SOME OBSERVATIONS ON THE GENUS *ARISAEMA* ON THE NILGIRI HILLS, SOUTH INDIA

BY

EDWARD BARNES, B.Sc. (Lond.).

(*With 2 plates*).

The South Indian species of this interesting genus do not appear to have received the attention that they deserve. Of the five species of *Arisaema* included in the Flora of the Presidency of Madras (Part IX by Mr. C. E. C. Fischer, published in 1931) *A. pulchrum* is known from only one specimen and *A. Wightii* until recently was known only from material 'all in a more or less dilapidated condition, hardly permitting a precise conception' (Fischer); and even the two very common species, *A. tortuosum*, Schott, and *A. Leschenaultii*, Blume, have received little attention in the field for many years. The collections made by the writer have resulted in the founding of four new species, descriptions of which have recently appeared or are in process of publication (*A. Barnesii*, Fischer, *A. translucens*, Fischer, *A. tylophorum*, Fischer, Kew Bull. 1933, 339, and *A. convolutum*, Fischer, in the press).[1] The observations recorded below include some additional information about these new species as well as some further obervations on several of the older ones.

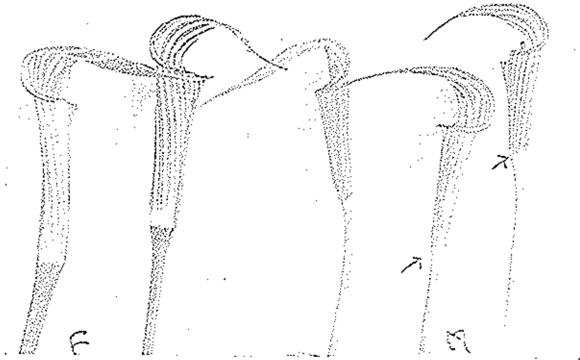
DISTRIBUTION

In South India this genus is almost entirely confined to the higher hills.

On the Nilgiris by far the commonest species is *Arisaema Leschenaultii*, Blume. It is usually found in sholas, and there are very few sholas above 6,000 ft. in which it is not to be found. It generally grows on the ground in leaf-mould. A number of sholas on the Wenlock Downs show a remarkable absence of undergrowth; in these sholas *A. Leschenaultii* becomes epiphytic. An example that may be quoted is the shola on the side of Anikalbetta ('Staircase'), where at least 90 per cent of the plants of this species were found to be growing on moss-covered branches, in forks or on outstanding roots of trees. On some of the highest hills, such as Pichalbetta, its characteristic place of occurrence is on the margins of sholas or under the shade of bushes. In wet places it is not uncommon in the open amongst grass or in cracks between rocks. The spathe of *A. Leschenaultii* varies in colour from light green or yellowish-green striped with white to dark crimson-purple with lighter stripes. Generally those plants that grow in dense shade or in wet situations have spathes that are green and white while those that grow in dry or exposed places tend to have more or less purple spathes.

A. tortuosum, Schott, appears to be the most widely distributed species of this genus in India. It is found in dryer places and down to lower levels than the other species in the Nilgiris.

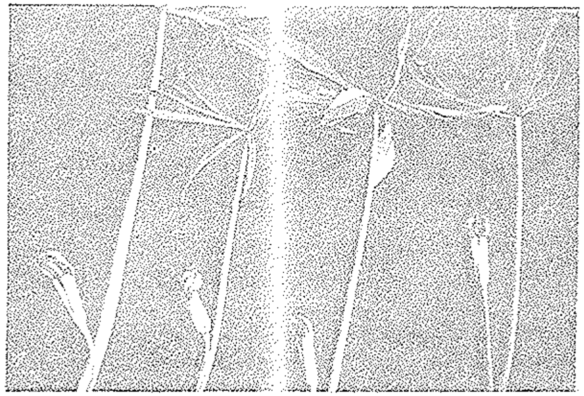
[1] Now published Kew Bull. 1934, 167.



1. *Arisaema Leschenaultii* Blume.
Female and male inflorescences.

2. *Arisaema Leschenaultii* Blume.
A. Seedling. B. Detached corm.
C. Undetached corm.

3. *Arisaema translucens* Fischer.



4. *Arisaema translucens* Fischer.

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It is not found much above 6,000 ft. except the non-typical form with five leaflets, which grows up to about 8,000 ft. It often grows in the open and is common on road sides and on the margins of clearings in sholas on the ghats. The colour of the spathe and appendage of the spadix varies from green or purplish-green to almost black.

A. Barnesii, Fischer, is not uncommon between 5,000 ft. and 6,500 ft. in sholas, but does not appear to occur at higher levels. It has been found in Longwood Shola, Kotagiri, near Pykara Falls, at Neduvattam and in Thiashola. It has been found only in the ground. The colour of the spathe varies from green with white stripes to dark purple with white stripes.

A. convolutum, Fischer, has been found to be common in several sholas above Parson's Valley, and a few specimens have been seen in Governor Shola near Ootacamund and on the sides of Emerald Valley. It appears to require a wet climate and a fairly high altitude (7,500 ft.). It grows both in leaf-mould on the ground and on moss-covered branches or roots of trees.

A. translucens, Fischer, has been found only in Thiashola and its neighbourhood. It is found amongst undergrowth in dry sholas down to about 5,500 ft. It was also found growing in cracks in rocks in a dry shola.

A. tylophorum, Fischer, has been found at Neduvattam, at the upper end of the Ouchterlony Valley and in Thiashola (6,000-7,000 ft.). It grows in the ground and is usually found on the edges or in the more open parts of sholas.

Except the non-typical form of *A. tortuosum* which flowers in March and April, all the above mentioned species of *Arisaema* flower in May and June on the Nilgiris.

Number of Leaflets

Below are given the results of counts made of all plants seen at the times and places mentioned. The number in the brackets is the number of leaflets, and the number before the bracket is the number of plants found to have that number of leaflets.

A. Leschenaultii. Longwood Shola. 27-5-32.

Each plant had one leaf.
Males: 2 (5), 5 (6), 96 (7), 80 (8), 50 (9), 16 (10), 4 (11),
Females: 3 (8) , 6 (9), 12 (10), 4 (11), 3 (12).
Number of leaves with odd number of leaflets: 168.
Number of leaves with even number of leaflets: 119.

A. tortuosum, typical form. Banagudi Shola. 18-6-32.

Each plant had two leaves.
Monoecious: 2 (7), 5 (8), 32 (9), 4 (10), 4 (11), 1 (12).
Males: 5 (5), 4 (6), 37 (7), 6 (8).
Number of leaves with odd number of leaflets: 78.
Number of leaves with even number of leaflets: 20.

Early flowering, non-typical form. Longwood Shola and Dodabetta. April 1933.

Each plant had two leaves with five leaflets.

This plant differs from the normal form in having pedatisect leaves always having five leaflets, in occurring at higher altitudes, in flowering in March and April, and in the spathe becoming black on withering, and not yellow.

A. Barnesii, typical form. Thiashola at lower altitudes. 12-6-33.

Each plant had one leaf.
Males: 23 (5), 5 (6), 13 (7), 8 (8), 2 (9).
Females: 1 (7), 3 (8), 1 (10).
Non-typical form. Thiashola at higher altitudes. 12-6-33.
Males: 3 (5), 10 (7), 1 (8).
Females: 2 (7), 1 (9).

This plant differs from the typical form in the markings on the spathe, notably in the presence of a white patch at the base of the limb, and in the appendage becoming green and filamentous at the tip instead of ending in a knob. It may be a variety of *A. Barnesii* or, less probably, a cross between this species and *A. tylophorum* in which most of the characters of the former are dominant.

Species as a whole:
Number of leaves with odd number of leaflets: 67.
Number of leaves with even number of leaflets: 14.

A. convolutum. Pennant Shola, Nilgiri Downs. 21-5-33 and 3-6-33.

Each plant had one leaf.
Males: 1 (7), 4 (8), 11 (9), 11 (10), 7 (11), 2 (12), 1 (13).
Females: 2 (10), 4 (11), 6 (13), 1 (13), 1 (14), 1 (15).
Number of leaves with odd number of leaflets: 26.
Number of leaves with even number of leaflets: 26.

A. translucens. Thiashola. 9 and 12-6-33.

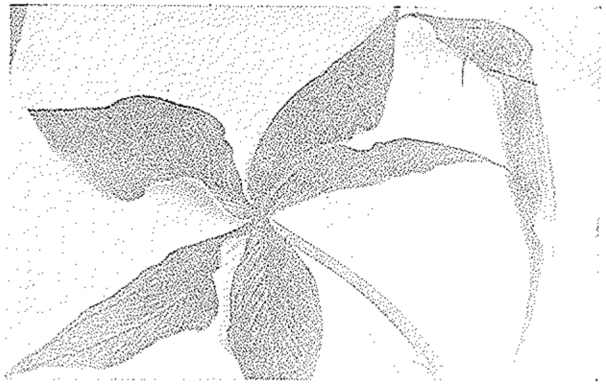
Each plant had one leaf.
Males: 2 (6), 7 (7), 9 (8), 15 (9), 11 (10), 3 (11).
Females: 3 (11), 5 (12).
Number of leaves with odd number of leaflets: 28.
Number of leaves with even number of leaflets: 27.

A. tylophorum. Thiashola 8-6-33 and Neduvattam 14-6-33.

Each plant had one leaf.
Males: 19 (5), 8 (6), 5 (7).
Females: 1 (5), 10 (6), 24 (7).
Number of leaves with odd number of leaflets: 49.
Number of leaves with even number of leaflets: 18.

(The proportion of plants having odd numbers of leaflets was considerably greater than is indicated by the above figures, as at the time of counting, the inflorescences of many male plants had disappeared. There were very many leaves with five leaflets, but it was not possible to be certain in many cases whether these were immature plants or males whose inflorescences had died off. Only plants with recognisable inflorescences were counted.)

On examining these figures it will be seen that only in two species, *A. translucens* and *A. convolutum*, are there approxi-



5. *Arisaema Wightii.*

6. *Arisaema Barnesii* Fischer.
Female left. Male right.

7. *Arisaema tylophorum* Fischer.

8. *Arisaema convolutum* Fischer.

mately equal numbers of leaves with an odd and an even number of leaflets. In these two species only may the leaves be regarded as strictly radiatisect, and even in these the leaflets are not all of exactly the same size. In the other species the leaves with an odd number of leaflets are in a large majority. The leaves of *A. Barnesii* and *A. tylophorum* are therefore to be regarded as palmate. *A. Wightii* has obviously palmate leaves. In the case of *A. Leschenaultii*, the count suggests that the palmate arrangement of the leaflets is not very pronounced; the leaflets are of slightly different size, but mere inspection gives the impression of a radiate leaf. *A. tortuosum* stands apart in having pedately arranged leaflets.

These results may be interesting in connection with the evolution of this genus. It appears probable that the species having most typically radiatisect leaves (*A. convolutum* and *A. translucens*) have evolved from plants having sagittate simple leaves, which are common in related genera, by way of genera having palmate leaves. This suggestion is supported by the fact that in *A. convolutum* and in *A. Leschenaultii* (and probably in other species) in the bud the leaflets are arranged in three groups, one at the end of the petiole and in a line with it, and one folded downwards on each side of the petiole.

Proportions between the Sexes

The following figures were obtained at the same times as those of the previous section.

A. Leschenaultii. This species is dioecious.

Female: 28.
Male: 253.

It is seen that nine times as many male as female inflorescences were found. It is thought that probably there is not a constant ratio between the sexes, but that the ratio varies with conditions. In making the count it was noticed that in moist and more favourable situations females were relatively more numerous than in dry places. In Governor Shola, which is much moister in May and June than Longwood Shola, no complete count was made, but females appeared to be almost as numerous as males.

A. tortuosum. Some inflorescences contain both male and female flowers, and others male only.

Monoecious: 24.
Male: 26.

A. Barnesii. This species is dioecious.

Typical: Female: 5. Male: 51.
Non-typical: Female: 3. Male: 14.

A. convolutum. This species is dioecious.

Female: 15.
Male: 37.

In this case males were certainly relatively more numerous

than these figures indicate. Many leaves were seen without inflorescences; some of these were immature plants, but many were males whose inflorescences had died and disappeared, the leaf expanding fully later than the opening of the inflorescence in this species.

A. translucens. This species is dioecious.

Female: 8.
Male: 47.

A. tylophorum. This species is dioecious.

Female: 35.
Male: 32.

This count was taken too late in the season when many male inflorescences had disappeared. Almost certainly males outnumber females.

It is seen that in the dioecious species, with the possible exception of *A. tylophorum*, the male inflorescences greatly outnumber the females. In the case of *A. tortuosum* there are almost equal numbers of male and monoecious inflorescences.

Fertilisation

A. Leschenaultii. In this species at the bottom of the tube of the spathe in front where the edges overlap, it will be noticed that in the male inflorescence the two edges arch away from one another so as to form a small roundish orifice about 1 × 2 mm. in medium-sized plants (Fig. 1). The male flowers do not extend to the bottom of the spadix, but there is a bare space at the base of the column. At the same level the spathe is slightly dilated. There is thus an annular space at the bottom of the inflorescence for which the orifice referred to acts as an exit. In the case of the female inflorescence there is no definite orifice at the base of the spathe, but the outer edge of the spathe is slightly thickened and presses firmly on the under edge and overlaps it to a greater extent than in the case of male spathes. The female flowers also extend to the bottom of the column in most cases so that there is no free annular space, or only a very narrow one. The way in which these modifications of the spathe aid cross-fertilisation appears to be as follows. An insect entering a male inflorescence is able, if not too large, to crawl down the spadix to the bottom, and by way of the annular space get to the orifice and escape. It is probable that insects crawl down the spadix and not down the inner side of the spathe as the surface of the latter is very smooth (and, incidentally, not wetted by water). The obvious purpose of the appendage of the spadix appears to be to attract insects and lead them to the fertile parts of the inflorescence. In a well-developed male inflorescence of about average size there were found to be 130 male flowers each consisting of 3 or 4 stamens. The male flowers at the middle of the fertile part of the spadix ripen first, then those lower down, and lastly the uppermost. The indehisced anthers contain so much pollen that they are distended to about three times the diameter of the empty

cell. When the ripe anther is touched, the pollen is exuded in great quantity through a slit in the top. So much pollen is produced that by the time all anthers have dehisced the annular space at the bottom of the inflorescence is usually choked with it. An insect that enters the inflorescence and makes its escape by the orifice will therefore almost certainly carry away a good deal of pollen with it. If in crawling down the spadix it does not get covered with pollen from the dehiscing anthers with which it comes into contact, it will do so in wading through the pollen in the annular space at the bottom. Should such an insect now enter a female inflorescence it will crawl down the appendage of the spadix to the female flowers. The ovaries are packed tightly together and the insect will have to pass between two rows of stigmas. Before reaching the bottom, however, it will get jammed, as space becomes more and more restricted owing to the conical shape of the column on which the female flowers are packed. In its struggles to escape, the insect is very likely to scatter a good deal of the pollen it is carrying onto the stigmas in its neighbourhood. Numerous insects thus caught are found in almost every female inflorescence after it has been open for a few days. A collection of such insects was forwarded to the British Museum and Dr. F. W. Edwards has very kindly furnished the following determinations.

Tube A.

Contains 6 species of *Mycetophilidae*:

Platyura sp. 1,	2 specimens.
Acnemia sp.,	1 specimen.
Phronia sp.,	5 specimens.
Mycetophila sp.,	1 specimen.
Delopsis sp. 1,	1 specimen.
Delopsis sp. 2,	1 specimen.

Tube B.

Contains the following *Diptera*:

Mycetophilidae.

Platyura sp. 1,	1 specimen.
Platyura sp. 2,	1 specimen.
Sciophila sp.,	1 specimen.
Sciara (at least 3 spp.),	12 specimens.

Dolichopodidae.

Psilopus sp.,	2 specimens.
Neurigona sp.,	1 specimen.

Phoridae.

Gen. indet., sp. 4, 1 specimen of each.

Acalyptrata.

Gen. indet., sp. 2, 1 specimen of each.

Also 3 small *Homoptera* (2 species).

The flies in Tube A were all small enough to be able to escape from the male inflorescence by way of the aperture at the base of the spathe. It appears probable therefore that some or all of these insects are concerned in cross-fertilisation of this species of *Arisaema*.

The insects in Tube B were all of such a size that they would not be able to escape from a normal sized male inflorescence by way of the aperture. They would therefore appear to be casual visitors and not usually concerned in cross-fertilisation. In addition to these insects a number of other visitors are frequently found in the inflorescences. A small spider finds them a good hunting ground, a cricket appears to use them to shelter in and a small caterpillar finds in them a suitable place for pupation.

On the female spadix above the fertile flowers there are almost always a number of filiform neuters. The uppermost of these are often turned upwards at some distance from the end. These neuters probably act as an obstacle to large insects which, as they are not likely to be carrying pollen, are to be excluded, for they are likely to damage the female flowers or at least to act as obstructions. Neuters are very rarely found on male spadices.

The large excess of male inflorescences (see previous section) makes it likely that many of the smaller insects that enter a female inflorescence will have previously been in a male inflorescence. The length of time the inflorescences remain open probably varies with elevation and weather. A male inflorescence observed lasted 10 days and a female one showed no signs of being over after an equal length of time. This long period of activity will also help to insure efficient cross-fertilisation. That cross-fertilisation is successfully brought about is shown by the high percentage of ovaries that develop. In a plant that was examined it was found that out of 155 ovaries all were developing except three, and these developing berries contained 1-7 seeds, mostly 3, 4 or 5. Two female inflorescences examined had respectively 7 and 12 neuters and 125 and 198 female flowers which contained up to 9 ovules.

The inflorescences of all the species of *Arisaema* referred to in these notes have an unpleasant smell, which is doubtless for the purpose of attracting the flies concerned in their cross-fertilisation. In many specimens the smell is not very strong and it is difficult to locate the place of origin of the smell. In some large specimens of *A. Leschenaultii* found in Thiashola which had dark purple spathes and very stout appendages to the spadix, the smell was very strong. By cutting off the spathe at the base and smelling the various parts of the inflorescence, it was found that the smell came from the appendage of the spadix. By contact with the appendage the upper part of the tube of the spathe had also acquired the smell, but other parts appeared to be free from it. The pendant acuminate or caudate end of the limb of the spathe probably serves as a first alighting place for the attracted flies. What induces the flies to penetrate to the bottom of the inflorescence is not obvious.

A. tortuosum. In this species there is an aperture at the base of the spathes of both the male and the monoecious inflorescences. The probability of cross-fertilisation taking place is obviously increased if the insect is able to escape from one monoecious inflorescence and enter another.

As in *A. Leschenaultii* the smell is definitely associated with the appendage of the spadix. Here the long exserted appendage

serves both as an attraction to the flies because of its smell, and as an alighting place for them. The lowest male flowers ripen first. Ovaries contain up to 7 ovules. Three ripening spadices had 112, 141 and 167 berries, which mostly contained 3, 4 or 5 seeds.

A. translucens and *A. Barnesii*. In these species there is an orifice at the base of the male spathe but not in the case of the female. The general scheme for cross-fertilisation is probably like that in *A. Leschenaultii*. The smell was not sufficiently strong in the specimens examined and the parts were too small for the locating of the source of the smell. In the non-typical form of *A. Barnesii* female inflorescences had about 100 ovaries containing 4-8 ovules. The berries contained one or two seeds.

A. convolutum. In this species there is a definite orifice at the base of the male spathe, but not at the base of the female. Cross-fertilisation is probably brought about as in *A. Leschenaultii*. In contrast with *A. Leschenaultii* and *A. tortuosum*, in this case it is the very long tail of the limb of the spathe that is the source of the very unpleasant smell that the inflorescence has; this tail also serves as a settling place for the flies that are attracted.

One plant had 185 female flowers and the ovaries contained up to 4 ovules.

A. tylophorum. In this species the base of the spathe in both male and female inflorescences is dilated. There is a definite aperture in the case of the male spathe and apparently one in the female, but observations are incomplete. There are fewer flowers to an inflorescence in this species than in the others—about 60-80 in both male and female—and it appears probable that the scheme of cross-fertilisation is not quite the same as with *A. Leschenaultii*. The inflorescences have only a faint smell and its location could not be determined. There are usually 6 ovules in each ovary, sometimes 5 or 4. There are usually 1 or 2 seeds in each berry, occasionally three.

In each of these species the pollen consists of spherical bodies 0.015-0.02 mm. in diameter: in *A. Leschenaultii*, *A. Barnesii* and *A. translucens* the surface of the grains is slightly echinate; in *A. tortuosum*, *A. tylophorum* and *A. convolutum* it is granular.

Folding of the Spathe

In this genus one side of the spathe overlaps the other side. It was thought that it would be of interest to find whether, as in certain twining plants, some species are right-handed and others left-handed.

The following figures were obtained:—

	Right	*Left*
A. Leschenaultii	66	52
A. tortuosum	22	6
A. Barnesii	27	29
A. convolutum	14	15
A. translucens	23	30
A. tylophorum	36	25

(Right means the side of the spathe on the observer's right overlaps the other side, and left the opposite. No distinction is made between males and females in this count.)

It is quite definite that none of these species is completely right- or left-handed. In the cases of *A. Barnesii* and *A. convolutum* the right side is the outer as often as the left. The right side appears to overlap the left more often than the reverse in *A. Leschenaultii*, *A. tortuosum* and *A. tylophorum*, and the opposite is the case with *A. translucens*. Whether the statements made in the last sentence would be confirmed if sufficiently large numbers were counted appears to be somewhat doubtful.

Root and Vegetative Reproduction

In *A. Leschenaultii* there is a corm, oblately spherical in shape and up to about 2 in. in diameter in normal-sized specimens. The under surface is very much puckered and pale green in colour. Dissection shows that this puckered surface is that of the corm of the previous season. In May it is only about $\frac{1}{8}$ in. thick and easily separates leaving the surface of the new corm white and smooth. The foot of the stem is broadened where it joins the corm and from this broadened base there emerge about 20 stout fleshy roots. These roots radiate more or less horizontally. They have numerous branches and these are provided with root hairs. The surface of the main roots is puckered transversely for its first inch or two and is pinkish, this colour being due to numerous minute pinkish-purple longitudinal dashes. The finer roots are white and the root tips yellow. The lowest part of the stem is covered with a brown membranous skin broken irregularly along its upper edge. Above and within this there are three or more membranous blunt-tipped leaves clasping the stem; these vary in colour from white below to dark purple above. From the outer edge of the corm at a slightly lower level than that at which the roots emerge, and originating apparently from the old corm, several underground stems grow out. These run horizontally for about 4 ins. and the tip enlarges till it is about $\frac{1}{2}$ in. in diameter. The greater part of the stem then shrivels and the enlarged part forms a new corm. The horizontal stems and the enlarged ends are covered with membranous blunt-tipped scales which are brown, except the two end ones which cover the bud on the corm, and these are light purple. The newly-formed corm is pear-shaped and lies horizontally with the bud at the blunt end and the residue of the stem at its narrow end. Apparently these corms produce only a leaf next season and establish a larger corm, and produce an inflorescence only in a subsequent season.

In *A. tortuosum* the under side of the corm is covered with the cream-coloured shrivelling residue of the corm of the previous season. Embedded in this old corm near its edges there are to be found several small spherical white corms. These have their bluntly conical buds facing upwards. Round the bottom of the stem just above the level at which the roots emerge small buds are found. It appears, therefore, that in this species the new corms take two years to form, being present as buds on the side

of the mature corm one year and developing in the residue of that corm the next season.

In *A. convolutum* small upward-pointing corms were found round the upper part of the mature corm. An immature plant growing near a mature one had a corm about ¾ in. in diameter. On one side of this small corm there was a brown shrivelled stem which tapered down to about ⅛ in. in diameter. This narrow end was near the upper part of the corm of the mature plant and had evidently grown out of it although connection had now ceased. Whether the underground stem and the small corm on the side of the mature one are somewhat different modes of reproduction or only stages of the same mode is not certain.

In the case of *A. translucens* underground stems developing into corms are also found. In June stems were found about 5 ins. long; the forward 1½ ins. was enlarged to about ½ in. in diameter and the other part was shrivelling. The widened end was dark green with purple markings, and narrowed suddenly to a long point. Round the terminal bud there were a few membranous scales and behind these a few white root-tips were emerging.

In the case of *A. tylophorum* there were small corms emerging from the upper part of the mature corm at a slightly higher level than the roots. These were found on immature plants that had not yet produced an inflorescence as well as on mature male and female plants. No underground stems were found and the fact that the small corms had their tips pointing upwards suggests that they develop beside the parent plant. Small corms with tips upwards were also found round the upper part of the mature corm in *A. Barnesii*.