The Osteology and Relationships of Certain Gobioid Fishes, with Particular Reference to the Genera *Kraemeria* and *Microdesmus*[1]

WILLIAM A. GOSLINE[2]

INTRODUCTION

AMONG TROPICAL MARINE PERCIFORM FISHES there is a group of elongate, presumably burrowing forms of small to medium size that superficially resemble one another. Many of these, after varied systematic placement, have come to rest, somewhat uneasily, in the catch-all percoid family Trichonotidae (cf. Schultz, 1943: 261). An investigation of the osteology of one of these genera, *Kraemeria*, showed it to be a gobioid. Comparison with Smith's (1951) account of *Paragobioides copleyi* indicated that it, too, was a gobioid. Smith erected for the single genus *Paragobioides* the family Paragobioididae, which, however, he places near the percoid families Ammodytidae and Trichonotidae. Dr. George Myers called to my attention several years ago the resemblance between *P. copleyi* and the supposedly blennioid family Microdesmidae. Dr. L. P. Schultz has been kind enough to turn over to me two paratypes of *Microdesmus multiradiatus* for dissection. These, too, prove to be members of the perciform suborder Gobioidei.

The main purpose of the present paper is to place the genera *Kraemeria* and *Microdesmus* securely among the gobioid fishes. This has not been difficult, for osteologically the gobioids exhibit many distinguishing characters. A glance at the branchiostegal ray structure, the suspensorium, or even the caudal skeleton would seem sufficient to determine whether or not a fish is a member of the suborder Gobioidei. Indeed, the gobioids have often been treated as a separate order from the Perciformes, e.g., by Jordan (1923), Regan (1936), Smith (1949), and Koumans (in Weber and de Beaufort, 1953). On the other hand Berg (1940), Schultz (1948), and others consider the gobioids as a suborder of the Perciformes. I have no strong personal preference on the matter and assign the gobioids a subordinal status in this paper principally as a matter of conservatism.

Having brought *Microdesmus* and *Kraemeria* into the Gobioidei, the question arises as to the status of these two genera within the suborder. To aid in determining these points, several gobioids of the most divergent types available have been skeletonized. As there appears to have been very little comparative osteological work done on the gobioid fishes, these skeletons are reported on in some detail. The species skeletonized are as follows:

Microdesmus multiradiatus, Panama, formerly U.S.N.M. 85766
Kraemeria samoensis, Marshall Islands
Eleotris sandwicensis, Hawaiian Islands
Ptereleotris microlepis, Marshall Islands
Eviota epiphanes, Hawaiian Islands
Gobiodon rivulatus, Marshall Islands
Kelloggella oligolepis, Hawaiian Islands
Awaous stamineus, Hawaiian Islands

The classification of these species, except for *Microdesmus* which has always been con-

[1] Contribution No. 65. Hawaii Marine Laboratory.
[2] Department of Zoology and Entomology, University of Hawaii. Manuscript received March 3, 1954.

sidered a blennioid, according to Koumans (1931), apparently would be as follows:

Order Gobioidea
- Family Eleotridae
  - *Eleotris sandwicensis*
  - *Ptereleotris microlepis*
  - *Eviota epiphanes*
- Family Gobiidae
  - Subfamily Gobiodontinae
    - *Gobiodon rivulatus*
  - Subfamily Gobiinae
    - *Awaous stamineus*
    - *Kelloggella oligolepis*
- Family Taenioididae
  - Subfamily Taenioininae
    - *Paragobioides copleyi*
- Family Psammichthyidae
  - [=Kraemeriidae]
    - *Kraemeria samoensis*

The osteology of these species might be more assimilable if the external appearance of each could be illustrated. However, this is not feasible. The best that can be done in this regard is to provide citations to existing figures of these species. These are: *Kraemeria samoensis*, (called *Vitreola sagitta*), Jordan and Seale, 1906, pl. 37, fig. 1; *Microdesmus multiradiatus*, Meek and Hildebrand, 1928, pl. 98, fig. 3; *Eleotris sandwicensis*, Jordan and Evermann, 1905, fig. 210 on p. 480; *Ptereleotris microlepis*, Koumans (in Weber and de Beaufort), 1953, fig. 91 on p. 367; *Eviota epiphanes*, Jordan and Evermann, 1905, fig. 211 on p. 482; *Gobiodon rivulatus*, Günther, 1877, pl. 109, figs. F and G; *Awaous stamineus* (the closely related, if not identical species *Gobius crassilabris* is illustrated by Günther, 1877, pl. 108, fig. B), Valenciennes, 1842, pl. 5, fig. 5; and *Kelloggella oligolepis*, Jordan and Evermann, 1905, fig. 215 on p. 488.

I wish to thank Dr. L. P. Schultz of the U. S. National Museum for turning over to me the specimens of *Microdesmus*, and Dr. D. W. Strasburg of Duke University for providing the Marshallese material from which the specimens of *Kraemeria*, *Gobiodon*, and *Ptereleotris* were drawn.

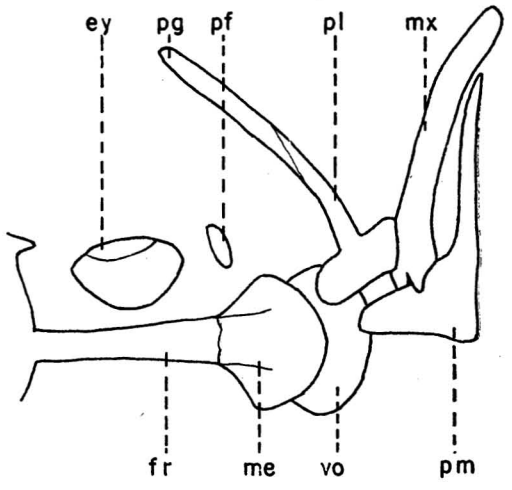

FIG. 1. Anterior portion of head skeleton (plus eye) of *Kraemeria*, from above. EY, eye; FR, frontals (the suture between the frontals is not visible in the interorbital region); ME, mesethmoid; MX, maxillary; PF, prefrontal; PG, pterygoid; PL, palatine; PM, premaxillary; VO, vomer.

COMPARATIVE OSTEOLOGY

Jaws

The jaw structure of the gobioids investigated seems to differ to only a minor degree from that of typical percoids. The strength of the jaws varies from fish to fish: in *Gobiodon* the jaws are short and heavy, in the other species longer and lighter. All the forms have a simple ascending pedicel to the premaxillary. In *Ptereleotris* this pedicel extends to above the middle of the eyes and is longer than the toothed portion of the premaxillary (undoubtedly indicating a protrusible upper jaw); in the other forms the pedicel is much shorter. In all except *Eleotris* the tooth-bearing portion of the premaxillary tapers to a more or less pointed tip laterally (Fig. 1). In *Eleotris*, the upper surface has a flange (similar to that shown by Gregory, 1933: 346 for *Eleotris pisonis*). The maxillary is usually a curved bar of approximately uniform cross-section behind its head (Fig. 1). In *Microdesmus* the maxillary is produced anteriorly from its articulation with the premaxillary

pedicel as a strut that nearly meets its fellow from the other side in front of the premaxillaries. The lower jaw seems to show little variation in the gobioids examined.

Suspensorium

Regan (1911: 730, 731) uses the shape of the palatine as a character for differentiating between the Eleotridae and the Gobiidae. For the Eleotridae he states, "Palatine with an ascending stem articulating directly with a lateral ethmoid apophysis behind the origin of the maxillary process," and for the Gobiidae, "Palatine T-shaped with a posterior process for articulation with the lateral ethmoid." In this feature, *Eleotris sandwicensis* agrees well with Regan's first statement and with his figure of *E. marmorata* (1911: 730, fig. 1). *Awaous* (Fig. 2*c*) shows distinctly the gobiid palatine as described by Regan though it can hardly be called T-shaped. However, the palatines of *Ptereleotris* (Fig. 2*a*), *Eleotris*, and *Gobiodon* (Fig. 2*b*) appear to be more or less intermediate between the eleotrid and gobiid types. Indeed, one strongly suspects that Regan's palatine differentiation is not as distinctive as it appears. In *Microdesmus* (Fig. 2*d*) the palatine is a double-headed bone of peculiar shape which seems to be nearer that of *Awaous* than *Eleotris*. In *Kraemeria* (Fig. 1) the palatine does not seem to articulate directly with the skull at all, almost certainly not with the lateral ethmoid, a small bone lying loose in the flesh.

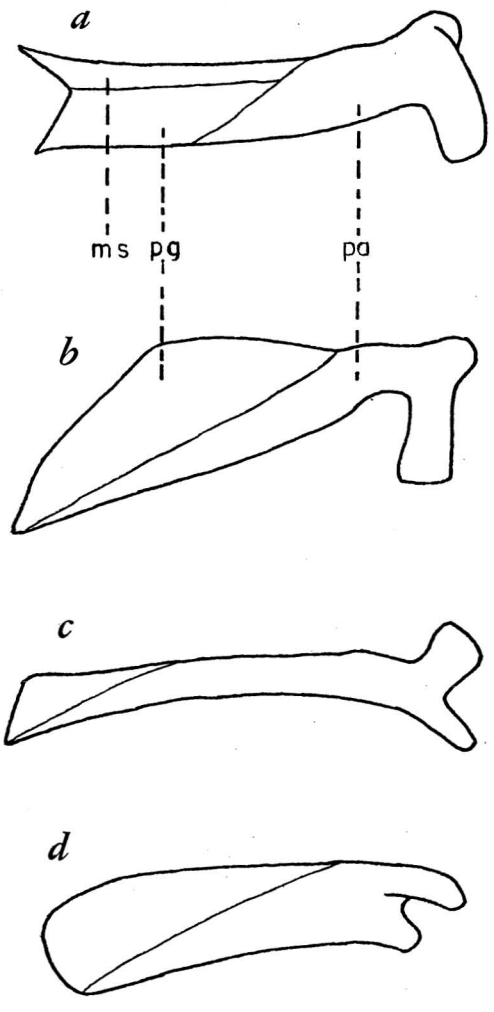

FIG. 2. Right palatopterygoid strut, from outside, of: *a*, *Ptereleotris*; *b*, *Gobiodon*; *c*, *Awaous*; *d*, *Microdesmus*. MS, mesopterygoid; PA, palatine; PG, pterygoid.

In *Eleotris* the palatopterygoid strut is more or less fused to the quadrate in typical percoid fashion (as shown in Regan, 1911: 730, fig. 1) although the mesopterygoid is reduced. In *Awaous* and *Gobiodon*, however, the palatopterygoid strut has become loosely and movably articulated with the quadrate and is thus a more or less independent unit from the rest of the suspensorium. In addition, the mesopterygoid has dropped out completely and the palatine extends backward to the very base of the strut. In all these features *Kraemeria* (Fig. 3*a*) and *Microdesmus* (Fig. 3*b*) resemble the gobiids rather than the eleotrids examined. There can be no doubt that the eleotrid type of palatopterygoid structure represents the least departure from the basic percoid suspensorium.

The most peculiar feature of the gobioid suspensorium is that the rear portion, between the articular and the cranium, instead of comprising the usual single hyomandibular-metapterygoid-quadrate strut, is composed of two struts with a large non-osseus area between

them (Fig. 3). The anterior of these is made up centrally of the symplectic and metapterygoid and the posterior by the preopercle, which has become an integral part of the suspensorium rather than a superficial covering bone. Both supports run between the hyomandibular above and the quadrate below. The non-osseus space between the two struts is covered externally by heavy jaw musculature which so often gives the gobies a fat-cheeked appearance. (The necessity for space for this musculature may have been the causal agent in the development of the peculiar gobioid suspensorium.) I am unaware of a similar suspensorial structure in any other fishes. The closest approach to it may be that of the order Gobiesociformes. This structure seems to be common to all the gobioids. It is found in *Kraemeria* and *Microdesmus*, and is figured by Smith (1951: 522, fig. 1) for *Paragobioides copleyi*.

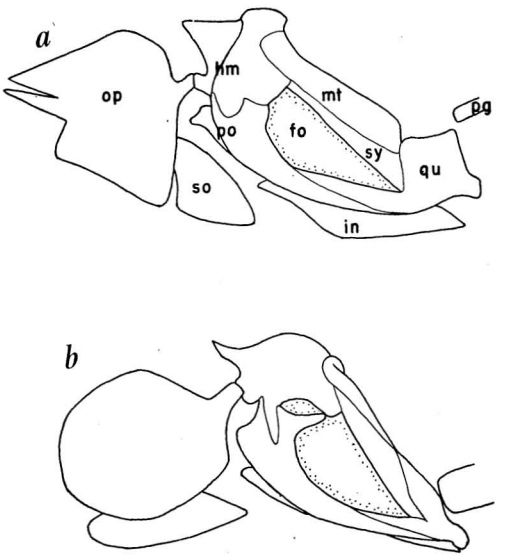

FIG. 3. Right suspensorium (except palatopterygoid strut) and opercular bones, from outside, of: *a*, *Kraemeria*; *b*, *Microdesmus*. FO, non-ossified area; HM, hyomandibular; IN, interopercle; MT, metapterygoid; OP, opercle; PG, pterygoid; PO, preopercle; QU, quadrate; SO, subopercle; SY, symplectic.

Opercular Series

The three opercular bones are present in all the gobioid fishes examined. I find nothing about them noteworthy in reference to the present study.

Gill Openings

The gill openings of all the species here investigated except *Kraemeria* are broadly attached to the isthmus. In *Microdesmus* the gill openings are restricted to a subvertical slit running partly ahead of and partly below the pectoral fins. In *Kraemeria* the gill openings extend far forward, and the gill covers are narrowly attached to the isthmus.

Branchial Arches

The glossohyal in gobioid fishes has recently been dealt with by Takagi (1950). He believes that the primitive gobioid glossohyal is a bar (as it is in most fishes) and that the broad fan-shaped and the forked form are specializations within the group.

Among the fishes investigated here *Pterelectris* has a very long, narrow glossohyal (similar to type A of Takagi's fig. 3), *Eleotris* a subtriangular bar (similar to type B), *Microdesmus* and *Kelloggella* a spatulate glossohyal (nearest to type C), *Gobiodon* a triangular glossohyal (of type C), *Kraemeria* a bar with a slight fork at the tip (near type F), and *Awaous* a broadly forked bar (of type V). Though these glossohyal types agree in general with Takagi's findings, my inability to read more than the summary of his article prevents my checking them in detail.

Another bone that seems to vary greatly in both extent and shape is the urohyal. Inasmuch as the significance of this variation is unknown it will not be described.

A highly diagnostic character for gobioid fishes would seem to be the ceratohyal structure and the branchiostegal ray configuration. The least specialized representation of these features would appear to be that of *Eleotris*.

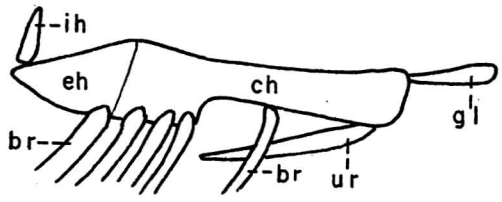

FIG. 4. Right hyoid arch, from outside, of *Kraemeria*. BR, branchiostegal rays; CH, ceratohyal; EH, epihyal; GL, glossohyal; IH, interhyal; UR, urohyal.

Here, as in the other gobies examined (e.g., *Kraemeria*, Fig. 4), the ceratohyal deepends rather abruptly about two-thirds of the way back. In front of this deepened section lie two branchiostegals; on the rear section are three more. The branchiostegals on the narrow and those on the deep section are separated by a considerable interspace. On the epihyal of *Eleotris* there is a sixth branchiostegal. In all of the other gobioids examined there is only one branchiostegal ray on the narrow portion of the ceratohyal, only five branchiostegals in all, and the interspaces between the first and the others is even wider than the interspace between the first pair and the last four in *Eleotris*. This one (or two) plus four sequence of branchiostegal rays not only seems to be characteristic of all the gobies, but to my knowledge is unique to the group. This same sequence is shown by Smith for *Paragobioides* (1951: 522, fig. 1).

So far as I can discern, the other most significant gill arch character within the gobioid fishes occurs in the lower pharyngeals. In *Awaous* the toothed upper surface of these two lower pharyngeals forms a single, coalesced, subtriangular plate. On the lower surface, however, the junction between the two sides shows as a median suture. In *Kelloggella* the two lower pharyngeals are contiguous but not fused. In the others examined, except *Kraemeria*, the lower pharyngeals are separate. In *Kraemeria* the two lower pharyngeals are fused with no sign of a suture either above or below. In *Microdesmus* the lower pharyngeals are small and widely separated.

The anterior gill arches of most of the genera investigated have weakly developed, pectinate gill rakers. *Gobiodon* differs in having a double row of spiny gill rakers on the gill arches.

Cranium

The degree of ossification of the skull of the gobioids investigated seems to bear little relationship to the adult size of the fish. For example the skulls of a 1 inch *Eviota* and an 8 inch *Awaous* are equally well developed. In two of the fishes, *Kelloggella* and *Ptereleotris*, the frontal and ethmoid regions are not well ossified, but this may be because juvenile specimens of the species were skeletonized rather than because the species were small. There is a membrane-covered fenestra over the otic bulla of *Kraemeria*.

The two exoccipital condyles are always well separated. In all the genera examined except *Kelloggella*, *Kraemeria*, and *Microdesmus*, the supraoccipital extends down to the exoccipitals thus separating the epiotics (Fig. 5*b*). In *Kelloggella* and *Kraemeria* (Fig. 5*d*) the two epiotics meet narrowly on the midline behind the supraoccipital; in *Microdesmus* broadly.

In *Gobiodon* there is a crest running along the whole middorsal line of the skull from above the mesethmoid to the exoccipitals. In *Eviota* there is a moderately developed crest on the supraoccipital. The other genera examined have at most a small knob on the supraoccipital, not even that in *Kelloggella*.

The parietals in the gobioid fishes seem to be absent invariably. Among the fishes dealt with here the area the parietals would normally cover is filled in two different ways. In *Eleotris*, *Ptereleotris*, *Awaous*, and *Kraemeria* (Fig. 5*d*) the parietal region is covered by the frontals which run back along the sides of the supraoccipital to the epiotics; the sphenotic in these fishes is small. In *Eviota* (Fig. 5*b*), *Kelloggella*, *Gobiodon*, and *Microdesmus* the sphenotic extends across the upper surface of the skull on each side to the supraoccipitals, thus separating the frontals from the epiotics.

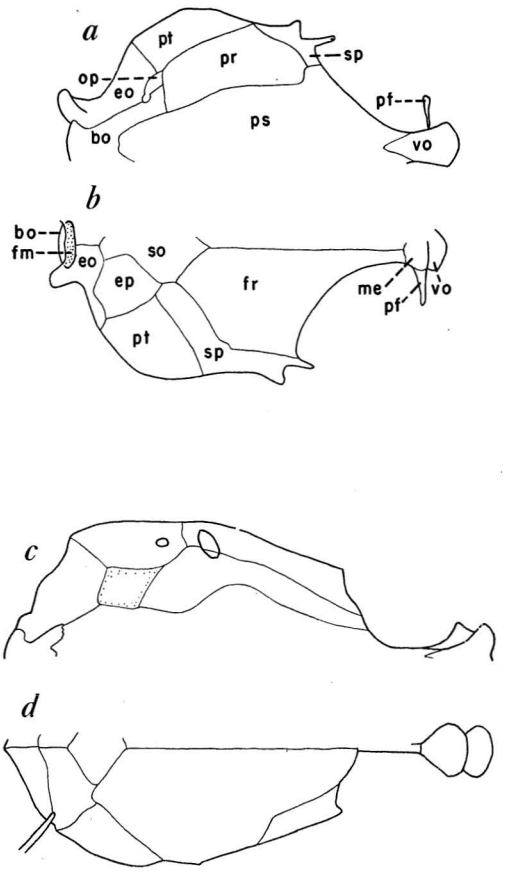

FIG. 5. Skull of *Eviota*, *a*, *b* (*a*, left half from above; *b*, left half from below) and of *Kraemeria*, *c*, *d* (*c*, right half from below; *d*, right half from above). BO, basioccipital; EO, exoccipital; EP, epiotic; FM, foramen magnum; FR, frontal; ME, mesethmoid; OP, opisthotic; PF, prefrontal; PR, prootic; PS, parasphenoid; PT, pterotic; SO, supraoccipital; SP, sphenotic; VO, vomer. The non-ossified area on the ventral surface of the *Kraemeria* skull is partly stippled.

In all the gobioid fishes at hand the skull is abruptly narrowed between the orbits. In the interorbital region the dorsal surface of the skull may be flat as in *Eleotris* and *Awaous*, form a concave trough as in *Ptereleotris* and *Eviota*, or a narrow ridge as in the other genera. The prefrontals are always rather small and may be firmly attached to the skull, more or less movably attached, or completely free as in *Kraemeria* (Fig. 1).

The vomer is toothless in the genera under discussion.

There is no basisphenoid.

The individual bones of the lower surface of the cranium of some of these fishes are not sufficiently well demarcated to allow their certain determination. Consequently, only two bones in this area will be mentioned. The alisphenoids appear to be lacking and, so far as I am aware, are unknown in gobioid fishes. With regard to the opisthotics, Regan (1911: 729) states that these bones are, "large, reaching basioccipital and separating exoccipitals from prootics." Actually, the opisthotics appear to be very variable in the gobioid fishes. In *Awaous* they agree well with Regan's statement and his figure of *Eleotris marmorata* (1911: 730, fig. 1). In *Eviota*, however, the opisthotics are quite small (Fig. 5*a*). In *Kelloggella* and *Kraemeria* they appear to be altogether lacking, and in this agree with *Mistichthys luzonensis* (Te Winkel, 1935: 473). It seems certain that the opisthotics are of no value as a distinguishing character for the gobioid fishes.

Pectoral Girdle

The pectoral girdle shows various stages of degeneration among the fishes examined here.

Regan (1911: 729) states that the posttemporal is forked in gobioid fishes. This is true for the various species investigated except *Kelloggella* and *Kraemeria*. In *Kelloggella* the lower prong of the fork is made up of a ligament at the end of which is a minute ossification (which may possibly represent the detached opisthotic). In *Kraemeria* the posttemporal is a simple strut.

The pectoral radials are said by Regan (1911: 729) to be, "4, large, laminar, united to form a plate." This is more or less true of all the species dealt with here except *Kraemeria*, which has only three actinosts (Fig. 6). It seems probable that the uppermost actinost is the missing one, as this one is reduced to a very weak strut in *Kelloggella*.

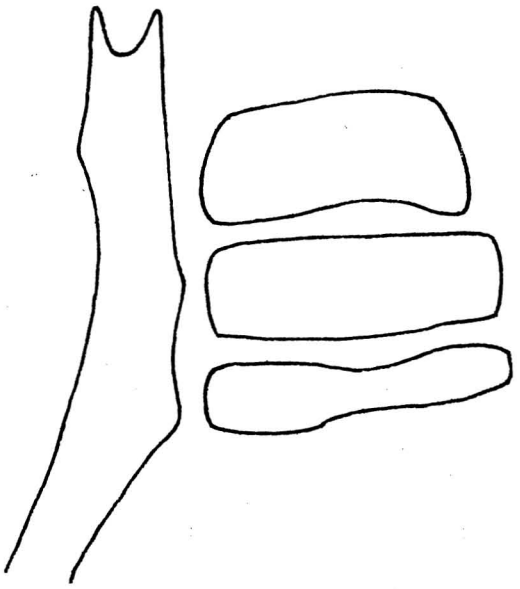

FIG. 6. Left pectoral girdle, from outside, of *Kraemeria* showing cleithrum and the three actinosts.

Regan uses the primary pectoral girdle as a method of distinguishing between the Eleotridae and Gobiidae. Of the Eleotridae Regan (1911: 730) states: "Hypercoracoid [scapula] and hypocoracoid [coracoid] well developed; radials [actinosts] inserted on hypercoracoid, hypocoracoid, and on the ligamentous or cartilaginous tissue between these bones;" of the Gobiidae: "Hypercoracoid absent; radials inserted on the cleithrum, only the lowest in contact with the hypocoracoid."

Among the larger or better ossified skeletons *Eleotris* and *Eviota* have a scapula and *Gobiodon* and *Awaous* do not. However, among the more weakly ossified pectoral girdles which include *Microdesmus*, *Ptereleotris*, *Kelloggella*, and *Kraemeria* I can find neither coracoid nor scapula. Consequently I can only conclude that the osteological characters of the pectoral girdle, if valid, are extremely difficult to use.

Vertebrae

Regan has given the vertebral number among gobioid fishes as 25 to 28 for the Eleotridae and 25 to 34 for the Gobiidae. Among the species investigated here *Ptereleotris*, *Eviota*, *Kelloggella*, *Gobiodon*, and *Kraemeria* each has 26 vertebrae. However, the vertebral count given by Reid (1936: 71) for *Microdesmus multiradatus* is 62, and the range of vertebral variation found by Reid in the genus *Microdesmus* is 42 to 62. Smith (1951: 521) gives the vertebral count of his *Paragobioides copleyi* as 59. Thus *Microdesmus* and *Paragobioides copleyi* have vertebral counts lying well beyond the normal vertebral range in the Gobioid fishes. It is true that these two genera are made up of far more elongate fishes than the usual goby. Nevertheless, there are other elongate gobioids that so far as known do not have more than 34 vertebrae (cf. Hora, 1924: 156).

Caudal Skeleton

The caudal skeleton of the gobioid fishes (Fig. 7*a–c*) appears to be highly diagnostic. Above and below the main wings of the hypural fan are small splint-like bones. In front of the upper splint is a large plate-like ossicle that appears to lie free in the membrane above the urostyle, or which, in *Awaous*, is attached along its anterior edge to the preurostylar neural spine. These main features of the gobioid caudal skeleton seem to be constant in all of the species examined; variations in some of the minor features are illustrated in Figure 7*a–c*.

The small island of bone above the urostylar vertebra does not seem to be essentially different from that found in the typical percoid *Epinephelus*. However, *Epinephelus* and most other perciform fishes (Fig. 7*d–f*) examined do not have the splint-like bones above and below the hypural fan. Smith's figure of *Paragobioides copleyi* (1951: 522, fig. 1E) does not show these splints either, but as they are small they may have been overlooked.

Fins

In the fishes dealt with here there is either approximately (*Eleotris*, *Microdesmus*) or ex-

actly (*Awaous*, *Kelloggella*, *Eviota*, *Gobiodon*, *Kraemeria*) one soft dorsal (or anal) ray per vertebra in the region occupied by these fins. *Ptereleotris* differs rather sharply from the foregoing genera in having two or three soft rays per vertebra.

All of the genera examined except *Microdesmus* have a separate spinous dorsal of five or six soft spines, the last of which is somewhat separated from the others; the interneural of the first spine extends between the 3rd and 4th neural arches and the last between the 7th and 8th neural arches. In *Microdesmus* the dorsal is a single undifferentiated fin the first interneural of which lies between the 4th and 5th vertebra.

The number of principal caudal rays is indeterminable in several of the species investigated.

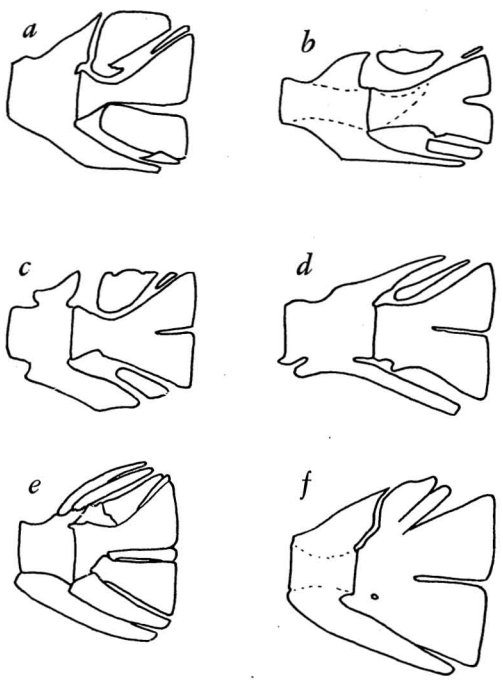

FIG. 7. Caudal skeleton of three gobioids (*a*, *Ptereleotris*; *b*, *Kraemeria*; *c*, *Kelloggella*), of two percoids (*d*, *Crystallodytes cookei* (Trichonotidae); *e*, *Ammodytes tobianus*), and of a blennioid (*f*, *Istiblennius gibbifrons* (Blenniidae)).

The pectoral fin is more or less rounded in all of these species. The number of pectoral rays is 12 in *Microdesmus* and only 8 in *Kraemeria*. The low number of pectoral rays in *Kraemeria* is probably correlated with the degeneration of the pectoral girdle in this fish.

The pelvic fins of *Eleotris*, *Ptereleotris*, *Eviota*, *Kraemeria*, and *Microdesmus* are separate. Those of *Awaous*, *Gobiodon*, and *Kelloggella* are fused. There are five soft rays in the pelvic fins of all except *Eviota*, which has four, and *Microdesmus*, which appears to have only three soft rays.

RELATIONSHIPS

I believe there can be no question regarding the allocation of *Microdesmus* and *Kraemeria* to the gobioid fishes. Both of these genera agree with most of the characters by which the gobioid fishes have been and can be defined: the absence of parietals from the skull and the peculiarities in the suspensorium, hyoid arch, and caudal skeleton. In all these features *Microdesmus* and *Kraemeria* disagree with both the blennioid and the trichonotid fishes.

By contrast the chief features by which these two genera can be and have been separated from the gobioid fishes are as follows.

In *Kraemeria* the gill openings extend rather far forward, but they also do in the gobioids *Glossogobius*, *Chaenogobius*, and *Trimma* (Schultz, 1943: 223, 248). The epiotics meet below the supraoccipital, but they also do in *Kelloggella* as noted above. The opisthotics are absent, but Te Winkel has been unable to find opisthotics in *Mistichthys* and I have been unable to find them in *Kelloggella*. The lower fork of the posttemporal is lacking, but it also is in *Kelloggella*. Finally, the pectoral girdle and fin are greatly reduced, but in this *Kraemeria* merely shows a terminal stage in a reduction demonstrated in other gobioids.

Microdesmus differs from the typical gobioids chiefly in the great elongation of the

body and in the apparently correlated increase in number of vertebrae and change in dorsal fin structure. In the typical gobioids the vertebral number is apparently around 26, but in some of the more elongate species the number reaches 34. *Microdesmus*, with 42 to 62 vertebrae seems to be simply the terminal point in a line of gobioid specialization for which intermediate steps are known. The absence of a separate spinous dorsal fin is also known in other gobioid genera, most of them again elongate forms; in many of these the dorsal spines are poorly differentiated from the soft rays.

It may be well, at this point, to summarize the salient characters which would seem to distinguish the Gobioidei, including *Kraemeria* and *Microdesmus*, from other suborders of the Perciformes.

Parietals lacking. Branchiostegals (4) 5 or 6, the first one or two well separated from the others. Mesopterygoid narrow or absent. Preopercle and symplectic widely divergent above, with an interspace between them. Hypurals with a splint-like bone above and below.

A host of less diagnostic characters might be added. Nevertheless, it is necessary to weed out of the existing diagnoses of the gobioid fishes, for example those of Regan (1911: 729) and Koumans (in Weber and de Beaufort, 1953: 1), a number of the features usually listed.

The pelvic fins may be reduced (*Microdesmus*) beyond, "4 or 5 soft rays." The epiotics are not always (*Kelloggella*, *Microdesmus*, and *Kraemeria*), "separated by the supraoccipitals." The opisthotic is not always large (*Eviota*, *Kelloggella*, *Kraemeria*). The lower pharyngeals are not always separate (*Awaous*, *Kraemeria*). The posttemporal is not always forked (*Kelloggella*, *Kraemeria*). There may be only three actinosts (*Kraemeria*). Finally, the number of vertebrae may be very much greater than 34 (*Microdesmus*).

Before attempting to establish the position of *Microdesmus* and *Kraemeria* within the Gobioidei it may be well to list in phylogenetic key form the principal osteological differences between the various forms here examined.

1a. Branchiostegal rays 6. . . . . **Eleotris**
1b. Branchiostegal rays 5.
2a. Two or three soft dorsal interneurals to each neural spine. . . . . **Ptereleotris**
2b. Usually one soft dorsal interneural to each neural spine.
3a. Fewer than 30 vertebrae; a separate spinous dorsal fin of 5 or 6 spines.
4a. Four actinosts and 12 or more pectoral rays; gill membranes broadly attached to the isthmus.
5a. No crest running along the whole top and back of head; branchial arches without or with weakly-developed gill rakers.
6a. Lower pharyngeals separate; sphenotics meeting the supraoccipital.
7a. Epiotics separated by the supraoccipital; pelvics separate. . . . . **Eviota**
7b. Epiotics meeting behind the supraoccipital; pelvics united. . . . . **Kelloggella**
6b. Lower pharyngeals fused; sphenotics not meeting the supraoccipital . . . . . **Awaous**
5b. A crest running along the top and back of skull; branchial arches with two rows of spinous gill rakers. . . . . **Gobiodon**
4b. Three actinosts and 8 pectoral rays; gill membrane narrowly united to the isthmus. **Kraemeria**
3b. Sixty-two vertebrae; no separate spinous dorsal fin. . . . . **Microdesmus**

This synopsis indicates the general opinion that in the Gobioidei *Eleotris* is undoubtedly nearest to the basic percoid stock from which the gobioids appear to have arisen. Beyond *Eleotris* there would seem to be a number of

lines of specialization as well as a major grouping around the typical gobies. With the meager amount of material at hand it seems impossible to delimit these adequately or properly. About all that can be said is that a division between the gobioid fishes with ventrals separate and those with ventrals united may be convenient, but that it probably does more to obscure than to clarify the true phylogenetic sequences within the Gobioidei.

KRAEMERIIDAE

As noted by numerous authors, e.g., Schultz (1943: 262), the genus *Kraemeria* has been described at least three times, i.e., as *Kraemeria* (Steindachner, 1906: 41), and *Vitreola* (Jordan and Seale, 1906: 393) from Samoa, and as *Psammichthys* (Regan, 1908: 246) from the Seychelles. The genus has been placed among the gobioids by Jordan and Seale (1906: 393), Regan (1911: 733), etc., and with the trichonotids by Regan (1908: 246), Fowler (1938: 300), Schultz (1943: 262), etc. A family (Psammichthyidae) was first erected for it by Regan (1911: 733).

Aside from *Kraemeria* only two other genera seem to have been attributed to the Kraemeriidae. One of these is *Gobitrichonotus* Fowler (1943: 85). This genus would seem to differ from *Kraemeria* chiefly in that the pelvics are fused and the two dorsal fins are completely separate. In these features *Gobitrichonotus* is intermediate between the typical gobies and *Kraemeria*, thus making the Kraemeriidae more difficult to define.

More recently Whitley (1951: 402) has described the rather nondescript genus *Parkraemeria* as a kraemeriid. Whether or not this fish is actually related to *Kraemeria* I am unable to judge.

The question of the rank to be attributed to *Kraemeria* and *Gobitrichonatus* within the Gobioidei cannot be finally determined until more is known about the other forms of the suborder. Tentatively, and in part because it causes no nomenclatorial innovation (cf. Berg, 1940: 487), the two genera *Kraemeria* and *Gobitrichonotus* may be recognized as a family Kraemeriidae. The family may, perhaps unsatisfactorily, be distinguished from other gobioid families as follows:

Scaleless, small-eyed gobioid fishes with a projecting chin. Gill openings extending rather far forward, the gill covers narrowly attached to the isthmus. Pectoral rays 8 or 9. Dorsal and anal free from the caudal. Pelvics separate or united. Dorsals separate or united.

If *Parkraemeria* actually belongs to the Kraemeriidae several of the diagnostic features given above will have to be omitted, leaving a rather weak residue, for *Parkraemeria* lacks a projecting chin and has large eyes and 15 pectoral rays.

MICRODESMIDAE

The microdesmids, to my knowledge, have been universally treated as blennioid fishes, and have been accorded family status, c.f. Regan (1912: 274). The Microdesmidae consists, according to Reid (1936), of a single genus *Microdesmus* described by Günther (1864: 26) containing 10 species from both coasts of tropical America and from the Cameroons. However, certain species from the tropical western Pacific not included by Reid apparently also belong with the microdesmids. In 1858 Bleeker described the genus *Gunnellichthys* from the East Indies. Jordan (1923: 233) placed this genus in his provisional family Chaenopsidae, and de Beaufort (in Weber and de Beaufort, 1951: 447) allocated it to the Pholidichthyidae. It appears from evidence presented below, that *Gunnellichthys* must not only be extracted from the above families but removed from the blennioid fishes altogether and placed with *Microdesmus* among the gobioids.

Kendall and Goldsborough (1911: 324) described the genus *Paragobioides*, based on *P. grandoculis* from the Marshall Islands. This species has been allocated to the percoid fam-

ily Trichonotidae by Fowler (1938: 206) as well as to the gobioid Taeniodidae (Hora, 1924: 162). It was supposedly redescribed from Line Island specimens by Fowler (1938: 206), but since Fowler's redescription states in part: "gill openings wide, extend well forward," there seems some doubt that Fowler had Kendall and Goldsborough's species.

In 1951 Smith described *Paragobioides copleyi* and erected for the genus the family Paragobioididae, which he places near the Ammodytidae and Trichonotidae. As Dr. Strasburg first pointed out to me, Smith's description and figure of *Paragobioides copleyi* differ in only minor respects from those given by de Beaufort (*loc. cit.*) for *Gunnellichthys pleurotaenia*. (In *Gunnellichthys pleurotaenia* the dorsal and anal fins are said to be attached by a low membrane to the caudal; in *Paragobioides copleyi* the dorsal and anal are said to end before the caudal base. In *G. pleurotaenia* the pelvic rays are said to be 2; in *P. copleyi* they, "vary from 4–6." In *P. copleyi* the chin protrudes; in *G. pleurotaenia*, the figure does not show a protruding lower jaw.) It would seem therefore that *Paragobioides copleyi* and *Gunnellichthys pleurotaenia* may well be congeneric.

Another species with a banded color pattern similar to those of *Gunnellichthys pleurotaenia* and *Paragobioides copleyi* is *"Cerdale" bilineatus*, rather briefly described but not figured by Clark (1935: 394) from the Galapagos. About all that can be said from Clark's description is that his species most probably belongs in the *Gunnellichthys-Paragobioides-Microdesmus* group.

The differences between *Paragobioides copleyi* and *P. grandoculis* would seem to be of about the same magnitude as those separating the former species from *Gunnellichthys pleurotaenia*. Smith has already noted (*op. cit.*: 521) the more anterior origin of the pectoral and the different coloration of *P. copleyi*. In addition, unlike *P. copleyi*, the dorsal rays of *P. grandoculis* are said to be "somewhat produced beyond membrane."

Without specimens at hand it seems futile to try to determine whether *Microdesmus*, *Gunnellichthys*, and *Paragobioides* are separate and valid genera. It may be that all three will have to be combined into a single genus (*Gunnellichthys*) but in order to make as few nomenclatorial changes as possible the three genera may provisionally be maintained as separate. They may be separated, probably artificially and certainly unsatisfactorily, by the following key:

1a. Pelvic soft rays 2 or 3.
  2a. Body without a well marked longitudinal stripe. Dorsal and anal united to the caudal by a membrane . . . . . **Microdesmus**
  2b. Body with a well-marked longitudinal stripe.
    (3a. Dorsal and anal free from the caudal . . . . . **"Cerdale" bilineatus** Clark)
    3b. Dorsal and anal connected with the caudal by a low membrane . . . . . **Gunnellichthys**

1b. Pelvic soft rays 4 to 6. Caudal free from the dorsal and anal . . . **Paragobioides**

The osteology of *Microdesmus multiradiatus* has been dealt with above. That of *Paragobioides copleyi* has been described by Smith (1951). The main differences I can find between these two accounts are as follows. In *P. copleyi* the radials of the first few dorsal rays are said, and shown (Smith, 1951: 521 and fig. 1B), to be quite isolated and subhorizontal; in *Microdesmus* they are well developed and interdigitate with the tips of the neural spines. In *P. copleyi* the pectoral girdle is well ossified and exactly as described and shown by Regan for the Gobiidae; I am unable to determine the details of the pectoral girdle structure in *Microdesmus*. The skull is said to be highly cartilaginous in *P. copleyi* (in which the total length of the fish was only 2 to 3 inches), whereas in a skeleton of *M. multiradiatus* (5.5 inches in length) the skull is well ossified. In *P. copleyi* there is said to be a large mesopterygoid, but I believe that this

bone is really the pterygoid, as no pterygoid is shown in Smith's figure (1951: 522, fig. 1). Smith also shows (same fig.) the ceratohyal as a bone of even depth throughout, whereas in *Microdesmus* the ceratohyal is abruptly deepened posteriorly. Again in *P. copleyi* there are, as mentioned above, no splint-like bones shown (Smith, 1951: 522, fig. 1E) above and below the hypural fan, but this I suspect may be an omission. These differences are in no way significant, in my opinion.

The family to which these genera belong may provisionally be called the *Microdesmidae* (following Regan, 1912; Reid, 1936; etc.). The peculiarities of the family within the suborder Gobioidei consist chiefly of the elongation of the body with the correlated increase in vertebral number and the continuous dorsal fin without distinction between spines and rays. In addition, however, it has a peculiar maxillary structure in that the maxillaries send out anterior prolongations which meet or nearly meet each other on the midline in front of the premixillary pedicels.

The family thus defined seems to be of circumtropical distribution. The Microdismidae, however, have been associated hitherto with temperate blennioid families. From these they can, I believe, be differentiated externally by having two widely separated nostrils on each side of the head, one near the snout rim and the other just in front of the eye. Internally, they can be separated by any of the gobioid features listed above, and also by the complete absence of a circumorbital ring of bones. The elimination of the tropical microdesmids from the temperate series of blennioid families seems logical geographically as well as phylogenetically.

Among tropical groups the Microdesmidae may perhaps most easily be confused superficially with the Trichonotidae or certain of the tropical blennioid groups, e.g., the Pitroscirtinae, Xiphasiidae, Congrogadidae, etc. From the Trichonotidae the Microdesmidae may be differentiated externally by the presence of small, round, somewhat embedded scales. From the blennioid groups the Microdesmidae may perhaps most easily be separated superficially by the fact that the anterior nostril lies about on the snout rim (well above the snout rim in blennies so far as I can determine).

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