SKELETON OF CYPRINOID FISHES IN RELATION TO PHYLOGENETIC STUDIES.

II. The Systematic position of *Psilorhynchus* McClelland.

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Introduction.

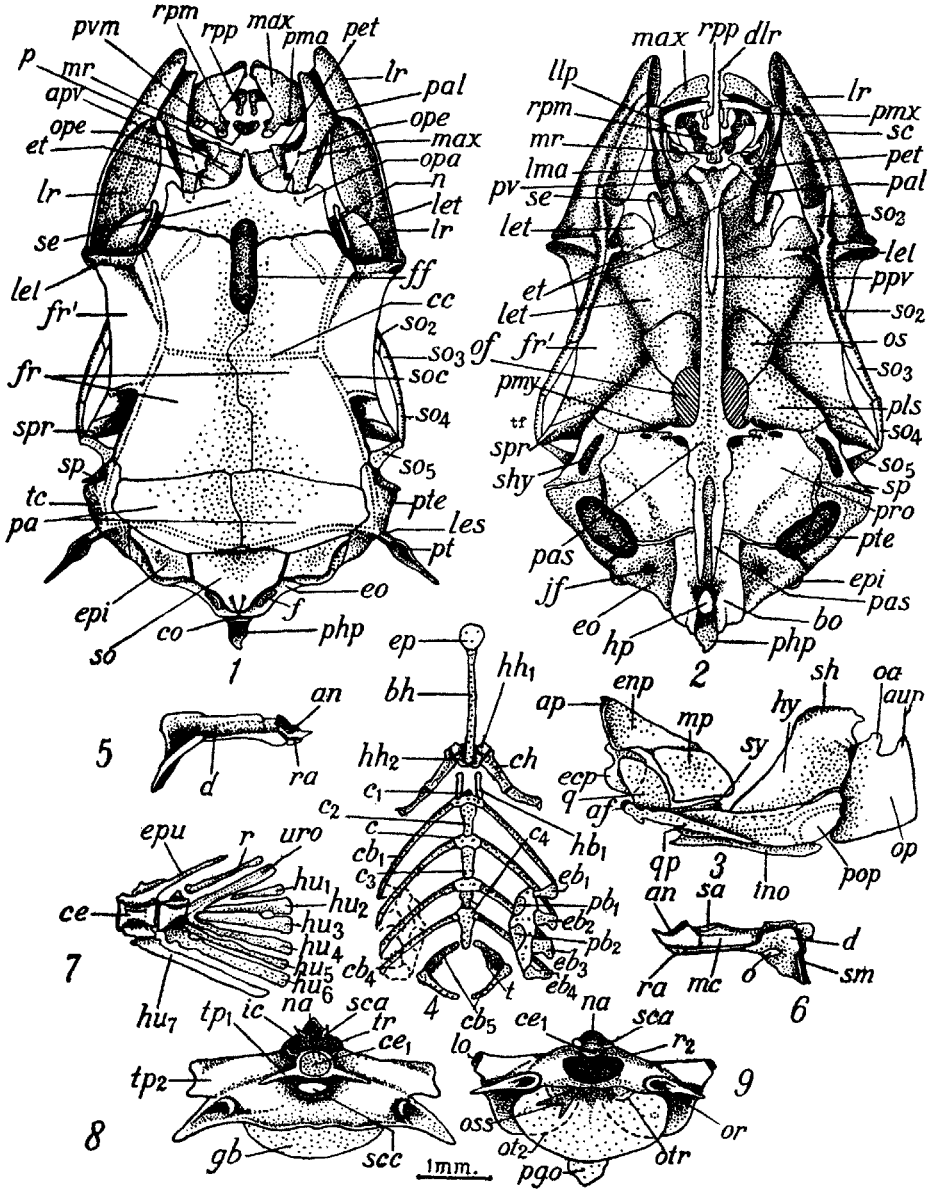
Hora (1925) established the family Psilorhynchidae to accommodate the Assamese hillstream fish *Psilorhynchus* McClelland after a careful examination of the external characters and also of the pharyngeal bones. He pointed out that each pharyngeal bone carried four teeth which were arranged in a single row. This feature associated with the presence of a number of simple rays in the paired fins precluded the inclusion of *Psilorhynchus* in the Cyprinidae. Similarly he pointed out that the absence of barbels and the presence of a free gasbladder in the abdominal cavity separated it from the Homalopteridae and Gastromyzonidae; and from the Cobitidae, it is distinguished, 'by the presence of large scales, by the presence of several simple rays in the horizontally placed paired fins, by the absence of barbels and in its general facies' (Hora, 1925).

In describing the family characters, Hora (1925) again referred to the nature of the arrangement of the teeth on the pharyngeal bones and with regard to the gasbladder, he pointed out that it was normal but reduced and according to him, 'it is either entirely free in the abdominal cavity or is partially covered by bone. The posterior chamber is very small and the anterior is covered by thick fibrous coat.' Obviously there is difference in the nature of the disposition of the gasbladder in these species. A progressive degeneration of the bladder is noticed in both species of *Psilorhynchus*, viz., *balitora* and *sucatio*.

It was suggested to me by Dr. Hora during our discussions on phylogenetic studies, that I should also examine the small hillstream cyprinine fish *Parapsilorhynchus* Hora which closely resembles *Psilorhynchus*. Accordingly specimens of *Parapsilorhynchus* were made available to me from the collections of the Indian Museum, Calcutta. *Parapsilorhynchus* differs from *Psilorhynchus* in three important external characters, viz., the possession of two cylindrical barbels, of the concealed upper lip and of the commencement of the dorsal opposite the ventrals (Hora, 1921). The gasbladder in *Parapsilorhynchus* is typically cyprinine in having an anterior and a posterior portion.

Observations.

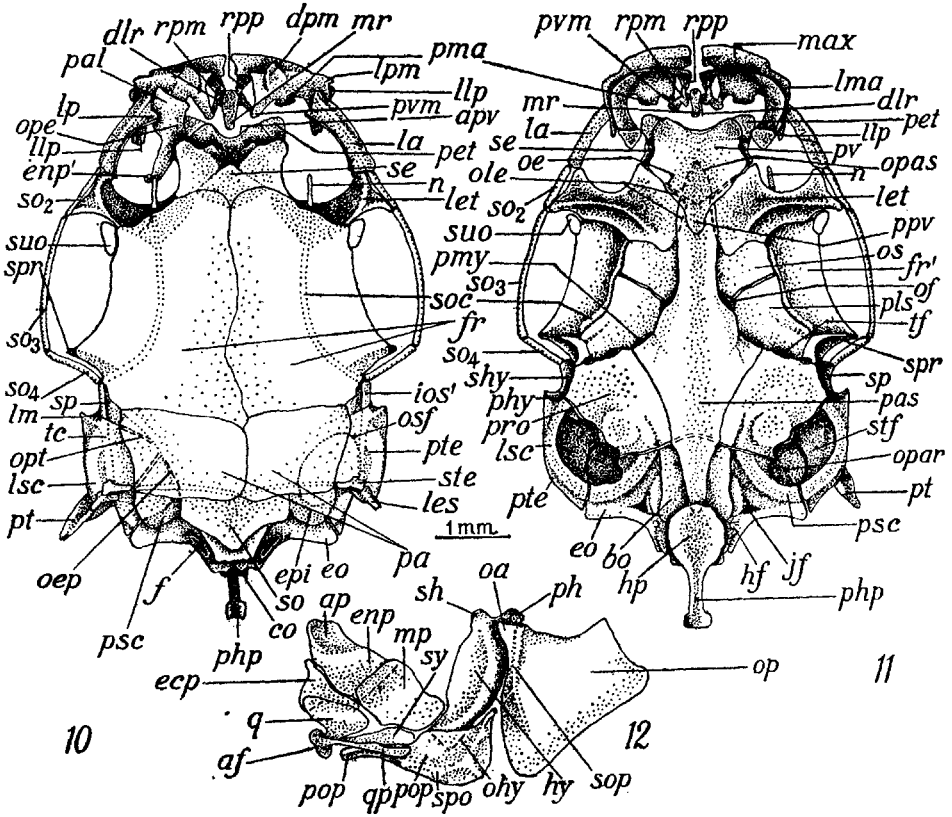
I have examined *Psilorhynchus sucatio* (Ham.) and *Parapsilorhynchus tentaculatus* (Annandale). There is a general flattening of the skull in both *Psilorhynchus* and *Parapsilorhynchus* which is obviously an adaptation for hillstream life and the former is also known to burrow in sand; in the specimen of *Psilorhynchus* examined by me, the skull appears to be comparatively longer than in *Parapsilorhynchus*.



TEXT-FIG. 1. Dorsal aspect of the skull of *Psilorhynchus sucatio* (Ham.).
TEXT-FIG. 2. Ventral aspect of the skull of *P. sucatio*; the palatines, the nasals and the post-temporals are not drawn.
TEXT-FIG. 3. The upper jaw of *P. sucatio*; the palatine is not drawn.
TEXT-FIG. 4. The hyobranchial apparatus of *P. sucatio*.
TEXT-FIG. 5. Lateral view of the left ramus of the lower jaw of *P. sucatio*.
TEXT-FIG. 6. Mesial view of the left ramus of the lower jaw of *P. sucatio*.
TEXT-FIG. 7. The caudal fin skeleton of *P. sucatio*; the fin rays are not drawn.
TEXT-FIG. 8. Anterior view of the Weberian ossicles and gasbladder of *P. sucatio*.
TEXT-FIG. 9. Ventral view of the Weberian ossicles and gasbladder of *P. sucatio*; the os suspensorium is drawn on one side.

The ethmoid region: The premaxilla in *Psilorhynchus* and *Parapsilorhynchus* show the characteristic cyprinid rostral process (figs. 1, 2, 10, 11, *rpp*) which however, does not sit on the median rostral (*mr*) but is away from it. The lateral limb (figs. 2, 10, 11, *llp*) is bent almost at right angles to the horizontal one carrying the rostral process and shows an expanded posterior part. The maxilla of *Psilorhynchus* shows two peculiarities: the dorsal premaxillary process so prominently noticed in the cyprinid maxilla (fig. 10, *dpm*) is absent in it. Further, the prevomerine process (figs. 1, 2, *pvm*) of the maxilla in *Psilorhynhcus* shows a very short rostral process (*rpm*) which unlike that in the cyprinids (figs. 10, 11, *rpm*) does not form a fork with the dorsal part of the maxilla (figs. 1, 2, *max*) to hold the premaxilla in it. The maxilla also shows a small projection (fig. 1, *pma*) towards the palatine and an elongated one (*pvm*) towards the prevomer in *Psilorhynchus*.

The median rostral (figs. 1, 2, 10, 11, *mr*) in both *Psilorhynchus* and *Parapsilorhynchus* is a short rodlike structure with two dorsolateral projections (*dlr*) for the attachment of ligaments from the rostral processes of the maxilla.



TEXT-FIG. 10. Dorsal aspect of the skull of *Parapsilorhynchus tentaculatus* (Annandale); the palatine and the post-temporal are drawn on one side.

TEXT-FIG. 11. Ventral aspect of the skull of *P. tentaculatus*; the palatines are not drawn and the post-temporal is shown on one side.

TEXT-FIG. 12. The upper jaw of *P. tentaculatus*; the palatine is not drawn.

The supraethmoid part of the ethmoid (fig. 1, *se*) is very broad in *Psilorhynchus* and extends in the form of a projection (*p*) in the middle. In *Parapsilorhynchus* (figs. 10, 11, *se*) it is not so broad and is seen as two lateral winglike extensions dorsally

to the prominent prevomerine projection (*apv*). In front of the ethmoid in *Psilorhynchus* (fig. 1, *et*) dorsally, the prevomerine projection (*apv*) is seen and on either side of these two, i.e., the ethmoid and the prevomerine projection, as in the Cyprinidae (figs. 10, 11 *pet*), the pre-ethmoid (figs. 1, 2, *pet*) is noticed. There is a large median indentation in the posterior border of the supraethmoid (*se*) in *Psilorhynchus* caused by a fossa (fig. 1, *ff*) noticed between the supraethmoid and the frontals (*fr*); in *Parapsilorhynchus* this is absent.

In *Psilorhynchus*, the lateral ethmoid (fig. 1, *let*) is seen in the dorsal aspect only partially since the lateral extension of the frontal (*fr'*) covers the posterodorsal part of it. Ventrally the lateral ethmoid (fig. 2, *let*) forms the floor of the anterior orbitotemporal region. In *Parapsilorhynchus*, a large part of the lateral ethmoid (fig. 10, *let*) is seen dorsally as in the other cyprinids but ventrally, it (fig. 12, *let*) does not extend as far posteriorly as in *Psilorhynchus*. In both genera, the lateral processes, viz., the lacrimal process and the one on the opposite side are poorly developed, thereby differing from the Homalopteridae and the Gastromyzonidae where these processes are well developed.

The lacrimal (figs. 1, 2, *lr*) is excessively enlarged in *Psilorhynchus*, a feature not noticed in any cyprinid studied by me (figs. 10, 11, *la*) and is very suggestive of the condition met with in the Homalopteridae and Gastromyzonidae. Probably the lacrimal of *Psilorhynchus* represents a united lacrimal and rostral, the latter being a sensory canal ossicle in front of the lacrimal in forms where these can be seen separately; it may not be a fused jugal-lacrimal-rostral since there is a large ossicle posterior to the lacrimorostral probably representing a jugal (fig. 2, so_2). In *Parapsilorhynchus* the lacrimal (figs. 10, 11, *la*) is not enlarged and is as in any other cyprinid; there is no rostral sensory canal ossicle in front of the lacrimal. However, there is a thin ossicle behind the lacrimal which may be the jugal (so_2). Both in *Psilorhynchus* and *Parapsilorhynchus*, the sensory canals are not separate but are incorporated in the lacrimal (or lacrimorostral, fig. 2, *sc*) and jugal; in the Homalopteridae, the sensory canal is independent of the lacrimorostral.

I prefer to consider the palatine here, though it forms a part of the upper jaw. In *Psilorhynchus*, the palatine (fig. 1, *pal*) is elongated and the anterior third of it is noticed in association with the lacrimorostral; this articulation is suggestive of the facet developed either in the palatine of *Cirrhina* (Cyprininae) to articulate with the lacrimal or as that in the Homalopterid examples. In *Psilorhynchus* the palatine shows a short posterior portion (fig. 1, *opa*) projecting ventrally to the supraethmoid for articulation with the entopterygoid and towards the pre-ethmoid, it also shows an articular facet. In *Parapsilorhynchus*, though the palatine is not so elongated as in *Psilorhynchus*, there is a projection towards the maxilla and the other processes are as in *Psilorhynchus*.

The edentulous prevomer (fig. 1, *apv*) of *Psilorhynchus* extends in front of the ethmoid (*et*) a feature also noticed in the cyprinids (fig. 10, *apv*). The bone is not broad in *Psilorhynchus* (fig. 2, *pv*) but shows a long posterior process (*ppv*); in *Parapsilorhynchus* the bone is very broad (fig. 11, *pv*) and the posterior process (*ppv*) is very short.

The orbitotemporal region: In *Psilorhynchus*, the frontals (fig. 1, *fr*) are wide and laterally they extend over the optic region; between the two frontals and the posterior edge of the supraethmoid (*se*), there is a median fontanel (fig. 1, *ff*) included which appears to be peculiar to *Psilorhynchus*. In no other cyprinid including *Parapsilorhynchus* is such an ethmoid fontanel noticed. In the Cobitidae, between the frontals and parietals there is generally a large or small frontoparietal fontanel; in the Gastromyzonidae, a few genera like *Vanmanenia*, *Crossostoma* and *Glaniopsis* show frontoparietal fontanel. According to Sagemehl (1891) no importance need be attached to the occurrence or otherwise of the latter fontanel in fishes since it appears to be a fortuitous character. The occurrence of fontanels either in the anterior or posterior dorsal region of the skulls of hillstream and sand burrowing

fishes and the Cobitidae which are mud-dwellers may not be, however, without significance.

The orbit is very large in *Psilorhynchus* since it has to accommodate a large eye; this is also a feature noticed in *Parapsilorhynchus*.

Two small supraorbitals (figs. 10, 11, *suo*) are noticed in *Parapsilorhynchus*; in *Psilorhynchus*, the bones are completely wanting.

On either side of the frontals in *Psilorhynchus*, posterior to the lacrimorostral, there are four suborbital sensory canal bones, the first of which is fairly large (fig. 2, so_2) and has been compared to a jugal. In the frontals the supraorbital canals (*soc*) run and the two are connected by a commissure (*cc*). In *Parapsilorhynchus* there are only three suborbital sensory canal ossicles (so_2, so_3, so_4) posterior to the lacrimal and the supraorbital canals which run in the frontals are not connected together by a commissure.

The orbitosphenoid (figs. 2, 11, *os*) and pleurosphenoid (*pls*) bound the optic foramen (*of*) anteriorly and laterally both in *Psilorhynchus* and *Parapsilorhynchus*. It was noticed, however, in *Gyrinocheilus* (Ramaswami, 1952*a*, in press) that the lateral ethmoid extended so far posteriorly as to bound the optic foramen ventrally also. In *Psilorhynchus* and *Parapsilorhynchus* the orbitosphenoids and the underlying parasphenoid do not form an interorbital septum. In the ventral view of the skull of *Psilorhynchus* and *Parapsilorhynchus*, between the pleurosphenoid and the parasphenoid the opening of the posterior myodome (figs. 2, 11, *pmy*) is noticed through which the posterior rectus muscle of the eyeball passes for insertion inside the myodome.

In *Psilorhynchus* the parasphenoid (fig. 2, *pas*) shows a forking in the posterior region as in *Crossocheilus*, one of the Cyprininae studied by me. Such a forking is not seen in the parasphenoid of *Parapsilorhynchus*.

In each eye-ball, there are two cup-shaped sclerotic bones.

The occipito-auditory region: Dorsally this region shows the two parietals (fig. 1, *pa*); the sphenotic (figs. 1, 2, *sp*) discloses a short spinelike process (*spr*) anteriorly and peculiarly, at the region the sphenotic comes in contact with the pterotic posterior to the hyomandibular articulation, the two are separated by a gap. Ventrally the sphenotic shows a single articular facet (fig. 2, *shy*) for the hyomandibular articulation. In *Parapsilorhynchus* the sphenotic shows a sphenotic process (figs. 10, 11, *spr*) and dorsally, there is an independent sensory canal ossicle (fig. 10, *ios'*) sitting on it connecting the supraorbital (*soc*) canal with the temporal canal (*tc*). Ventrally, the sphenotic shows a facet (fig. 11, *shy*) for the hyomandibula which is in close contact with the other facet (*phy*) in the pterotic.

The pterotic (figs. 1, 2, *pte*) in *Psilorhynchus* comes in contact with the postero-lateral edge of the frontal (*fr*) and receives the supraorbital canal which in this region is designated the temporal canal (*tc*). At this region the last suborbital bone (so_5) (sometimes called the postorbital bone also) receives the sensory canal to proceed as the infraorbital canal below the eye. Posteriorly the pterotic also shows the passage into the occipital and laterally into the lateral line canals; at the commencement of the latter, the lateral extrascapular (fig. 1, *les*) is seen sitting on the post-temporal (*pt*). In *Parapsilorhynchus* the independent sensory ossicle (fig. 10, *ios'* sitting on the sphenotic (*sp*) connects the supraorbital (*soc*) canal with the temporal (*tc*). Anteriorly the temporal canal gives off a branch (*lm*) which connects the one in the opercular to go off as the mandibular canal in the preopercular and the lower jaw.

In the cyprinids generally, the post-temporal articulates with the skull by two facets: one coming in contact with the epiotic and the other, when present, with the pterotic. In both *Psilorhynchus* and *Parapsilorhynchus*, the post-temporal (figs. 1, 2, 10, 11, *pt*) has only a single articular facet with the pterotic.

In *Parapsilorhynchus*, there is a deep subtemporal fossa (fig. 11, *stf*) whose outline could be easily made out in the dorsal aspect also (fig. 10, *osf*) through the

transparent parietal (*pa*). In *Psilorhynchus* (fig. 2, *stf*) it is very shallow and resembles more that in some Homalopterid examples.

The exoccipitals in *Psilorhynchus* and *Parapsilorhynchus* exclude the supra-occipital (figs. 1, 10, so) from forming the roof of the foramen magnum; also there is a lateral fossa (*f*) in each exoccipital, which is a feature noticed in all Cyprinidae, Catostomidae and Cobitidae.

The basioccipital (fig. 2, *bo*) of *Psilorhynchus* shows a short pharyngeal process (*php*) through which the aorta passes and also a bony projection (*hp*) for the attachment of the horny pad; in *Parapsilorhynchus* also these structures are noticed, only the pharyngeal process (figs. 10, 11, *php*) is very long.

In the structure of the upper (fig. 3) and the lower jaws (figs. 5, 6) *Psilorhynchus* resembles the cyprinids closely. However, there are two peculiarities not commonly seen in the Cyprinidae. The hyomandibular (*hy*) shows a single articular facet (*sh*) for articulation with the sphenotic region. The upper opercular edge shows a deep indentation so that there is a prominent auricular process (*aup*) and the opercular arm (*oa*) seems to be directed not anteriorly but vertically. There is no articular process at the region the preopercular gives articulation to the hyomandibula. The opercular does not carry a sensory canal in it. In *Parapsilorhynchus*, the upper jaw is typically cyprinid; the hyomandibula has two articular facets, one with the sphenotic (fig. 12, *sh*) and the other with the pterotic (*ph*). The opercular shows the prominent opercular arm (*oa*), the auricular process and the sensory canal (*sop*) in it which connects the temporal (fig. 10, *tc*) with the preopercular canal (fig. 12, *spo*).

Peculiarly in *Psilorhynchus* (fig. 6) the lower jaw shows a large orifice (*o*) in the dentary (*d*). This feature is not seen in any other cyprinid including *Parapsilorhynchus* studied by me.

In *Psilorhynchus* the hyobranchial apparatus exhibits only one pair of hypobranchs (fig. 4, hb_1) and this is unique. In the cyprinids, there are always three pairs of hypobranchs including *Parapsilorhynchus* and in *Gyrinocheilus* (Ramaswami, 1952*a*, in press) there are only two pairs. In *Psilorhynchus* there is a considerably elongated basihyal (fig. 4, *bh*) with a roundish cartilaginous epiphysis (*ep*). In *Parapsilorhynchus* there are, as in the Cyprinidae, three pairs of hypobranchs and two pairs of pharyngobranchs. While the fifth ceratobranch in *Psilorhynchus* (fig. 4, cb_5) shows four teeth (*t*) arranged in a row, in *Parapsilorhynchus*, the teeth follow the cyprinid plan.

The Weberian apparatus: In *Psilorhynchus* the gasbladder is divided into a large anterior (fig. 8, *gb*) and a smaller posterior (fig. 9, *pgb*) portions (see Hora and Mukerji, 1935, Pl. VII, fig. 5). The cyprinids also show a division into two. In *Psilorhynchus* the anterior part is partially protected by the enlargement of the dorsal rib (the transverse process of previous authors) of the second vertebra (fig. 8, tp_2) which does not, however, extend on the ventral aspect (fig. 9). Anteriorly a part of this dorsal rib is folded to show a lateral opening (fig. 9, *lo*); this is probably the first step towards the modification of the bony capsule seen in the Nemachilinae (Cobitidae) and the Homalopteridae. The first vertebra shows a round centrum (figs. 8, 9, ce_1) with a pair of dorsal ribs (tp_1). The neural arch of the second vertebra (*na*) which probably arises as an independent cartilage-bone shows in front of it the claustrum (not shown in the figures 8, 9) and scaphium (*sca*) with its prominent processus ascendens stapedis. A slender intercalarium (*ic*) articulates mesially with the second centrum; the tripus, which is cyprinid in shape, is enclosed in the capsule formed by the dorsal rib of the second vertebra and shows a processus anterior, a processus posterior and a processus articularis. The posterior process of the tripus (*otr*) comes in contact with the anterior part of the gasbladder. The tripus in being enclosed resembles the condition in the Nemachilinae and Homalopteridae; but in the latter two, the tripus assumes almost a Y-shape with one of the limbs longer and this limb comes in contact with the centrum

of the third vertebra. In *Psilorhynchus*, on the other hand, the tripus is, however, of the shape noticed in the cyprinids as remarked above. In *Parapsilorhynchus* the Weberian ossicles are not covered over by the capsular wall formed by an extension of the dorsal rib of the second vertebra and therefore, they are typically cyprinid showing the os suspensoria arising from the fourth vertebra. I have already discussed the origin of the Weberian ossicles in my previous paper (Ramaswami, 1952*a*, in press).

With regard to the gasbladder, it has been recorded by Hora (1925) that in *Psilorhynchus* two types are found: one with a free gasbladder and the other enclosed in bone in the same species of the genus. I am obviously examining the second type where the bladder is partially enclosed. I am unable to comment on the other as I have not examined the species with a free gasbladder.

The caudal fin skeleton: In *Psilorhynchus* and *Parapsilorhynchus* the last vertebra shows a prominent urostyle (fig. 7, *uro*) with an unconnected radial in front and with six hypurals (hu_1-hu_6) ventrally to it. The preceding two vertebrae also contribute epurals and hypurals for supporting the fin skeleton. Thus *Psilorhynchus* does not show any variation from the cyprinid type.

Discussion.

Having studied a large number of cyprinid skulls, I am in a position to compare the skulls *Parapsilorhynchus* and *Psilorhynchus* in order to evaluate their mutual relationships.

Parapsilorhynchus is a typical cyprinid, for it exhibits the following characters common to all cyprinids:

1. The premaxilla shows a rostral process.
2. The maxilla also shows a rostral process and the premaxilla is held in a fork of the maxilla. There are two facets posteriorly,—the prevomerine and the palatine, and the latter facet is capped with thick-connective tissue to articulate with the palatine.
3. The median rostral exhibits two dorsolateral processes generally for ligamentary connexion with the maxilla.
4. The supraethmoid portion is immovably articulated with the frontals and ventrally, the ethmoid with the projecting prevomerine portion gives articulation to the pre-ethmoid.
5. The lateral ethmoid does not show prominent lateral processes.
6. The pre-ethmoid gives articulation to the palatine.
7. The supratemporal connects the temporal canal with the lateral line and supraoccipital canals.
8. The post-temporal shows two limbs generally, one for articulation with the pterotic and the other with the epiotic.
9. The supraoccipital is excluded from the foramen magnum and the exoccipitals cover it dorsally. Each exoccipital shows a fossa in it; the basioccipital shows a prominent pharyngeal process which allows the dorsal aorta to pass through it, and a bony projection in front of the pharyngeal process for the attachment of a horny pad.
10. The orbitosphenoids and the pleurosphenoids along with the parasphenoid enclose the optic foramina.
11. The subtemporal fossa is noticed in the pterotic and the exoccipital for the insertion of the hyobranchial muscles.
12. The upper jaw shows a large preopercular which carries the mandibular sensory canal; from the temporal canal there may be a canal running in the opercular to reach the preopercular. The lower jaw shows the four typical bones, viz., the dentary, the angular, the retro-articular and the sesamoid angular.

13. The hyobranchial apparatus shows 3-4 copulae, two hypohyals, three hypobranchs and two pharyngobranchs. The fifth ceratobranch carries a number of curved teeth.
14. The Weberian ossicles are not covered by the extensions of the neural arches of the vertebrae; the intercalarium articulates mesially with the second centrum. The tripus is large, sickle-shaped and articulates mesially with the third centrum and the posterior process comes in contact with the anterior part of the bifid gasbladder.
15. The caudal fin skeleton shows an urostyle projecting dorsally from the last centrum with the hypurals below; epurals and hypurals are also contributed by the two vertebrae behind to support the fin rays.

Psilorhynchus, while disclosing a number of cyprinid features shows quite a few in which it is distinctive. These may have been developed in response to a life in fast-running brooks or to a life of burrowing in sand, which, therefore, are adaptive. Whatever may be the causes, *Psilorhynchus* in possessing these distinctive characters stands apart from the other members of the family Cyprinidae in which it was included by Regan (1911) and by Berg (1940).

Psilorhynchus exhibits the following cyprinid characters along with *Parapsilorhynchus:*

1. The large supraethmoid is immovably articulated with the frontals.
2. The pre-ethmoids give articulation to the palatine.
3. The premaxillae show rostral processes.
4. The exoccipitals roof the foramen magnum and show lateral fontanels.
5. The ventral subtemporal fossa gives attachment to the hyobranchial muscles.
6. The basioccipital shows a bony process for the attachment of a horny pad and a pharyngeal process.
7. The hyobranchial apparatus shows only two pairs of pharyngobranchs.

It may not be out of place here to state that *Gyrinocheilus* (Ramaswami, 1952*a*, in press), which is also a denizen of hillstreams does not show so many cyprinine features in its skull structure.

Psilorhynchus shows the following features in which it differs from the Cyprinidae in general and *Parapsilorhynchus* in particular:

1. The rostral process of the maxilla does not project to form a fork for the premaxilla.
2. The palatine is elongated and forms laterally an articulation with the lacrimorostral.
3. The possession of a unique ethmoid-frontal fontanel.
4. The lateral ethmoid is devoid of lateral processes.
5. The extraordinary growth of the frontals laterally and the absence of a supraorbital.
6. The enlargement of the lacrimal and of the jugal and the former forming a composite lacrimorostral.
7. The hyomandibula has a single facet for articulation with the sphenotic.
8. The presence of an elongated basihyal in the hyoid cornu and the possession of a single pair of hypobranchs and of the fifth ceratobranchial showing only four teeth arranged in a row as described by Hora (1925).

The features enumerated above are sufficiently distinctive to warrant the separation of *Psilorhynchus* from the Cyprinidae and to make it the type of the family Psilorhynchidae as has been done by Hora (1925). It has not been possible for me to find out which cyprinid genus gave rise to a form like *Psilorhynchus* and I have already pointed out that *Psilorhynchus* differs from *Parapsilorhynchus* in far too

many characters and therefore, the latter while showing the parallel external modifications also noticed in *Psilorhynchus*, is a typical cyprinid and cannot be considered as the progenitor of the former.

It is clear from the foregoing study that *Gyrinocheilus*, another hillstream species which I have studied and reported upon (Ramaswami, 1952*a*, in press) must have branched off early from the cyprinoid stock since it exhibits a few cyprinid features, while *Psilorhynchus* in showing a larger number of cyprinid characters must have branched off later. It must be stressed here that in the structure of the Weberian apparatus, *Gyrinocheilus* is more catostomid while *Psilorhynchus* shows more nemachiline and homalopterid affinities.

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Key to Lettering.

af., articular facet of the quadrate with lower jaw; *an.*, angular; *ap.*, articular facet of the entopterygoid; *apv.*, anterior process of prevomer; *aup.*, auricular process; *bh.*, basihyal; *bo.*, basioccipital; *c.*, unossified cartilage; c_1–c_4 copulae 1–4; cb_1, cb_4, cb_5, ceratobranchs 1, 4, 5; *cc.*, commissure between supraorbital canals; *ce.*, centrum; ce_1, first centrum; *ch.*, ceratohyal; *co.*, occipital condyle; *d.*, dentary; *dlr.*, dorsolateral processes of median rostral; *dpm.*, dorsal process of maxilla; eb_1–eb_4, epibranchials 1–4; *ecp.*, ectopterygoid; *enp.*, entopterygoid; *enp'*, entopterygoid process of palatine; *eo.*, exoccipital; *ep.*, epiphysis; *epi.*, epiotic; *epu.*, epural; *et.*, ethmoid; *f.*, exoccipital fontanel; *ff.*, ethmoid-frontal fontanel; *fr.*, frontal; *fr'.*, supraorbital extension of frontal; *gb.*, gasbladder; hb_1, hypobranchial 1; *hf.*, hypoglossal foramen; hh_1, hh_2, hypohyals 1, 2; *hp.*, bony plate for horny pad; hu_1–hu_7; hypurals 1–7; *hy.*, hyomandibula; *ic.*, intercalarium; *ino.*, interopercular; *ios'.*, independent sensory canal ossicle; *jf.*, jugular foramen; *la.*, lacrimo-rostral; *les.*, lateral extrascapular; *lel.*, *let.*, lateral ethmoid; *llp.*, lateral limb of premaxilla; *lm.*, branch to mandibular canal; *lma.*, lateral limb of maxilla; *lo.*, lateral opening in the dorsal rib of second vertebra; *lp.*, palatine process of lacrimo-rostral; *lpm.*, maxillary process for ligament; *lr.*, lacrimorostral; *lsc.*, lateral semicircular canal; *max.*, maxilla; *mc.*, Meckel's cartilage; *mp.*, metapterygoid; *mr.*, median rostral; *n.*, nasal; *na.*, neural arch; *o.*, orifice in the dentary; *oa.*, opercular arm, *oe.*, outline of ethmoid; *of.*, optic foramen; *ohy.*, outline of hyomandibular; *ole.*, outline of lateral ethmoid; *op.*, opercular; *opa.*, outline of palatine; *opar.*, outline of parietal; *opas.*, outline of parasphenoid; *ope.*, outline of pre-ethmoid; *opt.*, outline of pterotic; *or.*, orifice in the dorsal rib; *os.*, orbitosphenoid; *osf.*, outline of subtemporal fossa; *oss.*, os suspensoria; *otr.*, outline of tripus; ot_2, outline of dorsal rib 2; *p.*, median ethmoid process; *pa.*, parietal; *pal.*, palatine; *pas.*, parasphenoid; pb_1, pb_2, pharyngo-branchs 1, 2; *pet.*, pre-ethmoid; *pgb.*, posterior part of gasbladder; *pa.*, pterotic articular facet of hyomandibula; *php.*, pharyngeal process; *phy.*, articular facet for hyomandibula; *pls.*, pleuro-phenoid; *pma.*, palatine process of maxilla; *pmx.*, premaxilla; *pmy.*, posterior myodome; *pop.*, preopercular; *ppv.*, posterior process of prevomer; *pro.*, prootic; *psc.*, posterior semicircular canal; *pt.*, post-temporal; *pte.*, pterotic; *pv.*, prevomer; *pvm.*, prevomerine process of maxilla; *sa.*, sesamoid angular; *sc.*, sensory canal in lacrimorostral; *sca.*, scaphium; *scc.*, subcentral canal; *se.*, supraeth-moid; *sh.*, sphenotic articular facet of hyomandibula; *shy.*, facet for hyomandibula; *sm.*, symphysis meckelii; *so.*, supraoccipital; so_2–so_5, supraorbitals 2–5; *soc.*, supraorbital canal; *sop.*, sensory canal in opercular; *spo.*, sensory canal in preopercular; *spr.*, sphenotic process; *ste.*, supratemporal; *stf.*, subtemporal fossa; *suo.*, supraorbital; *sy.*, symplectic; *t.*, teeth; *tc.*, temporal canal; *tf.*, trigemino-facialis opening; tp_1, tp_2, dorsal ribs 1, 2; *tr.*, tripus; *uro.*, urostyle.