

Sexual dimorphism in the osteology and myology of monacanthid fishes

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Abstract

Sexual dimorphism in the body form of some monacanthid taxa is very pronounced. The female is usually deeper bodied with a more concave snout profile than the more streamlined male. In addition, the second dorsal and anal fins of the female are generally less elevated anteriorly than those of the male. These differences are reflected in variations of the underlying bones and muscles, particularly those adjacent to the bases of the second dorsal and anal fins. These differences are described and the reasons for them discussed.

Introduction

Differences in morphology between males and females of many species in the family Monacanthidae, commonly known as leatherjackets and filefishes, have caused considerable confusion in the past. Some of these differences now are better known, especially those involving body colour and scale structures (e.g., Randall 1964; Hutchins 1977, 1986; Tyler 1980). However, one which has received less attention in the literature entails the overall shape of the fish. Males of numerous species are usually more elongate than females, and possess convex dorsal profiles to the head, as against a more concave profile in females (Figure 1). These differences are further accentuated by the shape of the second dorsal and anal fins. The anterior portion of each fin often is prominently elevated in males, producing an elongate, swept-back lobe, whereas in females, these fins usually are much lower, the anterior fin rays sometimes being only a little longer than the middle rays (Figure 1). This has led some workers to recognise males and females of the same taxa as separate species (e.g., Fraser-Brunner 1941; Masuda et al. 1975; Hutchins 1977; Kotthaus 1979). This situation recently was explored in detail as part of a larger study on the morphology and phylogeny of the family (Hutchins 1988); however, much of that investigation still remains unpublished. The purpose of the present paper, therefore, is to report on this sexual dimorphism, and show how it is related to hitherto unreported differences in osteology and musculature that appear to be unique to the family.

Methods

Specimens of 96 of the 97 species considered valid (Hutchins 1988) were examined using radiography, whole skeletons, and cleared and stained material. For the last-mentioned examination, specimens were prepared following the trypsin digestion method of Taylor (1967). (The largest specimen cleared and stained was 105 mm SL). Where possible, the material examined for each species included adults of both sexes and unsexed juveniles.

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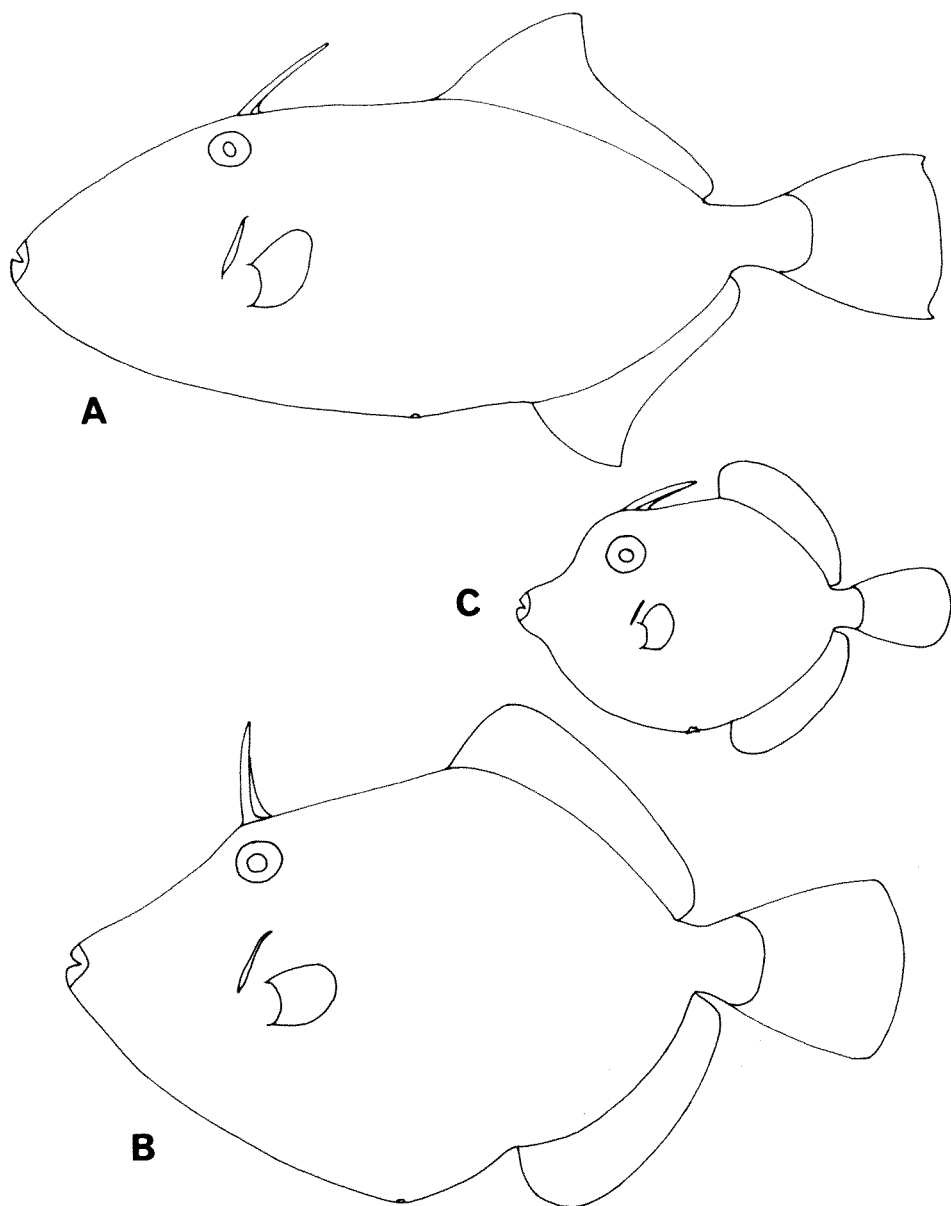


Figure 1 *Eubalichthys mosaicus* showing external differences in body form between A, male, 410 mm SL; B, female, 287 mm SL; and C, juvenile, 43 mm SL.

Results

A total of 57 species showed some form of sexual dimorphism in body and fin shapes, of which 21 species displayed significant variations. Twelve of the latter belong to the genera *Eubalichthys* (four species) and *Paramonacanthus* (eight species). The following synthesis is based on the examination of these taxa.

Internal scrutiny revealed obvious sexually related differences in the shape of the neural and haemal spines of the anterior vertebrae, the positioning of the basal pterygiophores of the second dorsal and anal fins, the size of the rounded spaces located distally between these basal pterygiophores (referred to hereafter as the interpterygiophore spaces), the shape of both the basal pterygiophore of the first dorsal fin and the ethmoid, the structure of the muscles controlling the anterior fin rays of the second dorsal and anal fins, the size of these fin rays and their basal flanges, and the shape of the pelvis. These differences are presented in more detail below.

The four predorsal neural spines of the male are often deformed when compared with those of the female (Figures 2A,B). The spines are more compressed and bent over in the male, the distal ends being deflected posteriorly (the predorsal neural spines of the female also may be curved posteriorly, but generally are shaped more like those of the juvenile [Figures 2B,C]). In some cases, the posterior two predorsal spines of the male are prominently distorted as if crushed (Figure 2A). Furthermore, the subsequent vertebrae may possess dorsal and haemal spines that are more slender in the male than in the female (Figures 2A,B), and, in some species, directed more obliquely rearwards. These differences all appear to be related to the position of the basal pterygiophores of the second dorsal and anal fins (referred to below as the dorsal and anal pterygiophores respectively). In the female and juvenile, the inner extremities of the anterior pterygiophores are always well separated from the centra of the vertebrae (Figures 2B,C). In the maturing male, however, the pterygiophores apparently migrate inwards as the fish grows, pushing over and partly enveloping the neural and haemal spines, and eventually reaching almost to the centra of the vertebrae (Figure 2A). Also, the vertebral spines of the male generally are less robust than those of the female, and thus are more easily deformed as a result of this inwards movement (the movement of the large anteriormost dorsal pterygiophore probably exerts sufficient force on the adjacent vertebrae in some species to almost crush their neural spines). These changes affect only the anterior 10 or so vertebrae of the male, most of which are positioned beneath the elevated portions of the second dorsal and anal fins. The more posterior vertebrae are similar in shape to those of the female.

The interpterygiophore spaces — usually circular to oval in shape — are greatly enlarged anteriorly in the male, but much smaller in size posteriorly (Figure 2A). In the female and juvenile (Figures 2B,C), the spaces are more uniform in size. It appears that as the male matures, bone surrounding the interpterygiophore space is reabsorbed, causing the space to become larger. Even the distal tips of the adjacent neural spines are affected by this absorption (Figure 2A). These enlarged interpterygiophore spaces occur only beneath the elevated portions of the second

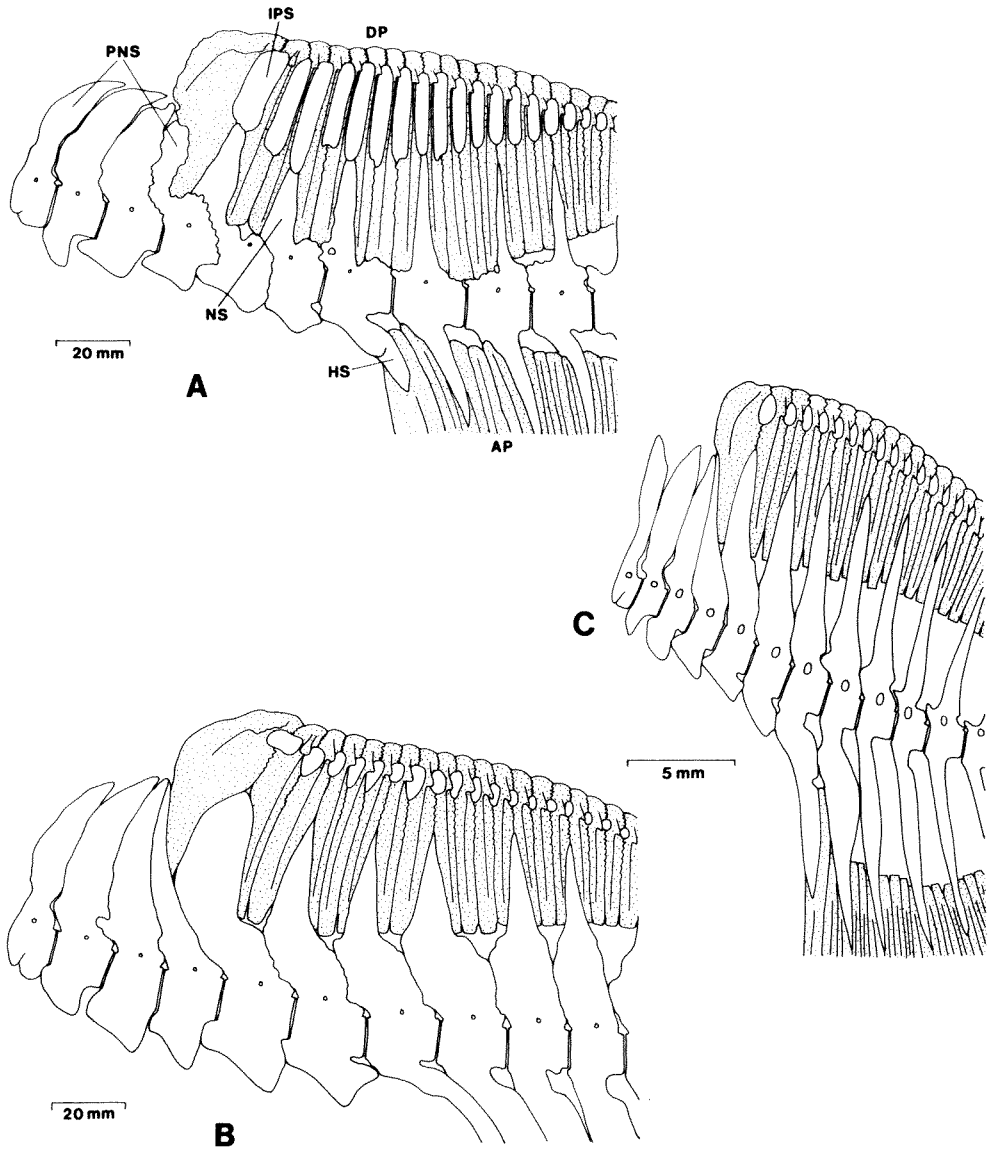


Figure 2 *Eubalichthys mosaicus*, lateral view of anterior portion of axial skeleton showing differences in vertebrae and pterygiophores of A, male, 410 mm SL; B, female, 420 mm SL; and C, juvenile, 53 mm SL (anteriormost vertebra and epipleural ribs not shown, anterior end faces left, and pterygiophores stippled; abbreviations — AP, anal pterygiophores; DP, dorsal pterygiophores; HS, haemal spine; IPS, interpterygiophore space; NS, neural spine; PNS, predorsal neural spines).

dorsal and anal fins of the male. The largest interpterygiophore space is usually associated with the longest fin ray.

Changes to the head shape mostly involve the dorsal profile (lateral view) of the snout and forehead. In the female and juvenile, the dorsal profile of the head is usually straight to concave, whereas in the male it is more convex. This is due to differences in the shape of both the basal pterygiophore of the first dorsal fin, which is located on the dorsal surface of the cranium, and the ethmoid. The pterygiophore of the male generally is longer and lower in height than in the female, the condition in the latter being similar to that of the juvenile; the dorsal profile of the ethmoid in the male is more convex than in the female. In addition, the males of some species of *Paramonacanthus* usually develop a prominent dorsal ridge on the ethmoid which further accentuates the convexity of the snout.

Males of some taxa that are small enough to clear and stain (*Paramonacanthus*) possess certain lateral muscle bands which do not clear in trypsin. The muscles controlling the movement (erectores dorsales and anales, and depressores dorsales and anales, see Winterbottom 1974) of the elevated fin rays of the second dorsal and anal fins remain a translucent brownish colour to almost opaque (Figure 3A), whereas the remaining muscles of the male, as well as all muscle tissue in the female and juvenile, become totally transparent (Figure 3B). Furthermore, when freshly killed male specimens are heated in boiling water (i.e. cooked), these non-clearing muscle bands turn a noticeably more greyish colour than the surrounding flesh which typically is white.

The elevated portions of the second dorsal and anal fins of the male consist of noticeably thickened rays (Figure 3A). The bases of these fin rays possess enlarged, mushroom-shaped ventral flanges, one to each ray. However, the more posterior rays, as well as all fin rays of the female and juvenile, are narrower and possess only small ventral flanges (Figures 3A,B). Furthermore, the distal ends of the dorsal and anal pterygiophores that support these enlarged flanges also are noticeably thickened, a condition not found in the more posterior pterygiophores of the male, nor in any of the pterygiophores of the female and juvenile.

The monacanthid pelvis lies just under the skin along the ventral profile of the abdomen. Sexual dimorphism is sometimes evident in the size of the dorsal lobe near the rear end of the pelvis (small in the female and the juvenile, relatively large in the male) and the shape of the pelvic shaft. In several species of *Eubalichthys*, for example, the shaft is noticeably curved in the deep-bodied female and juvenile, but is much straighter in the more slender male (Figure 4).

In some male individuals of *Paramonacanthus*, sexual dimorphism is not always as obvious as indicated above. These males may be only slightly deeper than the typical female form, with a rather straight snout, and the fin rays only a little more elevated. The sizes of the interpterygiophore spaces also are only slightly larger in these examples, and the inner extremities of the basal pterygiophores do not reach the neural and haemal arches. Furthermore, the muscles associated with the elevated

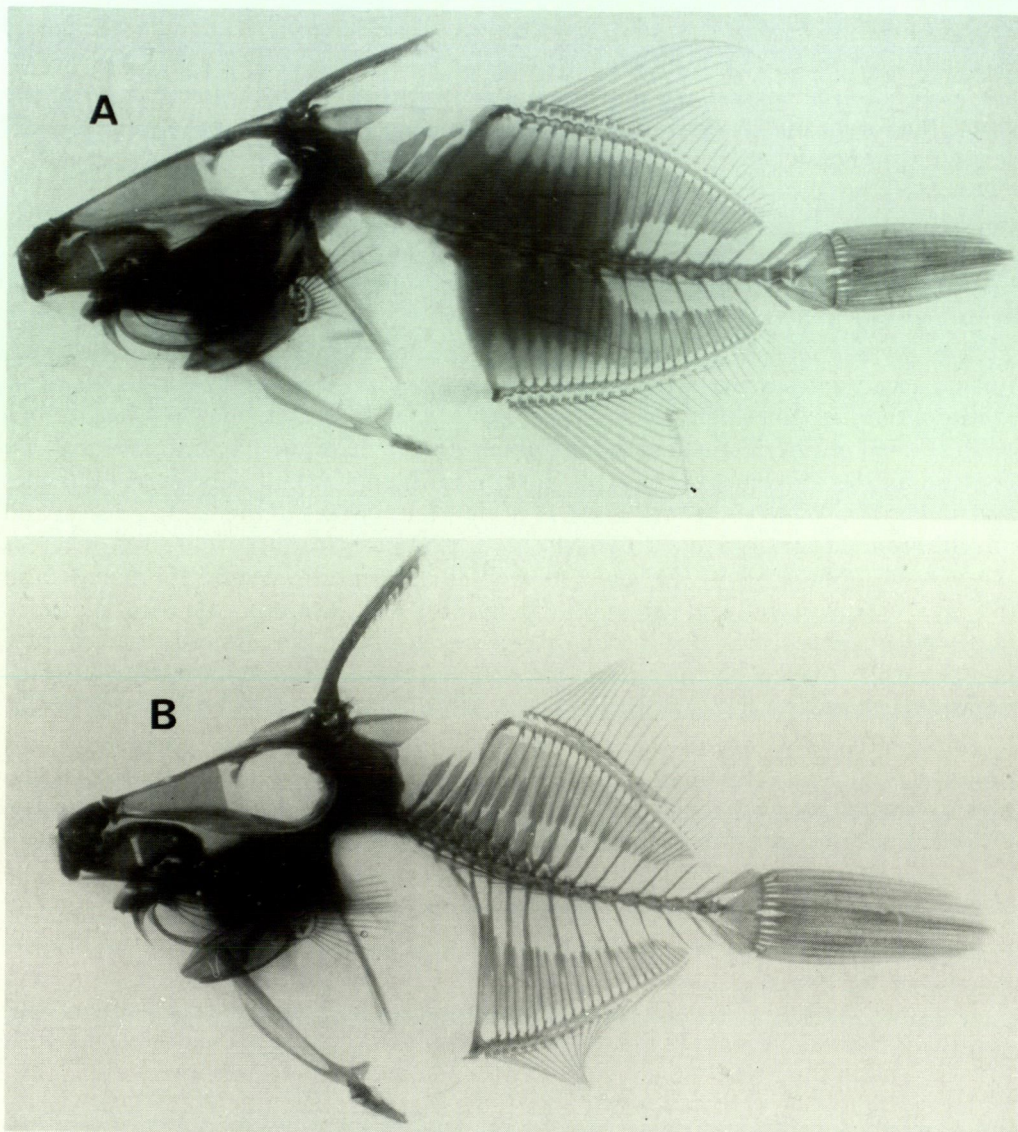


Figure 3 *Paramonacanthus nematophorus* (cleared and stained) showing differences in osteology and musculature between A, male, BPBM 19815, 57 mm SL; and B, female, BPBM 19815, 35 mm SL.

portions of the fins are more likely to clear after treatment with trypsin. Nevertheless, internal gross examination of these deeper-bodied males indicate that they possess apparently normal testes.

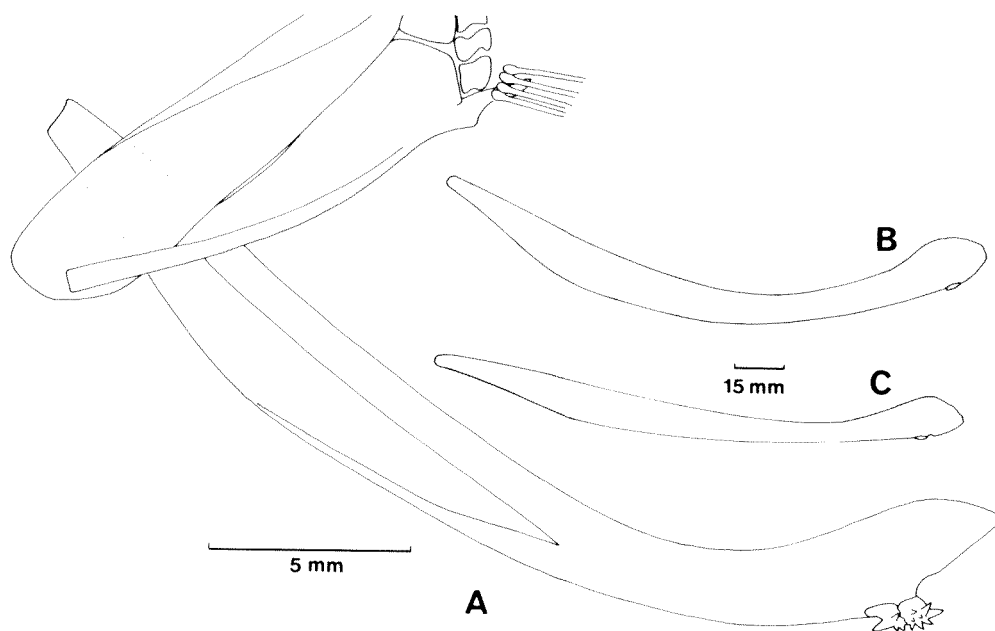


Figure 4 *Eubalichthys mosaicus* showing differences in shape of pelvis (anterior end facing left) between A, juvenile, 53 mm SL (portion of pectoral girdle also illustrated); B, female, 350 mm SL; and C, male, 340 mm SL.

Discussion

The sexual dimorphism outlined above attests to the similarity in body form between the adult female and juvenile, whereas the adult male of some monacanthid species is often more streamlined. This is effected by osteological changes that occur in the male with increasing size. The reduction in height of the predorsal neural spines, inwards movement of the basal pterygiophores of the second dorsal and anal fins, increased size of the interpterygiophore spaces, straighter pelvis, and changes in shape of the head bones all contribute to the male's more elongate shape. Furthermore, as some of these changes occur only in the region beneath the elevated portion of both the second dorsal and anal fins, it can be presumed that there must be a relationship between the shape of the male's body, its elevated fin rays, and the non-clearing musculature associated with these rays. What could be the possible benefits of this to the male?

The second dorsal and anal fins are the primary means of propulsion in monacanthids. However, in those species with obvious sexual dimorphism in the shape of the fins, the method of propulsion also varies between the sexes. Whereas the fins of the female and juvenile propel the fish by moving in an undulatory motion

along the length of the fin, underwater observations show that the male can achieve additional propulsion by moving the anterior elevated portions of the fins from side to side in a flapping motion. To achieve this, the muscles controlling the elongate fin rays would have to be capable of producing a greater energy output, which in turn would require a greater vascularization of the muscle tissue. Thus the condition of these muscles could be due to a higher haemoglobin content. (It is noteworthy that both the major blood vessels and the highly vascularized gills also do not clear in trypsin in either sex, remaining a dusky colour similar to the muscle tissue of the male). This finding is also supported by the thicker anterior fin rays and larger ventral flanges, which suggests that these rays have been strengthened for more powerful swimming.

It may be concluded, therefore, that the advantage to the male of its more slender shape and elevated fin rays must be an increase in its swimming ability. Furthermore, those males which have deeper bodies and less elevated fins would appear to be competitively at a greater disadvantage than their more streamlined relatives.

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