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Newly found facets in the asexual and sexual reproduction of *Gonium pectorale* (Chlorophyta, Volvocales)

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Some details of asexual and sexual reproduction in *Gonium pectorale* MÜLLER were observed by light microscopy under controlled laboratory conditions. Each cell of a newly formed asexual colony initially grew only a single flagellum. The gamete bore a slender cytoplasmic protrusion at the base of flagella. Plasmogamy was initiated by the union of the tips of the protrusions between two gametes. This structure has not been previously described in the gamete of *Gonium*.

Key Index Words: *asexual reproduction*; *Chlorophyta*; *flagellar emission*; Gonium pectorale; *isogamous conjugation*; *mating papilla*; *sexual reproduction*; *Volvocales*.

The general features of asexual and/or sexual reproduction in *Gonium pectorale* MÜLLER have been observed in cultures by HARTMANN (1924), SCHREIBER (1925), STEIN (1958b) and KUSUMOTO *et al.* (1978). Nevertheless, some details on the reproduction of this alga seem to have been left for more careful studies. In this paper, I describe the mode of flagellar emission in daughter colony formation and the presence of cytoplasmic protrusion in conjugating gametes.

Materials and Methods

Water samples from which *Goiunm pectorale* was isolated were collected at a small pond in the Keio Senior High School campus, Hiyoshi, Kohoku-ku, Yokohama-shi, Kanagawa Prefecture, in April 1979. The methods of culture, mating and observation are the same as described previously (NOZAKI and KASAKI 1979). Cultures of UTEX 805, 806, 826, 827, 2075 and 13 (STARR 1978) were also used in this study and maintained under the same conditions.

Observations and Discussion

General features of asexual reproduction were essentially the same as previously reported by HARTMANN (1924), STEIN (1958b) and KUSUMOTO *et al.* (1978). Each of 8 or 16 vegetative cells divided three or four times to form an 8- or 16-celled daughter colony within its gelatinous sheath. Sometimes the divisions occurred only twice and a 4-celled colony was formed (Fig. 1). However, it is on the mode of flagellar emission in a daughter colony that my observations differed from the previous reports. Just after the successive divisions, each cell of the daughter colony grew only a single flagellum. As a result, newly formed colonies had uniflagellate cells (Figs. 1-2). Later, before or after colony liberation, these cells began to grow the second flagellum (arrow, Fig. 3). The two flagella became equal in length within a half-day after the daughter colony formation.

Flagellar emission of this type has not been previously reported in *Gonium pectorale*. The figures of HARTMANN (1924 Fig. C)

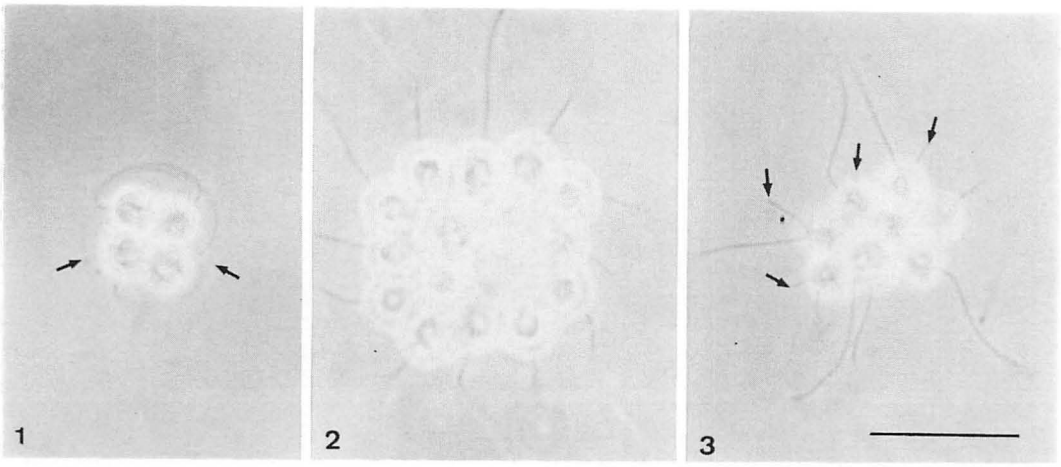


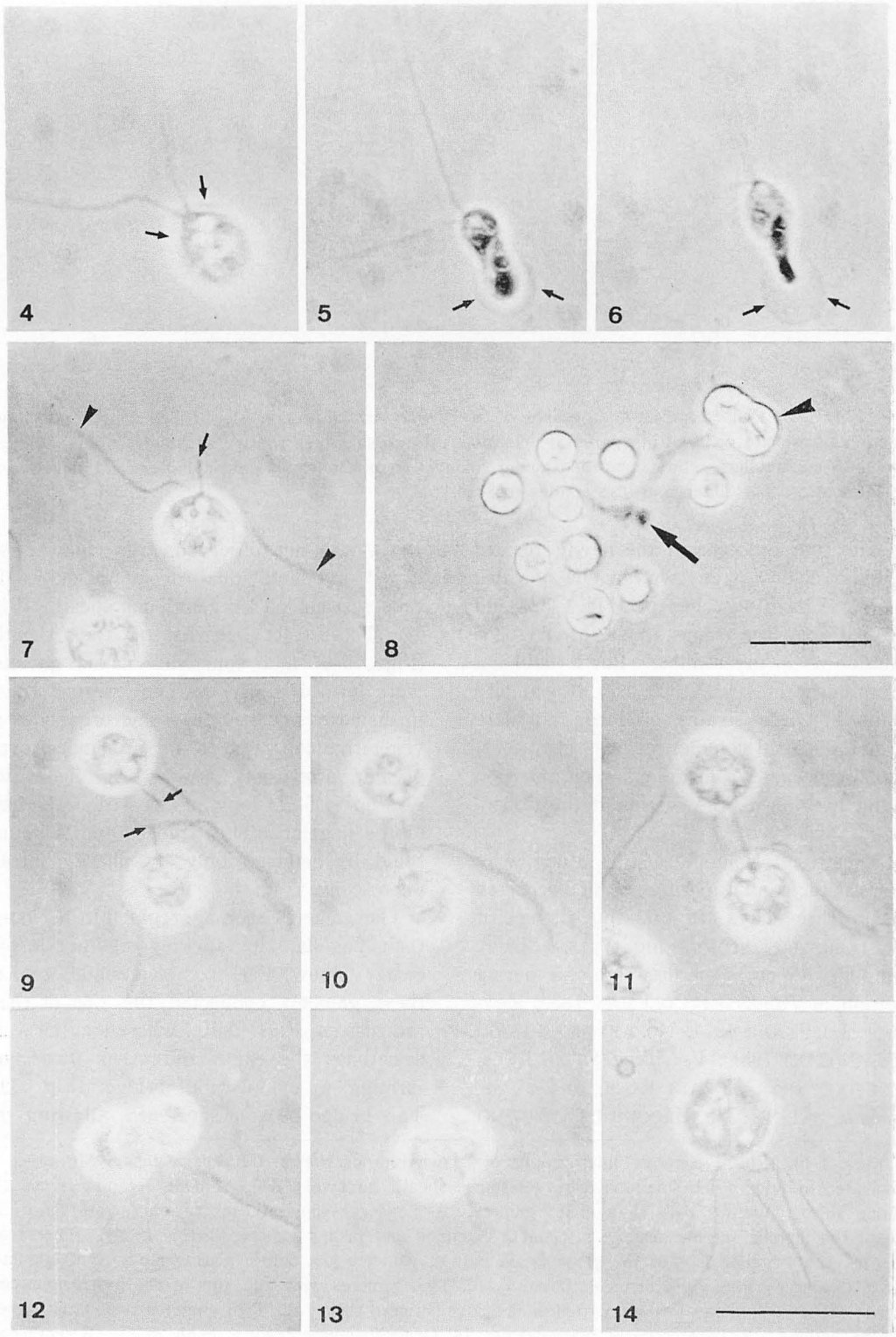
Fig. 1-3. Phase contrast micrographs of *Gonium pectorale* MÜLLER. 1. 4-celled daughter colony with uniflagellate cells within parental gelatinous cellular sheath (arrows) ; 2. Newly formed colony with 16 uniflagellate cells; 3. 8-celled young colony. Arrow indicates developing second flagellum. Scale in Fig. 3 is 20 μm and also applies to Figs. 1-2.

indicate that the cells of the newly formed daughter colony have two flagella of equal length. I have observed in UTEX 827 and 2075 strains the same mode of flagellar emission as in my strains. But I could not determine it in UTEX 805, 806, 826 and 13 strains. These strains produced no more normal 16-celled colonies at my laboratory, probably because of modification or mutation during long-term preservation at the Collection.

The strains isolated in this study were heterothallic, and a mating reaction occurred one to three days after mixing colonies of two complementary mating types. Colony clumping, which is the first sign of a mating reaction in *Pandorina* (COLEMAN 1959, RAYBURN and STARR 1974, NOZAKI and KASAKI 1979, NOZAKI 1981), *Volvulina* (STEIN 1958a, CAREFOOT 1966, NOZAKI 1982a) and *Astrephomene* (STEIN 1958a, BROOKS 1966, NOZAKI 1983), was not observed. A colony dissociated into individual ovoid to ellipsoidal cells surrounded by gelatinous sheaths (Fig. 4). These cells then cast off their sheaths (Figs. 5-6) and spherical, naked gametes were formed (Fig. 7). They were 5-12 μm in diameter and had the same organelles as vegetative cells except for a slender cytoplasmic protrusion (arrow, Fig. 7), which was up to 5 μm long and located at the base of the flagella. This transparent structure could be detected only by phase contrast microscopy.

The gametes soon aggregated in a clump, their flagellar tips sticking together in one center (arrow, Fig. 8). Meanwhile, two of these gametes connected the tips of their protrusions (Figs. 9-10), whose lengths were sometimes the same and other times not, forming a cytoplasmic bridge (Fig. 11). This bridge became shortened, allowing the

Figs. 4-14. Phase contrast micrographs of sexual reproduction in *Gonium pectorale* MÜLLER. 4. Dissociated individual cell surrounded by gelatinous sheath (arrows) ; 5-6. Gamete escaping from the cellular sheath (arrows) ; 7. Biflagellate gamete. A slender cytoplasmic protrusion (arrow) is at the base of the flagella (arrow heads) ; 8. Gamete clumping and fusing gametes (arrow head). The arrow indicates the flagellar tips of the gametes; 9. Pair of gametes just before plasmogamy. Both gametes bear a slender cytoplasmic protrusion (arrow) ; 10. Two gametes with the tips of the protrusions connected; 11. Two gametes forming cytoplasmic bridge between them; 12. Two gametes fusing with their anterior regions; 13. Late stage of plasmogamy; 14. Quadriflagellate zygote. Scale in Fig. 8 represents 20 μm. That in Fig. 14 represents 20 μm, and applies to Figs. 4-7 and 9-14.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anterior regions of the two protoplasts to approach each other, and finally the two gametes fused (Fig. 12). After this, plasmogamy proceeded from lateral to posterior portions (Fig. 13). A quadriflagellate zygote was formed in the clumping group and then separated from the clump (Fig. 14).

STARR (1962) reported a "protoplasmic protrusion" in the anterior region of the gamete in *Volvulina pringsheimii* STARR. He observed that plasmogamy was initiated by the union of the tips of the protrusions of the two gametes, and said that this structure was one of the diagnostic attributes by which *V. pringsheimii* may be distinguished from *V. steinii* PLAYFAIR. Later, however, CAREFOOT (1966) observed a very similar structure in the gamete of *V. steinii* and named it "mating papilla". Mating papillae have also been observed in the related isogamous genera, *Pandorina* (NOZAKI 1982b) and *Astrephomene* (BROOKS 1966, NOZAKI 1983). The mating papillae reported for these algae are, in general, not as long as the cytoplasmic protrusion of *G. pectorale*, which also can be called a mating papilla on the basis of its function.

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野崎久義: *Gonium pectorale* (緑藻・オオヒゲマワリ目) の無性・有性生殖上の新知見

Gonium pectorale MÜLLER の無性生殖と有性生殖を培養条件下で詳細に光顕観察したところ若干の知見が得られた。無性生殖で形成された娘群体の各細胞からは最初1本だけ鞭毛が突出し1鞭毛型の細胞となる。その後，2番目の鞭毛が突出し始め等長2鞭毛型となる。配偶子は鞭毛基部に細長い細胞質の突起をもつ。細胞質融合は2個の配偶子の突起の先端同士の結合から開始した。この様な配偶子の突起に関しては *Gonium* 属において今までに報告がないが，近縁の *Pandorina*, *Volvulina*, *Astrephomene* の各属で観察されている接合突起 (mating papilla) と同じものと考えられる。(223 神奈川県横浜市港北区日吉四丁目一番二号 慶応義塾高等学校)