. A comparison of annual leader measurements of five Sitka spruce provenances at Rhondda Forest, South Wales. The mean annual leader growth is converted to percentage of the pre-attack increment. The trees were 6 years old in the spring of 1980 when they were completely defoliated by the green spruce aphid (*Elatobium abietinum*).

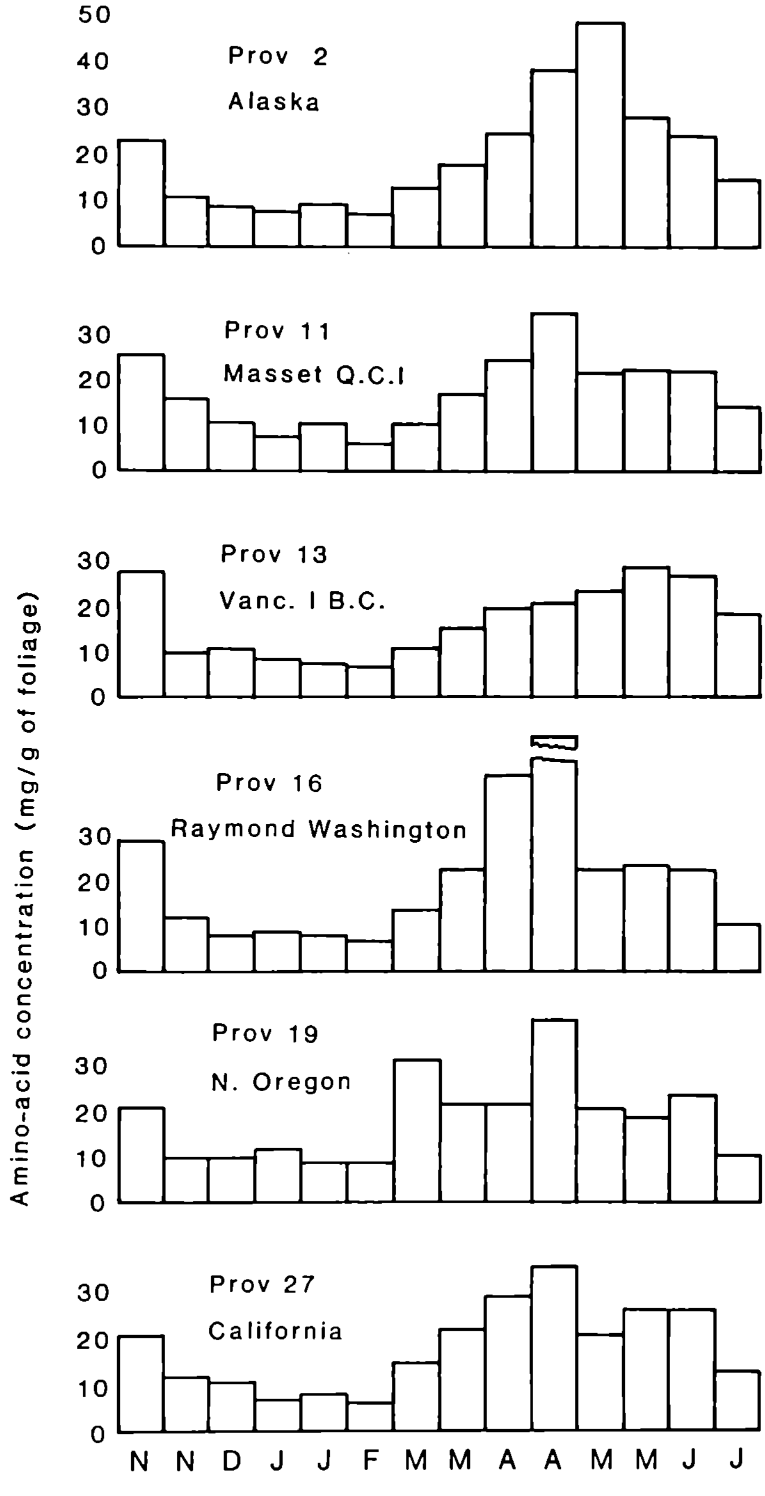

Figure 3. Total amino-acids in foliage of six provenances of Sitka spruce at Alice Holt, Hampshire, 1976/7. The period from November to July is when the aphid *Elatobium abietinum* is most frequently encountered. In this particular season from the late autumn through the winter all the provenances tested show similar trends in amino acid concentration. Some variability is apparent in late spring but the general overall pattern is a steady rise in concentration up to early May, followed by a decline during June to July. In contrast to Norway spruce, there is no major displacement at the start of the growing season between provenances of Sitka spruce in total foliar amino-acid concentration that could be expected to influence differences in aphid populations.

Discussion

In Britain *E. abietinum* usually reaches its peak in numbers in the late spring, after which winged forms are produced and the population declines rapidly. This period of increase coincides with high concentration of amino-acids present in the needles just before bud burst. There are only small variations in flushing time between provenances of Sitka spruce and therefore differences in the relative amino-acid concentration (see Figure 3) are not so evident as during the protracted flushing period of Norway spruce (see Figure 1). The greater differences between dates of shoot growth cessation that have been demonstrated in Sitka spruce provenances by Lines and Mitchell (1966) and Kraus and Lines (1976) could prove to be more influential in defining the period and degree of subsequent damage.

The early cessation of growth brought about by unusually dry weather in 1972 and 1973 in many parts of Britain produced foliage of a quality favourable for aphid development in the autumn months (Bevan and Carter, 1975). A higher concentration of foliar amino-acids at the onset of the bud setting period would then occur at a time when temperatures were still high enough for the aphid population to increase rapidly. Northern provenances with a long dormant period would therefore be at a greater risk from the more damaging early winter attack resulting in the depletion of unmobilised carbohydrate reserve materials in the needles necessary for future shoot growth (Carter, 1977). Such provenances would also have a tendency to carry a greater over-wintering population that could quickly exploit and damage many more needles in the warmer weather in the following spring (see Figure 4). From this hypothesis it follows that by choosing provenances with the shortest possible period of dormancy the risk of serious damage from this aphid could be significantly reduced.

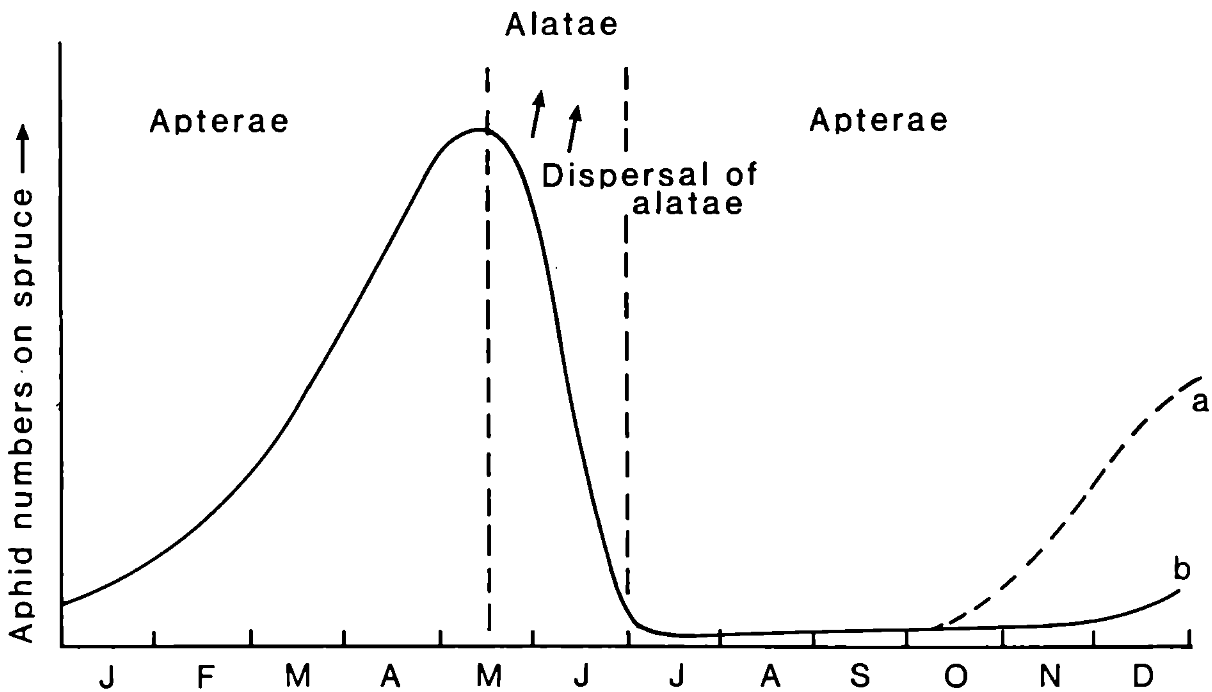

Figure 4. Annual population pattern of *Elatobium abietinum* on Sitka spruce in Britain. The divergence in the aphid numbers at the end of year are for: (a) an infested tree that has entered dormancy by early autumn, e.g. northern provenances; (b) a tree that has continued in active growth into early winter, e.g. southern provenances.

When Day (1984) sampled foliage for aphid populations in North Antrim Forest between 23 and 24 May 1983, he found that aphid population density was greatest on the more southerly provenances. In the spring of 1980 at Rhondda Forest trees of different origins showing equivalent severe defoliation were recorded, but it has been the southern provenance that has subsequently regained its former height-growth trend quicker than the other origins. Possible explanations for these apparent differences between North Antrim and Rhondda forests can be offered; one being that the larger growing provenances have normally only a short dormant period available for attack, the later the defoliation in the spring the less damaging it is to subsequent growth (Carter, 1977). An additional or alternative factor could be the amount of carbohydrate reserves available for subsequent growth in relation to tree size. Newly planted transplants and small trees with limited root systems show a more adverse reaction to *E. abietinum* than larger trees. Similar aged trees of the more northern origins are significantly smaller than southern ones and could possibly have proportionally fewer reserves to assist recovery.

Acknowledgement

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