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Morphology and Infraciliature of the Marine Ciliate *Oxytricha saltans* (Cohn, 1866) Kahl, 1932 (Protozoa, Ciliophora, Hypotrichida)

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해산 하모충류 *Oxytricha saltans* (Cohn, 1866) Kahl, 1932의 형태와 섬모하부구조 (原生動物, 有毛門, 下毛目)

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적 요

중국 칭다오(북위 36도 08분, 동경 120도 43분)의 새우양식장에서 채집된 해산 하모섬모충류가 *Oxytricha saltans* (Cohn, 1866)로 밝혀져 형태 및 생태에 관한 연구를 실시했다. 서식처에서 채집한 표본과 실험실에서 배양한 것을 각각 생체 관찰하고 protargol로 염색하여 섬모하부구조를 관찰했다. 크기가 작아 분류학적 연구가 미흡했던 본 종에 대해서 새로운 식별기재를 제시했고 상세히 재기재 했으며 근연종 *Actinotricha saltans* sensu Dragesco, 1963에 관해 논의했다.

Key words: Protozoa, marine hypotrichs, morphology, infraciliature, *Oxytricha salltans*.

INTRODUCTION

The marine periphyton in saprobic waters usually contains an extremely diverse assemblage of ciliates. Of those ciliates, one of the most numerous ones belongs to the hypotrichous ciliates (Borror, 1972a).

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Because of their delicate morphology and small size many species have been little known about their biology, if any, inadequately described by using classical cytological methods.

During the investigation of the ecological roles of free living ciliates at the cultivation of marine water bodies, a hypotrichous ciliate has been found on substratum from some shrimp culture ponds near Qingdao. After a careful study of morphology, we convinced that it was a population of *Oxytricha saltans*. In the present paper, we focus on its general morphological features of both natural and cultured cells because the data on the nondividing individuals of this species are still few and its morphology, especially its infraciliature, remained poorly known in spite of the numerous papers concerning the species (Kahl, 1932; Wang, 1934; Dragesco, 1963; Hemberger, 1982).

MATERIALS, METHODS, AND TERMINOLOGY

Samples were collected at shrimp culture ponds around the Gulf of Jiaozhou, Qingdao, People's Republic of China (36° 08′ N; 120° 43′ E). Several individuals were cultured in petri dishes containing boiled sea water (salinity 28‰) with shrimp meat (see Song, 1991). Some cells were maintained at the same time with other small ciliates and flagellates.

The body shapes of the living specimens on slides were drawn without being covered by cover slips. The infraciliature was revealed by the protargol silver method of Wilbert (1975). In order to demonstrate the micronucleus, the Feulgen technique was used. Drawings of the impregnated specimens were made with a camera lucida. All counts and measurements were carried out under the compound microscope at a magnification of X1600.

The terminology is based on the publications of Foissner (1982), Hemberger (1982), and Corliss and Lom (1985). The classification scheme is according to Corliss (1979).

The abbreviations in the figures and table are as follows:

AL: anterior longitudinal fiber
AM: adoral membranelles
AZM: adoral zone of membranelles
BC: buccal cirrus(i)
C: cirrus(i)
CC: caudal cirrus(i)
DK: dorsal kinety
EM: endoral membrane
FC: frontal cirrus(i)
LMC: left marginal cirrus(i)
Ma: macronucleus
Max: maximum
Min: minimum
n: number of individuals examined
PF: peripheral fiber
PL: posterior longitudinal fiber
PM: paroral membrane
RMC: right marginal cirrus(i)
SD: standard deviation
Sx: standard error of the mean
TC: transverse cirrus(i)
Vr: coefficient of variation
VC: ventral cirrus(i)
X: arithmetic mean

SYSTEMATIC ACCOUNT

Phylum Ciliophora Doflein, 1901
Class Polyhymenophora Jankowski, 1967
Order Hypotrichida Stein, 1859

Family Oxytrichidae Ehrenberg, 1838

Genus *Oxytricha* Ehrenberg, 1830

Oxytricha saltans (Cohn, 1866) (Figs. 1-11, Table 1)

Actinotricha saltans Cohn, 1866 [cited from Hemberger, 1982 (p. 255); Wang, 1934 (p. 64, fig. 11) [not *Actinotricha saltans* sensu Dragesco, 1963].

Actinotricha hyalina Perejaslawzewa, 1895 [cited from Hemberger, 1982 (p.255)].

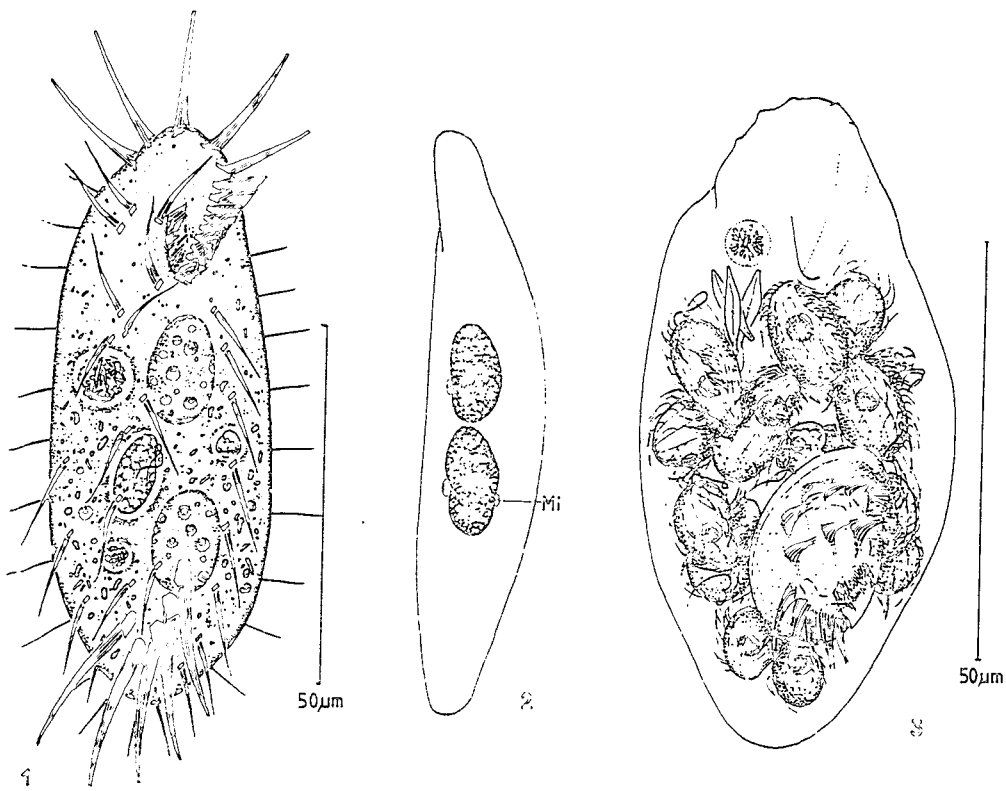
Oxytricha (Actinotricha) saltans Kahl, 1932 (p. 604-605, fig. 113: 25) [not *Oxytricha saltans* Vuxanovici, 1963].

Tachysoma saltans Borror, 1972b (p. 15) (in part); Hemberger, 1982 (p. 255) (in part).

Material Examined: 50 wild specimens collected from the Gulf of Jiaozhou China, from 7 June to 23 June 1991 and cultured ones in laboratory. Protargol impregnated specimens were analysed biometrically and their data were summarized in Table 1.

New Diagnosis: Ellipsoid marine *Oxytricha*, about 50-80μm long by 15-25μm wide *in vivo*, with 2 macronucleus-segments and 2 to 3 micronuclei; constant 7 frontal cirri distinctly shifted backwards, 5 ventral, 5 transverse and 3 caudal cirri; 8-10 left and 5-7 right marginal cirri, of which the latter beginning from posterior half of body; 5 to 6 (usually 5) dorsal kineties arranged in pattern of 4+1/2 or 4+1/2+1/2.

Description: Body rarely contractile, body shape of natural and cultured population rather variable, outline ovoid to elongate-lanceolate, but usually long elliptical with anterior end somewhat tapered (Fig. 1); laterally flattened, ventral surface flat, dorsal surface slightly convex (Fig. 2). Buccal field very narrow and short,



Figs. 1-3. *Oxytricha saltans* from living specimens. 1, Ventral view; 2, Lateral view (combined with Feulgen stained specimens to show the macro-and micronuclei); 3, Body shape in well nutritional state.

Table 1. Biometric characteristics of *Oxytricha saltans*. All data were based on protargol-impregnated individuals.

Characteristic	Min	Max	X	SD	Sx	Vr	n
Length in μm	64	86	76.1	6.14	1.54	8.1	16
Width in μm	27	45	35.1	9.70	2.45	28.1	16
Length of adoral zone membranelles in μm	14	21	18.4	2.06	0.52	11.2	16
Length of cilia in dorsal kineties in μm	9	13	10.6	1.51	0.57	14.3	7
Length of Ma in μm	11	21	16.0	2.88	0.72	18.0	16
Width of Ma in μm	8	13	9.9	1.44	0.36	14.5	16
No. of adoral membranelles	13	18	15.1	1.69	0.45	11.2	14
No. of macronucleus-segments	2	2	2.0	0.00	0.00	0.0	26
No. of micronuclei	2	3	—	—	—	—	4
No. of frontal cirri	7	7	7.0	0.00	0.00	0.0	26
No. of ventral cirri	5	5	5.0	0.00	0.00	0.0	26
No. of transverse cirri	5	5	5.0	0.00	0.00	0.0	26
No. of caudal cirri	3	3	3.0	0.00	0.00	0.0	7
No. of the cirri in left marginal row	8	10	9.2	0.66	0.16	7.1	16
No. of the cirri in right marginal row	5	7	5.6	0.81	0.20	14.6	16
No. of dorsal kineties (1/2 counted as one)	5	6	5.3	0.47	0.14	8.9	11

about one-fourth of length of entire body. Pellicle flexible, no conspicuous cortical granules recognized. Endoplasm colorless, often filled with many greasily shining with large globules of 1-5μm in posterior part of body: food vacuoles containing bacteria, zooflagellates and small ciliates (Figs. 3,4). Contractile vacuole absent. Macronuclear segments ellipsoidal, distinctly separated from each other (Fig. 7). Micronuclei spherical, lying close to macronucleus dorsoventrally (Fig. 2). Cirral pattern rather constant (Figs. 5,7; Tab. 1). Five anterior spine-like components of adoral membranelles ca. 20μm long, highly developed to form large and straight apical styles radiating from anterior border of animal. 2-3 posterior membranelles covered by pellicle and usually separated from anterior part (Fig. 5). Two short and straight undulating membranes (PM, EM) present. Seven frontal cirri constantly arranged and considerably shifted backward, of which first three located at rear part of frontal field, buccal cirrus near posterior end of endoral membrane and the rest behind level of cytostome (Fig. 5). Five ventral cirri fine and five transverse cirri strong relatively. Marginal cirri separated at posterior end, scarcely beyond lateral borders;right ones very particular, extending anteriorly only to about half length of entire cell. Caudal cirri fine, containing only 2 pairs of basal bodies, each with about 12μm long cilium (Fig. 7). Cilia on dorsal side bristle-like, approximately 10μm long, arranged in five (mostly) to six rows, some of them being more or less shortened (Figs. 8-11). All dorsal kineties composed of pairs of basal bodies, anterior kineties only being ciliated.

Occurrence and Ecology: This species is encountered frequently in shrimp culture ponds

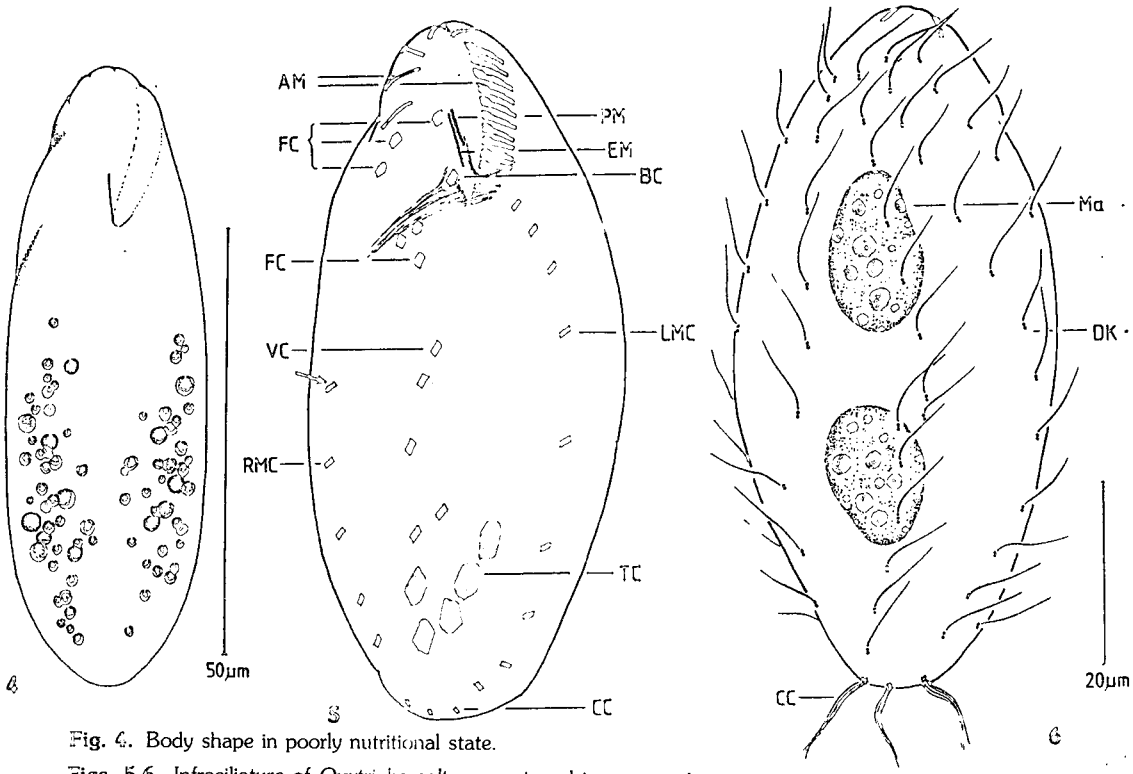


Fig. 4. Body shape in poorly nutritional state.

Figs. 5-6. Infraciliature of *Oxytricha saltans*, protargol impregnated specimens. 5, Ventral view, the arrow marks the strongly shortened right marginal row; 6, Dorsal view.

(Qingdao = Tsingtao, 36° 08′ N; 120° 43′ E) containing a lot of organic matter from May to July. The main environmental factors of the habitat are: Water temperature 19-21°C; pH 7.9-8.0; Salinity 30-32‰: Oxygen saturated.

Remarks: The two ring-like permanent vacuoles which were described by Cohn (1866, cited from Hemberger, 1982) and Wang (1934) have not been observed in our samples. In contrast to most other hypotrichs, *O. saltans* often remains quiet, with its adoral membranelles and cirri keeping still. This resting period is terminated by a sudden spring (Creeping movement; Swimming very seldom), like that of hymenostomate ciliate *Cyclidium*, giving a very steady and forward movement. Sometimes, it can be also observed that the animal "sticks" to the bottom with the long and stout transverse cirri.

Nomenclature: Kahl (1932, p.604) classified *Actinotricha* only as a subgenus of *oxytricha*. Thus the correct name in his revision is *"Oxytricha (Actinotricha) saltans"* and he is, therefore, the author of the combination of the species.

Discussion: The identification of the oxytrichs (family Oxytrichidae) is difficult because of their rather uniform infraciliature and their similar morphogenesis. The classification systems presented by Kahl (1932), Borror (1972b), Corliss (1979), and Hemberger (1982) were based on different taxonomic procedures so that they are also quite different. For a long time, there has been much confusion about the systematic position of *Oxytricha saltans*. The species was originally described as *Actinotricha saltans* inhabiting marine water (Cohn, 1866, cited from Hemberger, 1982). Later, it was reported from the Black Sea, Mediterranean and North Sea and its generic status was changed to the genus *Tachysoma* because of the "absence of the caudal cirri" (Kahl, 1932). Thereafter it has been reported from the South China Sea (Wang, 1934) and France (Dragesco, 1963).

According to the redescription by Kahl (1932), *Actinotricha saltans* has the following features: "... marine

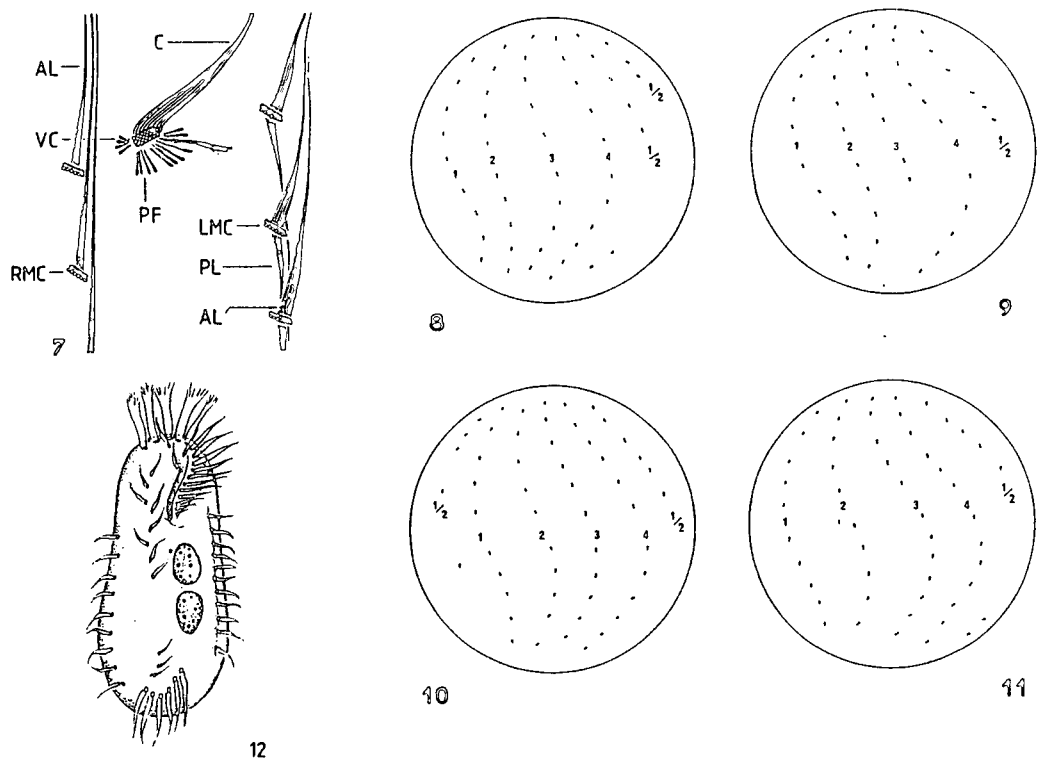


Fig. 7. Part of cirri to demonstrate the peripheral fiber, the anterior and posterior longitudinal fiber (portargol impregnated specimen).

Figs. 8-11. Schematic drawings of the dorsal kineties of *Oxytricha saltans*.

Fig. 12. *Actinotricha saltans* sensu Dragesco. Illustration after Dragesco (1963).

Form mit 5 auffallend radial gespreizten Frontal-Membramellen; einige Frontal-Cirren hinter dem Perstomogrund; die rechte marginals Reihe bis auf 3 oder 4 hintere (ventrale) Cirren verschwunden; Dorsalbristale ziemlich hoch ...". This matches well with our present specimens. Besides the population studied here, Wang (1934) and Dragesco (1963) reported it also from different seas. The specimen collected by Wang in South China Sea must be a population of *O. saltans*. He wrongly depicted the arrangement of right marginal cirri and overlooked the long dorsal cilia.

In Borror's (1972b) and Hemberger's (1982) revisions, five species are synonymized as *Tachysoma saltans*. that is, *Actiontricha saltans* Cohn, 1866; *A. hyalina* Perejaslawzewa, 1885; *Tachysoma parvistyla* Stokes, 1887; *T. fusiformis* Gelei and Szabados, 1950; *Oxytricha saltans* Vuxanovici, 1963. Compared with the present *Oxytricha saltans*, the latter three species mentioned above can not be identified as *O. saltans* because *T. fusiformis* has no *saltans*-typical frontal membranelles (Gelei and Szabados, 1950), and the frontal cirri of *O. saltans* Vuxanovici, 1963 and *T. parvistyla* are limited within the buccal field, however, those of *O. saltans* (Cohn, 1866) are not. Probably, the name of *Oxytricha saltans* Vuxanovici, 1963 is invalid because Vuxanovici (1963) superficially described *O. balladyna* as *O. saltans* (Song and Wilbert, 1989).

Hemberger (1982) investigated a population from soil and found a thoroughly different ciliary pattern. The results of his work allowed us to have the opportunity to discriminate the species confused for more than a century. He obviously overlooked the ciliary characters of *O. saltans*, such as backward shifted frontal cirri, long dorsal cilia and shortened right marginal row. These characters were perfectly redescribed

by Kahl (1932). In the present work, the identification and comparison have been performed on morphological level but not - as widely done - on the morphogenetic level because we consider that morphology alone is enough.

The specimen recorded from Roscoff, France by Dragesco (1963) was not *O. saltans*. Because the overall pattern of *A. saltans* sensu Dragesco is in no way similar to that of the Cohn's original description (Dragesco, 1963; Hemberger, 1982), we convinced that Dragesco described other species, very probably a new species. It differs from *O. saltans* mainly in that it has no caudal cirri and differs by the arrangement of frontal cirri, the body shape and the absence of the long bristle-like dorsal cilia. Among other small marine *Tachysoma* or *Oxytricha* spp., it can be separated by the position of marginal cirri which are placed at a considerably high level and thus make a very large gap posteriorly. The first 5 adoral membranelles also show that they are strong even though they are neither in radiation shape nor much longer than others. In the light of general aspects, *A. saltans* sensu Dragesco, 1963 is most closely related to *Tachysoma parvistyla* Stokes, 1887, but the latter is a fresh water form and has more frontoventral cirri (Kahl, 1932; Stokes, 1887). Because the species *Actinotricha saltans* sensu Dragesco has been remained unmentioned since 1963 (Fig. 12), a further study is considered to be very necessary.

ABSTRACT

The morphology and ecology of the marine hypotrichous ciliate, *Oxytricha saltans* (Cohn, 1866) Kahl, 1932 collected from shrimp culturing pond of Qingdao (Tsingtao, 36° 08′ N; 120° 43′ E), P.R. China were investigated. Collected samples were observed directly and we also observed cultured ones and stained specimens. In relation to this species we redescribed the morphology and infraciliature in detail using protargol method, presented a new diagnosis and discussed some synonyms and the related species, *Actinotricha saltans* sensu Dragesco, 1963.

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