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# 主論文の要約

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## 学位論文題目

Comparative anatomy and phylogenetic systematics of lizaedfishes  
(Actinopterygii: Aulopiformes: Synodontidae)

(エソ科魚類の比較解剖学ならびに系統分類学に関する研究)

## Introduction

The family Synodontidae (*sensu* Nelson, 2006, including four genera and about 57 species) is mainly marine and bottom-living species that inhabit shallow and coastal waters of the Atlantic, Indian and Pacific oceans in tropical and temperate regions. Classification and phylogenetic relationships of the Synodontidae have been variously studied by many studies. For example, Baldwin and Johnson (1996) inferred the interrelationships of the Aulopiforms based on morphological characters and recognized the monophyly of the family Synodontidae. Sato and Nakabo (2002) proposed taxonomic position and phylogenetic relationships of *Paraulopus* and also inferred the monophyly of the family Synodontidae. Davis (2010) studied interrelationships within the order Aulopiformes mainly based on the molecular data, and the family Synodontidae was referred to be monophyletic when molecular and morphological data were used. Additionally, Davis (2010) also proposed that *Trachinocephalus* has possibility to be nested within *Synodus* following his result. However, their study materials of synodontids were limited in six to 11 species. Accordingly, to propose reliable classification of the Synodontidae, the phylogenetic relationships of this family should be reconstructed by using many study materials, especially those of *Synodus* to reveal its validity with materials of *Trachinocephalus*.

The purposes of this study are to reconstruct the phylogenetic relationships of the Synodontidae based on the osteological and myological characters, and to evaluate the classification of synodontids based on the phylogenetic relationships. Life styles, and adaptive characters and behavior of this family based on the reconstructed relationships are also discussed in this study.

## Materials and Methods

Total of 18 synodontid species and three species of outgroups, as following, were examined. Synodontidae: *Harpadon nehereus* (Hamilton, 1822); *Harpadon squamosus* (Alcock, 1891); *Saurida brasiliensis* Norman, 1935; *Saurida nebulosa* Valenciennes, 1850; *Saurida normani* Longley, 1935; *Saurida tumbil* (Bloch, 1795); *Saurida umeyoshii* Inoue & Nakabo, 2006; *Saurida undosquamis* (Richardson, 1848); *Synodus evermanni* Jordan and Bollman, 1890; *Synodus foetens* (Linnaeus, 1766); *Synodus hoshinonis* Tanaka, 1917; *Synodus lucioceps* (Ayres, 1855); *Synodus oculus* Cressey, 1981; *Synodus sageneus* Waite, 1905; *Synodus saurus* (Linnaeus, 1758); *Synodus synodus* (Linnaeus, 1758); *Synodus*

*variegatus* (Lacépède, 1803); *Trachinocephalus myops* (Forster, 1801). Outgroup: Paraulopidae, *Paraulopus nigripinnis* (Günther, 1878); Aulopidae, *Aulopus japonicus* Günther, 1877; Pseudotriconotidae, *Pseudotriconotus altivelis* Yoshino & Araga, 1975. The phylogenetic analysis followed the cladistics approach (Hennig, 1966). The recognized morphological characters were compiled in MacClade version 4.0 (Maddison and Maddison, 2000) and analyzed by using PAUP\* 4.0b10 (Swofford, 2002), with the optimization of characters by using ACCTRAN and DELTRAN options. Three species from the families Paraulopidae, Aulopidae and Pseudotriconotidae having a close relationship with the Synodontidae were used as outgroups for the analysis.

## Results

**[Morphological descriptions]** Recognized osteological and myological characters used in the analysis were described in following sections: circumorbital bones, neurocranium, jaws, hyoid arch, branchial arches, pectoral girdle, pelvic girdle, median fin supports, postcranial axial skeleton, caudal skeleton and the associated muscles.

**[Relationships]** Characters in 101 transformation series were used for analysis and a single strict consensus tree of six most parsimonious cladograms was obtained. Clade 1A, including all examined synodontids, is unambiguously supported by 14 synapomorphies (e.g., the kattle-shaped quadrate, with produced anterior limb capped with cartilaginous tip and the medial process of the fifth ceratobranchial well developed). Of those, five characters were newly found in this study. Accordingly, the monophyly of the family Synodontidae can be strongly supported. The following five major clades were recognized in this family. Clade 2A, including species of the genera *Saurida* and *Harpadon*, is unambiguously supported by 11 synapomorphies (e.g., teeth on the ectopterygoid, and the presence of a gap between the fourth basibranchial and fifth ceratobranchial). Clade 2B, containing species of the genera *Synodus* and *Trachinocephalus*, is unambiguously supported by 16 synapomorphies (e.g., the rostral cartilage enlarged and loosely attached with the ethmoid, and the lowermost actinost expanded). Clade 3A, including species of the genus *Saurida*, is unambiguously supported by five synapomorphies (e.g., the median maxillo-premaxillary ligament connecting the premaxilla with the maxilla and six hypurals). Clade 3B, consisting species of the genus *Harpadon*, is unambiguously supported by 15 synapomorphies (e.g., the maxilla extremely short and the presence of ligaments linking opercular bones). Clade 14B, including *Synodus saurus* and *Trachinocephalus myops*, is unambiguously supported by four synapomorphies (e.g., the presence of tiny spines on the supraorbital and the posterior portion of the posterior process of the pelvic girdle extremely long).

**[Classification]** The family Synodontidae is redefined to include three genera: *Saurida* (Clade 3A), *Harpadon* (Clade 3B) and *Synodus* (Clade 2A). *Trachinocephalus* is synonymized under *Synodus* having the priority over *Trachinocephalus*, because *Synodus* becomes paraphyletic if *Trachinocephalus* is retained.

**[General discussion]** Based on the reconstructed relationships, the benthic life style, and some adaptive characters and behaviors (e.g., the absence of swimbladder, swallowing of entire prey, strong swimming for catching prey from the sea bottom) were regarded as fundamental adaptations in the common ancestor of this family. The genera *Saurida* and *Synodus* share the benthic life style but independently developed the adaptive characters and behaviors (e.g., the presence of teeth on the ectopterygoid and the A2 originating from the hyomandibula and preopercle in *Saurida*, but the

lowermost actinost well expanded and the median maxillo-premaxillary ligament connecting the premaxilla and ethmoid in *Synodus*), while the genus *Harpadon* occupied the specialized benthopelagic life style with some derived characters, such as the absence of the ethmo-maxillary ligament and adductor mandibula section 3 partly situated posterior to section 2.

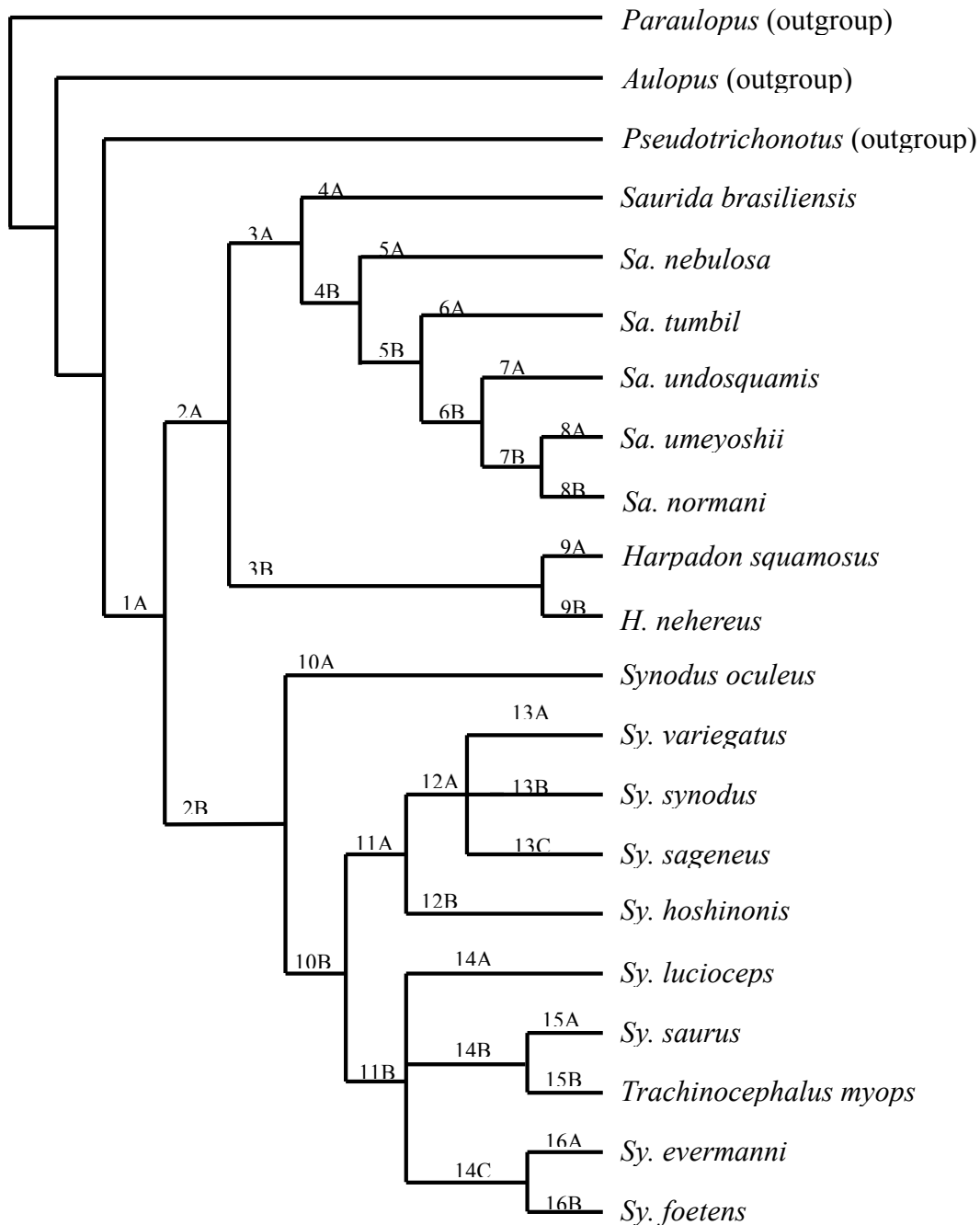


Figure A strict consensus tree of six most parsimonious phylogenetic relationships of 18 synodontid species.