RESPIRATORY AND OTHER ADAPTIVE MODIFICATIONS IN THE GENUS *GYRINOCHEILUS* VAILLANT AND THEIR SIGNIFICANCE IN CONSTITUTING THE FAMILY GYRINOCHEILIDAE HORA.

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INTRODUCTION.

The remarkable genus *Gyrinocheilus* was established by Vaillant[1] in 1902 for *Gyrinocheilus pustulosus* from Borneo. In 1906, Berg[2] described *G. kazanakoi* from a part of South-eastern Thailand, now in Cambodia. The first fish, *Psilorhynchus aymonieri*, referable to this genus was, however, described by Tirant[3] in 1883, but as he placed it in the genus *Psilorhynchus* McClelland and gave poor description and figures, no notice of it seems to have been taken by later workers, until Hora[4] in 1935, having obtained photographs of the type-specimen, preserved in the Museum of Natural Sciences of Lyons, was able to decide that it was not a *Psilorhynchus* but a *Gyrinocheilus* identical with *G. kazanakoi* Berg.

The systematic position of the genus remained a matter of controversy for a long time. Vaillant referred it to the subfamily Homalopterinae and Boulenger [5] opined that it should represent a separate subfamily. Berg had erected a subfamily Gyrinocheilini to accommodate it, in 1906.

Regan [6], in 1911, however remarked that the place of *Gyrinocheilus* "in the system seems to be in the family Cyprinidae next to *Crossocheilus* and *Discognathus*". He also added, "to make it the type of a separate family or subfamily would merely obscure its relationships". Weber and Beaufort [7], included it in the family Cyprinidae without any comment. Hora[8], in 1923 erected the family Gyrinocheilidae for this genus and stated that:

> "There seems to be little doubt that judging from their appearance the members of the genus *Gyrinocheilus* are remarkably similar to those of the genera *Crossocheilus* and *Garra*, but this outward similarity, in my opinion, is directly correlated with the life of these fishes in moderately rapid running waters. The presence of "the slender toothless lower pharyngeals", the structure of the scales, the remarkable modification of the gill-openings to form inhalent and exhalent apertures and the

[1] Vaillant, M. L., *Notes Leyden Mus.* XXIV, pp. 107-122, figs. 30-32, pls. i-ii; *Comp. Rend. Acad. Sci.* CXXXV, p. 702 (1902).

[2] Berg, L. S., *St. Petersberg Trav. Soc. Nat. Compt. Rend.* XXXVII, pp. 305-307; *deutsches Re's* 364-366 (1906).

[3] Tirant, *Bull. Soc. Etudes Indochines*, p. 35 (1883).

[4] Hora, S. L., *Rec. Ind. Mus.* XXXVII, pp. 459-461, figs. 2 (1935).

[5] Boulenger, G. A., *Camb. Nat. Hist.* VII, p. 582 (1909).

[6] Regan, C. T., *Ann. Mag. Nat. Hist. Soc.* VIII, (8), pp. 29-30 (1911).

[7] Weber and Beaufort, L., *Fish. Indo-Austral. Archipel.* III, p. 224 (1916).

[8] Hora, S. L., *Journ. Nat. Hist. Siam Soc.* VI, p. 159, pl. xii (1925).

> structure of the mouth, lips and jaws are in my opinion better defined characters than those that seperate Cyprinidae, Cobitidae and Homalopteridae from one another."

Hora's fixation of the position of the genus has not so far been questioned and later workers, such as Berg[1] and Smith[2], have accepted the family in their systems of classification. Jordan[3], however included *Gyrinocheilus* under the family Homalopteridae.

A search through literature reveals that nothing further has been done to evaluate Hora's findings. The genus deserves thorough treatment and the elucidation of its affinities will definitely throw more light in understanding the systematics of other allied genera.

Dr. Hora placed at my disposal some specimens of this interesting genus which enabled me to work out the systematic position and details of some internal organs of *Gyrinocheilus*. A comparison of *Gyrinocheilus* with other allied genera, the respiratory and other adaptive modifications that form its family characteristics, its internal anatomy and their important details are given in the following pages.

The work was carried out in the laboratories of the Zoological Survey of India, under the guidance of Dr. S. L. Hora. I am highly indebted to him for his help, guidance, encouragement and supervision. I have examined 15 specimens of *Gyrinocheilus aymonieri* (Tirant) from Siam, now preserved in the collection of the Zoological Survey of India, Calcutta.

AIR-BLADDERS OF *Garra*, *Crossocheilus* AND *Gyrinocheilus*.

In the classification of Cyprinoid fishes, the form and structure of the air-bladder are regarded as characters of great taxonomic value. The genus *Gyrinocheilus* cannot be assigned to the Homalopteridae as it possesses a well-developed air-bladder lying free in the abdominal cavity. In this respect, it agrees with the true Cyprinid fishes, but we may compare the structure of the bladder here, in the genera *Garra*, *Crossocheilus* and *Gyrinocheilus* supposed to be closely related by Regan.

Hora (1923, *loc. cit.* p. 160), gives the following description of the air-bladder of *Gyrinocheilus* which fits in with almost all the specimens that I have examined :

> "The anterior chamber is almost circular in outline and has very thin walls, but is covered by a thick fibrous coat which attaches it firmly to the body wall; just at its termination the pneumatic duct from the oesophagus opens into the bladder. This chamber is followed by a short narrow tube, which dilates into another chamber, behind which the bladder is continued as a narrow cylindrical tube to its termination. The walls of the last three parts are moderately thick."

The narrow tube that connects the two dilated chambers is about half the length of the anterior chamber. In the case of *Garra*, the form of the air-bladder varies among its species and even among the different individuals of the same species. In all the less modified species of *Garra*, such as *adiscus*, *rossicus*, *blanfordi* and *rufus*, the bladder is of

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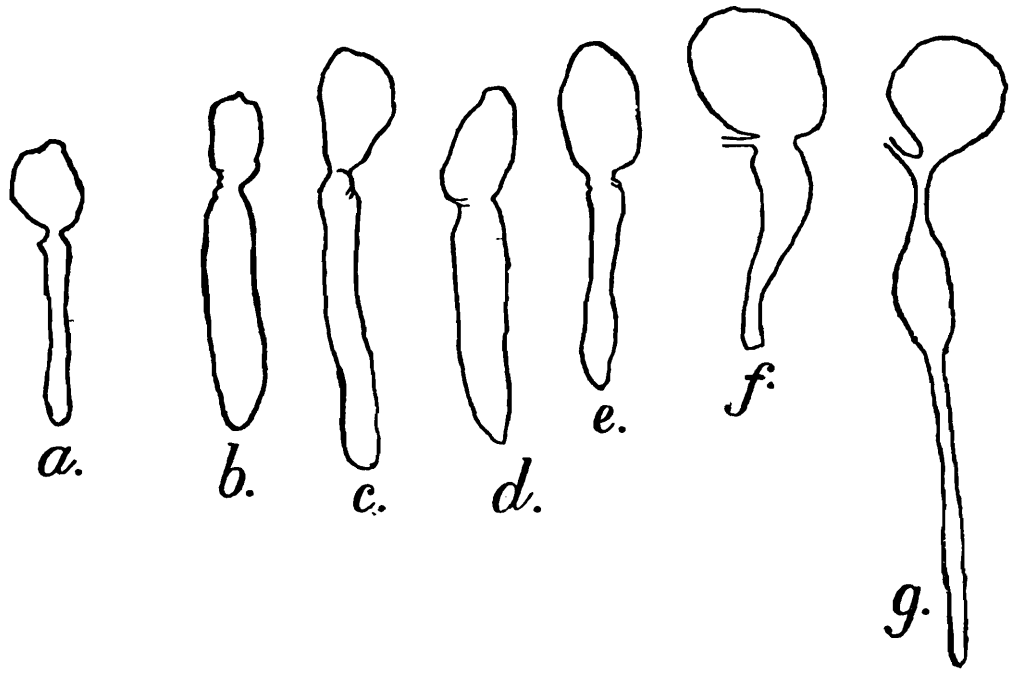
[1] Berg. L. S., *Classification of fishes both recent and fossil*, p. 269, 445 (1947). English and Russian, J. W. Edwards, Ann. Arbor, Michigan, U. S. A.

[2] Smith, H. M., *Bull. U. S. Nat. Mus.* (188), pp. 281-286 (1945).

[3] Jordan, D. S., *Stanford. Univ. Publn. Biol. Ser.*, III, p. 145 (1923).

the normal type generally present in the Cyprinidae, such as *Labeo* and *Cirrihina*. The anterior chamber is smaller than the posterior and is in the form of a short massive cylinder. The posterior chamber is almost as broad as the anterior and thence it gradually tapers to the end. But in the specialised species of *Garra* such as *gravelyi*, *jenkinsonianum* and *mullya* and in *Crossocheilus*, the posterior chamber, instead of being swollen in the middle is of uniform thickness throughout, with its wall somewhat thickened. In still more specialised forms such as *stenorhynchus*, *arabica*, *gotyla*, *nasutus* and *lissorhynchus* the whole of the bladder is greatly reduced and is covered by a thick, fibrous coat and is firmly fixed to the body wall. In some species the posterior chamber is greatly reduced and its cavity almost obliterated. (After Hora[1].)



TEXT-FIG. I.—Comparative drawings of the air-bladders of the various species of *Garra* *Crossocheilus* and *Gyrinocheilus* ("after Hora") ×⅔
a. Garra mullya; *b. Garra jenkinsonianum*; *c. Garra gravelyi*; *d. Garra mullya* hill-stream form; *e. Crossocheilus latia*; *f.* and *g. Gyrinocheilus aymonieri.*

The air-bladder of *Gyrinocheilus* would thus appear to be almost like the specialised species of *Garra* and *Crossocheilus*. In all these forms, the posterior chamber shows great reduction and the walls are thickened. The air-bladder of *Gyrinocheilus* is more reduced than that of *Crossocheilus*, but is larger than those of the more highly specialised species of *Garra*.

A comparison of the drawings of the air-bladders of the various species given here show the trend of modifications in these fishes. Judging by this character alone, *Gyrinocheilus* is definitely assignable to the true Cyprinid stock.

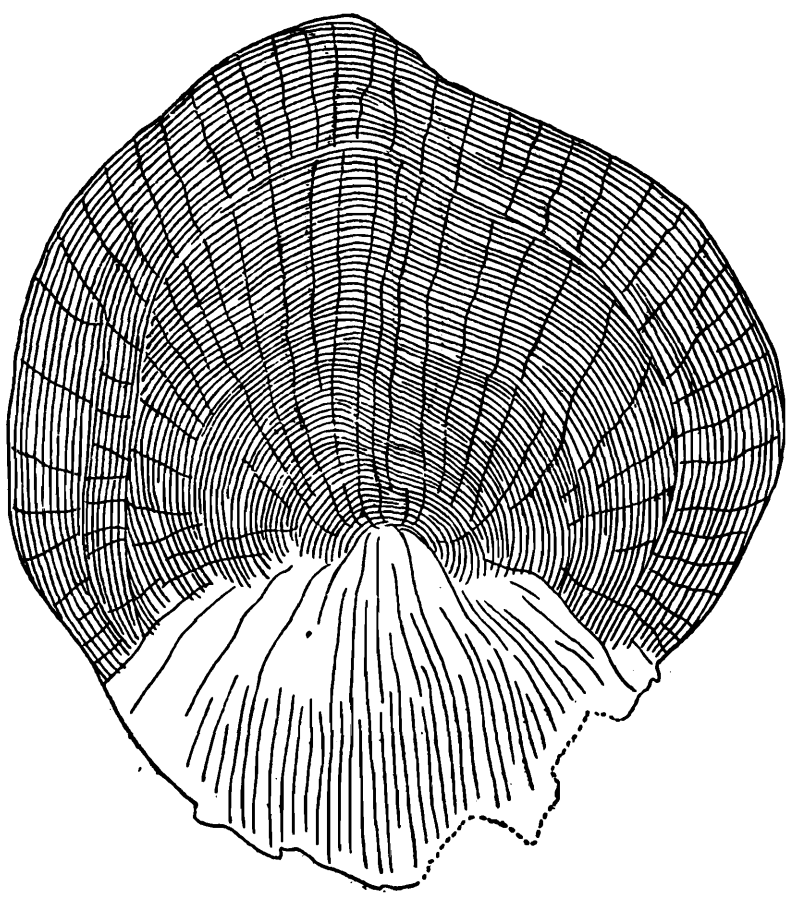
STRUCTURE OF SCALES IN *Gyrinocheilus*, *Garra* AND *Crossocheilus*.

A scale from below base of dorsal fin was taken in each case and studied. The scale of *Gyrinocheilus* is oval in shape with an undulating margin. The basal region is more conical than the top. The top portion

[1] Hora, S. L., *Rec. Ind. Mus.* XXII, p. 546 (1921).

is lobed and the scale is compressed laterally. The nucleus is in the center. There are about 40 or 50 circulii and about 40 to 45 radii. Only about 40 of them reach the center.

The scale of *Garra* resembles that of *Gyrinocheilus* in shape and structure. The nucleus is almost near the center, though not exactly so. The radii and the circulii are also disposed of as in that of *Gyrinocheilus*. The scale of *Crossocheilus* is more or less like that of *Garra* and *Gyrinocheilus* in outline but the apex is a bit conical. The nucleus is eccentric and is towards the base. The radii and the circulii are comparatively lesser in number. The scale of *Gyrinocheilus* is thus more allied to *Garra* than to that of *Crossocheilus*. Judging by this character also, the genus is assignable to the true Cyprinid stock of fishes.



TEXT-FIG. 2.—Drawing of a scale from below base of dorsal fin of *Gyrinocheilus aymonieri* × 18.

ALIMENTARY CANAL OF *Gyrinocheilus*.

The alimentary canal of *Gyrinocheilus* has been fully described and figured by Vaillant. (1902, *loc. cit.*, pl. I and II.) The oesophagus and the stomach are bent in the form of a U. The intestines are coiled up and gradually tapers towards the caecum.

The late Dr. H. M. Smith informed Dr. Hora, that the fish feeds on algae and slime and that it scrapes encrusting material with the help of its jaws. The belief that the peculiar lips are used for scooping up mud on which the fish is supposed to feed is erroneous, and actually the fish scrapes algae from rocks. The contents of stomach and intestines were found to consist of amorphous vegetable matter in a number of specimens.

THE GILL-OPENINGS AND GILL-RACKERS.

The branchial openings are modified in a remarkable way. "Each gill-opening is divided into an upper slit-like portion, which serves as an inhalent opening and communicates with the posterior part of the mouth cavity immediately in front of the gills and a lower much wider portion which serves as an exhalent aperture and is guarded by a large membranous flap," as remarked by Hora[1].

The gill-rackers of *Gyrinocheilus* are set close together and prevent the scrapped food from being carried out with the respiratory current.

RESPIRATORY AND OTHER ADAPTIVE MODIFICATIONS.

Gyrinocheilus is a herbivorous fish and its jaws are adapted for scrapping algae from stones and other submerged objects. The lips act as a sucker for the fish to maintain itself in running water by adhering to stones. It has been observed that even in an aquarium tank in still water, the fish attach themselves to the bottom or to the vertical glass front. Inasmuch as this fish uses its suctorial mouth for maintaining its position, it would seem that it has lost all its ability to breathe like ordinary fishes and always relies on its inhalent pores for the inspiratory current. For this purpose the mouth is ventral in position in order to facilitate its attachment of the lips to the substratum.

Smith[2] has observed that the amount of water which may enter the branchial opening is limited and in order to secure sufficient oxygen, the fish breathes in very rapidly. Observations made on these fishes up to 12 cm. length in a large aquarium, have proved that their respiratory rate is 230 per minute as evidenced by the movements of the opercular flaps. It is believed that the respiratory current is initiated and carried by the opercular flaps.

Gyrinocheilus lives in torrential streams as well as in swamps. This habitat might be responsible for the large eyes and better marked colouration and body form.

DISCUSSION.

The above noted details and comparisons show one particular point. The genus *Gyrinocheilus* resembles *Garra* and *Crossocheilus* in the disposition and modification of the air-bladder and the structure of the scales, thereby sharing with them the true Cyprinid characters. But it is unique in the modification of its gill-opening into an inspiratory and expiratory channels, which has not been met with in any of the Cyprinoid fish. Usually the trend in all members of the hill-stream fishes of the family Homalopteridae is the reduction of the gill-openings to a minimum but not a complete physiological severance from the mouth. Even in extreme cases, the water is sucked in through the mouth and let out through the greatly reduced gill-openings. But in *Gyrinocheilus* the mouth serves little purpose in the respiratory mechanism of the fish. This is a great modification and a remarkable characteristic feature, peculiar only to this genus among the Cyprinoid fishes.

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[1] Hora, S. L., *Jour. Bomb. Nat. Hist. Soc.*, XXXVI, pp. 549-550 (1933).

[2] Smith, H. M., *Jour. Nat. Hist. Siam Soc. N. H. Suppl.* VIII, pp. 11-14 ; 187-189 (1931).

The structure and dentition of the pharyngeal bone are characters of great taxonomic value in Cyprinoid fishes. Toothless, slender-pharyngeal bone of *Gyrinocheilus* are sufficiently diagnostic for separating it from other families of Cyprinoid fishes.

The discontinuous geographic distribution of the genus is also significant. It is found in Siam and Borneo and is absent from the Malay Peninsula, Sumatra and Java. In all probability the ancestral stock evolved on the mainland, probably in Siam and then went down to Borneo *via* the shallow South China Sea, when there was a land bridge in this region. The genus appears to be much younger than *Garra* or *Crossocheilus* in age for they are very widely distributed, even extending to Africa. Whatever may be the pattern of dispersal, it is clear that it never migrated *via* the so-called Malayan arch passing through the Malay Peninsula and Sumatra. Zoo-geographical considerations would also favour the separation of the genus from its parental stock.

In view of the various considerations advanced above, I am of the opinion that *Gyrinocheilus* should stand separate from other Cyprinoid fish as the sole representative of the family Gyrinocheilidae Hora.