ON TERMINOLOGIES FOR SEXUAL STRUCTURES OF CHAROPHYTES

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(Received for publication on April 19, 1969)

The controversy with regard to the systematic position of the group stems, in large measure from the divergent opinions of investigators with regard to the exact nature of the complex sexual organs, evident also from the different terms used for these structures. Even today, there is no unanimity among investigators in this respect.

Early investigators who regarded the charophytes as angiosperms applied the terms 'anther' and 'pistil' for the male and female organs respectively. Likewise, other terms were adopted according as they were regarded as bryophytes or algae (*cf.* Papenfuss, 1955).

Male Gametangium

The mature structure in which the antherozoids are developed has been called the antheridium. Its structure is well known and hence it is not necessary to describe it here. The factor of consequence in its structure is the protective covering round the sexual cells. According to Papenfuss (1955) it is the most important single factor which removes the charophytes from the green algae or in fact from all thallophytes. This is an indisputable factor of consequence which differentiates thallophytes from higher plants.

The interpretation of Goebel (1930) (*cf.* also Smith, 1955) is that the male gametangium is a compound structure in which each of the cells of the spermatogenous filaments is an antheridium. The charophytes may thus resemble the algae in the possession of unicellular sexual organs. Smith (1955) in accepting Goebel's interpretation also reverts to the old name 'globule' used by Sachs (1882) and other botanists for the entire male gametangium. But as Papenfuss (1955) points out, no explanation is furnished for the formation of the primarily produced sterile covering around the fertile cells by this interpretation. Thus, any attempt to squeeze the charophytes into the green algae or to regard them as a division of the algae will have to provide a more acceptable explanation of the presence of the sterile covering around the sexual cells. The difference between the outer covering of the antheridium of charophytes and that of the antheridial jacket of higher plants is that the former is more complex, furnishing proof of the uniqueness of organs as well as of the group. If on the other hand the charophytes are to be regarded as non-algal (?), as Desikachary and Sundaralingam (1962) suggested, there should be no objection to the term antheridium for the male sexual structure as it is a general term which has been used to describe the male sexual organs of the lower as well as higher plants. Sundaralingam (1960, 1962 *a*, *b*; 1963, 1965, 1966) has attempted to establish homology of antheredium (the entire male gametangium) with a branch of the second order in the genus *Chara*. Even if it is so the term antheredium for entire male gametangium would be a misnomer if the charophytes are to be regarded as an algal group as proposed by Chadefaud and Emberger (1960), Chapman (1962) and Round (1963). If objection is raised to the use of the term antheridium and a distinct name for the male sexual structure is called for, then the term "spermatogemma" or "sperm bud" may be considered.

Female Gametangium

When considering the female sexual structure, the choice of a suitable term for it before and after fertilization becomes more difficult.

Horn (1956) has reviewed the terms which have been used in the past. A few of these terms are considered here.

In many monographs, both recent and old, the term 'oogonium' has been given to the female sexual structure. This term is inappropriate, for by acceptable standards (*cf.* Jackson, 1930) the oogonium is usually a sac within which one or more oospheres are contained. The oogonium is found in thallophytes and does not have a sterile covering around it before fertilization. While the term "cogonium" may be used to designate the cell containing egg and its sister sterile cells as was formerly intended by De Bary who first used the term, it cannot be applied to the complex female sexual structure of the charophytes.

A reversion to the old term 'nucule' has been suggested by some botanists. This term originally used according to Smith (1955) by Sachs in 1882 means "a little nut" and though non-committal, seems to be more suitable for the structure formed after fertilization. The term 'archegonium' used by earlier workers has against it the fact that the development of the female structure in charophytes is completely different to that in the archegoniates. Moreover, the neck and venter of the archegonium are completely different in appearance, though the cutting off of the "wendugzellen" may be compared to the formation of the axial row with the egg cell above instead of below the sterile cells.

The terms "Eiknopse" (egg bud) and "sporophydium" (spore bud) may be considered next. The latter has been recommended by Horn (1956) as it well expresses present-day ideas of the morphological nature of the female structures of the charophytes. But it may be argued that the term 'bud' is associated with the nascent state. The 'spore bud' or 'sporophydium' (oogonium) cannot be regarded as the nascent state of the oospore for, prior to the formation of the oospore, an important event, namely, fertilization occurs, which transforms the oosphere into the oospore. Thus, it is not a mere process of unfolding or expansion, as is expected in a transformation from the bud to the adult condition, but the formation of a new diploid structure. For this reason, the terms "spore bud", "sporophydium" or "sporophyas" seem to be not very precise.

The term "egg bud" on the other hand seems more suitable for it implies all the stages prior to the time when the egg is ready for fertilization. As an alternative the term 'oogemma'—egg bud, Caruel's term for the archegonium (Jackson, 1930) may be adopted. It is a term which is no longer in use for the archegonium and hence may well be adopted for the female structure of the charophytes.

A suitable term for the ripe fructification has to be found also. The term sporocarp or spore fruit, though somewhat appropriate, has against it the fact that it is associated with totally different structures formed in heterosporous ferns. The association of the term spermocarp with a structure formed after fertilization in *Coleochaete* precludes

its adoption here. Moreover, the term spermocarp means seed fruit and as such not suitable. The term 'cystocarp' is also unacceptable for the same reasons (*cf.* Horn, 1956). The term 'nucule' is used by some botanists to designate the fructification. It has been regarded as too general a term by Horn (1956) who suggests that three terms are suitable, namely sporocarp, spermocarp or sporangium. Of the three, he prefers the last-mentioned one, but if it is considered too general, he suggests the term oosporangium for the entire structure which includes the oospore or zygote.

An argument against the adoption of the above term is the following. The oospore is actually surrounded by the wall of the oogonium which is therefore the legitimate wall of the oosporangium. In oogamous algae such as *Oedogonium*, *Volvox*, etc., the 'egg' or 'oosphere' is the contracted protoplast of the female cell and the 'oogonium' is the cell containing the former. After post-fertilization changes, such as the development of a wall around the fertilized egg, it is transformed into the oospore and the oogonium may consequently be termed the oosporangium. Thus, in the charophytes, if the term oosporangium is to be used, it must be restricted to the cell which contains the oospore or to what corresponded to the oogonium formerly (now enclosing the fertilized egg or oospore), and not to the whole fructification which consists of the remnants of the spiral cells (sterile envelope) which have undergone post-fertilization changes, the oogonium and zygote. If the term oosporangium is used for the entire fructification as Horn (1956) suggests, it would mean that the oosporangium would include some additional cells such as the spiral cells together with the real oosporangium (oogonium with post-fertilization changes).

Horn (1956, p. 230) states in support of the term oosporangium that "in becoming the oospore, the fertilized oosphere forms two membranes of its own to constitute the oospore wall or sporine. The outer sporine membrane, the ectosporine, is the result of thickening of the original oogonium membrane, whilst the inner, the endosporine, is formed by oospore plasma after fertilization". This statement seems to be contradictory as in the first sentence it is stated that the oospore forms both the membranes, while in the second it is stated that the outer membrane, the ectosporine is due to the thickening of the original oogonial membrane and is not formed by the oospore.

Horn (1956, p. 282) also states that in case of *Chara* "in most species the ectosporine is of fairly bright colour and clearly delimited from the adjacent membranes....The endosporine finally in all species is distinctly delimited from the ectosporine". Thus, it is evident from Horn's statement that the wall of the oogonium which becomes the ectosporine after fertilization retains its entity and hence the term oosporangium must be limited to this membrane and the parts enclosed by it.

Till the question of terminologies is settled the non-committal terms, globule and nucule suggested by Migula for the fructification of charophytes, appear to be more preferable for the time being.

SUMMARY

The controversy regarding systematic position of the group stems from the divergent opinions with regard to the nature of reproductive organs of charophytes. Globule is the term suggested by Sachs for the male reproductive structure. 'Antheridium' is commonly used in current literature. The term spermatogemma is suggested here.

Nucule, oogonium, sporophydium spermacarp are the terms appearing in the literature for the female reproductive structure. The term oogama is suggested for the same. The term 'Nucule' can be used for the fertilized structure.

Author is grateful to Prof. Mrs. E. A. Gonzalves for her valuable guidance and suggestions.

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