

博士学位論文要約

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論文題目 Title	Taxonomic studies of the genus <i>Fallacia</i> (Bacillariophyceae) and its related species in Japan		

Introduction

Diatoms (Bacillariophyceae) are unicellular, eukaryotic microalgae. The remarkable feature is the highly differentiated cell wall (frustule) made by silica ($\text{Si}_2\text{O} \cdot n\text{H}_2\text{O}$). The current taxonomic system of diatoms was built up based on the morphological characters of the frustule. Since 1970s, the electron microscope (EM) has been used in the study of diatoms. Most unclear and unrevealed features in light microscopy (LM) have been observed. Numerous new genera have been erected including the genus *Fallacia*. Species in *Fallacia* were formerly placed in the genus *Navicula* sect. *Lyratae* and sect. *Bacillares* (cf. Hustedt 1928-1966). Mann & Stickle in Round et al. (1990) described this new genus based on four major features, namely cell with blunt round poles, a single basically H-shaped chloroplast, lateral lyre shaped sterna (appearing hyaline areas in LM) and well-developed porous conopeum. However, most of the 58 species transferred by Mann & Stickle and other species (89 currently accepted species in this genus now) have not been well observed in EM. In recent years, based on detailed observations by EM, three species have been transferred to the genus *Microcostatus*, one species has been transferred to the genus *Biremis* and four species have been transferred to the genus *Pseudofallacia*. Now there are still many species have not been studied in detail. There is also little information about *Fallacia* species in Japan, Currently thirteen *Fallacia* species have been reported (Sawai, Nagumo & Toyoda 2005; Fujita & Ohtsuka 2005; Watanabe 2004). This research aims to study the morphology of *Fallacia* species in detail and interpret the taxonomic relationship with morphological and molecular data.

Material and Methods

Benthic diatom samples have been collected from intertidal areas in Japan. *Fallacia* species have been isolated and cultured. Detailed morphology of vegetative cells was observed from natural population or culturing samples. Sexual reproduction and auxosporulation was observed in a rough culture derived from numerous cells isolated from natural population. Morphological observations were using LM, scanning electron microscope (SEM) and transmission electron microscopy (TEM). Hierarchical cluster analysis was used to analyze the morphological characters. The Ribulose-1, 5-biphosphate carboxylase (*rbcL*) gene of cultured species was used in phylogenetic analysis.

Results

Fifteen *Fallacia* species and two *Sellaphora* have been observed in detail. Four new *Fallacia* species, a new variety and a new combination were proposed, namely *Fallacia* sp. nov. 1, *F.* sp. nov. 2, *F.* sp. nov. 3, *F.* sp. nov. 4, *F. oculiformis* var. nov. and *F. hodgeana* comb. nov.. Those

Fallacia species were divided into four morphological groups. Group 1 including *F. fracta*, *F. tenera*, *F. gemmifera*, *F. litoricola* and *F. hodgeana* possess a combination of features such as 1. a single longitudinal line of areolae between raphe and lateral area; 2. narrow axial area. 3. two longitudinal sterna slightly constrict centrally; and 4. internal terminal pore locate on the two terminal. Group 2 including *F. cf. forcipata*, *F. sp. nov. 1*, *F. sp. nov. 2*, *F. sp. nov. 3* and *F. sp. nov. 4* possess a combination of features such as 1. typical lyre-shaped sterna; 2. usually multiple lines of areolae or wide space between raphe and sterna; and 3. areolae uncovered by conopeum only present at two terminals. Group 3 including *F. oculiformis* var. nov. and *F. florinae* possess the following features: 1. convex lateral area; 2. wide axial area; 3. possessing terminal opening holes; and 4. presenting complicate surface structure. And Group 4. including *F. teneroides*, *F. inscriptura* and *F. pulchella*. possess the following features such as 1. multiple longitudinal lines between lateral areas; and 2. slightly convex lateral area.

Six cultured *Fallacia* species were compared with other species from GeneBank by using molecular phylogenetic analysis based on *rbcL* gene. The result shows all *Fallacia* species forming a monophyletic clade, although not with high bootstrap support. This clade comprised four clades, three of them with high bootstrap value. The Clade 1 includes *F. tenera*, *F. litoricola*, *F. fracta* and *F. hodgeana* corresponding to the morphological Group 1 in hierarchical cluster analysis. The Clade 2 includes *F. cf. forcipata* (Genebank) and *F. sp. nov. 4*. The Clade 3 includes *F. monoculata* and *F. sp. nov. 3*. The *F. pygmaea* was not close to any branches, treated as single Clade 4.

The sexual reproduction of *F. tenera* was observed. The auxosporulation was type IA1a in Geitler's classification. Two paired gametangia formed two anisogametes in each of them. Two auxospores formed in the thecae of gametangia after a trans physiological anisogamy. The perizonium of the auxospore was consisted of a set of transverse bands and five longitudinal bands. The primary transverse band was about twice wider than the secondary ones. The circular incunabular scales presented at the two terminals of auxospore and on the surface of a primary transverse band. The primary longitudinal band has acute terminals and was flanked on both sides by two secondary longitudinal bands, which were semilanceolate. All longitudinal bands were immediately beneath the transverse bands.

General discussions

The species in Group 1 (Clade 1) are naviculoid with large terminal opening and more areolae not covered by a conopeum. It makes the lumen and cytoplasm connected with exterior more easily. Most species in this group are epipellic species, with considerable moving ability. Whereas the species in other groups are epipsammic with limited moving ability and possess elliptical outline with small terminal openings and fewer areolae uncovered by a conopeum. The result of molecular phylogenetic analysis based on *rbcL* suggests *Fallacia* species formed an unrobust clade. However, the morphological results suggest *Fallacia* species do share many features, different from related genera such as *Sellaphora*, *Navicula s.s.* and *Pseudofallacia*.