*Bull. Fish. Res. Stn., Ceylon Vol. 17, No. 2, pp. 169–176, December, 1964.*

# A Preliminary Study of the Defensive Spines of some Malayan Freshwater Fishes

By

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## Introduction

In a previous paper (Fernando and Fernando 1960) the defensive spines of the Ceylonese freshwater fishes were studied and their role as defence mechanisms against predatory fishes discussed. The previous literature on defensive spines was critically reviewed. In the present paper fifteen Malayan freshwater fishes have been examined. The Malayan fauna numbers over two hundred species in freshwaters but those chosen for study have been selected to illustrate the main morphological types of defensive spines. An attempt has also been made to give some indication of the possible mechanisms of defence under field conditions. It is hoped that these ideas will be tested out in the field and modified and expanded.

## Types of defensive spines

The defensive spines of the Ceylonese freshwater fishes have been divided into three types by Fernando and Fernando (1960). This classification is adopted here with with modification. The spines can be divided into (1) Simple, (2) Denticle-bearing, and (3) Venom-carrying. These three types have been described in some detail by Fernando and Fernando (loc. cit). The Malayan species show the same general features and therefore detailed descriptions are omitted in the present paper.

## Simple spines

This type has a smooth surface generally and is devoid of cutting denticles. The spine is erected and maintained in a vertical position by muscles attached to the base. They fold backwards but cannot be pushed forwards beyond the vertical position because of the dorsal processes of the vertebral column and the presence of accessory spines which buttress them at the front end. There is no locking mechanism at the base of the spine.

Simple spines are found in the Cyprinidae where they usually occur singly at the anterior end of the dorsal fin. A typical example amongst the Malayan species is *Probarbus jullieni* Sauvage (Fig. 1). An interesting variation of the simple spine is found in *Acrossocheilus deauratus* (C. & V.). The spine bears on its posterior face two rows of denticles which are conical in shape and serve for the attachment of fin tissue (Figs 2, 2a). There is no locking mechanism and there are the typical accessory spines at the anterior end of the dorsal fin in front of the main spine. These features place it in the simple spines. Also there are two rows of ' denticles '. Only one row occurs on a single face in denticle-bearing spines. Hora (1930) discusses this type of modification of spines in torrent fishes

In one of the catfishes studied, *Glyptothorax major* (Boul.), the dorsal fin bears a typical simple spine (Fig. 3). It agrees with the simple spines in being smooth, lacking denticles and has no locking mechanism but possesses an accessory spine in front.

In members of the families Anabantidae, Cichlidae and Mastacembelidae the dorsal fin bears a series of simple spines. The spines are stout and the fin tissue is attached to alternate sides of the spine as in *Anabas testudineus* Bloch (Fig. 4) and *Trichogaster pectoralis* (Regan) (Fig. 5) or the spine is surrounded by fin tissue as in *Mastacembelus* (Fig. 6.). The ventral fines also have similar spines but they are slightly smaller in size in *Anabas* and *Trichogaster* and reduced to two in number in

* This is an expanded account based on a paper read at the 10th Pacific Science Congress, Honolulu in 1961, when the author was a Lecturer in the Zoology Department, University, Singapore.

*Mastacembelus.* The mechanism of spine erection is the same as that for single spines but there are no accessory spines. The spines can be lowered backwards but can stand considerable pressure. They cannot be pushed forwards beyond the vertical position due to their bases coming in contact with dorsal processes of the vertebral column. *Anabas testudineus* has in addition a pair of backwardly directed pelvic spines which enable it to crawl on moist ground.

The series of simple spines is referred to as the multiple type by Fernando and Fernando (1960).

### Denticle-bearing spines

These are restricted to the catfishes (Nematognathi). They fall into two groups on whether the denticles are borne on one or two faces of the spine. They have a locking mechanism to maintain the spine in an erect position. They are borne on the pectoral and dorsal fins.

### Bagriid type

These bear cutting denticles only on the posterior face of the spine. They occur in the families Bagriidae, Siluridae, Sisoridae and Akysidae. The spines are of rather uniform type except that the locking mechanism of the dorsal spines is different from that of the pectoral spines. The morphology of these has been discussed by Fernando and Fernando (1960). In the dorsal spine of *Mystus nigriceps* (Val.) (Fig. 8) and the pectoral spine of *Mystus nemurus* (Val.) (Fig. 10), the denticles are directed backwards or downwards whilst in the pectoral spines of *Mystus nigriceps* and *Glyptothorax major* they are directed laterally and the terminal portion of the denticles is curved slightly backwards The effectivenesss of the former type for piercing flesh is greater than the latter. If penetration is achieved however the laceration would be greater with the latter type especially as the spines move out in a slightly different position from where they moved in due to the movement of the fish.

To the Bagriid type also belong the pectoral spines of *Achondronichthys melanogaster* (Blkr.) (Fig. 11), *Wallago tweedei* (Hora and Misra) (Fig. 12) and *Ompok bimaculatus* (Bloch) (Fig. 13). In all these species the denticles are greatly reduced in size and can be considered ineffective for penetrating flesh. In the largest species *Wallago tweedei* the terminal portion of the spines is soft but still bears denticles.

### Clariid type

These spines bear denticles on the anterior and posterior faces. So far only the pectoral spines have shown this type of denticle arrangement. The denticles are usually directed backwards. Morphologically the typical Clariid spine differs little from the venom-carrying spines. None of the Malayan species examined had this latter type. Descriptions of venom-carrying spines are given by Halstead, Kuninobu and Hebard (1953) and Fernando and Fernando (1960).

In the Malayan forms only degenerate spines of the Clariid type were found. The degree of reduction of the denticles varies in the three species studied. In *Clarias batrachus* (L.) the structure of the spine resembles most closely that of *Heteropneustes fossilis* (Bloch), a form with venom-carrying spines. In *Clarias teysmanni* (Blkr.), the arrangement of the denticles is irregular. In *Clarias nieuhofi* (Val.) the denticles are confined to the anterior face only but there are indications of denticles on the posterior face also (Figs. 14-16). The spines of *Clarias* spp. examined so far do not appear to be capable of piercing human flesh under normal circumstances of handling. Halstead (1959), however lists *Clarias* among fishes capable of stinging. It is possible that in some species the denticles are similar in arrangement to that found in forms like *Heteropneustes fossilis*. The denticles in *Clarias* spp. show considerable variation even within the same species. Their use in specific diagnosis (Tweedie 1952) should be viewed with misgivings.

The presence of different degrees of reduction of denticles in the Clarriid type so far examined indicates that there has been degeneration of this type probably from a venom-carrying condition. An examination of the possible sites of venom tissue in these species might give a clue to this problem.

There are no Malayan species with venom-carrying spines amongst those examined. There are no records of painful stings received by people handling freshwater species which could be attributed to venom-carrying spines. A common South-East Asian species with venom-carrying spines is *Heteropneustes fossilis*. This species has been studied by Fernando and Fernando (1960) and the venom apparatus described by these authors and also by Bimachar (1944).

## Functioning of the defensive mechanism

The simple spines whether single or multiple would serve to make the effective size, as far as the predator is concerned, larger. Since the predator usually attacks its prey from behind (Figs. 17-19), the initial contact with the predator's jaw, however slight, would provide the latter with an impression of the size of the prey and this might in itself deter it from pursuing the prey. Lawrence (1957) has estimated the size of forage fishes of the largemouth bass and has foumd that the maximum size of the prey is limited by the mouth width of the predator. Other factors are no doubt involved. In the case of simple spines the strong jaws of the predator (if large) would find little difficulty in lowering the spine backwards. This would be easier if the prey were momentarily stationary.

In the case of the denticle-bearing spines the dorsal and pectoral spines would come in contact with the jaws if the predator snaps the fore-part of the fish. Otherwise the prey could bend sideways and inflict a sting if held from the rear portion (Fig. 20). This lateral bending is very quick and effective in catfishes of small size. Once the predator has snapped at its prey it might swallow the prey head first which would be difficult with species having erected and locked dorsal and pectoral spines. Even in species with simple spines swallowing might be made difficult by the spines.

In the functioning of the defensive mechanisms whose morphological basis consists of spines many other factors are no doubt involved. Behaviour patterns of the prey and predator and their sensory mechanisms no doubt play a part.

Further studies on the actual predation under field conditions would be very useful in elucidating the defensive mechanisms involved. There is almost certainly selective predation in freshwaters. It is the basis of this selection which needs study. The defensive spines may provide but a few clues. The problem of predation is of considerable interest especially where new species are introduced and may have significance as to their success or elimination.

## Defensive spines in relation to size and habits

The fifteen species of Malayan freshwater fishes dealt with in the present paper are listed in Table 1. The maximum recorded size, normal habitat and the food of each species is given. This data has been supplied by Mr. Eric R. Alfred, Curator of Zoology, National Museum, Singapore.

In the forms with simple spines either single or multiple there is an increase in the size of the spines with increase in size of the fish. This indicates that the primary function of these spines is to strengthen the fin. Their value in defence mechanisms is only secondarily acquired and of relatively little functional significance compared to their other role.

In the case of the denticle-bearing spines there is a reduction of the denticles, their effectiveness and the locking mechanisms in larger species. The most degenerate types of spines occur in *Wallago tweedei* and the largest species of *Clarias* (Table 1). *Mystus* spp. are relatively small and also live in estuarine waters where the predatory fishes are as a rule larger. In these species the spines are well developed and the locking mechanism is strong.

It is possible to trace a series from effective to ineffective defensive spines. One starting with *Mystus* followed by *Ompok* and *Wallago* and the other starting with *Clarias batrachus* followed by *Clarias teysmanni* and *Clarias nieuhofi*.

*Glyptothorax major* and *Achorndronichthys melanogaster* live in "riffles" and their spines are probably of greater value in strengthening the fins than as defensive mechanisms.

## Evolution of defensive spines

There is no doubt that the initial thickening of fin rays arose as a strengthening device for the fins. Spines at the anterior end of fins or fin-like structures were not unknown in early fishes (see Romer 1946). It is difficult to trace the lines of evolution to the condition in the modern species because of the commonness of spines associated with fins. It appears rather certain that in the species studied two trends have occurred. One of them leading to a strengthening of the fin and only secondarily of defensive value as in the Cyprinidae, Anabantidae, Cichlidae and Mastacembelidae; and the other the development of denticles and a locking mechanism with a more definite defensive function associated. Two facts which are of importance are the additional strenghtering of fins with spines of the simple type in torrential and large forms and the degeneration of the defensive spines of the denticle-bearing type with increase of size and changes in habits.

A very tentative scheme for the evolution of spines in freshwater fishes has been drawn up in Table 2.

## Summary

The defensive spines of fifteen Malayan freshwater fishes have been studied morphologically.

The clssification of spines has been slightly modified from the previous work of Fernando and Fernando (1960). They are divided into simple, denticle-bearing and venom-carrying. The simple spines are further sub-divided into single and multiple and the denticle-bearing into Bagriid and Clariid types. The latter agree morphologically with the venom-carrying spines of previously studied forms and may be a degenerate condition.

Simple spines occur singly in the Cypriuidae where they are found at the anterior end of the dorsal fin. A spine of similar structure occurs in the catfish *Glyptothorax*. In the families Anabantidae, Cichlidae and Mastacenbelidae simple spines occur as a series. Denticle-bearing spines occur in the catfishes (Order-Nematognathi). Those having denticles on one face occur in the Bagridae, Siluridae, Sisoridae, and Akysidae. They are referred to as Bagriid type. In the other type denticles occur on the anterior and posterior faces of the spine. They are referred to as Clariid type. None of the Malayan species studied had venom-carrying spines and they are unlikely to be found in the freshwater species. The functioning of the defensive mechanism whose morphological basis are spines is discussed and the relation between the size and habitat on the effectiveness of the spines is mentioned. The evolution of defensive spines is discussed briefly.

## Acknowledgment

I wish to thank Mr. Eric R. Alfred, Curator of Zoology, National Museum, Singapore, for identifying the specimens used in this study and for providing a considerable amount of material and comments of the habits of the species.

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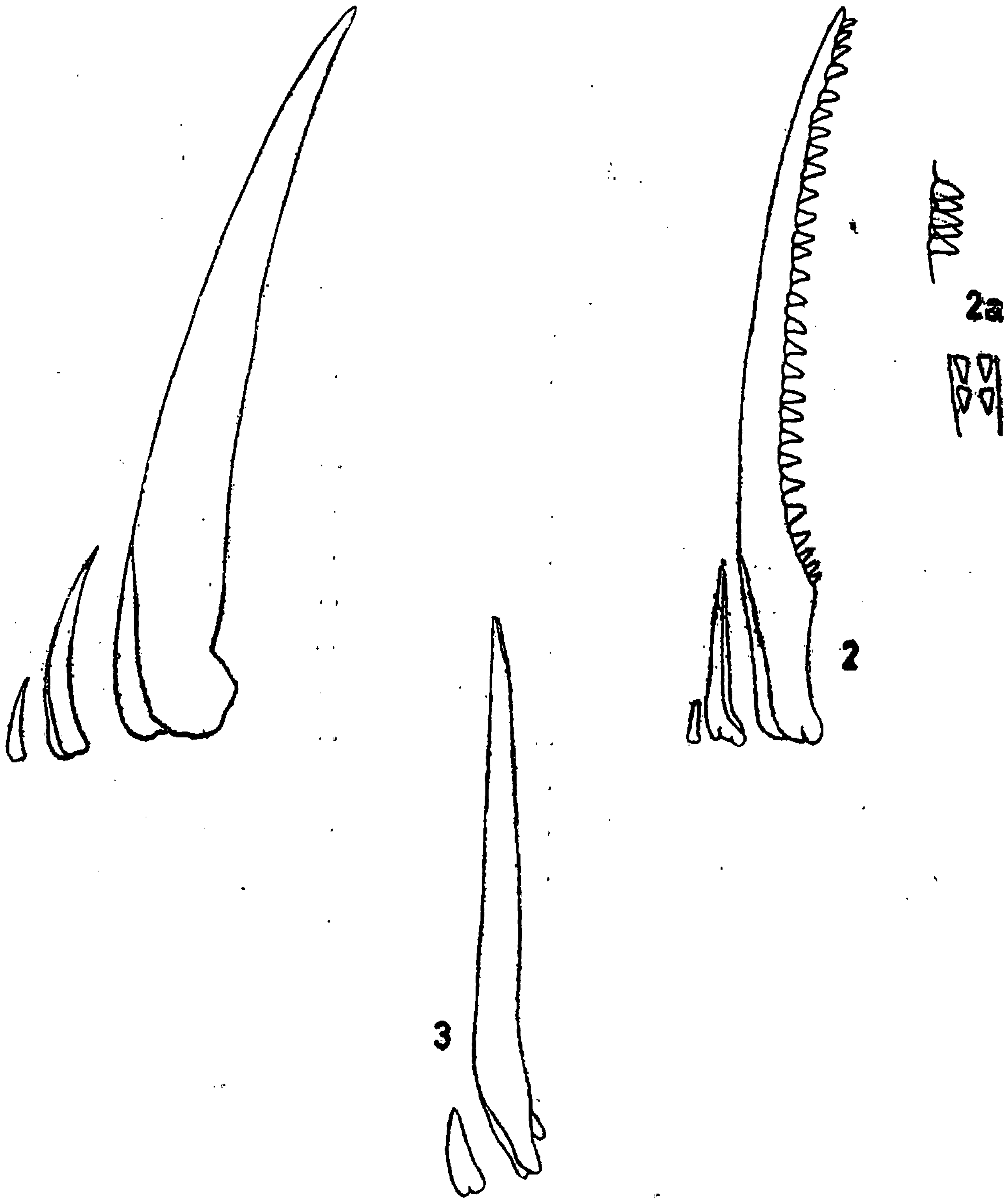
TABLE I

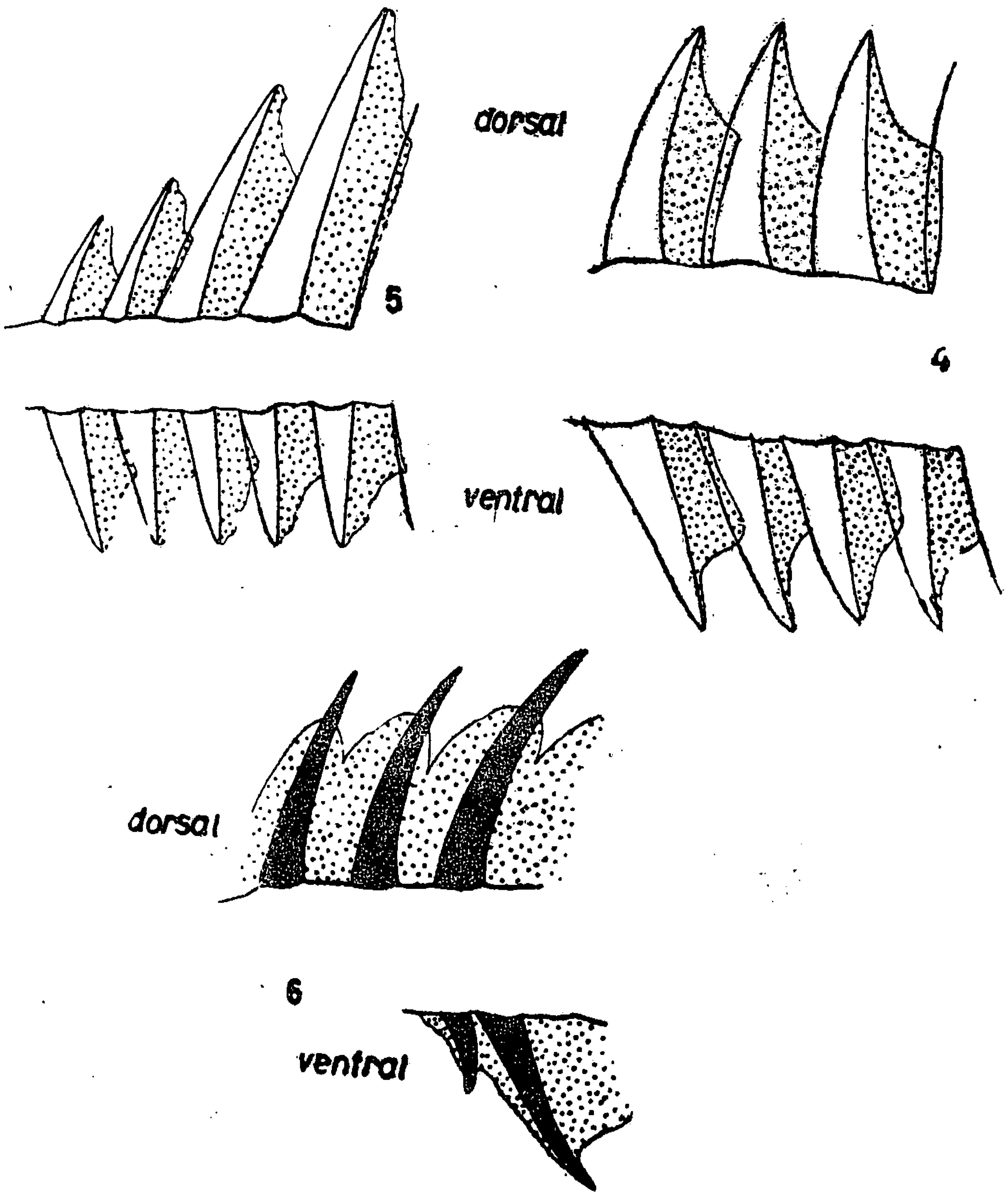
| *SPECIES* | *Max. size in Malaya in cms.* | *Habitat* | *Food Habits* |
|---|---|---|---|
| *Mystus nigriceps* | 26·2 | streams | carnivore |
| *Mystus nemurus* | 28·0 | streams | carnivore |
| *Glyptothorax major* | 7·3 | riffles | carnivore |
| *Achondronichthys melanogaster* | 10·0 | riffles | carnivore |
| *Ompok bimaculatus* | 20·5 | streams | insectivore, carnivore |
| *Wallago tweedei* | 1,425 | rivers | carnivore |
| *Clarias teysmanni* | 18·0 | forest-streams | carnivore ? omnivore ? |
| *Clarias nieuhofi* | 31·0 | forest-streams | carnivore ? omnivore ? |
| *Clarias batrachus* | 20·0 | wide | carnivore ? omnivore ? |
| *Probarbus jullieni* | 1,200 | rivers | carnivore (Mollusca) |
| *Acrossochielus deauratus* | 30·0 | mountain streams | insectivore |
| *Anabas testudineus* | 13·0 | wide | omnivore |
| *Trichogaster pectoralis* | 22·0 | ricefields | herbivore |
| *Mastacembelus maculatus* | 23·5 | streams and ponds | carnivore |
| *Mastacembelus unicolor* | 130 | wide | ommivore ? |

TABLE II

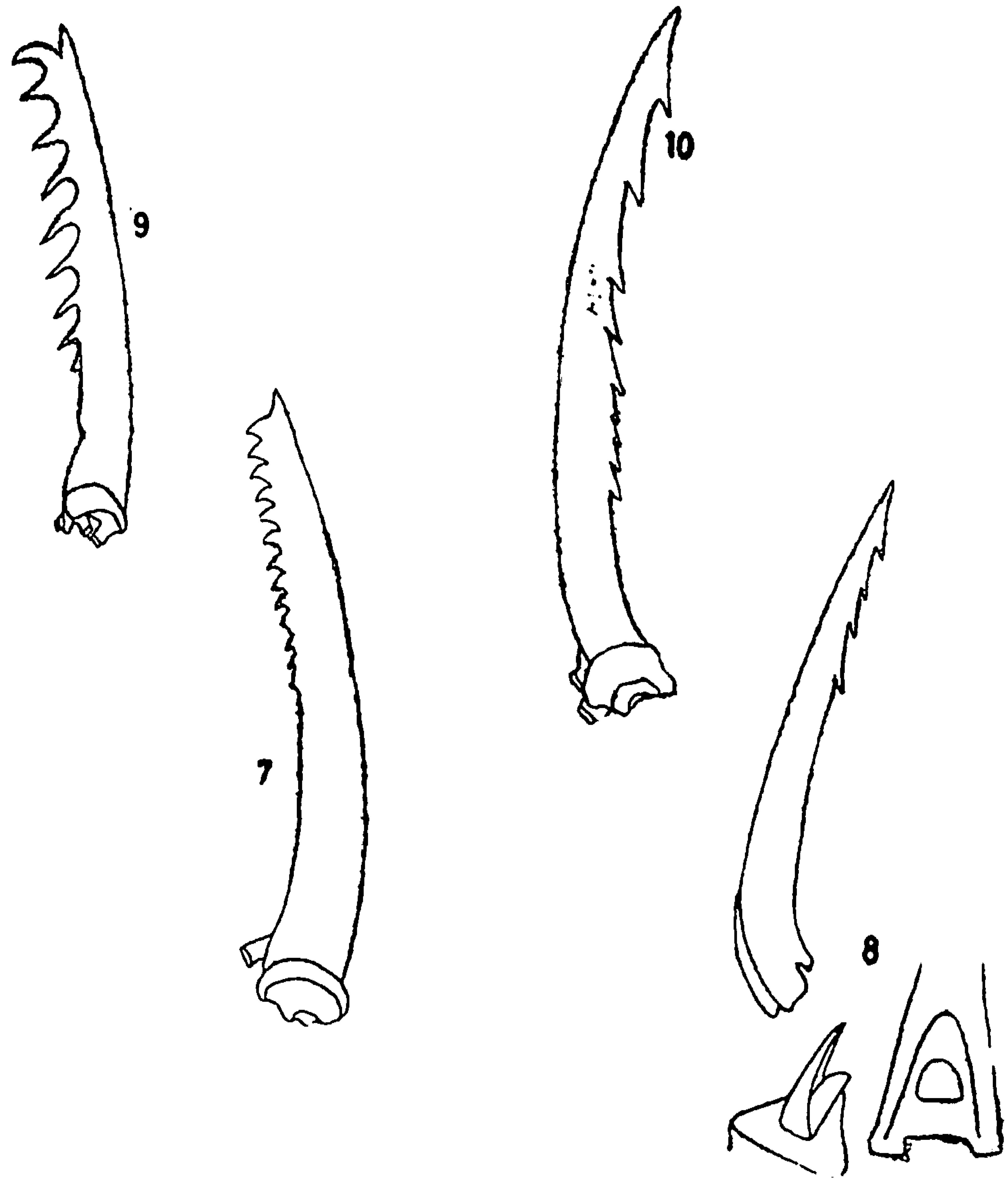
Fin ray .. Thickened fin rays
- Single spine at anterior end of dorsal fin with accessory spines. No locking mechanism. *Cyprinidae, Glyptothorax*
  - Spine and soft segmented rays for attachment of fin tissue. *Glyptothorax*
  - Spine with conical denticles for attachment of fin tissue. *Acrossocheilus*
  - (both: Torrent forms)
- Further thickening of fin rays .. Multiple spines in dorsal and ventral fin. No locking mechanism
  - *Anabantidae*
  - *Cichlidae*
  - *Mastacembelidae*
- (Torrent forms and the above: Simple spines)
- Rudimentary denticles on spine or thickened fin ray. Locking mechanism ..
  - Denticles on posterior face only of spine
    - *Bagriidae*
    - *Siluridae*
    - *Sisoridae*
    - *Akysidae*
- Venom-Carrying spines. *Heteropneustidae*
  - Denticles on anterior and posterior faces of spine. *Clariidae*
- (Denticle-bearing spines)



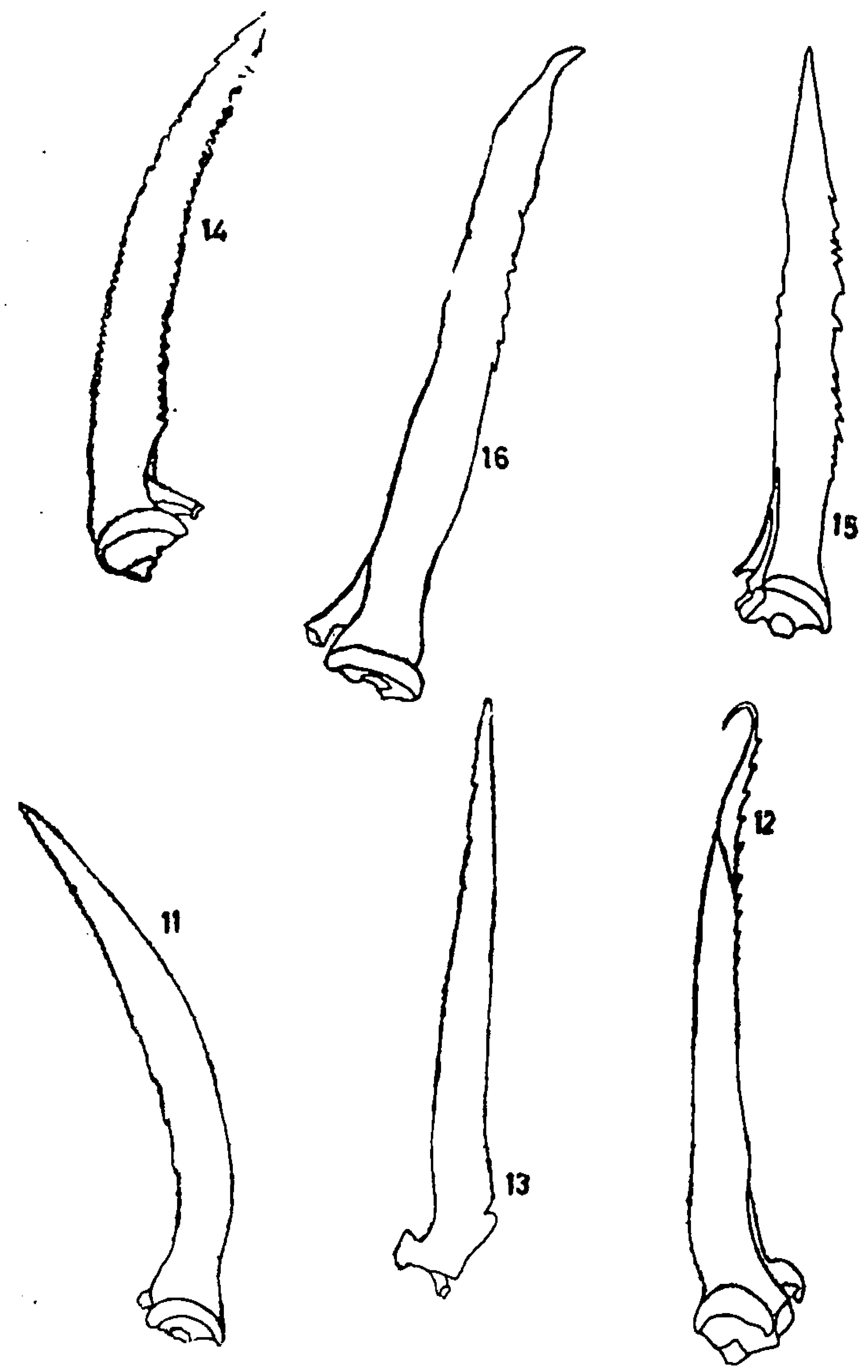

Figs. 1–3—Simple spines, single type. 1. *Probarbus jullieni*. 2. *Acrossocheilus deauratus*. 2a. Showing lateral and en-face view of denticles. 3. *Glyptothorax major*. All dorsal spines.



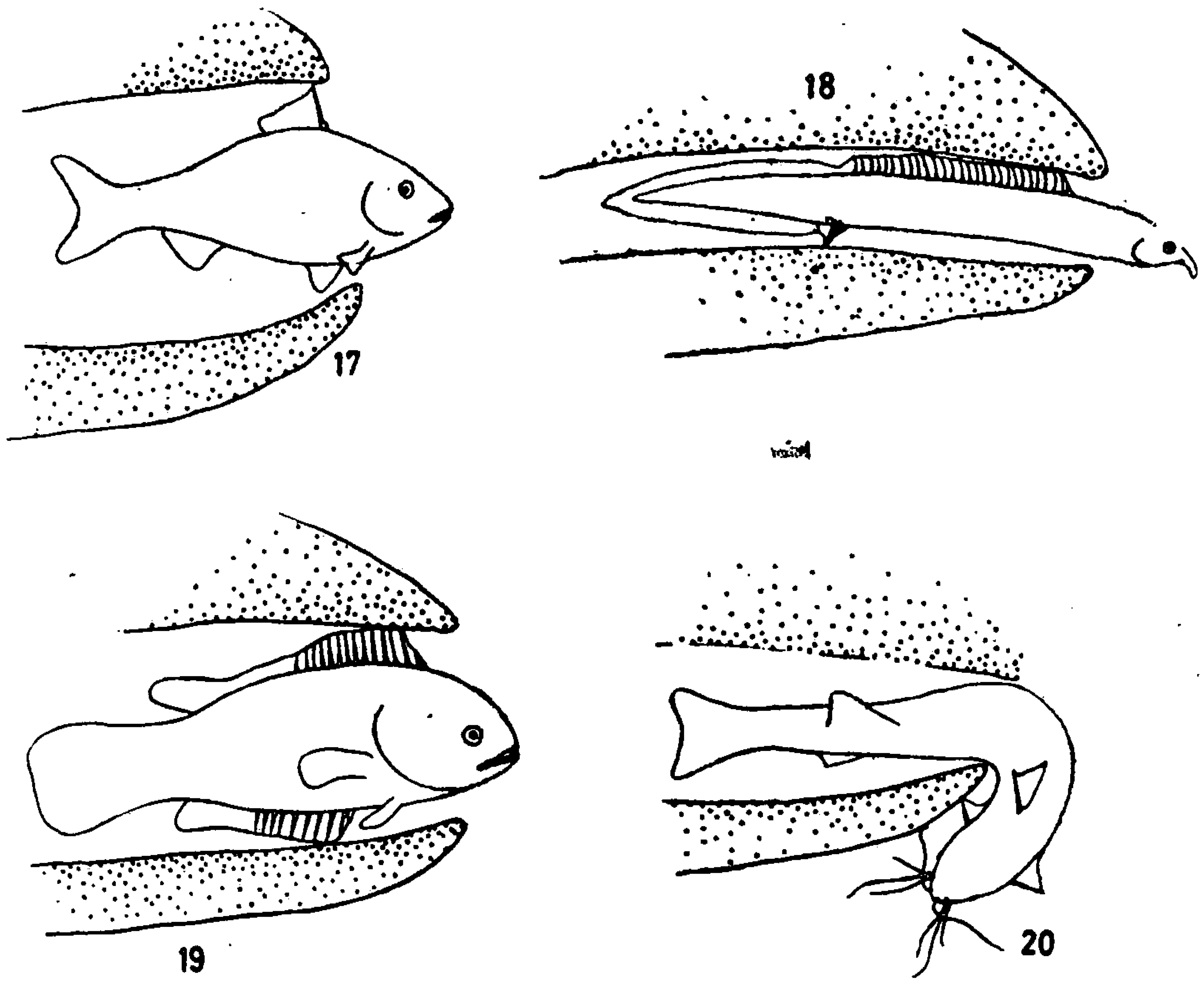

Figs. 4–6—Simple spines, multiple type. 4. *Anabas testudineus*. 5. *Trichogaster pectoralis*. 6. *Mastacembelus maculatus*.




Figs. 7–10—Denticle-bearing spines. 7. *Mystus nigriceps*, pectoral spines. 8. *Mystus nigriceps*, dorsal spine and locking mechanism. 9. *Glyptothorax major*, pectoral spine. 10. *Mystus nemurus*, pectoral spine.




Figs. 11–16—Denticle-bearing spines, pectoral. 11. *Acondronichthys melanogaster*. 12. *Wallago tweedei*. 13. *Ompok bimaculatus*. 14. *Clarias batrachus*. 15. *Clarias teysmanni*. 16. *Clarias nieuhofi*.




Figs. 17–20 Diagramatic representation of the functioning of defensive spines. 17. Simple, single type. 18. and 19. Simple, multiple type. 20. Denticle -bearing type.