NOTES ON THE IDENTIFICATION OF SOME BRITISH SPECIES OF *CALLITRICHE*

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Pearsall (1934) and Clapham (1952) point out the difficulty in identifying species of *Callitriche*, with considerable justification. The main reason for difficulty is that the only certain aid to identification is the characters of the mature fruit and often a plant to be identified is in a sterile condition. Identification keys, therefore, are obliged to contain vegetative characters, which here mean chiefly leaf characters. The variability of leaf form in some of the species, however, causes confusion. Again, it is sometimes stated that lower leaves of some species are linear, while upper leaves are oblong. This does not take into account the mode of growth of the plant under different circumstances. It is perfectly possible, as will be shown, for lower leaves to be oblong and upper leaves to be linear, a fact which would cause considerable confusion in identification.

A description follows of the general habit of growth in a species which displays marked variation in leaf form. In view of the importance of fruit form in the identification of species, a description of the fruit is also given. Four species are described : *C. intermedia* Hoffm., *C. obtusangula* Hegelm., *C. stagnalis* Scop., and *C. hermaphroditica* L. (*C. autumnalis* L.)

Leaf form in C. intermedia

When the crown is submerged, linear leaves only are formed. When the crown arrives at the surface, obovate leaves are formed. Between the true obovate leaves and the original linear leaves, however, transitional leaves will appear. Once the crown arrives at the surface it will remain at the surface as long as the water level does not rise. Elongation of the internodes must then result in older leaves being carried down beneath the surface. It is evident then that beneath the surface will be found linear leaves at the base of the shoot, then linear-obovate transitional leaves and finally obovate leaves. In this way typically obovate leaves may be found well beneath the surface. It is therefore misleading to refer obovate leaves to the floating state only. Again, if the level of the water rises and the crown is submerged, then linear leaves will be formed. In this case lower leaves may be obovate and upper leaves linear. It is therefore misleading to refer to lower leaves as though they were necessarily linear, even though, from a consideration of the development of the seedling, growing upwards from the bottom mud of a pool, the sequence of events is certainly linear leaves at the base and then, when the surface is reached, obovate leaves.

Fruit Form

The female flower of *Callitriche* consists of a syncarpous ovary, 4-celled by secondary septation (Clapham, 1952), with typically 2 bracteoles. These latter may not be present in some species. The 2 styles are terminal in the young fruit, but, due to developmental changes with maturity, the styles may appear to arise from the sides of the ovary. When

the fruit is viewed from above, 4 lobes are seen, corresponding to the 4 cells. The prominence or otherwise of these lobes and whether they diverge from the point of insertion of the styles or are parallel are of considerable diagnostic importance. Unfortunately, a distinction is made between a less prominent lobe (termed a keel) and a more prominent lobe (or wing), the dividing line between the two states being somewhat obscure. In the present description, the margins of the lobes are described as keels. These are barely discernible in *C. obtusangula* (Fig. 2B 1-4). In *C. hermaphroditica* (Fig. 2D 1-4) a wing is present in addition. In the young fruit the keels may not be easily seen but in the mature fruit, due to the maturation of the seed within the more or less transparent fruit wall, the keels become more prominent. In any case, the young fruits of all 4 species to be described are remarkably similar and should not be used for identification. Where grooves are referred to these relate to the indentations between lobes – in fact between the original 2 carpels, whose positions are indicated by the style origins (Fig. 2C 3).

In this description a distinction will be made between terminal styles (Fig. 2C 1) and lateral styles (Fig. 2A 1). Again, some species have persistent styles and others have styles which fall early. It appears to the writer that the terminal style is associated with persistence and the lateral style with early falling. All styles are initially terminal. In *C. intermedia* for example, the lobes grow over the styles so that these appear lateral. Constriction may result in early fall. In *C. stagnalis*, the lobes grow under the styles keeping them in an erect, terminal position. Here there is no constriction and the styles persist.

Methods and materials

Material of *C. intermedia* (obovate-leaved), *C. obtusangula*, and *C. stagnalis* was obtained from a drainage ditch at Tanybwlch near Aberystwyth, Cardiganshire. Linear-leaved material of *C. intermedia* was obtained from the river Rheidol near Aberystwyth. The floral characters of the linear-leaved form agreed with that of the obovate-leaved form. These forms were also shown to be identical by means of transplant experiments (these are described elsewhere – Jones, 1955). *C. hermaphroditica* was gathered from the outflow of Llyn Maelog in Anglesey, probably its southernmost locality in Britain.

In order to arrive at a ' typical ' fruit form, ten fruits from each species were drawn silhouetted in face view with the aid of a camera lucida. The fruits were mature and in the case of each species were from several shoots. The average length and breadth of the ten fruits were calculated and a ' typical ' fruit constructed diagrammatically to these dimensions, taking into consideration the general form shown by the ten fruits. Side views and views from above were constructed with a binocular microscope, a camera lucida being used initially to find the correct proportions. The views from above may not, in all cases, show the full thickness of the fruit as this had to be cut transversely and the top part placed on a slide. Otherwise it was found difficult to maintain the fruit absolutely upright.

Lengths of styles (mean of 10 styles from 5 fruits) were recorded where the fruit was mature and where the style was evidently entire. At later stages of fruit development, the distal portions of styles were commonly broken off. Filament lengths were taken from stamens with mature anthers. The length quoted is an average of 10 filament lengths, except in *C. hermaphroditica* where stamens were scarce. Here only 2 stamens were found with dehisced anthers and where it could be assumed that the filaments were of maximum length. Bracteoles were found to be very variable in size and the bracteoles, illustrated in Fig. 2, 5 and 6, represent the largest recorded. Chromosome numbers were estimated from root-tip squashes.

Leaves were fixed in formalin-acetic-alcohol, and were sufficiently transparent after

a few days for details of venation to be clearly seen. For subsequent examination, leaves were transferred through a range of alcohols to water and mounted between glass in the negative carrier of a photographic enlarger. Photographic negatives were then made by projecting the image of the leaf on to a lantern plate, a millimetre grid being also projected on to the same plate to give the scale. The projected image from these negatives was then traced at suitable magnifications.

Aid in identification of the species was derived from : Hegelmaier (1864), Samuelsson (1925), Pearsall (1934), Butcher and Strudwick (1946) and Clapham (1952). Nomenclature follows that of the last quoted.* I should like also to acknowledge gratefully the facilities afforded me to examine the *Callitriche* species in the Welsh National Herbarium at the National Museum of Wales, Cardiff.

Since this account was written, a paper has appeared on the section *Eucallitriche* Hegelm. in the Netherlands, containing an account of the distribution and morphology (including chromosome morphology) (Schotsman 1954). In general (where the same morphological features are referred to) there is close agreement between the description of the first three of four species which follows and Schotsman's description of these species, if allowance is made for Schotsman's retention of the name *C. hamulata* Koch (with cogent reasons given for this) while in the present paper *C. intermedia* G. F. Hoffm. is used.

In the following description, where comparative statements are made, these refer only to the four species of *Callitriche* described.

A. Callitriche intermedia

Leaf form (Fig. 1A 1-5)

The greatest range in leaf form is shown here. The extreme linear leaf is up to 4 cm. long by 1 mm. broad and has a pincer-like tip. While an emarginate tip may be seen on leaves in still water, the exaggerated pincer tip is displayed by leaves of plants found in running water. This may be connected with the maintenance of shoots in a horizontal or inclined plane by the water current since shoots submerged in still water in a horizontal plane produce leaves with pincer tips. The extreme obovate leaf is up to 2 cm. long by some 5 mm. broad. The tip of the leaf is emarginate, as indeed are all leaves of all four species described. The outline of the obovate leaf is of little use in separating *C. intermedia* from *C. obtusangula*. Figs. 1A 3 and 5 show how the tip of the leaf may be rounded or more or less pointed. The leaves 3, 4 and 5 are all from the same shoot, being separated from each other by 3 nodes. Leaf 3 was formed when the crown was at the surface. The level of the water then rose and leaf 4 is the result of submergence on the development of a leaf which had attained a certain stage under aerial conditions. The influence of submergence is greater on the basal part of the leaf since in *C. intermedia* this part develops last. Accordingly this leaf has a rounded tip and is attenuated basally. The crown subsequently arrived at the surface once more. Leaf 5 shows a somewhat pointed tip while basally it is broader than leaf 3. Leaf 5 reflects the influence of submergence in early development through its pointed tip while the later conditions of floating existence have resulted in the broader base. While, in the other 3 species considered, it appears that the range of leaf form is less marked, at the same time the writer considers that leaf shape cannot be relied upon in identification, unless the history of the shoot with regard to submergence or emergence is known.

In the obovate leaf 3 veins are present with possibly branching from the 2 lateral veins. In the linear leaf a single vein occurs. It appears that leaf shape and venation are controlled by separate factors. In the transition from obovate leaf to linear, it is

* Except for *C. autumnalis* which, according to Mr. J. E. Dandy, is an illegitimate substitute for the earlier *C. hermaphroditica L.*

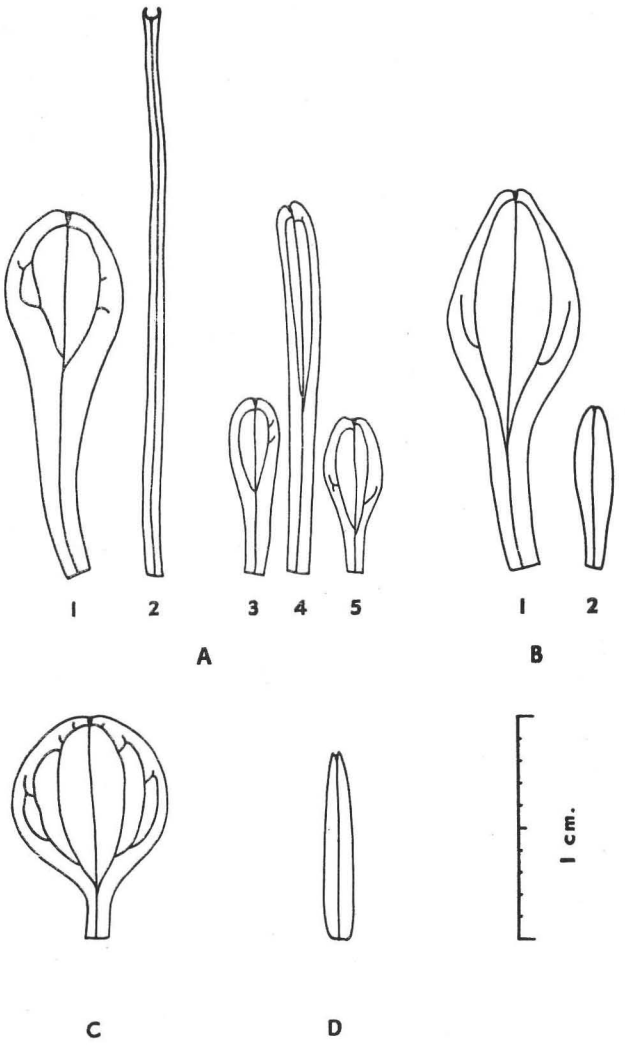

Fig. 1. Leaves of four species of *Callitriche*.
A. *C. intermedia*. 1 and 2 represent extremes of leaf form, 1 from a floating crown in still water and 2 from a submerged crown in running water. 3, 4 and 5 are leaves from the same shoot, there being three nodes between each leaf. Leaf 3 formed in a floating crown. The crown was then submerged and leaf 4 is the result of early development under floating conditions and later development under submerged conditions. The crown later arrived at the surface again and leaf 5 shows the influence of early development under submerged conditions and later development under floating conditions. B. *C. obtusangula*. 1. Leaf from floating crown. 2. Leaf from submerged axillary shoot. C. *C. stagnalis*. Leaf from floating crown. D. *C. hermaphroditica*. Leaf from submerged crown.

possible to have a leaf which is linear in outline with 3 veins. The converse is not true, however. As soon as an obovate leaf becomes discernible, the 3-veined condition occurs.

Fruit form and styles (Fig. 2A 1-4)

Fruits 1·3 mm. long by 1·4 mm. broad. In face view the fruits are not narrowed towards the base. Grooves and keels of medium development, the keels being parallel. Styles are lateral, between 1 and 2 mm. long and fall early. All fruits which have been observed in the Aberystwyth district over a period of some 9 years have been sessile. On

this latter character and by the possession (at least at times) of linear leaves with widened and deeply emarginate apices, the present description would appear to apply to subsp. *hamulata* (Koch) Clapham. Schotsman (1954) refers to stalked and non-stalked fruits, sometimes on the same plant, a character suggesting subsp. *pedunculata* (DC.) Clapham.

Bracteoles (Fig. 2A 6)

Those of the male flower small and falcate. Bracteoles of the female flower rare but of the form of the male bracteoles where present.

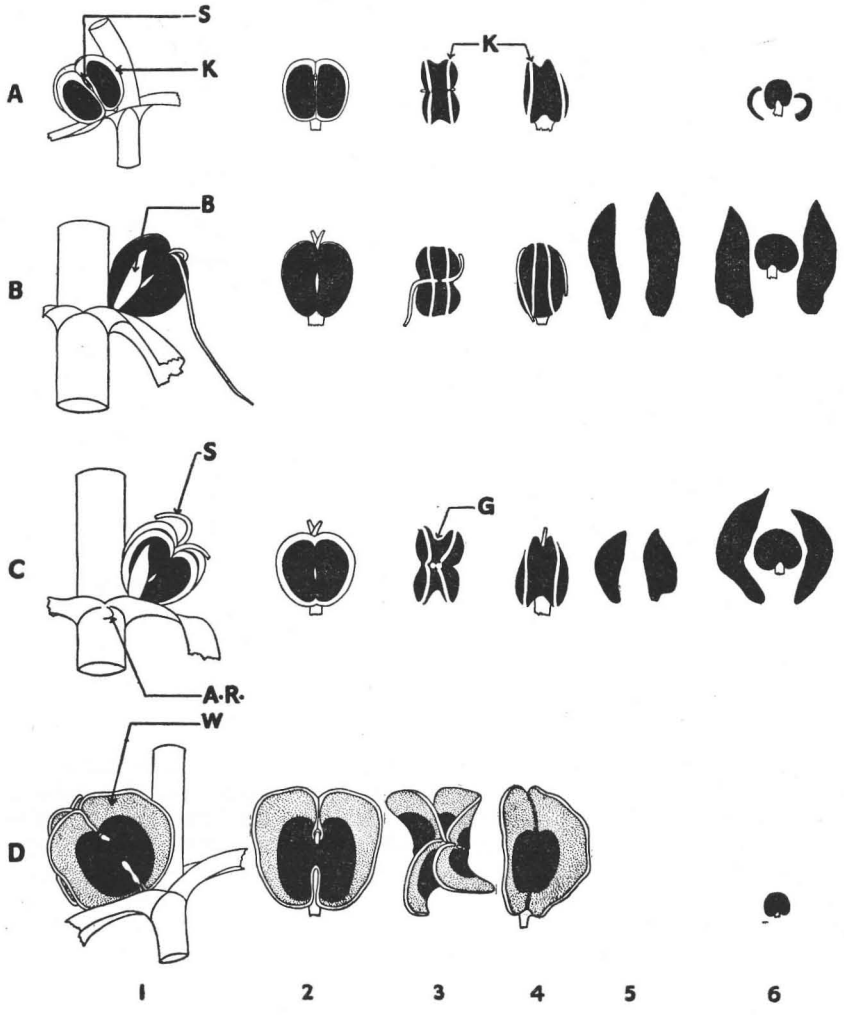

Fig. 2.

A. *C. intermedia*. B. *C. obtusangula*. C. *C. stagnalis*. D. *C. hermaphroditica*. 1. General habit of fruit at node. 2. Face view of typical fruit (diagrammatic). 3. Fruit viewed from above. 4. Fruit in side view. 5. Bracteoles of female flower. 6. Male flower (full length of stamen filament not shown). S – Style. K – Keel. B – Bracteole. G – Groove. A.R. – Adventitious root. W – Wing.

Stamens (Fig. 2A 6)

Filaments between 1 and 2 mm. and anthers small.

Chromosome number

2n = 38.

B. CALLITRICHE OBTUSANGULA

Leaf form (Fig. 1B 1 and 2)

Under conditions of still or slowly running water where the plant is usually encountered, obovate leaves about 1·5 cm. long by about 5 mm. broad are produced in the floating crowns. 3 veins are present with possibly secondary branches. The surface of the leaf bears raised ribs corresponding to the veins. More or less linear leaves are produced on submerged axillary shoots. These leaves are 1-veined, up to about 1 cm. long and 1 to 2 mm. broad. Under conditions of submergence in running water (under experimental conditions – Jones, 1955) linear leaves approximating more to those of *Callitriche intermedia* have been produced but without the pincer tip.

Fruit form and styles (Fig. 2B 1-4)

Fruits 1·6 mm. long by 1·5 mm. broad. In face view the fruits are narrowed slightly towards the base. Grooves and keels are poorly developed, characters which readily separate this species from the others described. Keels parallel. Styles terminal, about 4 mm. long and persistent.

Bracteoles (Fig. 2B 5 and 6)

Bracteoles of male and female flowers large and straight.

Stamens (Fig. 2B 6)

Filaments about 8 mm. and anthers large.

Chromosome number

2n = 10.

C. CALLITRICHE STAGNALIS

Leaf form (Fig. 1C)

In its typical form the leaf enables the species to be readily identified, the typical leaf being short (about 1 cm. long) and very broad (about 7 mm.). At least 5 veins are usually present. Leaves of submerged axillary shoots are also obovate in form. The first few leaves of the seedling are linear and 1-veined (Jones, 1955). While no seedlings have been grown by the writer beyond the 3 or 4 leaf stage, all seedlings of *C. stagnalis* which have been seen under natural conditions have linear initial leaves which then grade into very large multi-veined leaves, some 2·5 cm. long and 1 cm. broad (somewhat of the form figured for *C. obtusangula* in Fig. 1B 1). Subsequent leaves while still large – some 2 cm. long by about 1·3 cm. broad – are of the 'typical' rounded form. The large leaved form has always been found in the sterile condition and is probably a juvenile form. The chromosome number of the large form is 2n = 10.

Fruit form and styles (Fig. 2C 1-4)

Fruits 1·6 mm. long by 1·7 mm. broad. In face view the fruits are narrowed slightly towards the base. Grooves and keels are well developed, the keels diverging noticeably

from the point of insertion of the styles. Styles are terminal, about 3 mm. long and persistent.

Bracteoles (Fig. 2C 5 and 6)

Bracteoles large, those of the female being straight and those of the male slightly falcate.

Stamens (Fig. 2C 6)

Filaments 4-5 mm. long, anthers large.

Chromosome number

2n = 10.

D. CALLITRICHE HERMAPHRODITICA

Leaf form (Fig. 1D)

Linear leaves only are described (this plant having been found by the writer always submerged). The leaf is about 1 cm. long and about 1·5 mm. broad. The leaf is broader at the base than at the tip and is characteristically curved downwards towards the base of the shoot. Leaf 1-veined.

Fruit form and styles (Fig. 2D 1-4)

Fruits 2·7 mm. long by 2·8 mm. broad. The size of the fruit alone is sufficient to identify this species. In face view the fruit is narrowed slightly towards the base. Grooves are very conspicuous, the lobes being produced into well-marked wings with sinuate margins. Wings are divergent. Styles are lateral, about 2 mm. long and fall early.

Bracteoles

Bracteoles are absent.

Stamens (Fig. 2D 6)

Filaments are short (1-2 mm.) and anthers are small.

Chromosome number

2n = 6.

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