

Pollination of the Genus *Hydrilla* (Hydrocharitaceae) by Waterborne Pollen Grains: II. Air Bubbles Cause the Male Flower to Surface

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田中法生* : クロモ属 (トチカガミ科) における水面上花粉による送粉 : II. 気泡による雄花の浮上

Hydrilla verticillata (L. f.) Royle (Hydrocharitaceae), which constitutes a monotypic genus *Hydrilla*, is pollinated by waterborne pollen grains (pollen-epihydrophily). The female flowers open on the water surface by elongating the hypanthium from the female spathe at the leaf axil. By contrast, the male flowers are liberated from the spathe as buds, which then open on the water surface, and the pollen grains fall off and float on the surface (Cook 1982, 1988). The floating pollen grains are moved by the wind or currents and are then sucked into the funnels of female flowers and transferred to the stigmas (Tanaka 2000). Surfacing of the male flower is essential for this pollination mechanism. However, the mechanism that causes the male flower to surface is not clear. Furthermore, the mechanism is unknown in other epihydrophilous genera, in which the male flowers are detached from mother plants and float on the water surface: *Enhalus* (1 species), *Lagarosiphon* (9), *Nechamandra* (1), *Vallisneria* (4), *Appertiella* (1), and *Elodea* (1). In this study, I observed the details of the surfacing of male flowers in *Hydrilla*.

Materials and Methods

Several male and female *Hydrilla verticillata* (L. f.) Royle plants were studied. They were collected from Shishizuka Pond in Tsuchiura, Ibaraki Prefecture, Japan, and cultivated in Tsukuba Botanical Garden. Pollination was observed in an indoor aquarium. The light intensity at the water surface was about 5,000 lx, the photoperiod was 9 h, and the water temperature varied between 20 and 28°C.

Results and Discussion

Spathes containing mature male flowers produce gas continuously, and this forms bubbles (Fig. 1). Since the gas is produced only when the plants are irradiated, it is probably oxygen that is produced by photosynthesis. While bubbles surface one after another, the upper side of the spathe opens and the male flower fully matures. Then, the male flower is wrapped in a bubble, and surfaces due to its buoyancy (Figs. 2, 3 and 4).

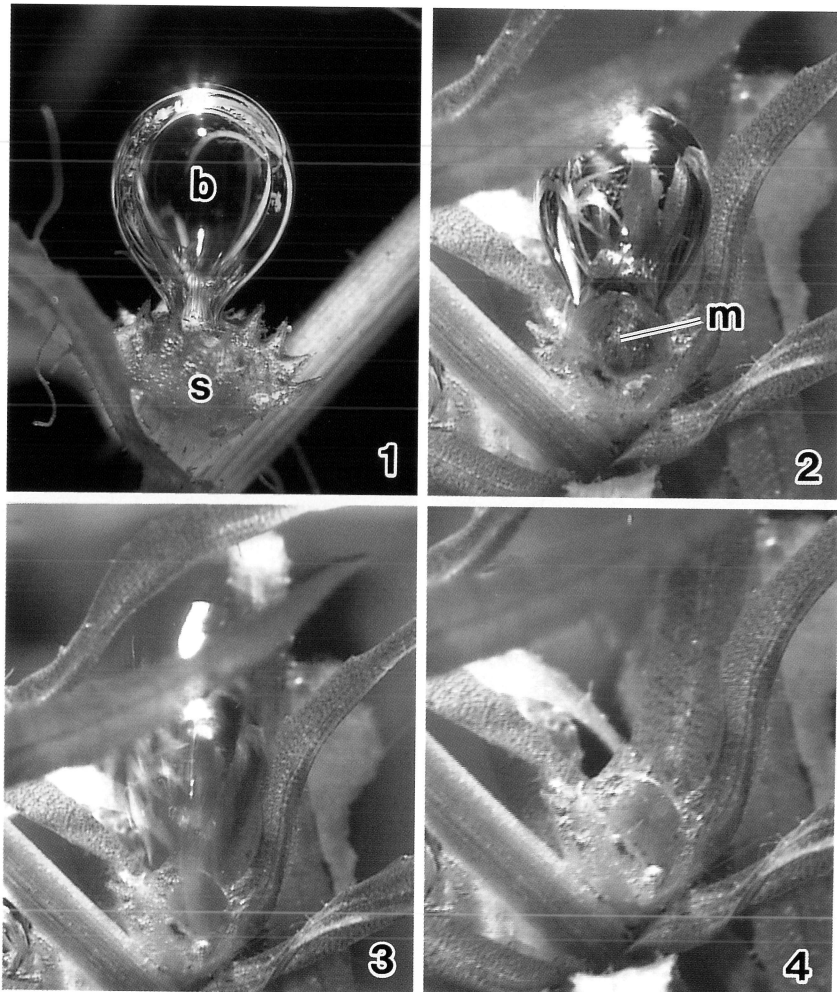
It is clear that photosynthesis is closely related to the surfacing of the male flower in *H. verticillata*. Cook (1982) stated that the entire pollination process takes place only in sunlight. Although he did not give a reason, the mechanism of surfacing of the male flower is a reasonable explanation for the nature of the flowering.

Although the mechanism of surfacing of the male flower is an important factor in understanding

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epihydrophily, no mechanism has been reported in other epihydrophilous species. The male flowers of *Enhalus acoroides* (L. f.) Royle are liberated from spathes only when a low spring tide occurs during the day (den Hartog 1970). The control of flowering in *E. acoroides* has not been determined. If the male flower of *E. acoroides* surfaces via the buoyancy of air bubbles produced by photosynthesis, like *H. verticillata*, this may explain why flowering occurs only during the day.

Epihydrophilous species in which the male flowers detach from the mother plants and float on the water surface are peculiar to the Hydrocharitaceae. Since a molecular phylogenetic analysis showed that epihydrophily resulted from parallel evolution in four lineages in the Hydrocharitaceae: *Elodea*; *Lagarosiphon*; *Enhalus*; *Vallisneria* and *Hydrilla* (Tanaka *et al.* 1997), it is necessary for comprehending the process of their parallel evolution to investigate whether the mechanism of surfacing differs.



Figs. 1-4. A series of surfacing of male flower in *Hydrilla verticillata*. 1: Spathe with male flower produces bubbles continuously. Spathe is about 2 mm in width. b = bubble, s = spathe. 2: Upper side of the spathe opens and the male flower matures. m = male flower. 3: Male flower is wrapped in a bubble and surface due to its buoyancy. 4: Empty spathe.

Summary

Although surfacing of the male flower is essential for epihydrophilous species, in which the male flowers are detached from mother plants and float on the water surface, the mechanism that causes the male flower to surface is not clear. In this study, it is showed that male flower of *Hydrilla verticillata* (L. f.) Royle (Hydrocharitaceae) is wrapped in a bubble which is oxygen produced by photosynthesis, and surfaces due to its buoyancy.

摘 要

雄花が親株から離脱して水面に浮遊する水面媒種において、雄花が水面に浮上することは不可欠な過程であるが、雄花が浮上する仕組みについては知られていなかった。今回の観察の結果、クロモ（トチカガミ科）においては、光合成によって生じた酸素の気泡に雄花が包まれ、それによる浮力によって水面まで浮上することが明らかになった。

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