VARIATION IN *ARUM MACULATUM*

By C. T. Prime

A study of variation in *Arum maculatum* L. was made as part of an investigation into the general biology of the British species, and the following paper gives a short account of the results.

1. Leaf variation

A. maculatum is slow to germinate; in the first six months the hypocotyl develops a small tuber which by the autumn following (one year after sowing) has developed three or four roots with a small shoot. The first leaf appears above ground in the following spring. This leaf is oval and only after three or four years is the characteristic sagittate shape developed. At maturity the plant usually bears three leaves though the number varies between two and four or even five. The most characteristic shape is shown by the second and third leaves, the first leaf being generally smaller, and borne on a shorter petiole (Table 1).

Table 1
Leaf length in *Arum maculatum*

Length of first leaf	8·47 cm. $\pm$ ·12 ($\sigma = 1{\cdot}32$)
Length of second leaf	10·69 cm. $\pm$ ·12 ($\sigma = 1{\cdot}48$)
Length of third leaf	11·79 cm. $\pm$ ·12 ($\sigma = 2{\cdot}20$)

The third leaf may vary in length from 5-19 cm. and from 4-14 cm. in width. Observation and measurement show that any particular leaf form tends to be retained year by year (Table 2).

Table 2
The correlation between leaf dimension in successive years in *Arum maculatum*

Petiole length	in 1943 and 1944	·58 (P.E. = ·09)
Leaf length	in 1943 and 1944	·48 (P.E. = ·09)
Leaf width	in 1943 and 1944	·31 (P.E. = ·06)

The distribution of the spotted and unspotted leaf forms (var. *immaculatum*) has been investigated by Pethybridge (1903) who gives the following results.

Sussex :	99% unspotted
Hereford :	5 : 1 unspotted to spotted
Lincoln :	92% unspotted
Northumberland :	90% unspotted
Ireland :	500 : 1 unspotted to spotted

It is not said how these figures were obtained, whether they were visual impressions or otherwise. Bromfield (1856) also says the unspotted form is commoner in the North of England.

A more thorough investigation was undertaken with the assistance of other observers, whose help is gratefully acknowledged. The results are shown on the map (Fig. 1) which shows clearly that the unspotted form becomes more frequent as one goes further north; there is clear evidence of a cline. The existence of this cline helps to confirm the northern limit of the species. It would be reasonable to regard most of the isolated clumps of spotted plants in northern Scotland (e.g. Aberdeen, Angus) as introduced, a view held by most local observers. Sowter (1949) draws the northern limit of the species between the River Forth and Argyll, and this is supported by the evidence from the cline. Thus there are twelve spotted to four unspotted records north of Sowter's line, but four spotted to fourteen immediately south of the line. If the above explanation is correct, it does not explain why the spotted plant was introduced rather than the unspotted. Possibly, it was considered the more ornamental, or perhaps it was more common at the time of introduction. Moreover the cause of the cline itself remains unexplained.

On the continent, Hock (1934) records a different result, considering the spotted form commoner in North Germany than in the South. All the native plants of Denmark are unspotted, but these belong to a separate chromosome race ($2n = 28$).

In addition to the change in the degree of spotting the size of the plant in this country decreases as one goes further north. The luxuriant growth of the southern plants, which sometimes reach 30 cm., gradually diminishes, 15-20 cm. being the normal height of the Scottish plants.

The leaves of *A. maculatum* contain cyanophoric glucosides. Several hundred tests (Prime 1951) indicated differences in the glucoside content, but these did not appear to be correlated with any other variation.

The stomatal index is not so constant as in other species, and there is no significant difference between plants from different localities, or plants with differing chromosome number. Stomatal index determinations varied from 7·0 to 11·5, the average being 9·28.

2. Floral variation

Miller Christy (1914) drew attention to the rolling of the spathe; if it is rolled anti-clock-wise from above he described it as sinistral, if conversely as dextral. In over 1,200

TABLE 3
The numbers of sinistral and dextral spathes

Locality	*Sinistral*	*Dextral*	*Approximate level of statistical significance*	*Observer*	*Date*
Essex	645	583	10%	Miller Christy	1914
Hereford	278	220	10%	Armitage	1921
Croydon, Surrey	106	91		Prime	1946
Croydon, Surrey	537	463	3%	Prime	1947
Croydon, Surrey	560	440	·1%	Prime	1948
Northumberland	36	18		Temperley	1949
Aberdeen	11	8		Kerr	1949
Beckenham, Kent	55	45		Sherwood	1949
Culford, Suffolk	10	7		Thompson	1950
Whitby, Yorks.	11	6		Little	1950
Bryanston, Dorset	13	12		Hawkins	1950
Mildenhall, Suffolk	349	314	20%	Southwell	1950
Stroud, Gloucester	24	35		Hughes	1950
Alton, Hants.	179	140	13%	Langridge	1950
Swindon, Wilts.	190	157	10%	Timperley	1950
Bristol, Glos.	22	17		Timperley	1950
Total	3026	2556	·1%		

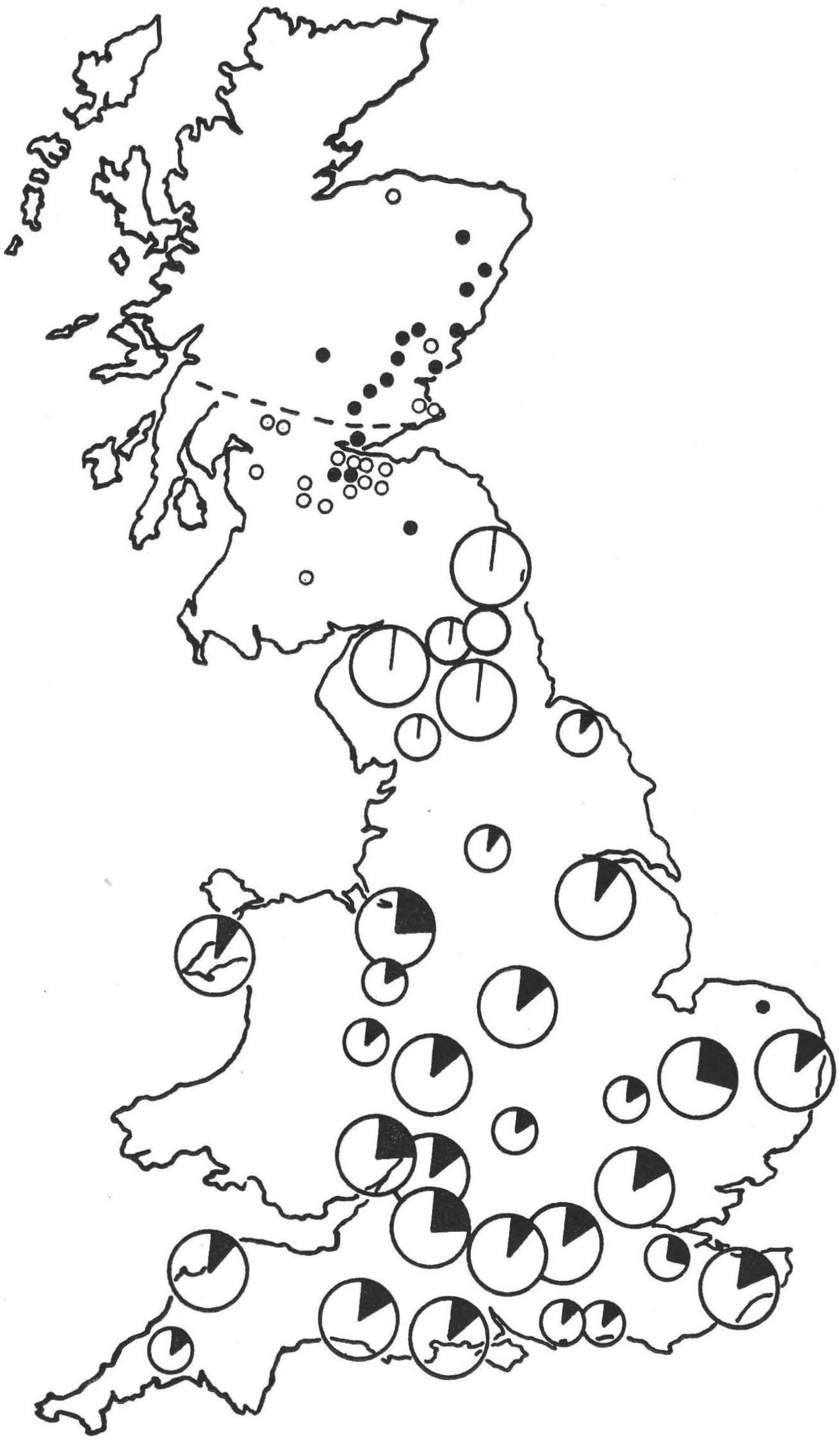

Fig. 1. The distribution of maculate and immaculate forms of *A. maculatum*. The percentage of spotted leaves is shown as the darkened sector of a circle. The largest circles are based on over 100 counts, the smaller on less than 100. Isolated records of spotted and unspotted forms are shown as the smallest black or white circles. Sowter's northern limit for the species is given as a dotted line.

counts he found 10% excess of the sinistral form, a result later confirmed by Armitage (1921). Further results are given in Table 3, and the help of observers is gratefully acknowledged.

The total figures show the differences to be highly significant. It may be noted that there is no evidence of any clinal variation in this character.

In some polyploids there is a relationship between pollen grain size and chromosome number. Pollen from over a hundred samples of *A. maculatum* from over twenty-five localities was measured but it was all of similar size. The pollen of plants from Denmark ($2n = 28$) has the same diameter ($41{\cdot}5 \pm {\cdot}024$; $\sigma = 1{\cdot}7$) as that of the British plants and so also has the pollen of *A. italicum* Mill. and *A. neglectum* (Townsend) Ridl.

3. Fruit variation

This has been investigated by Colgan (1911) who compared spotted and unspotted plants, and Salisbury (1942). The following data are based on further counts of several hundred fruits just before ripening. The data may be presented and compared in various ways.

Table 4

The average number of fruits in *A. maculatum* and var. *immaculatum*

	Total number of fruits examined	*Average number ovules per fruit*	*Average number ripe seeds per fruit*
A. maculatum	1305	$1{\cdot}95 \pm 0{\cdot}39$ ($\sigma = 1{\cdot}40$)	$1{\cdot}36 \pm {\cdot}036$ ($\sigma = 1{\cdot}17$)
var. *immaculatum*	2973	$1{\cdot}73 \pm {\cdot}024$ ($\sigma = 1{\cdot}31$)	$1{\cdot}18 \pm {\cdot}021$ ($\sigma = 1{\cdot}09$)

The differences shown in Table 4 are statistically significant and further analysis of the figures in Table 5 by the x^2 test shows that they are due to a tendency for *A. maculatum* to bear a larger number of fruits with a high number of ovules.

Table 5

The relation between the number of ovules per fruit and the total number of fruits

	Number of ovules per fruit									
	0	1	2	3	4	5	6	7	8	
A. maculatum	101	463	350	222	135	25	8		1	Data for '35, '40 and '41
var. *immaculatum*	202	1215	926	473	120	33	3	1		
	Number of ripe seeds per fruit									
	0	1	2	3	4	5				
A. maculatum	163	549	161	148	19	3		Data for '35, '36, '40 and '41		
var. *immaculatum*	396	1608	638	119	11	—				

The data for Tables 4 and 5 are based on several years' figures, but if data for separate years are analysed, they show that in some years there is no difference between the percentages of ripe ovules per fruit in the two forms. Thus the differences shown in Table 4 are really due to a large difference in one or two years.

Table 6 shows no significant statistical differences in 1936, 1940 and 1941, but

Table 6

The number of fruits and ovules in *A. maculatum* and var. *immaculatum* for 1935, '36, '39, '40 and '41.

	Number of fruits		*Number of ripe seeds*	
Year	*maculatum*	*immaculatum*	*maculatum*	*immaculatum*
1935	306	600	679	930
1936	143	824	228	1178
1939	376	507	368	598
1940	208	803	212	755
1941	341	473	435	529

significant differences in 1935 and 1939. Further in 1935, the number of ovules in *A. maculatum* was greater than expectation, while in 1939 the reverse was the case.

The average seed output (average number of ripe seeds per fruit × average number of fruits per spike) of the two forms is shown in Table 7.

TABLE 7
The average seed output of *A. maculatum* and var. *immaculatum*

	Average number fruits per spike	*Average number seeds per fruit*	*Seed output*
A. maculatum	26·63 ± ·41 (σ = 6·74)	1·36 ± ·036 (σ = 1·17)	36·21
var. *immaculatum*	27·98 ± ·34 (σ = 6·77)	1·18 ± ·021 (σ = 1·09)	33·01

Thus the significant differences observed between the seed production of the two forms do not account for the preponderance of the var. *immaculatum* and it is unlikely that they have any biological significance. A difference in the rate of vegetative reproduction would account for the greater frequency of var. *immaculatum* but individual corms vary so greatly in this respect that it has not been possible to demonstrate an overall significant difference. Many other factors, besides the reproductive, could operate to produce the observed distribution.

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