THE SCALES OF THE HOMALOPTERID FISHES[1].

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(Plates II-IV.)

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[1] Part of the thesis approved for the degree of the Doctor of Philosophy of the Calcutta University.

Introduction.

In 1932, Hora gave a comprehensive account of the " Classification, Bionomics and Evolution of Homalopterid Fishes " and subdivided the family into two groups characterised by a number of well-defined morphological characters. From a detailed study of the material available to him in the various Museums of Europe and the Indian Museum at Calcutta, he was led to conclude that the family is polyphyletic in origin, Homalopterinae having been evolved from the Cyprinidae and the Gastromyzoninae from the Cobitidae. This view has been generally accepted by later workers such as Smith (1945, p. 273).

Chang (1945) made a comparative study of the girdles and their adjacent structures in the Chinese Homalopteridae, but as I have not seen his paper I am not in a position to say whether or not he expressed an opinion on the phylogeny of the family. Hora (1932, p. 273) had found structural differences in the basipterygium of the Homalopterinae and the Gastromyzoninae.

Ramaswami (1948, p. 531), after a detailed study of the skull of *Balitora* and *Bhavania* of the Homalopterinae and of the *Gastromyzon* of the Gastromyzoninae has listed as many as thirteen differences which help to differentiate the skulls of these two groups of fishes.

Since it has now been generally recognised that, like all other structures scales also vary and present characters of all degrees of significance and stability, for a further elucidation of this view, Dr. Hora entrusted me with the work of the scales of the Homalopterid fishes. The material of this family available in the Zoological Survey of India has been used for this purpose. In all cases, the scales were taken from below the base of the dorsal fin and treated with a weak solution of caustic potash (KOH) and then cleaned with fine needles under a binocular microscope. Canada Balsam mounts were then prepared and microphotographs taken for detailed study.

I am grateful to Dr. S. L. Hora, Director, Zoological Survey of India, for suggesting me this problem and for affording me facilities to work in the Laboratories of the Zoological Survey of India. I am also obliged to him for constant help and guidance in carrying out this work.

Historical Review.

The Homalopterid scales were first described by Cockerell (1909, pp. 205-207), who considered these fishes " as very aberrant Cobitids " and assigned them to Homalopterinae, which he regarded as a subfamily of Cobitidae. He described without figures scales of three species, *viz.*, *Gastromyzon borneensis* from Sarawak (Borneo), *Homaloptera maculata* from the Khasi Hills (Assam), and *Homaloptera brucei* from Meekalan (Tenasserim). The last two species belong to *Balitora* Gray and their correct identification would be *Balitora brucei brucei* Gray, and *B. b. burmanicus* Hora.

Commenting on the Cobitid and Homalopterid scales, Cockerell observed that " The scales, all of essentially the same type, are more or less degenerate, but hardly specialized. They appear to represent the

earlier type of Cyprinoid scale in a weak form, and that is why they remind one of certain scales of various genera of true Cyprinidae"

In 1912, Cockerell published a figure (Plate xxxiv, fig. 17) of the scales of *Homaloptera maculata* (=*Balitora brucei brucei*) from the Khasi Hills.

In 1920, Hora revised the Indian Homalopteridae and recognised three genera, *Balitora* Gray, *Bhavania* Hora and *Homaloptera* v. Hass. He published the figures of the scales of *B. maculata*, *B. brucei* and *Bhavania annandalei*. His account shows that he was not familiar with Cockerell's work on the *Homalopterid* scales but his description of the *Balitora* scale agrees with that of Cockerell. He described the scales of two more genera, *Bhavania* and *Homaloptera* without attaching any taxonomic significance to the structure of the scales in different genera

In 1931, Fang published figures of scales of three species of *Sinohomaloptera* to show the development of keel in the three forms but did not refer to the structure of the scales.

Description of Scales.

Fortunately the collection of the Zoological Survey of India contains a fair proportion of the genera and species described in the family Homalopteridae. In the first instance, descriptions with brief comments, where necessary, will be given, and then the significance of scale structures in the elucidation of inter-relationships between the various genera in each subfamily and finally the phylogeny of the family will be discussed.

Sub-family *Homalopterinae*.

It has been possible to study the scales of the genera *Homaloptera*, *Balitora*, *Bhavania*, *Sinohomaloptera*, *Sinogastromyzon* and *Hemimyzon*. In the case of the generalized genus *Homaloptera*, scales of eleven species are described and figured here. Similarly, scales of three species of *Balitora* are described. The material has helped to evaluate evolutionary trends within the members of the *Homalopterinae*.

Homaloptera ocellata van der Hoeven.

(Plate II, fig. 1.)

The scale of *Homaloptera ocellata* is somewhat irregularly oval in shape with a well-defined nucleus, situated almost at one-third of the distance between the base and the apex. It is almost one and a half times as long as broad, and is sculptured with well-marked radii and circuli. There are about 28 circuli, more widely spaced in the apical region but very closely packed in the basal region. There are about 8 complete radii going to the apex in two batches of 4 each with a wide space in between the batches. There are one or two incomplete radii at the sides also. There are about 17 basal radii almost equally spaced

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Homaloptera bilineata Blyth.

(Plate II, figs. 2 & 3.)

The scale of *Homaloptera bilineata* has already been described by Hora (1920) without figures; it is three-fourth as broad as long with a bluntly pointed apical region and a broad basal region. In the scale figured here the outline of the base is irregularly crenulated, but this character varies considerably. The nucleus is a fairly defined, structureless area situated considerably nearer the base than the apex. There are 24 to 26 circuli, more widely spaced in the apical area. No complete radii, either in the apical or basal region, can be made out, but in plate II, fig. 3 there are indications of a few incomplete basal radii. The lateral sides may be parallel or convex but in spite of differences in shape, the characteristic features of the scale are fairly constant. The identity of the broken type specimen can thus be fully established with that of a fresh specimen.

It may be noted that this scale differs markedly from that of *H. ocellata* not only in its pointed apical region but also in the absence of any well marked radii, either apical or basal. It may here be recalled that Vinciguerra (1890) had proposed a separate genus *Helgia* for this species along with his *H. modesta* and though Hora (1932) had merged it in the synonymy of *Homaloptera*, the structure of the scale would, at any rate, justify the separation of the two genera.

Homaloptera rupicola (Prashad & Mukerji).

(Plate II, fig. 4.)

The scale of *Homaloptera rupicola* is slightly longer than broad with the lateral borders almost straight, and the basal and apical borders somewhat arched. The nucleus is well defined and is situated in the basal half. There are about 28 circuli, more widely spaced in the apical region and more clearly marked in the lateral areas. The radii are also well marked, 12 in the apical region and 18 in the basal region, besides a few incomplete ones at the sides.

Though differing in shape, the general structural similarity of this scale with that of *H. ocellata* (Pl. II, fig. 1) may be noticed. It may here be recalled that Prashad and Mukerji (1929) had established the genus *Chopraia* for this species which Hora (1932) had merged in the synonymy of *Homaloptera*. The structure of the scale would justify such a merger.

Homaloptera smithi Hora.

(Plate II, fig. 5.)

The scale of *Homaloptera smithi* is five-sixth as broad as long with the lateral sides somewhat concave. The base as well as the apex are slightly arched. The nuclear area commences at a distance of one-fifth of the total length from the base but its boundaries are not clearly defined. There are about 30 to 40 closely set circuli in the basal region but with the exception of about 13 outer circuli the others are interrupted at

various stages by the ill-defined nuclear area. There are 28 to 30 basal radii, of which 9 reach the nuclear area while the others are reduced in size as they proceed laterally. The apical radii are not well defined and in the scale figured here there are about 6 on one side and only 2 on the other.

Though this scale differs in specific characters from the scales of *H. ocellata* and *H. rupicola*, the general pattern is very similar.

Homaloptera wassinki Bleeker.

(Plate II, fig. 6.)

The scale of *Homaloptera wassinki* is four-fifth as broad as long with the nuclear area situated at a distance of one-fifth of the length from the base. The lateral sides are slightly concave while the basal and the apical regions are curved. The apical border is broadly pointed. The circuli are very fine and closely packed in the basal region but only about 15 outer ones encircle the apical region where they are very prominent and widely spaced. There are about 7 basal radii and the same number of incomplete radii in the apical region.

In its general appearance, the scale is not unlike that of *H. ocellata* but the number of circuli as well as radii is fewer.

Homaloptera amphisquamata Weber & de Beaufort.

(Plate II, fig. 7.)

The scale of *Homaloptera amphisquamata* is almost circular in outline but its nucleus is placed very close to the base. There are about 25 circuli which are closely set in the basal region but are relatively widely spaced in the apical portion. There are about 12 radii in the basal and 12 in the apical areas while a few incomplete ones are situated laterally also.

Though, owing to the smallness of size, the shape has become circular instead of oval in this scale, the general pattern of the *H. ocellata* scale is still preserved.

Homaloptera orthogoniata Vaillant.

(Plate II, fig. 8.)

The scale of *Homaloptera orthogoniata* is very slightly longer than broad and is almost circular in appearance. The nuclear area is small and well defined ; it commences at a distance of 2/5 of the length from the base. There are about 45 circuli, which are fine and compact in the basal region and somewhat more widely spaced in the apical region. The radii are absent from the basal and the apical regions but a few incomplete ones (about 9 in number) are present at the sides.

As in *H. amphisquamata*, the general pattern of the *H. ocellata* scale is maintained in this scale though it has the circuli and the radii more disorganised.

Homaloptera gymnogaster Bleeker.

(Plate II, fig. 9.)

The scale of *Homaloptera gymnogaster* is only slightly longer than broad and is almost circular except that the sides are straight. The nuclear area which is fairly large and amorphous is almost central in position. There are about 13 circuli which are more widely spaced in the apical region. There are about 45 radii in all, of which about half the number is confined to the basal region and the others are distributed irregularly in the lateral areas. The radii of the apical area are inconspicuous.

This scale differs from all the scales described so far in the possession of a large, oval, nuclear area, otherwise the general pattern is more or less the same as in *H. ocellata.*

Homaloptera modiglianii Perugia.

(Plate II, fig. 10.)

The scale of *Homaloptera modiglianii* is somewhat broader than long and has a large eccentric, oval, nuclear area. The circuli are confined to the peripheral region of the scale and are about 12 in number. As the nuclear area is considerably nearer the base than the apex, the circuli in the basal region are finer and more compactly arranged. The radii are about 25 in number and are restricted to the base and the adjoining lateral areas; they are short and inconspicuous.

The specific characters of this scale are that (i) it is broader than long, (ii) a large, oval, structureless nuclear area, (iii) smaller number of circuli and (iv) absence of radii to the apical and adjoining lateral areas.

Homaloptera weberi Hora.

(Plate II, fig. 11.)

The scale of *Homaloptera weberi* is but very slightly longer than broad and, but for the conical apex, it is more or less circular in outline. The nuclear area is large but eccentric in position, being much nearer the base than the apex. In the basal region and at the sides, there are about 18 circuli but they are disorganised in the apical portion and can hardly be made out. The basal radii are short and conspicuous, and about 25 in number. There are a few radii going to the apex and of these 8 to 10 can be made out.

Both in regard to its conical shape and the form and extent of the nuclear area, this scale differs specifically from others described above.

Homaloptera heterolepis Weber & de Beaufort.

(Plate II. fig. 12.)

The scale of *Homaloptera heterolepis* is transversely oval in outline and is considerably broader than long; the length being four-fifth of the breadth. The nuclear area is well defined and is eccentric in position;

it is nearer to the base than to the apex. There are 24 circuli which are more completely arranged in the basal area but are more widely spaced laterally and in the apical region. There are 34 radii all round the scale, being more numerous in the basal region and sparse in the lateral areas.

This scale is specifically distinct from all other scales described above as it is much broader than long.

Balitora brucei Gray.

(Plate III, fig. 1.)

The scale of *Balitora burcei* has already been described and figured by Cockerell (1912) and Hora (1920) and there is very little further to be said about it here. It may, however, be noticed that the disorganisation of the nuclear area as already noticed in certain species of *Homaloptera*, such as *H. gymnogaster* and *H. modiglianii*, is still further accentuated in *Balitora*, showing thereby the types of *Homaloptera* species that may have given rise to *Balitora*.

Balitora maculata Gray.

(Plate III, fig. 2.)

The scale of *Balitora maculata* has already been described and figured by Hora (1920), but its general similarity in structure to the scales of *Homaloptera gymnogaster* may be noticed, though it is longer than broad.

Balitora brucei burmanicus Hora.

(Plate III, fig. 3.)

The scale of *Balitora brucei* var. *burmanicus* was briefly referred to by Cockerell (1912) but not actually described by him in detail; it is of the generalised *Homaloptera*-type, almost as broad as long with a slightly arched base and conical apex. There is a well-defined nuclear area situated entirely in the lower half of the scale. There are about 30 well marked circuli, compactly arranged in the lower portion and somewhat more widely spaced in the apical portion. Though there are 26 radii in all, only 6 of them are complete while the others are either in small bits haphazardly arranged. The basal radii are finer and more compactly arranged.

The structure of the scale of *B. b. burmanicus* supports Hora's (1949) views that this, as well as *B. b. melanosoma* Hora and *B. b. mysorensis* Hora, narrow-headed and more *Homaloptera*-like forms of *Balitora*, are more primitive than the highly specialised members now found in the Assam Hills and the Eastern Himalayas, zones of intense Himalayan movements.

Bhavania australis (Jerdon).

(=*Bhavania annandalei* Hora).

(Plate III, fig. 4.)

The scale of *Bhavania annandalei* was described by Hora (1920), but its resemblance to the generalised scales of *Homaloptera*, particularly to that *H. wassinkii*, may be noticed here. In discussing the affinities of his genus, Hora (1920; 1932, p. 277) pointed out that *Bhavania* must have evolved from *Homaloptera*-like ancestors. The structure of the scale supports such a view.

Sinohomaloptera kwangsiensis Fang.

(Plate III, fig. 5.)

The scale of *Sinohomaloptera kwangsiensis* described here differs considerably in structure from the keeled dorsal scales of three forms figured by Fang (1931). Unfortunately, the specimen from which I took the scale is now missing from the collection so I am not in a position to explain this marked deviation in structure which may be due to the separate positions of the scales on the body.

In the scale figured here, the nuclear area is small but well-defined. The circuli, about 42 in number, are well marked and there are indistinct indications of about 16 radii which are irregularly distributed all over the scale.

Though differing in form, the structural resemblance of this scale to those of *Homaloptera bilineata* with regard to the nuclear area, circulii and radii may be noted.

Sinogastromyzon sp.

(Plate III, fig. 6.)

The sculpture on the scale of *Sinogastromyzon* is very poorly developed but in general outline and the arrangement of circulii and radii recalls the scale-structure in several species of *Homaloptera*. The lower half of the scale is almost rectangular while the apical half is conical. The circulii, about 34 in number, can be made out with great difficulty, and the same is the nature of the 11 radii, except near the apex.

Sinogastromyzon is the most highly evolved genus among the Homalopterinae for life in torrential waters, and the structure of its scale seems to show the impress of the environment.

Hemimyzon sinensis (Sauvage & Dabry).

(Plate III, fig. 7.)

The scale of *Hemimyzon sinensis* is almost rectangular, much broader than long. It is rounded at the two corners. The nuclear area is eccentric and about 20 circulii can be made out with great difficulty. The radii are not clear.

This is a remarkable scale and I am unable to give its relationship with the other scales of the Homalopterinae.

RELATIONSHIPS OF THE HOMALOPTERINAE.

In the subfamily Homalopterinae, *Homaloptera* is undoubtedly a central genus which is represented by over 20 species distributed from Burma, Siam, Malay Peninsula, Sumatra, Java and Borneo. It is indeed remarkable that to the east or west of this central axis, no species of *Homaloptera sensu stricto* has so far been described though specialised genera of the Homalopterinae occur on both sides.

An examination of the species of *Homaloptera* shows great diversity in form among the members of this genus and attempts have been made in the past to distinguish them generically, such as *Helgia* Vinciguerra, *Chopraia* Prashad and Mukherji, etc. A causal glance at plate II, on which are given the scales of 11 species, will show much diversity in scale structure. In fact, the scales differ so considerably that they can be utilized for distinguishing species as the following synoptic key for the 11 species will show :—

1.	Well marked conical area at the apex ; radii absent or a few inconspicuous basal radii	*H. bilineata.*
	Well marked conical area at apex absent	**2.**
2.	Scale broader than long	**3.**
	Scale longer than broad	**4.**
3.	Length 4/5 of breadth ; nuclear area small and well defined ; conspicuous radii all round	*H. heterolepis.*
	Length slightly shorter than width ; nuclear area large ; basal and lateral radii inconspicuous ..	*H. modiglianii.*
4.	Apical area conical ; radii inconspicuous	*H. weberi.*
	Apical area crescentic ; radii conspicuous	**5.**
5.	Nuclear area large and central ; only basal radii conspicuously marked ..	*H. gymnogaster.*
	Nuclear area small and eccentric ; both basal and apical radii well marked	**6.**
6.	Scales almost circular	**7.**
	Scales almost rectangular	**8.**
7.	Conspicuous radii all round the scale ..	*H. amphisquamata.*
	Radii disorganised	*H. orthogoniata.*
8.	30 or more radii in the basal region ..	*H. smithi.*
	Less than 30 radii in the basal region ..	**9.**
9.	More than 15 basal radii	**10.**
	Less than 10 basal radii	*H. wassinki.*
10.	Scale considerably longer than broad ..	*H. ocellata.*
	Scale slightly longer than broad	*H. rupicola.*

If scale-structure can be regarded as of sufficient taxonomic value it will be obvious that the genus *Homaloptera* as constituted at present, is probably a heterogenous assemblage of forms. On the basis of the scale structure, different forms of *Homaloptera* seem to have given rise to various types of Homalopterine genera. For instance, the scale of *Balitora brucei burmanicus* is of the same type and pattern as that of *H. orthogoniata*, while the highly evolved species of *Balitora* have scales

in which a large part in the centre is disorganised and in this respect corresponds with the scales of *H. gymnogaster*, *H. modiglianii* and *H. weberi*. The scales of *Bhavania* are of the *H. wassinki*-type. The scales of *Sinohomaloptera* is generally of the *H. bilineata*-type, but without the apical cap. The scales of *Sinogastromyzon* and *Hemimyzon* are of much more specialised type but their general *Homaloptera*-like pattern is fairly obvious.

From the above discussion, one is led to conclude that the diversified forms of *Homaloptera* evolved into different genera both to the east and west of their main central range, so that the various genera become independently evolved from the *Homaloptera*-like ancestors.

Subfamily *Gastromyzoninae*

The scales of the following genera of the Gastromyzoninae have been studied and are described and figured here :—*Crossostoma* (two species), *Formosania* (one species), *Praeformosania* (one species) *Paraprotomyzon* (one species), *Protomyzon* (one species), *Beaufortia* (two species), *Pseudogastromyzon* (one species), *Gastromyzon* (one species), *Sewellia* (one species), *Parhomaloptera* (one species) and *Linparhomaloptera* (one species). According to Fang (1935), the members of the Gastromyzoninae can be readily divided into two groups—*Crossostoma* and allied genera in which the gill-openings extend to the ventral surface, and *Gastromyzon* and allied genera in which the gill-openings are restricted to above the base of the pectoral fins. The above listed genera can be grouped as under :—

Group 1.	Group 2.
Praeformosania	*Paraprotomyzon*
Formosania	*Protomyzon*
Crossostoma	*Beaufortia*
Linparhomaloptera	*Gastromyzon*
Parhomaloptera	*Pseudogastromyzon*
	Sewellia

It will be convenient to describe the members of the two groups separately and then discuss their affinities.

GROUP I.

Praeformosania pinchowensis Fang.

(Plate IV, fig. 4.)

The scale of *Praeformosania pinchowensis* is slightly longer than broad. There is a well-defined, small nuclear area which is situated near the base. The circulii and radii are clear and well-defined. There are 32 circulii which are compactly arranged in the basal area and widely spaced in the apical region. There are 19 radii, of which 8 are complete.

Formosania lacustre (Steindachner).

(Plate IV, fig. 3.)

In general appearance, the scale of *Formosania lacustre* is similar to that of *Praeformosania pinchowensis*, but differs from it in having a larger ill-defined nuclear area and innèr circulii not very clear. The scale is oval in outline, being considerably longer than broad. The nuclear area is eccentric. There are 14 circulii and 38 radii, of which 17 reach the nuclear area.

Crossostoma fascicauda (Nichols).

(Plate IV, fig. 1.)

The scale of *Crossostoma fascicauda* is similar to that of *Formosania lacustre* except in so far as the circulii and radii are better defined. It is irregularly oval, being considerably longer than broad. The nuclear area is somewhat diffuse and eccentric. There are 19 circulii and 27 radii, of which only 10 are complete.

Crossostoma davidi Sauvage.

(Plate IV, fig. 2.)

The scale of *Crossostoma davidi* is somewhat broader than long and is more or less circular in appearance. The nuclear area is small and wel-defined and is almost central in position. The circulii and radii are prominent; there are about 29 circulii and 36 radii. There are 8 complete radii and 10 very short while the others are of intermediate sizes.

Linparhomaloptera disparis (Lin.).

(Plate IV, fig. 13.)

Though smaller in size, the general structure of the scale of *Linparhomaloptera disparis* agrees with that of *Formosania*, except that the lateral and apical radii are not clearly defined or are absent. The nuclear area is only slightly eccentric. There are about 25 circulii and 26 radii. Only 10 radii are complete. The basal radii are more prominent.

The structure of the scale of this species indicates the close relationship between the genera *Linparhomaloptera* and *Formosania*.

Parhomaloptera microstoma (Boulenger).

(Plate IV, fig. 12.)

The scale of *Parhomaloptera microstoma* is irregularly circular in appearance, but with a large, eccentric nuclear area. There are about 12 circulii and the same number of radii which are irregularly distributed. Only 7 radii are complete.

This type of scale appears to have more affinities with the *Crossostoma*-type of scale rather than to those of *Praeformosania*, *Formosania* and *Linparhomaloptera*. The scale of *Crossostoma* is more primitive and generalised Cobitid type while that of *Parhomaloptera* is somewhat retrogressive in structure.

GROUP II.

Papaprotomyzon multifasciatus Pellegrin & Fang.

(Plate IV, fig. 5.)

Though the scale of *Paraprotomyzon multifasciatus* is as long as broad, it is asymetrical. The central ill-defined nuclear area is large and eccentric. There are 12 circulii in the peripheral region, more compactly arranged in the basal area and more widely spaced in the apical area. There are about 28 radii spread out in all directions and all of them reach the nuclear area.

In the Homalopterinae, it was noticed that disorganisation of the central zone was characteristic of the species adapted to a torrential environment. Using that as a criterion, it can be stated that *Paraprotomyzon* is more specialized than *Protomyzon*, and thus Pellegrin and Fang (1935) were correct in regarding their new genus more specialized than *Protomyzon*.

Protomyzon whiteheadi (Vaillant).

(Plate IV, fig. 6.)

The scale of *Protomyzon whiteheadi* is almost circular in outline with a small, well-defined central nucleus. The circulii and radii are well marked. There are about 29 circulii, concentric and equally spaced. The number of radii is 33 ; they are more numerous and conspicuous in the basal region. Almost all the radii are complete.

The general structural similarity of this scale to that of *Crossostoma davidi* may be noted.

Beaufortia leveretti (Nichols & Pope).

(Plate IV, fig. 7.)

The scale of *Beaufortia leveretti* is broadly oval in shape with an eccentric nuclear area. There are about 29 circulii and 17 radii, of which only 7 are complete. There are indications of the disorganisation of the scale particularly in the apical region.

Beaufortia pingi (Fang).

(Plate IV, fig. 8.)

The scale of *Beaufortia pingi* is quite different in shape and structure from that of *B. leveretti*. It is rhomboidal in shape with the apex circular and the base broadly pointed. The scale is longer than broad with the nuclear area situated slightly near the base. There are 27 circulii and 23 radii, of which only 5 are complete.

Gastromyzon borneensis Günther.

(Plate IV, fig. 10.)

The scale of *Gastromyzon borneensis* was described by Cockerell as early as 1909. The scale figured here agrees fairly closely with his description. There are 37 circulii and the nuclear area is small and well-defined. As many as 14 radii reach the nucleus.

Pseudogastromyzon fasciatus (Sauvage).

(Plate IV, fig. 9.)

The scale of *Pseudogastromyzon fasciatus* is elliptical in shape with its width considerably greater than its length. The disorganised nuclear area is large and eccentric. There are about 6 to 8 circulii, broad and wavy in the lateral and apical regions and compactly arranged in the basal region. There are about 47 radii, shorter and more numerous in the basal region.

This scale shows structural resemblance to that of *Paraprotomyzon*, but is more disorganised and is provided with lateral wings.

Sewellia lineolata (Cuv. & Val.).

(Plate IV, fig. 11.)

The scale of *Sewellia lineolata* is longer than broad with a slightly convex base, vertical sides and a rounded conical apex. The nuclear area is small, eccentric and well-defined. The radii and circulii are prominently marked. There are about 26 circulii, 22 radii in the basal region and 11 radii in the apical region. Of these, only 14 radii are complete.

Though *Sewellia* is a highly specialised Homalopterid genus, the structure of its scale is of the more primitive and generalized type.

INTER-RELATIONSHIPS OF THE GASTROMYZONINAE.

According to Fang (1935), the Gastromyzoninae can be readily grouped into two associations according to the nature of their gill-openings ; the *Crossostoma*-association, in which the gill-openings are in front of the pectoral fins and extend to the ventral surface for a short distance and the *Gastromyzon*-association, in which the gill-openings are restricted to above the bases of the pectoral fins which extend in front of the position of these openings. The first group comprises *Annamia* Hora, *Parhomaloptera* Vaillant, *Linparhomaloptera* Fang, *Vanmannenia* Hora, *Praeformosania* Fang, *Formosania* Oshima and *Crossostoma* Sauvage. The second group comprises *Paraprotomyzon* Pellegrin & Fang, *Sewellia* Hora, *Pseudogastromyzon* Nichols, *Beaufortia* Hora, *Protomyzon* Hora, *Neogastromyzon* Popta and *Gastromyzon* Günther.

The structure of the scale shows that the members of the first group studied here can be divided further into two groups. *Praeformosania*, *Formosania* and *Linparhomaloptera*, in which the scale is longer than broad, the nuclear area is well-marked and eccentric, the circulii and

radii are conspicuous and fully formed and the shape is more or less oval, forming a fairly homogenous assemblage of forms. The scales of *Crossostoma* and *Parhomaloptera* are circular; that of the former genus is fully sculptured and generalised while that of the latter is somewhat disorganised and, therefore, more specialized. The geographical distribution of the two genera would also indicate their distant relationship and independent specialisation after isolation.

In the group with restricted gill-openings, we have several lines of specializations. For example, the two Bornean genera, *Protomyzon* and *Gastromyzon* have scales in which the circuliiare fine and numerous and the radii fairly well-marked. Corresponding to the high degree of specialization attained by *Gastromyzon* as compared with *Protomyzon*, the scales differ markedly in shape, position of the nuclear area, etc. The scales of *Paraprotomyzon* and *Pseudogastromyzon* though differing in shape, possess a general structural similarity in so far as the nuclear area is large and disorganised and the circulii in the lateral and apical regions form broad wavy bands. *Paraprotomyzon* scale would seem to be more ancestral than the *Pseudogastromyzon* scale. The scales of the two species of *Beaufortia* differ from each other and from other scales in several important features but it is difficult to say anything at this stage about the affinities of this genus. The scales of *Sewellia* are of the generalized nature and would seem to indicate its evolution from a primitive stock independently.

From the data presented here, it would appear that more detailed comparative study of the scales from different regions of the body may reveal firm evolutionary trends in these specialised fishes and it is likely that the inter-relationship of the various genera may become clear.

Phylogenetic significance of the homalopterid scales.

Though the structures of the scales described here have proved helpful in understanding the probable affinities of the various genera within each subfamily, without a comprehensive knowledge of the Cobitid and Cyprinid scales, it is difficult to elucidate their precise systematic position. A comparison of the plates depicting the scales in the two subfamilies will show that they do differ as a lot from each other but it is difficult at this stage to tabulate the differences or to define them more precisely. The Gastromyzoninae scales are in general of the Cobitid type whereas the Homalopterinae scales are of the Cyprinid type. Since the Cobitidae and the Cyprinidae are closely related families, some genera of both have generalized scales. Cockerell (1909), who regarded Cobitid, Homalopterid and Cyprinid fishes as belonging to one family, considered the Homalopterid scales of *Gastromyzon* and *Balitora* as " of essentially the same type " as the scales of the Cobitid fishes are more or less degenerate, but hardly specialized. They appeared to him to represent the earlier type of Cyprinoid scale in a weak form and, according to him, are comparable to certain scales of various genera of true Cyprinidae. Much beyond that cannot be said even now.

REFERENCES.

CHANG, H., 1945.—Comparative study on the girdles and other adjacent structures in Chinese Homalopterid fishes with special reference to the adaptations to torrential streams. *Sinensia* XVI, pp. 9-26.

COCKERELL, T. D. A., 1909.—The Scales of the Cobitid and Homalopterid Fishes. *Proc. Biol. Soc. Washington* XXII, pp. 205-207.

———— 1912.—Observations on Fish Scales. *Bull. U. S. Bur. Fisheries* XXXII, p. 140, pl. xxxiv, fig. 17.

FANG, P. W., 1931.—Notes on new species of Homalopterine Loaches referring to *Sinohomaloptera* from Szechuan, China. *Sinensia*, I., p. 139.

HORA, S, L., 1920.—Revision of the Indian Homalopteridae and of the genus *Psilorhynchus* (Cyprinidae). *Rec. Ind. Mus.* XIX, pp. 195-215.

———— 1932.—Classification, Bionomics and Evolution of Homalopterid Fishes *Mem. Ind. Mus.* XII, pp. 263-330.

———— 1949.—Dating the period of Migration of the so-called Malayan element in the Fauna of Peninsular India. *Proc. Nat. Inst. Sci. India* XV, pp. 345-351.

PELLEGRIN, J. & FANG, P. W., 1935.—A new Homalopterid, *Paraprotomyzon multifasciatus* from Eastern Szechuan. *Sinensia* VI, No. 2, p. 103.

PRASHAD, B. & MUKHERJI, D. D., 1929.—The Fish of the Indawgyi Lake and the streams of the Myitkyina District (Upper Burma). *Rec. Ind. Mus.* XXXI, pp. 186-191.

RAMASWAMI, L. S., 1948.—The Homalopterid Skull. *Proc. Zool. Soc. London* CXVIII, pp. 515-538.

SMITH, H. M., 1945.—The Fresh-Water Fishes of Siam, or Thailand. *Bull. U. S. Nat. Mus.* No. 188, p. 272.

VINCIGUERRA, D., 1890.—Viaggio di Leonardo Fea in Barmania e regioni vicine. Pesci. *Ann. Mus. Cir. Stor. Nat, Geneva* (2), IX, pp. 328-35.