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链膝藻属的研究*

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链膝藻属 (*Sirogonium*) 为 Kützing 于 1843 年所建立。历来藻类分类工作者对其分类位置持两种不同意见: G. S. West (1916), G. M. Smith (1933), F. E. Fristsch (1935), C. C. Jao (饶钦止, 1935), E. N. Transeau (1934), M. S. Randhawa (1959), A. Gauthier-Lievre (1965) 和 J. Z. Kadlubowska (1972) 等认为它应为一个属; E. N. Transeau (1915), V. Czurda (1932), W. Krieger (1944)和 G. W. Prescott(1951) 等则认为它不足以建立属,而应隶于水绵属 (*Spirogyra*)。

描述和讨论

本属主要特征为: 无触手腻滑的果胶质的细胞壁外层,接合生殖为屈膝状的配子囊直接接合,不产生接合管,色素体平直或略弯曲,通常产生原配子囊[13,20]。本属与水绵属很相似,水绵属也有具平直或略弯曲的色素体的种类,如雅托水绵 (*S. jatobae* Transeau) 等。科林水绵 [*S. collinsii* (Lewis) Printz.] 和普雷水绵 [*S. prescottii* (prescott) Transeau] 也明显地产生原配子囊。反曲水绵 (*S. reflexa* Transeau) 的配子囊也呈屈膝状。这样,本属的独特特征只有两点: (1)没有果胶质的细胞壁外层; (2) 接合生殖为配子囊直接接合,不产生接合管。作者对这两点特征曾作过深入研究。

作者以点形链膝藻 [*S. sticticum* (Engl. Bot.) Kutz.] 为实验材料,用 0.02% 钌红 (ruthenium red) 水溶液染色,观察链膝藻属的细胞壁。结果,其细胞壁外层呈浅红色反应,这说明该层细胞壁为果胶质层。此外,又以上述材料和美貌水绵 (*Spirogyra pulchrifigurata* Jao) 制作超微切片,在透射电镜下观察,发现其细胞均具有果胶质的细胞壁外层,但点形链膝藻的果胶质壁比美貌水绵的薄 (图 6, 7)。这样,本属唯独"配子囊直接接合,不产生接合管。"这一十分重要的分类特征,在双星藻科中为本属所特有,足以区别于水绵属。因此,链膝藻属应予建立。

综上所述,本属唯一的独特特征是: 接合生殖为配子囊直接接合,不产生接合管。可是,本属全部 20 个种群 (J. Z. Kadlubowska, 1972; 朱婉嘉, 1980) 的接合生殖现象并不一致: 有配子囊直接接合后,始终不产生接合管的,如点形链膝藻 (图 1), 网纹链膝藻 (*S. reticulatum* Randhawa) 等;也有在配子囊直接相接后,才产生接合管的,如文特链膝藻 (*S. ventersicum* Transeau) (图 2)、伊利链膝藻 [*S. illinoiensis* (Transeau) Smith][17] (图 3) 等;更有配子囊产生突起,突起相接,形成接合管的(这种接合生殖与水绵属的梯形接合生

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殖相同），如黑孢链膝藻［*S. melanosporum* (Randhawa) Transeau］[6]（图 4）等。因此，本属的接合生殖现象应予以深入研究，从而修正其全部种群的分类位置。

Transeau 曾指出[19]："链膝藻属的接合生殖为不同藻丝的短而又弯曲的细胞的直接接合，能动配子在任何管状结构产生之前，可穿越宽大的孔口。由于雌配子囊继续发育，其细胞壁充分扩大，从而有时出现接合管的模样，但它很宽，容易区别于水绵属的接合管。"；"水绵属在两个配子移动并结合之前，产生显著的接合管，这一接合管由两配子囊的突起相接而成。"这样，Transeau 认为本属的配子囊直接相接后所产生的管不是接合管，仅是"管状结构"而已。并且其配子结合发生于"管状结构"产生之前，而水绵属的配子结合则发生于接合管出现之后。V. Czurda 和 G. M. Smith[3,16] 也认为本属在配子结合之前不产生明确的接合管。作者观察了广州河南岛的文特链膝藻（图 2）、黑孢链膝藻（图 4）和膨大链膝藻（*S. inflatum* Dixit）（图 5）等的大量生活标本和液浸标本，发现其配子还在配子囊时，已有显著的接合管，并且这时出现的接合管与含有成熟接合孢子的配子囊所具有的接合管没有什么区别。这现象没有一个标本例外。从上述事实说明本属的"管状结构"与水绵属的接合管同是产生于配子结合之前。此外，"管状结构"与接合管不但同是两个配子进行结合的通道，并且在形态结构上也没有原则性的区别。所不同者，仅在于本属的"管状结构"必需经过配子囊直接相接后才产生（图 2），而水绵属的接合管直接由配子囊的突起相接而成。因此，Transeau 所谓的"管状结构"实质上是次生接合管。

鉴于上述，并根据本属的独特特征在于：接合生殖为配子囊直接接合，不产生接合管。作者建议，本属具次生接合管的种群以及接合生殖与水绵属的梯形接合相同的种群拟改隶或复隶于水绵属。改隶于水绵属的有：印度链膝藻（*Sirogonium indicum* Singh）、黑孢链膝藻、膨大链膝藻、文特链膝藻、范达链膝藻（*S. vandalurense* Iyengar）、广州链膝藻（*S. guangzhouensis* Zhu）、美孢链膝藻（*S. calosporum* Zhu）、具齿链膝藻（*S. denticulatum* Zhu）、和褐孢链膝藻（*S. fuscosporum* Woodhead et Tweed）9 种。复隶于水绵属的有：武宁链膝藻［*S. hui* (Li) Transeau］、伊利链膝藻和卡马链膝藻［*S. kamatii* Kadlubowska = 武宁水绵小变种 *Spirogyra hui* (Li) Transeau f. *minor* Kamat］3 种。其余种群其配子囊直接相接后，始终保持相接状态，不产生任何接合管，因而拟保留于链膝藻属。

结　　语

链膝藻属与水绵属的区别在于接合生殖。前者为配子囊直接接合，始终不产生接合管；后者为梯形接合或配子囊直接接合，产生接合管。因此，以往记载的链膝藻属的全部 20 种群中，目前仅有：点形链膝藻、大孢链膝藻［*Sirogonium megasporum* (Jao) Transeau］、扁孢链膝藻（*S. phacosporum* Skuja）、假佛罗链膝藻［*S. pseudofloridanum* (Prescott) Transeau］、纤丝链膝藻［*S. tenuis* (Nordstedt) Transeau］、佛罗链膝藻［*S. floridanum* (Transeau) G. M. Smith］、斯里链膝藻（S. ceylanicum Wittrock）和网纹链膝藻 8 种；其余 12 种群拟改隶或复隶于水绵属。

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STUDIES ON THE GENUS *SIROGONIUM* KÜTZING (ZYGNEMATACEAE)

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The genus *Sirogonium* was established by F. T. Kützing in 1843. Up to date most phycologists have recognized it as a distinct genus, but V. Czurda (1932), H. Krieger (1944) and G. W. Prescott (1951) had ascribed all the species of the genus to the genus *Spirogyra*. The distinct features of the genus were shown to be that the lateral walls do not have an outer layer of pectose and it's conjugation takes place directly between the gametangia without the formation of conjugating tubes. Therefore it is easy to distinguish the genus from *Spirogyra*.

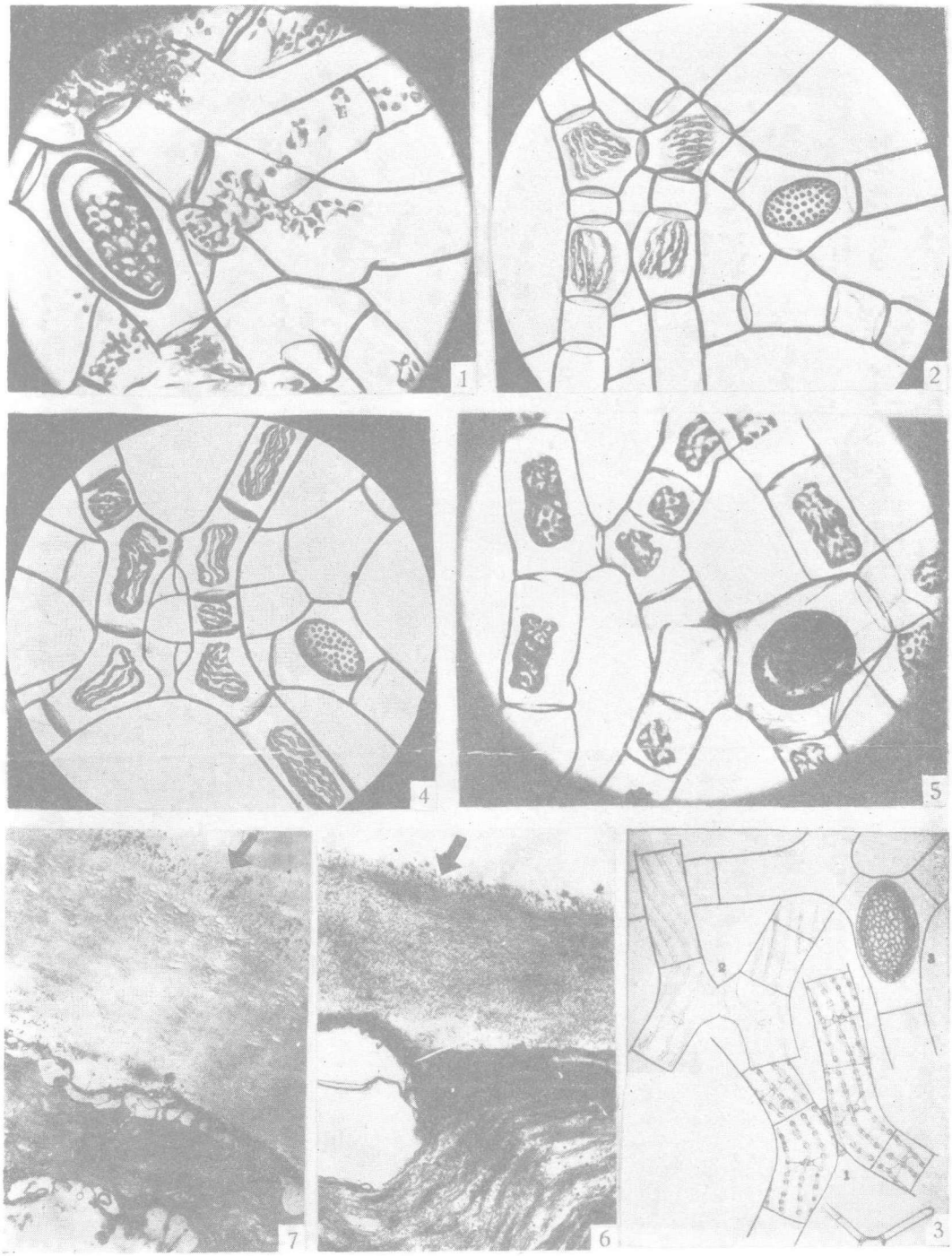
The external pectose layer of the cell wall was determined by electron microscope examination of *Sirogonium sticticum* (Fig. 6). This layer is much thinner than that of *Spirogyra pulchrifigurata*. So that there is only one distinct feature, i.e. the different form

of conjugation, to separate the genus from *Spirogyra*.

The genus is now known being represented by 20 species[2, 9]. Reviewing in detail the description of all the species of the genus along with its figures, the present writer has found that there are three different modes of conjugation: (1) for some of the species the two gametangia remain in contact condition without any tube after having directly joined; (2) for others conjugating tube occurred after the two gametangia having contacted; (3) some of the other species have scalariform conjugations. In this form the tubes originate from the union of papillae formed from the gametangia. Taking into consideration of the various modes of conjugation memtioned above the present paper is mainly devoted to the problems of conjugation of the genus and then serves to revise the classification of its species.

Transeau[19] recognized that in *Sirogonium* the canal originated from the two gametangia in contact was not really the conjugating tube, but the tube-like structure. And he also suggested that the motile gamete might have passed through the broad opening of the gametangia prior to the formation of any tube-like structure. Czurda and Smith[3, 16] also suggested that there might be no formation of a definite conjugating tube prior to gametic union. After a close examination of a great deal of materials about *Sirogonium inflatum, S. melanosporum, S. ventersicum* etc., we found that there are definite conjugating tubes, though the motile gametes are still in their own gametangia. These tubes appear to be the same tubes of the conjugation gametangia containing ripe zygospores. Furthermore, the conjugating tube and the "tube-like structure" are both the passage of the motile gametes. So that the "tube-like structure" should be recognized equal to any conjugating tube in *Spirogyra,* but derived from the direct conjugating gemetangia instead of from the papillae formed by the gametangia. Therefore this canal is a secondary conjugating tube.

On account of the above discussion the present writer propose that any species of *Sirogonium* that produces tube, whether primary or secondary, should be placed under the genus *Spirogyra.* Among them are *S. indicum* Singh, *S. melanosporum* (Randhawa) Transeau, *S. inflatum* Dixit, *S. ventersicum* Transeau, *S. vandalurensis* Iyengar, *S. guangzhouensis* Zhu, *S. calosporum* Zhu, *S. denticulatum* Zhu, *S. fuscosporum* Woodhead et Tweed, *S. illinoiensis* (Transeau) G. M. Smith, *S. hui* (Li) Transeau and *S. kamatii* Kadlubowska. The rest of the species in the genus are strictly recognized by the direct conjugation of the gametangia without any tube throughout.



1. 点形链膝藻 (Sirogonium sticticum), ×150; 2. 文特链膝藻 (S. ventersicum), ×75; 3. 伊利链膝藻 (S. illinoiensis) (引自 Transeau, 1914, 图版 28, 图 1—3); 4. 黑孢链膝藻 (S. melanosporum) ×90; 5. 膨大链膝藻 (S. inflatum) ×90; 6. 点形链膝藻细胞超微切片, ×1750; 7. 美貌水绵 (Spirogyra pulchrifigurata) 细胞超微切片, ×1750。(箭头所指为果胶质壁)