

## PHYLOGENETIC INTERRELATIONSHIP OF THE PERCIFORM ACANTHOCLINIDAE, GRAMMIDAE, PLESIOPIDAE, PSEUDOCROMIDAE AND OPISTOGNATHIDAE

HIN-KIU MOK, HUNG-JUNN CHANG and CHI-YING LEE

Institute of Marine Biology, National Sun Yat-Sen University  
Kaohsiung, Taiwan 80424, Republic of China

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Hin-Kiu Mok, Hung-Junn Chang and Chi-Ying Lee (1990) Phylogenetic interrelationship of the perciform Acanthoclinidae, Grammidae, Plesiopidae, Pseudochromidae and Opistognathidae. *Bull. Inst. Zool., Academia Sinica* 29(1): 29-39. Morphological evidences from the skeletal muscle and olfactory system bring about phylogenetic hypotheses of five perciform families with modified lateralis system, namely, Acanthoclinidae, Grammidae, Plesiopidae, Pseudochromidae and Opistognathidae. Four monophyletic groups are herein proposed: (1) all of these five families, (2) Grammidae-Opistognathidae, (3) Acanthoclinidae-Plesiopidae, (4) Pseudochromidae-Grammidae-Opistognathidae. The serranid *Aporops* and *Pseudogramma* which also have a modified lateralis system were compared to the above families. Although some similarities were noted, no recommendation is made in this paper to change the serranid status of these two genera.

**Key words:** Phylogeny, Perciformes, Acanthoclinidae, Grammidae, Plesiopidae, Pseudochromidae, Opistognathidae.

In the Percoidei a modified lateral line system is found in the families Pseudochromidae, Anisochromidae, Pseudoplesiopidae, Acanthoclinidae (Böhlke, 1960), Grammidae, Plesiopidae and in the serranid genera *Aporops* and *Pseudogramma* (also see below). They either have an interrupted, incomplete posteriorly, multiple lateral line system or have no lateral line at all. Among other perciforms, Opistognathidae and Congrogadidae also have incomplete lateral line. According to Nelson (1984), these two families are members of the perciform suborder Trachinoidei. The family Opistognathidae has been considered relatives of the above families by some ichthyologists (Myers, 1936; Okada and Suzuki, 1956). Interestingly, Godkin and Winterbottom (1985) placed the Congro-

gadidae as a subfamily of the percoid Pseudochromidae. Springer *et al.* (1977) have provided osteological evidences for the monophyly of Pseudochromidae, Pseudoplesiopidae and Anisochromidae and allocated them to the family Pseudochromidae. As for the genera *Aporops* and *Pseudogramma*, they have been placed either in the Pseudochromidae (Weber and De Beaufort, 1931; Norman, 1957), Grammistidae (Gosline, 1960; Nelson, 1984) or Serranidae (Kendall, 1976; Johnson, 1983). Johnson (1983) found convincing evidences supporting the serranid status of these two genera.

The similarity in the lateralis system among these families, namely, Pseudochromidae, Acanthoclinidae, Grammidae, Plesiopidae and Opistognathidae, suggests a possible monophyletic relationship. As little is known about their

detail interrelationship, the present research was set out to look for additional supporting evidences for their monophyly and for resolving their interrelationship.

## MATERIALS AND METHODS

For the observation of bone and cartilage, specimens collected in Taiwan waters or obtained by specimen exchanges arranged with other institutions were cleared and stained using the method of Dingerkus and Uhler (1977). Muscles were stained by Lugol's solution (Bock and Shear, 1972) to facilitate observation of their morphology. Comparison of morphological differences among the aforementioned families and other perciform representatives follows the discipline of cladistic analysis such that a proposal of their phylogenetic interrelationships can be presented. Only those characters with significant differences among the families concerned are reported in this paper. Since specimens of "anisochromids" were not available, *Pseudochromis*, *Dampiera* and *Pseudoplesiops* species were used as representatives of the Pseudochromidae. Unless specified, specimens were uncatalogued materials from the fish collection at the Institute of Marine Biology, National Sun Yat-sen University, Republic of China.

Material examined (measurements are standard length in millimeters; specimens in parentheses were used for myological study):

Centropomidae: *Ambassis urotaenia* 29.0, 31.5, 32.5.

Percichthyidae: *Malakichthys wakiyai* 70.0, 70.5, 77.0, 78.0, (103.0).

Serranidae: *Cromileptes altivelis* 58.0, (74.0), *Cephalopholis argus* (95.0); *Cephalopholis* sp. 48.5; *Trisotropis dermopterus* 135.0, (135.0); *Epinephelus caeruleopunctatus* 68.0; *E. fasciatus* (165.0); *E. megachir* 76.0; *Anthias*

*squamipinnis* 101.0; *Holanthias katayamai* 130.0; *Rypticus maculatus*, Indian River Coastal Zone Museum 107:1787 81.0, (150.0); *Diploprion bifasciatus* 101.5, (190.0); *Liopropoma japonicum* (120); *Pseudogramma polyacantha*, United States National Museum 242121 30.7, 38.5, (42.0, 43.0); *Aporops bilineatus* 46.0, 47.0, (54.0, 55.0); *Grammistes sexlineatus* 33.5, 39.5, 39.5, 73.5, 74.5, (77.0, 84.0, 87.0).

Pseudochromidae: *Dampiera melano-taenia* 33.5, 34.0, 43.0, 43.0, 44.5, 52.8, 63.5, 65.0, (65.0, 70.0, 72.0, 80.0, 82.0); *Pseudochromis tapeinosoma* 24.0, 25.5, (41.0); *Pseudoplesiops sargenti*, American Museum of Natural History 45638 SW 43.0.

Plesiopidae: *Callopleysiops altivelis* 72.5, (95.0); *Plesiops coeruleolineatus* 26.2; *P. nigricans* 106.0, (85.0).

Grammidae: *Gramma loreto*, Academy of Natural Sciences, Philadelphia 94667 33.0, 34.0, (41.0, 44.0, 44.0).

Acanthoclinidae: *Belonopterygium fasciolatum*, Western Australian Museum P27957-018 23.5, 38.5, (40.0, 47.0).

Glaucosomatidae: *Glaucosoma fauvelii* 120.0, 127.0.

Teraponidae: *Terapon jarbua* 67.0.

Banjosidae: *Banjos banjos* 230.0.

Kuhliidae: *Kuhlia mugil* 41.3, 47.0, (70.0).

Priacanthidae: *Priacanthus macracanthus* (219.0).

Apogonidae: *Apogon* sp. 47.0, (80.0, 84.0).

Acropomatidae: *Acropomus hanedai* 66.1, 91.5, (88.0, 98.0).

Branchiostegidae: *Branchiostegus japonicus* 130.5.

Lutjanidae: *Lutjanus monostigma* 80.0.

Blenniidae: *Istiblennius edentalus* 85.0.

Champsodontidae: *Champsodon guentheri* 65.0.

Mugiloididae: *Parapercis binivirgata* 103.0; *P. cephalopunctata* 40.0; *P. sexfasciata* 70.0.

Opistognathidae: *Lonchopisthus micrognathus*, Academy of Natural Sciences,

Philadelphia 134238 63.0, (64.0); *Opistognathus aurifrons*, Academy of Natural Sciences, Philadelphia 138141 58.2; *O. darwiniensis*, Western Australian Museum P25669-002 101.0, (110.0); *O. maxillosus*, Academy of Natural Sciences, Philadelphia 75168 75.0; *O. papuensis* Northern Territory Museum, uncatalogued specimen 205.0.

### RESULTS

Monophyletic relationship for the Plesiopidae, Opistognathidae, Pseudochromidae and Grammidae is supported by a unique character of the cleithrum. The lateroventral surface of the cleithrum in the majority of perciforms is smooth (Fig. 1A), whereas there appears a distinct ventrally or laterally projecting hook in pseudochromids, plesiopids, grammids and opistognathids (in *Opistognathus darwiniensis*, *O. macillosus*, *O. papuensis* and *Lonchopisthus micrognathus*, but absent in *O. aurifrons*; Figs. 1B, 1C; also see Gosline, 1960). This structure is also found in the

trachinoid *Parapercis binivirgata*, *P. cephalopunctata* and *P. sexfasciata* representing a possible convergent or synapomorphic condition.

A small coracoid foramen is observed in pseudochromids, grammids, plesiopids (in *Calloplesiops*, but absent in *Plesiops*), acanthoclinids, opistognathids, congrogadid (*Blennodesmus scapularis*; Godkin and Winterbottom, 1985) and some serranids (*i.e.*, present in *Diploprion*, *Pseudogramma*, *Aporops*, *Rypticus*, *Grammistes*, *Anthias* but absent in *Cromileptes*, *Trisotropis*, and *Epinephelus*; Figs. 1, 4). This foramen is not seen in other percoids examined.

In most serranid (such as *Diploprion*, *Liopropoma* and *Rypticus*) and other percoids, the numerous olfactory lamellae radiate out from either side of a central elongated rachis (Fig. 2A). The lamellae in *Pseudochromis*, *Dampiera*, *Aporops*, *Pseudogramma* and *Grammistes* are horizontally and asymmetrically arranged lacking the central rachis (Figs. 2B, 2C; also see Gosline, 1960). Olfactory lamellae in the first

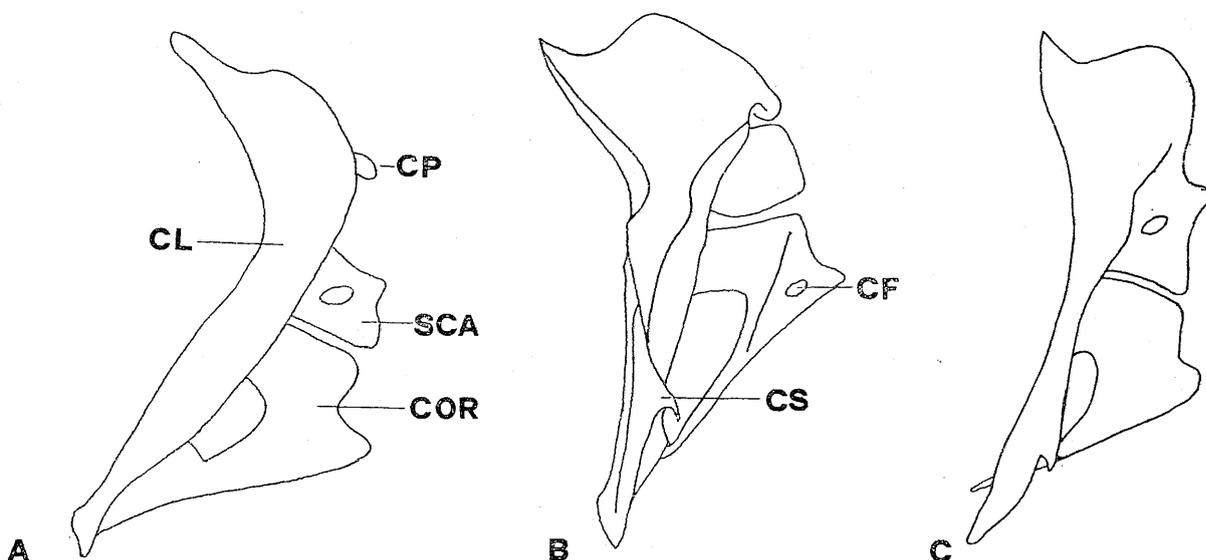


Fig. 1. Some percoid pectoral girdles showing the hook-like prong on the cleithrum (CP), the coracoid foramen (CF) and cleithrum spur (CS) in A, *Epinephelus caeruleopunctatus*; B, *Dampiera melanoaenia*; C, *Opistognathus darwiniensis*. CL, cleithrum; COR, coracoid; SCA, scapular.

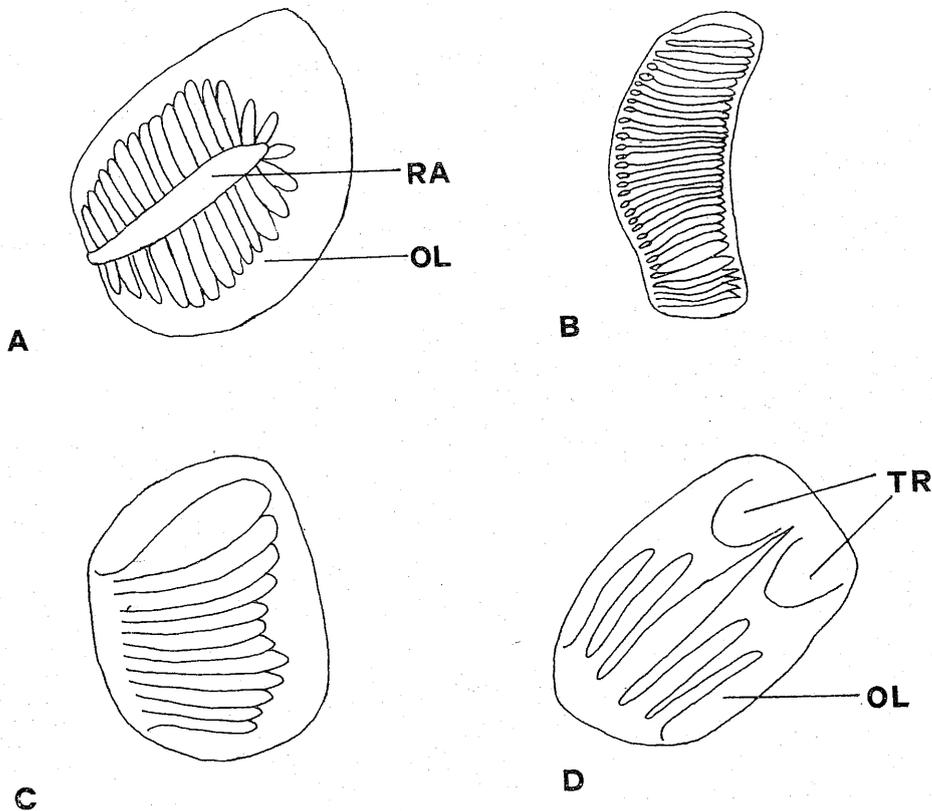


Fig. 2. Left side view of olfactory lamellae in the olfactory sac of A, *Glaucosoma fauvelii*; B, *Pseudogramma polyacantha*; C, *Dampiera melanotaenia*; D, *Gramma loreto*. OL, olfactory lamellae; RA, rachis; TR, trough on the floor of the olfactory sac.

two genera have fewer lamellae (6 to 9) than the other three (Fig. 2). The lamella are also few in *Gramma*, *Opistognathus*, *Plesiops* and *Belonopterygium* (3 to 6; Fig. 2D). Similarly, each lamella originates from the base of the structure, not from the central elongated rachis (Fig. 2D). Reduction in olfactory lamellae counts and absence of the central elongated rachis represent derived character states of perciform olfactory organ.

Johnson (1983) reported that the first dorsal pterygiophore of all members of Kendall's epinepheline-grammistine line (Kendall, 1976) is uniquely lacking an autogenous distal pterygiophore, while the following pterygiophores retain the distal pterygiophores. In *Aporops*, *Pseudogramma*, plesiopids, acanthoclinids and opistognathids, all proximal dorsal ptery-

giophores supporting the spines lack distal pterygiophores (Figs. 3A, 3E, 3F, 3H, 3I). Grammid, on the other hand, has distal pterygiophores in all proximal dorsal pterygiophores (Fig. 3G). The distal ends of adjacent pterygiophores of the dorsal spines in typical percoids are approximate to one another due to the presence of distal pterygiophores (Fig. 3G). Conversely, the distal ends of these pterygiophores in *Aporops*, *Pseudogramma*, acanthoclinids, plesiopids and opistognathids are widely separate (Figs. 3A, 3E, 3F, 3H, 3I). This broad separation between adjacent dorsal pterygiophores for the dorsal spines is primarily due to the absence of distal pterygiophores.

In typical percoids, the posterodorsal tip of the proximal-medial pterygiophore—a compound bone ontogenetically

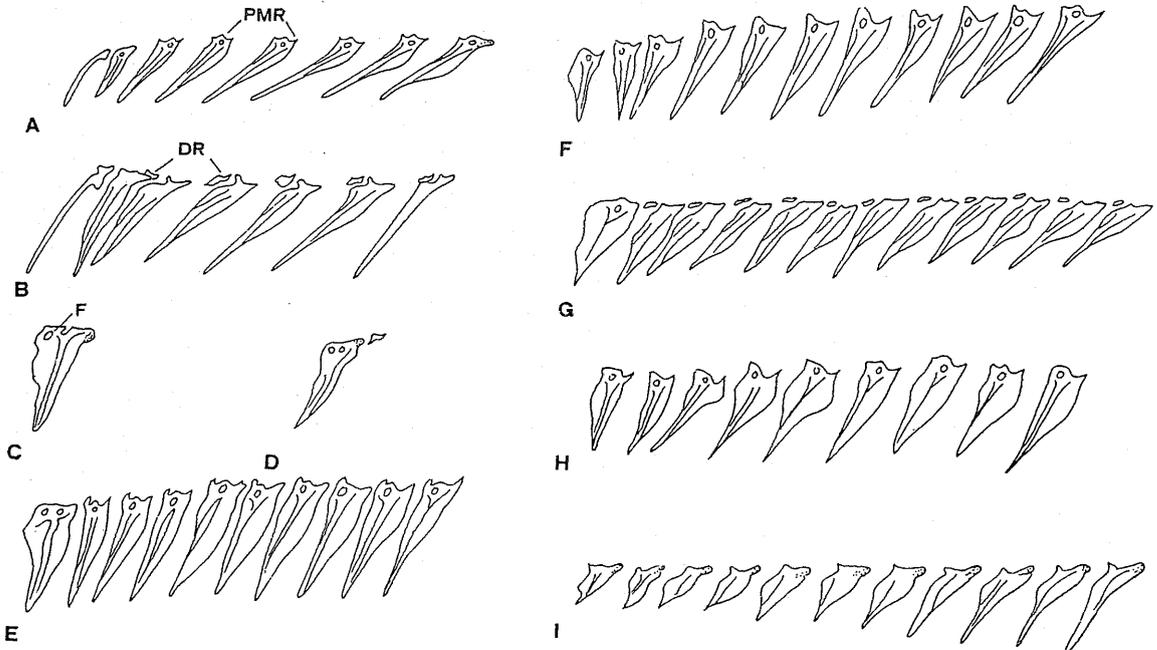


Fig. 3. All dorsal pterygiophores supporting the dorsal spines (except for *Belonopterygium fasciolatum* in which only half of these pterygiophores are shown), left side view, spines removed. A, *Pseudogramma polyacantha*; B, *Grammistes sexlineatus*; C, *Dampiera melanotaenia*; D, *Pseudochromiatapeinosoma*; E, *Calloplesiops altivelis*; F, *Plesiops nigricans*; G, *Gramma loreto*; H, *Belonopterygium fasciolatum*; I, *Opistognathus aurifrons*. F, foramen; DR, distal radials; PMR, proximalmedial radials. Cartilage stippled.

derived from the proximal and medial pterygiophores—supporting the dorsal spines is lined with cartilage (Fig. 3D) and is considered a generalized condition for percoids. Apomorphically, this part of these pterygiophores in *Aporops*, *Pseudogramma*, *Grammistes*, plesiopids and acanthoclinids is tapered and not lined with cartilage (Figs. 3A, 3B, 3E, 3F, 3H).

An interesting condition is expressed in *Grammistes* in which all dorsal pterygiophores (except the first one) for the dorsal spines retain the distal pterygiophores (also see Johnson, 1983); the distal ends of its third to seventh dorsal pterygiophores are widely separate from their immediate following pterygiophores (Fig. 3B). Except for the first dorsal spine in typical percoids which is interlocked with the first dorsal pterygiophore through a foramen, each of the following spines is

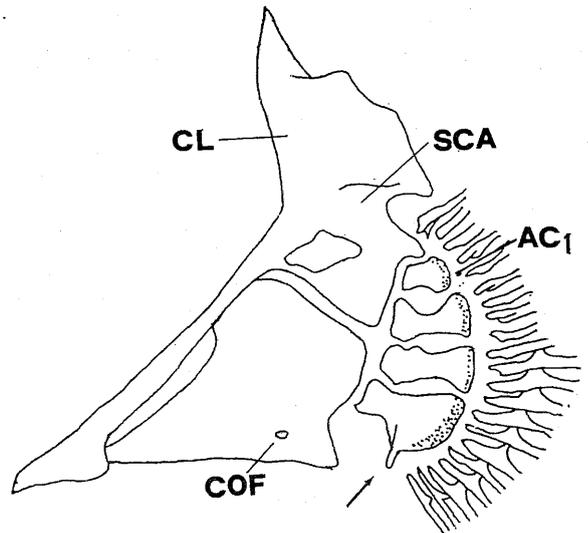


Fig. 4. Left side view of the pectoral girdle of *Opistognathus aurifrons* showing the small spur (pointed by the arrow) on the 4th actinost. AC1, the first actinost; CL, cleithrum; COF, coracoid foramen; SCA, scapular. Cartilages stippled.

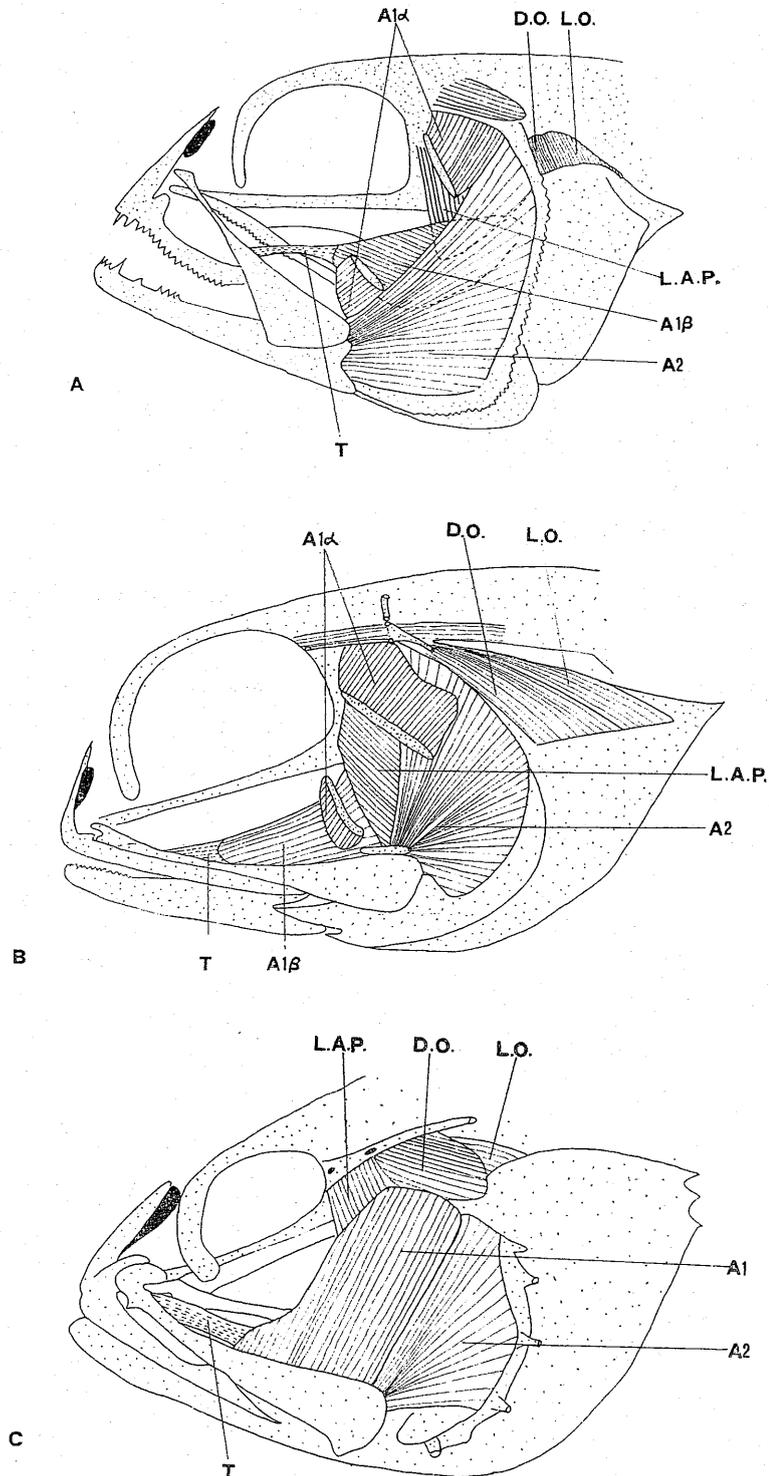


Fig. 5. Left side view of the cheek muscles of A, *Gramma loreo*, B, *Opistognathus darwiniensis*, C, *Pseudogramma polyacantha*. A1 and A2, adductor mandibulae; D.O., dilator operculi; L.A.P., levator arcus palantini; L.O., levator operculi. Cut surfaces of the  $A1\alpha$  are stippled. Cartilage shaded.

governed by the preceding distal pterygiophore and a small posteroanterior hook on the dorsal surface of its corresponding pterygiophore (Fig. 3G). A unique condition is expressed in *Pseudogramma*, *Aporops*, plesiopids and acanthoclinids, that all dorsal spines are interlocked with the dorsal pterygiophores through a hole (Fig. 3). The first dorsal proximal-medial pterygiophore in *Aporops*, *Pseudogramma* and *Grammistes* are thin (Figs. 3A, 3B; also see Kendall, 1976). In *Grammistes sexlineatus* this pterygiophore does not form a foramen for interlocking with the first dorsal spine (Fig. 3B). In most percoids, the muscle epiaxialis is free from the dorsal pterygiophore. In grammids and opistognathids, this muscle uniquely attaches to the dorsal pterygiophores (Fig. 7).

The muscle flexor ventralis externus in the caudal fin which is commonly occurred in percoids is absent in *Grammistes*, *Rypticus*, *Aporops*, *Pseudogramma*, *Liopropoma*, *Diploprion*, *Pseudochromis* (not in *Dampievia*), *Calloplesiops*, *Plesiops*, *Belo-nopterygium*, *Apogon* and *Priacanthus* among the percoids examined. However, this muscle does exist in *Gramma* and *Opistognathus*.

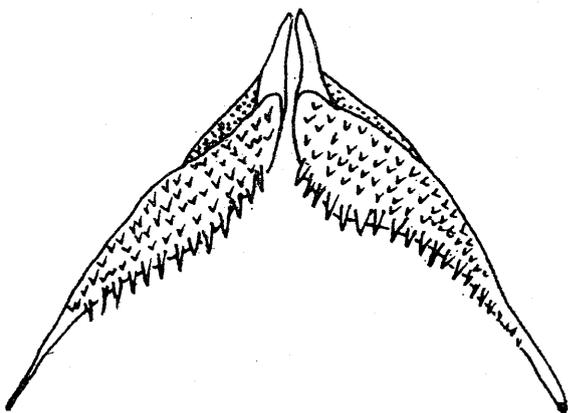


Fig. 6. Dorsal view of the 5th ceratobranchials of *Gramma loreto* showing the sharpened tips which lack the distal cartilage.

A component of the muscle adductor mandibulae in grammids and opistognathids is further subdivided into  $A_{1\alpha}$  and  $A_{1\beta}$  (Fig. 5). This muscle is not subdivided in pseudochromids, plesiopids, acanthoclinids (Smith-Vaniz, pers. comm.) and serranids. As such, its subdivision is treated as an apomorphic character state for this family group.

The fifth ceratobranchials in pseudochromids, grammids and opistognathids are pointed and without a cartilage on their tips representing a unique character for percoids (Fig. 6).

Reduction of pelvic ray number from a general percoid count of 5 to 4 and 2 in plesiopids and acanthoclinids respectively is apomorphic.

## DISCUSSION

The aforementioned unusual similarity among the Grammistini, Liopropomini, Pseudochromidae, Plesiopidae, Acanthoclinidae, Grammidae and Opistognathidae in the morphology of the coracoid, olfactory organ, dorsal pterygiophores and the muscle flexor ventralis externus indicate that these tribes and families may be close relatives of the Serranidae.

Monophyly of the Pseudochromidae, Grammidae Opistognathidae, Plesiopidae and Acanthoclinidae (Fig. 8) is supported by the reduction in number of olfactory lamellae and possibly by the presence of the spur on the cleithrum as well (Table 1). Absence of the latter structure in Acanthoclinidae is considered secondarily as surplus evidences indicating its affinity with Plesiopidae (Table 1).

Within the Pseudochromidae-Grammidae-Opistognathidae-Plesiopidae-Acanthoclinidae group, the following data may also help resolving their relationships.

According to the apomorphic characters of the muscle adductor mandibulae, muscle epiaxialis, pelvic ray count and

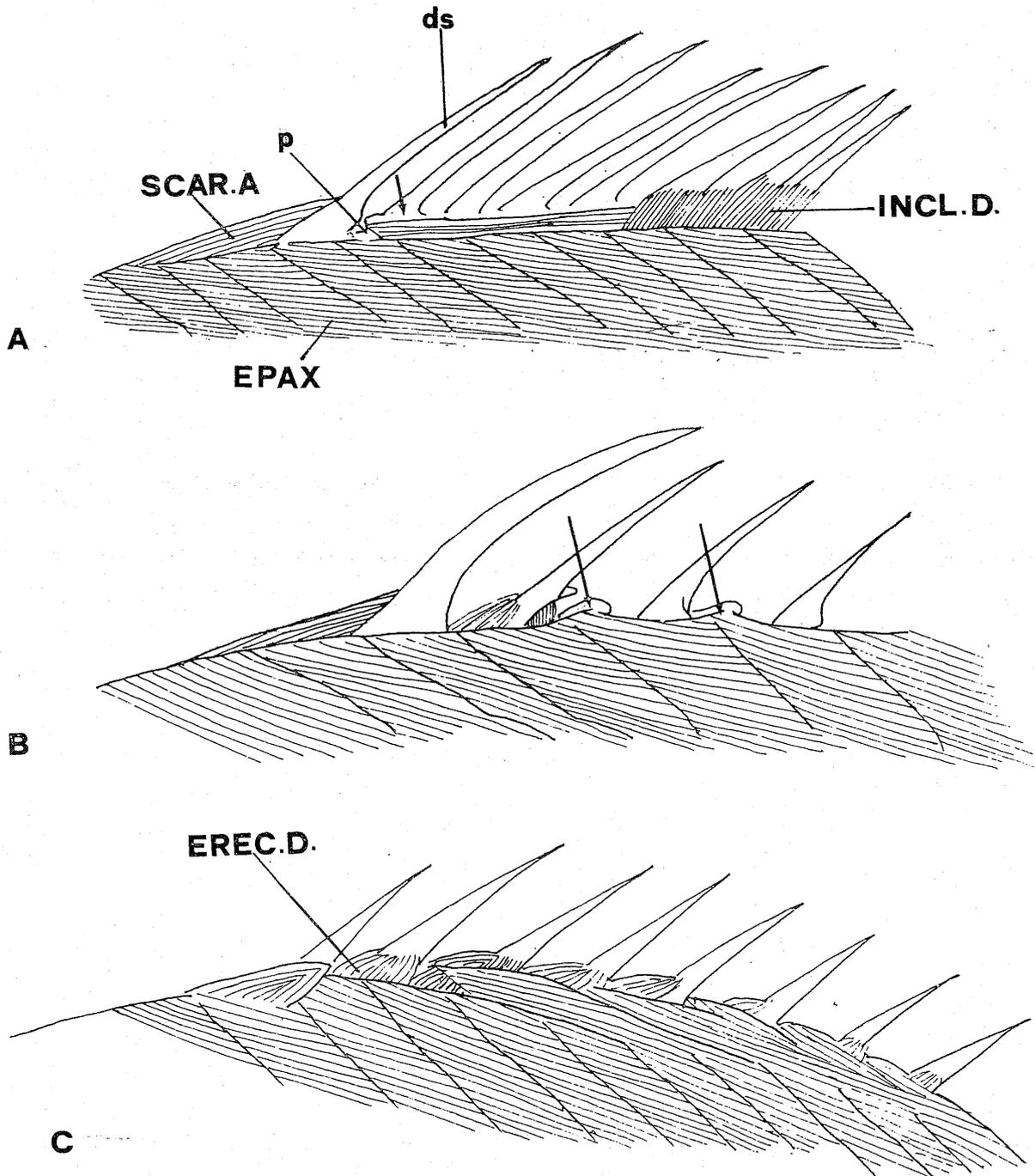


Fig. 7. Left side view of the dorsal region in A, *Grama loreto*; B, *Opistognathus darwiniensis*; C, *Epinephelus caeruleopunctatus*. DS, dorsal spine; EPAX, epaxialis; EREC. D., erectores dorsales; INCL. D., inclinatores dorsales; P, posterodorsal part of the first dorsal pterygiophore; SCAR. A., supracardinalis anterior. Site of myological attachment of the epaxialis to the dorsal pterygiophore is shown by the arrow(s).

Table 1  
Distribution of the apomorphic states of some characters  
in Acanthoclinidae, Grammidae, Opistognathidae,  
Plesiopidae and Pseudochromidae

| Apomorphic character state  | Families             |                |                      |                  |                      |
|---|----------------------|----------------|----------------------|------------------|----------------------|
|   | Pseudochrom-<br>idae | Gramm-<br>idae | Opisto-<br>gnathidae | Plesiop-<br>idae | Acantho-<br>clinidae |
| 1. Olfactory lamella count reduced  | +                    | +              | +                    | +                | +                    |
| 2. Spur on lateroventral edge of the cleithrum  | +                    | +              | +                    | +                |                      |
| 3. Anterior tip of the fifth ceratobranchials pointed and not framed with cartilage   | +                    | +              | +                    |                  |                      |
| 4. M. adductor mandibulae A <sub>1</sub> subdivided to A <sub>1α</sub> and A <sub>1β</sub>  |                      | +              | +                    |                  |                      |
| 5. M. epiaxialis associated with dorsal pterygiophores  |                      | +              | +                    |                  |                      |
| 6. All dorsal spines interlocked with the proximal-medial dorsal pterygiophore  |                      |                |                      | +                | +                    |
| 7. The posterodorsal tip of the proximal-medial dorsal pterygiophores supporting the spines tapered and not framed with cartilage |                      |                |                      | +                | +                    |
| 8. Pelvic ray count reduced   |                      |                |                      | +                | +                    |
| 9. All proximal-medial dorsal pterygiophores supporting the dorsal spines lack distal pterygiophore                               |                      |                | +                    | +                | +                    |

dorsal fin structure, Grammidae-Opistognathidae and Acanthoclinidae-Plesiopidae form two monophyletic groups (Fig. 8). Reduction in pelvic ray count as a synapomorphic character to support the monophyly of the Plesiopidae may not be a strong evidence comparing to the characteristics of the dorsal pterygiophore supporting the spines; reduction in pelvic ray count also takes place in *Pseudoplesiops* and *Anisochromus* of the Pseudochromidae (Godkin and Winterbottom, 1985). The Pseudochromidae is related to the Grammidae and Opistognathidae by showing a very uncommon character of the fifth ceratobranchial. In opistognathids absence of distal ptery-

giophores in all dorsal pterygiophores supporting the spines indicates a close relationship to the Acanthoclinidae and Plesiopidae (Table 1). However, in view of the derived character states of the fifth ceratobranchial, the muscles adductor mandibulae and epiaxialis, it is considered to be more likely that (1) Opistognathidae is related to Grammidae and (2) Pseudochromidae is the sister group of the Opistognathidae-Grammidae (Fig. 8). The monophyly of Opistognathidae is supported by a derived character state of the last pectoral actinost; there is a small spur not framed by cartilage on the ventroposterior corner of this actinost (Fig. 4).

PSEUDOCROMIDAE GRAMMIDAE OPISTOGNATHIDAE PLESIOPIDAE ACANTHOCLINIDAE

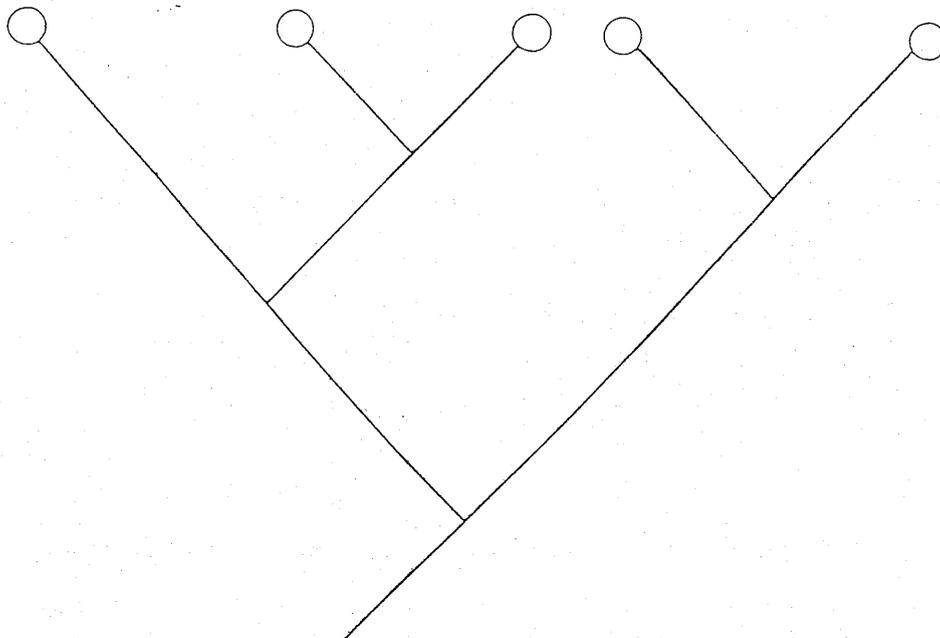


Fig. 8. A hypothetical cladogram for the perciform families Acanthoclinidae, Grammidae, Opistognathidae, Plesiopidae and Pseudochromidae in which the trunk lateral line is modified.

Interestingly, the genera *Aporops* and *Pseudogramma* share derived characters with the serranids (Johnson, 1983) and with the Plesiopidae, Acanthoclinidae and Opistognathidae. However, no derived characters have been noted between these two genera and the Pseudochromidae to which some ichthyologists (see above) have allocated them. Despite of the similarities among the *Aporops*, *Pseudogramma*, plesiopids, acanthoclinids and opistognathids noted in this study, we have no intention to remove these two genera from the Serranidae as such classification has already been justified by previous workers.

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## 鱸目魚類棘鰭銀寶科、線鱸科、七夕魚科、准雀鯛科 及後顎鱸科之親緣關係

莫顯蒼 張弘俊 李奇英

本文敘述鱸目魚類中側線間斷，後段缺如或完全缺如之五科，包括棘鰭銀寶科、線鱸科、七夕魚科、准雀鯛科及後顎鱸科，其骨骼、肌肉及嗅覺系統之形態變異，並就其親緣關係提出下列四個單元羣 (monophyletic groups)：(一)上述五科，(二)線鱸科及後顎鱸科，(三)棘鰭銀寶科及七夕魚科，(四)准雀鯛科、線鱸科及後顎鱸科。

鮨科 (Serranidae) 中之 *Aporops* 及 *Pseudogramma* 二屬亦具相似之側線形態，因此亦與上述五科作形態之比較，結果其他形態雖有相似之處，唯本文作者並不建議改變此二屬目前之分類位置。

