SCHIZOCARPIC VARIATION IN SYCAMORE (*ACER PSEUDOPLATANUS* L.) IN IRELAND

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Individual variation of the bark (Pagan 1974), shoots and branches (Worsdell 1915), leaf colour (Napp-Zinn 1959), flowers (Semm 1965, de Jong 1976), sex expression (Scholz 1960, Semm 1965, de Jong 1976), and seedlings (Thiselton-Dyer 1902, Worsdell 1915, Latter 1931, Marcet 1969) in *Acer pseudoplatanus* L. are extensive.

One further pattern of variation is schizocotyly (development of several cotyledons by splitting) which is simultaneously under genetic and environmental control (e.g., adverse environmental conditions such as poor nutrition), and consequently the extent to which it can be observed varies from year to year (Marcet 1969).

The fruits of sycamores are composed of two one-seeded mericarps (samara dicarpellata); however an increase in the number of carpels has often been observed (Pax 1885, Thiselton-Dyer 1902, Latter 1931, Scholz 1960, Marcet 1969, Pagan 1975, de Jong 1976, Binggeli 1980). De Jong (1976) observed 3- to 11-carpellate fruits in *A. pseudoplatanus*. Also, other variations are possible. Shape and angle of fruit wings are highly variable (Galoux and Falkenhagen 1965, Pagan 1975). Fruits can either be red or green and either glabrous or pubescent (Pagan 1975). There is a moderate tendency in *A. pseudoplatanus* for parthenocarpy (development of fruit without seeds) (de Jong 1976). Semm (1965) observed variation in fertility, fruit dry weight and in the number of fruits per inflorescence on different parts of the crown.

Although morphological variations of *A. pseudoplatanus* have been observed by numerous authors, variability of natural populations is less well known. Galoux and Falkenhagen (1965) investigated the morphological variability of samara along a geographical gradient in Belgium. There was a tendency for samaras of high altitude areas to be smaller than in the lowlands. Correlations between environmental ecological co-ordinates and morphological characters were high in descendants. Interestingly, schizocarpy (development of several mericarps by splitting) was not recorded. Pagan (1975) studied length, angle and weight variations of fruits in the Slovakian Carpathians. The angle was found to increase with altitude whereas the dry weight decreased; a similar decrease in dry weight and length of the samara key was observed in Poland (Bednarz and Krzaklewski 1975). In the years 1968 and 1971 only fruit angle was found not to vary. Polycarpellate fruits increased with altitude both as a proportion of the total number of seeds and in the number of different fruit types. Schizocarpic fruits were most common in the top third of the inflorescences.

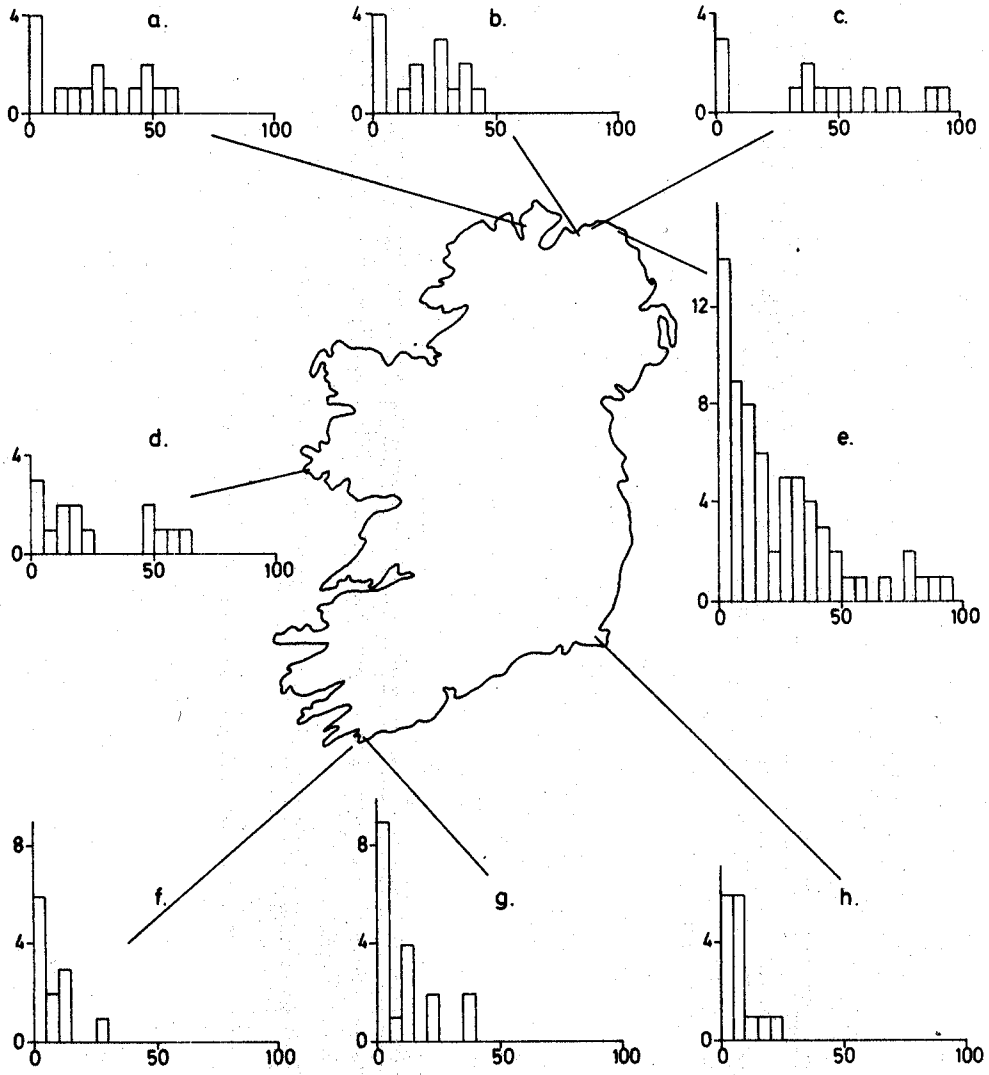

Figure 1. Geographical distribution of eight sampled *Acer pseudoplatanus* populations. The histograms show the frequency of % schizocarpic fruits — vertical axis, number of trees; horizontal axis, % of schizocarpic fruits per tree; a, Buncrana; b, Black Glen; c, Portstewart; d, Cleggan; e, Murlough Bay; f, Clear Island; g, Baltimore; h, Ballycogley.

In summer 1979, while investigating the seed production of sycamore at Murlough Bay (D1942), Co Antrim, schizocarpic fruits were discovered (Binggeli 1980). To find out the extent of this phenomenon and its possible occurrence in the rest of Ireland, large samples of trees from several sites were investigated during the following year.

SITES AND METHODS

Seeds were collected from each of a minimum of 12 trees in August and September 1980 from the following sites: Murlough Bay (D1942), Co Antrim; Portstewart (C8237) and Black Glen (C7636), Co Derry; Buncrana (C3533), Co Donegal; Cleggan (L6058), Co Galway; Baltimore (W0526), Co Cork and Ballycogley (T0311), Co Wexford (Fig. 1). One exception to this sampling regime was Cape Clear (V9622), Co Cork where all the trees were investigated. For every tree a minimum of 100 fruits were collected from at least two

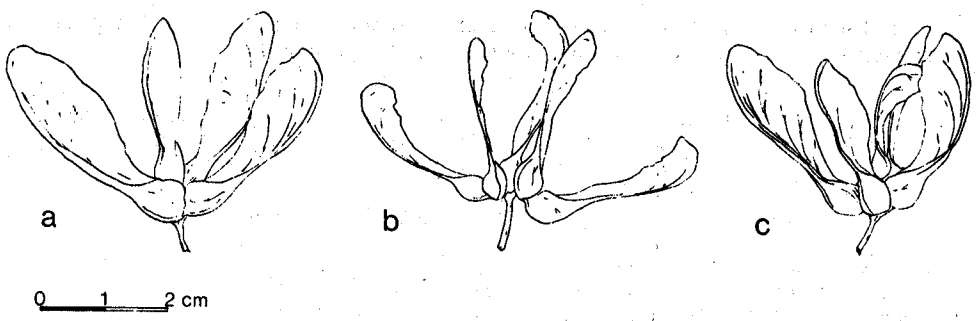

Figure 2. The three recognised types of fruit in *Acer pseudoplatanus*. a, Fruits with 2, 3 or more carpels situated on a single whorl; b, Fruits constituted of two or three whorls of two or more carpels; c, Fruits with a whorl of one or more carpels formed at the apex of the primary one.

branches from the easily accessible lower part of the crown and the number of each fruit type was counted (Fig. 2).

RESULTS

Fruit types

Numerous different fruit types were observed and were divided into 3 groups. These groups were chosen in the light of the work by de Jong (1976) on sycamore flowers and Worsdell (1916) on fruits of several species. In group I all the carpels are situated on a single whorl and includes fruits with two, three or more winged carpels (Fig. 2a). In group II the fruit is constituted of two or three whorls of two or more carpels (Fig. 2b), which probably originated from flowers possessing two or three free styles (de Jong 1976). Group III consists of fruits with a whorl of one or more carpels formed at the apex of the primary one (Fig. 2c). Some types of group III had a secondary whorl consisting of only one carpel; in some cases it was impossible to determine if the structure was the remains of the stigma or an underdeveloped carpel (classed in group I), or if the structure looked like a wing with or without a distinct nutlet (in group III). Some specimens had one or two carpels standing above the others on the whorl and were assumed to belong to the whorl.

A total of 57 fruit types was observed, 22 belonged to group I, 20 to group II and 15 to group III.

Intrapopulation variation

95.6% of the trees showed a degree of schizocarpy. All these trees had 3- carpellate fruits and 63% had 4- carpellate fruits. On individual trees 3- carpellate fruits were always more numerous than 4- carpellate fruits (Table 1). The ratios of 3- and 4- carpellate fruits varied very extensively from tree to tree, for instance, in Baltimore 3 trees with about 44% schizocarpic fruits showed ratios of 5.5, 15 and 25.

All the remaining 55 types of schizocarpic fruits were present on fewer trees in much smaller numbers. There was a tendency for 8- to 16-carpellate fruits to occur with 5- to 7-carpellate fruits. The frequency of fruits from groups II and III was very low in all trees.

The number of fruit types per tree was very variable from tree to tree, the highest recorded was 32 on a single tree at Murlough Bay.

There was no clear relationship between the percentage of schizocarpic fruits and the number of fruit types, although there was a tendency for low percentages of schizocarpy and few fruit types. However on Clear Island a tree with 38.4% schizocarpic fruits had only 3 types of fruits (2-, 3- and 4- carpellate) whereas a tree with 4.9% schizocarpic fruits possessed 7 types. At Murlough Bay a tree with 33.1% schizocarpic fruits bore only 2 types (2- and 3- carpellate).

The 8 populations show a similar pattern; many trees had low percentages of schizocarpic fruits and fewer trees with higher percentages (Fig. 1). In every population sampled the class 0 — 5% was the largest.

Table 1. Number of fruit types and percentage of schizocarpic fruits for the 3 groups and the percentage of trees bearing no schizocarpic fruits for the 8 populations.

	% schizocarpic fruits Group				No. of fruit types Group				% of trees without schizocarpic fruits
	Total	I	II	III	Total	I	II	III	
Ballycogley	6.7	6.54	0.14	-	8	6	2	—	6.7
Clear Island	9.1	8.7	0.31	0.09	13	8	3	2	0
Baltimore	13.9	13.75	0.1	0.05	8	5	2	1	6.7
Black Glen	18.5	18.22	0.23	0.05	11	8	3	1	7.1
Cleggan	21.9	21.3	0.5	0.1	9	5	3	1	7.7
Murlough Bay	22.1	21.0	0.7	0.4	47	19	14	14	3.4
Buncrana	24.5	23.75	0.65	0.1	18	9	8	1	0
Portstewart	46.2	44.93	0.34	0.93	22	12	5	5	0

Table 2. 3- and 4- carpellate fruits as a percentage of schizocarpic fruits

% 3- carpellate	% 4- carpellate
72.7	20.5
74.7	13.6
77.9	12.6
78.0	16.7
84.6	8.1
85.4	9.8
86.1	9.2
89.7	7.5

Interpopulation variation

Between the 8 populations there were large variations in the frequency of some classes of schizocarpic fruits (Table 1). The frequency of schizocarpic fruits increased from south (6.7% at Ballycogley) to north (46.2% at Portstewart); a similar increase was observed in the total number of fruit types (from 8 at Ballycogley and Baltimore to 47 at Murlough Bay). The number of fruits from group I were always more numerous than from group II, those in turn more numerous than group III. Portstewart and Murlough Bay are the only two sites with several fruit types from group III, and the latter population shows more types from group II and III combined than from group I, whereas all the other populations showed more types from group I than group II and III combined.

As the percentage of fruits from group I increased, the percentage of fruits from group II and III also increased. The increase in the percentage of 3- carpellate fruits of the total schizocarpic fruits is not related to the increase in the proportion of schizocarpic fruits. However the increase in 4- carpellate fruits when expressed as a proportion of schizocarpic fruits is highly correlated to the decrease in the percentage of 3- carpellate fruits (Table 2).

The 3 populations with trees bearing no schizocarpic fruits occurred in both the south and the north of Ireland and in other populations such trees never exceeded more than 7.7% of the total tree number. There was no correlation between the proportion of schizocarpic fruit bearing trees in a population and the frequency of schizocarpic fruits in that population.

DISCUSSION

It is possible to compare the results presented here with those from Slovakia, found by Pagan (1975). Both studies show the same variability in schizocarpy within and between populations. However in Ireland the extent of the variation was much greater, only 3.5% of the trees in Ireland had no schizocarpic fruits as opposed to 14.5% in Slovakia (in 1971). In Slovakia, in 1968, 80% of the trees bore no schizocarpic fruits, indicating therefore a large annual variation. Compared with 57 fruit types recorded in Ireland, Pagan found only 7 fruit

types, all of them belonging to our group I. Pagan (1975) presented the proportion of each fruit type as a percentage of schizocarpic fruits, but not as a percentage of total fruits (i.e., schizocarpic and bicarpellate), therefore a direct comparison with the results presented in this paper is not possible.

Apart from the possible environmental factors (i.e., nutrition, climate) being more suitable for inducing schizocarpy, its more pronounced expression in Ireland could be due to the fact that the Irish populations are semi-natural and the Slovakians natural. *A. pseudoplatanus* is alien to Ireland and was introduced to Scotland as early as the 15th century and much later to Ireland (Jones 1945), therefore it is likely that all Irish trees are descendants of cultivated origin. Six populations under study were planted and two populations (Murlough Bay and Buncrana) had a certain proportion of trees which had regenerated naturally. De Fraine (in Compton 1913) observed a higher percentage of schizocotyl seedlings among cultivated than among those of wild *A. platanoides*, so that it could be possible that sycamores from cultivated origin could produce a higher proportion of schizocarpic fruits.

High variability seems to be a normal trait in *Acer*. In *Acer rubrum* variation of several traits among trees within areas was as large or larger than the variation among geographic locations (Townsend 1972).

Schizocarpy of fruits of *A. pseudoplatanus* varies from Co Cork to Co Antrim. Other *Acer* species show latitudinal variability, for instance *A. rubrum* samara length (Townsend 1972) and in *A. saccharum* dry weight and the percentage of filled fruits (Gabriel 1978) were correlated with latitude. In 1981 sycamore populations in northern Scotland were examined and they appeared to have low percentages of schizocarpic fruits. However, since the samples were not taken during the same season and since schizocarpy varies from year to year, this need not invalidate the above hypothesis of latitudinal variation of schizocarpy.

Although population studies of fruit characteristics of *Acer pseudoplatanus* have been carried out by Galoux and Falkenhagen (1965), Pagan (1975) and in the present study, none of the authors studied the influence of the variation in sex expression or considered its implications. Scholz (1960) found that ♂ flowering specimens grew faster than protogynous (having female elements mature before male) monoecious specimens, the mean variation being 5 per cent. in height and 20 per cent. in stem diameter.

Flowering in sycamores has only been studied on botanical or amenity planted trees, and de Jong (1976) found 11 different types of *Acer* inflorescences. There is therefore a possibility that flowering types affect schizocarpy expression. Consequently a total study of flowering, fruiting and other tree characteristics on a large part of the range of the species could provide a better understanding of the variability of *Acer pseudoplatanus* and fully demonstrate the hypothesis of latitudinal variation of schizocarpy.

As schizocarpy is more common than generally acknowledged — even Galoux and Falkenhagen (1965) have not recorded it — and it is thought to be ancestral in the genus *Acer* (de Jong 1976), does it therefore provide an advantage or disadvantage for the reproduction of the species? Furthermore, since the annual variation of sex expression and schizocarpy of sycamores, and the environmental factors affecting those characters is not known, this leaves plenty of scope for further study.

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