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| Author(s)           | 亢, 世华                                                                                                                                                                    |
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# 学位論文内容の要旨

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氏名：亢 世華

## 学 位 論 文 題 目

Comparative morphology and phylogenetic relationships of the family Polynemidae  
(Pisces: Perciformes)

( ツバメコノシロ科魚類の比較形態学および系統類縁関係に関する研究 )

The family Polynemidae, known as threadfins, is classified into the perciform suborder Percoidei, and comprises eight valid genera and about 50 species. This family is characterized by the diagnostic features such as the body elongated to deep and compressed, the adipose eyelid covering the eye, and the pectoral fins divided into an upper part with 12 to 19 rays joined by membrane and a lower part with three to 16 separate filament-like rays.

Polynemidae has been variously classified by many ichthyologists. For example, Nelson (1984) recognized that Polynemidae includes seven genera. Feltes (1993) described a new genus *Parapolynemus*, and redefined the family including seven genera with synonyms of *Polistonemus* under *Polynemus*. Motomura (2004) recognized eight genera, *Eleutheronema*, *Filimanus*, *Galeoides*, *Leptomelanosoma*, *Parapolynemus*, *Pentanemus*, *Polydactylus* and *Polynemus*. Many authors showed various candidates of the sister group of Polynemidae; then, Kang et al. (2017) confirmed the monophyly of the family Polynemidae by 19 synapomorphies, and showed the evidences to support the sister relationship of Polynemidae and Sciaenidae. However, phylogenetic relationships providing the basis of the classification have not been reconstructed in the Polynemidae.

The goals of the present study are: (1) to show the monophyly of this family and the sister relationship of Polynemidae and Sciaenidae; (2) to describe its osteological and myological characters; (3) to reconstruct its phylogenetic relationships based on morphological characters; and (4) to discuss the classification of Polynemidae.

## **Materials and systematic methodology**

25 polynemid species in eight genera, and 86 acanthomorph species in 8 orders and 63 families were selected as study materials and comparative materials (of them, 11 sciaenid species were used as outgroup in phylogenetic analysis), respectively. Anatomical examinations were made on specimens stained in alcian blue and alizarin Red-S, and dissected under stereo-microscope utilized in the preparation of drawings.

In order to reconstruct phylogenetic relationships of Polynemidae, the cladistic approach formulated by Hennig (1966) was adopted. The outgroup comparison was used to determine the character polarity (Watrous and Wheeler, 1981; Wiley, 1981).

### **Monophyly of the family Polynemidae**

Kang et al. (2017) concluded that the monophyly of the family Polynemidae was strongly supported by 19 synapomorphies of Polynemidae such as the tooth plate present on the ectopterygoid, the metapterygoid and quadrate interdigitated medially, an unnamed bone present on the cephalic sensory canal extending from the supratemporal, the third actinost not supporting pectoral-fin rays, a rod-like process extending from the ventral margin of the coracoid, and the adductor mandibulae section 1 comprised the lateral and medial elements. In addition to the 19 synapomorphies, a single new synapomorphy was found in this study: levator arcus palatini divided into two subsections, anterior and posterior subsections. Thus, this study recognizes 20 synapomorphies supporting the monophyly of Polynemidae.

### **Sister relationship of Polynemidae and Sciaenidae**

Kang et al. (2017) proposed the sister relationship of Polynemidae and Sciaenidae supported by six synapomorphies including two rare (metapterygoid and quadrate interdigitated medially, and anterior extension of nasal canal present), two rather rare and two common derived characters. This study sustains this conclusion, and use Sciaenidae as the outgroup in the phylogenetic analysis.

### **Phylogenetic relationships of Polynemidae**

Phylogenetic relationships of the family Polynemidae were reconstructed by characters in 64 transformation series. Four most parsimonious trees of Polynemidae were obtained after the phylogenetic analysis. The tree length was 153, consistency index 0.49 and rescaled consistency index 0.35. In this study, the strict consensus tree was constructed on the basis of four parsimonious trees and adopted as the relationships of Polynemidae (Figure). Major clades in the relationships are

described as follows:

Clade A.—Includes all examined polynemids. After the phylogenetic analysis, the monophyly of the family Polynemidae was also unambiguously supported by the following three synapomorphies: fourth infraorbital covering fifth laterally, adductor section 2 restricted to posterolateral surface of second epibranchial, filament-like rays slightly elongate. This clade was also supported by three additional synapomorphies according to ACCTTRAN.

Clade B1.—Includes all examined polynemids, except for *Pentanemus quinquarius*, *Parapolynemus verekeri* and *Polynemus*, and was unambiguously supported by four synapomorphies.

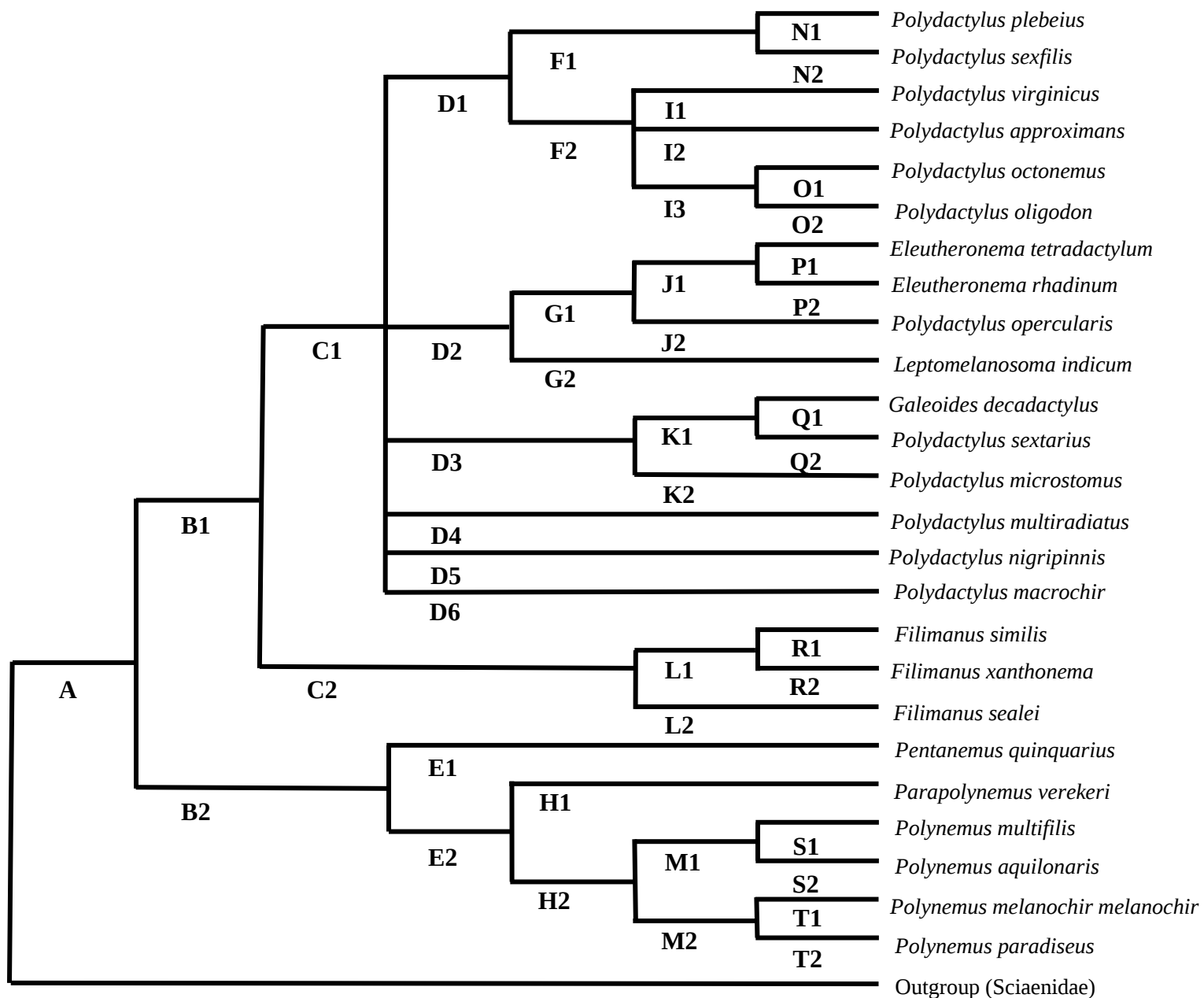
Clade B2.—Includes *Pentanemus quinquarius*, *Parapolynemus verekeri* and *Polynemus*, and was unambiguously supported by four synapomorphies. This clade was also supported by two synapomorphies according to ACCTTRAN.

Clade C1.—Includes *Polydactylus*, *Galeoides decadactylus*, *Leptomelanosoma indicum* and *Eleutheronema*, and was unambiguously supported by three synapomorphies.

Clade C2.—Includes the genus *Filimanus*, and was unambiguously supported by four synapomorphies. This clade was also supported by one synapomorphy according to DELTRAN.

Clade D2.—Includes *Polydactylus opercularis*, *Leptomelanosoma indicum* and *Eleutheronema*, and was unambiguously supported by three synapomorphies. This clade was also supported by two synapomorphies according to ACCTTRAN, and by one synapomorphy according to DELTRAN.

Clade D3.—Includes *Galeoides decadactylus*, *Polydactylus sextarius* and *Polydactylus microstomus*, and was unambiguously supported by two synapomorphies. This clade was also supported by one synapomorphy according to ACCTTRAN.



**Figure.** Strict consensus tree of four most parsimonious phylogenetic relationships of Polynemidae.

### Classification

The validity of genera *Filimanus*, *Pentanemus*, *Parapolyneumus* and *Polynemus* is supported in this study. However, the genus *Polydactylus* was assumed to be a non-monophyletic group in the four most parsimonious trees, because *Eleutheronema*, *Leptomelosoma* and *Galeoides* are nested within *Polydactylus*. To avoid to recognize the cladistically invalid genus, this study propose a newly-defined genus including species of *Polydactylus*, *Eleutheronema*, *Leptomelosoma* and *Galeoides* to clade C1. Accordingly, the latter three genera are synonymized under *Polydactylus* having priority over them.

This study redefined Polynemidae as a family including five genera. The new classification of Polynemidae is summarized as follow:

Family Polynemidae

*Filimanus* Myers, 1936

*Parapolynemus* Feltes, 1993

*Pentanemus* Günther, 1860

*Polydactylus* Lacepède, 1803 (synonyms: *Galeoides* Günther, 1860, *Eleutheronema* Bleeker, 1862 and *Leptomelanosoma* Motomura and Iwatsuki, 2001)

*Polynemus* Linnaeus, 1758 (synonym: *Polistonemus* Gill, 1861)