CHAPTER - III

LIGAMENTS
OBSERVATION

Ligaments constitute a very important structural unit of the head of fishes. The ligaments not only help to maintain a particular shape of the head by binding different endoskeletal structures but also they determine the direction and degree of movements of the bones. The ligaments when in action often cause a long chain of motions in a series (Liem, 1970). Thus the study of ligaments becomes an indispensable prerequisite for understanding the functional morphology of cranial region of the fishes.

Unfortunately this section of anatomy had drawn little attention of the earlier investigators excepting the human anatomists. Nevertheless earlier workers like Dobben (1937), Kayser (1962), Alexander (1967a, b), Yazdani (1969) observed few cranial ligaments of different groups of teleosts. Liem (1970) studied the cranial ligaments of nandid fishes in some detail and made an attempt to separate the ligaments into different groups on the basis of their topography. The actual breakthrough in the subject was achieved recently when Bandyopadhay (Ph.D. thesis, Calcutta University, 1980) studied all the cranial ligaments of some teleosts and named them in a very systematic manner. The present investigator has followed Liem (op. cit.) and Bandyopadhay (op. cit.) for grouping and naming the ligaments.

To avoid any repetition of facts, the detail description of the ligaments have been given on the ocular side of C. arel only and the difference if any, present on the blind side or in the rest of the fishes has been mentioned specially.

In order to provide a bird's eye view to all the cranial ligaments as revealed from the present study, a classified list of the same is given below. The said list will also serve as an index to the description of cranial ligaments for ready reference.
List of cranial ligaments found in the fishes under the present investigation

/Ligaments of neurocranium/
1. Lateral ethmoid - first infraorbital ligament.
2. Ethmoid - anterior pseudointerneural spine ligament.

/Ligaments between neurocranium and jaws/
5. Premaxilla - first infraorbital ligament.

/Ligaments between neurocranium and pectoral girdle/
6. Cleithrum - basioccipital ligament (Baudelot's ligament).

/Ligaments of jaw apparatus/
7. Maxilla - mandible ligament.
8. Intermaxillary ligament.
10. Intermandibular ligament.

/Ligaments between opercular apparatus and jaws/
11. Angular - interopercle ligament.

/Ligaments of the opercular apparatus/
15. Opercle - hyomandibular ligament.

17. Autopalatine - premaxilla ligament.
18. Quadrate - mandible (angular) ligament.

20. Pterygoid - lateral ethmoid ligament.
22. Autopalatine - ethmoid ligament.
23. Autopalatine - lateral ethmoid ligament.

25. Interhyal - hyomandibular ligament.

27. Epiphysal - interopercle ligament.

29. Urohyal - hypobranchial ligament.
/Ligaments of hyoid apparatus/

30. Brohyal - hypohyal ligament.
31. Interhyal - epihyal ligament.
32. Basihyal - hypohyal ligament.
33. Inter upper hypohyal ligament.
34. Inter lower hypohyal ligament.
35. Hypohyal - sixth branchiostegal ligament.

/Ligaments of branchial apparatus/

36*. Basibranchial - hypobranchial ligament.
37. Basibranchial - hypobranchial ligament.
38. Basibranchial - basibranchial ligament.
40. Hypobranchial - hypobranchial ligament.
41. Basibranchial - hypobranchial ligament.
42. Inter hypobranchial ligament.
43. Epibranchial - ceratobranchial ligament.

A detail description of the above mentioned ligaments is given below.

/Ligaments of neurocranium/

1. Lateral ethmoid - first infraorbital ligament

This is a small strip of ligament connecting the first infraorbital with the lateral ethmoid (Fig. 86). It is noteworthy to mention here that in C. bilineatus (Fig. 88) the above ligament is present in spite of the fact that the first infraorbital is absent.

On the blind side (Figs. 87, 89) this ligament is relatively strong.

2. Ethmoid - anterior pseudointerneural spine ligament

It is a strong, laterally compressed ligament connecting the ethmoid with the anterior pseudointerneural spine (Figs. 7, 8). After
leaving the cup shaped concavity of the ethmoid to which the ligament is attached, the latter runs upward, becomes wide in an anteroposterior direction and attaches to the ventral side of anterior pseudointerneural spine.

3. Maxilla-ethmoid ligament

It is a strong, elongated band of ligament having a swollen middle part which connects the head of maxilla with the ethmoid (Figs. 87, 89). Anteriorly the ligament is attached to the maxillary spine of maxilla and posteriorly it moves in an upward and backward direction and finally gets attached to the anterior rim of ethmoid.

It is found only on the blind side of head.

4. Maxilla-first infraorbital ligament

On the ocular side it is a short and moderately developed ligament connecting the maxilla with the first infraorbital (Fig. 86). It is attached to the maxilla just below the anterior border of lower orbit. In C. bilineatus where the first infraorbital is absent on the ocular side, the ligament is attached to other ligaments which would have been connected to the first infraorbital (Fig. 88).

On the blind side the ligament is strong and elongated in nature, connecting the first infraorbital with the head of maxilla (Figs. 87, 89).

5. Premaxilla-first infraorbital ligament

This is a thin band of ligament present only on the ocular side. The ligament connects the head of premaxilla with the first infraorbital (Fig. 86).
In C. bilineatus (Fig. 88), as the first infraorbital is absent on the ocular side, the posterior end of the above ligament gets fused with the lateral ethmoid-first infraorbital and maxilla-first infraorbital ligament.

6. Cleithrum-basioccipital ligament (Baudelot’s ligament)

It is a strong, roughly cylindrical ligament connecting the proximal part of the cleithrum with the ventral projection of basioccipital of the skull (Fig. 90). This ligament is symmetrical on both the sides and has been observed in all the fishes studied presently.

7. Maxilla-mandible ligament

It is a strong, elongated ligament connecting the upper and lower jaws (Figs. 87, 89). One end of the ligament is attached to the dorsal side of maxilla at about one-fourth of its length from the angle of the mouth, runs backward along the maxilla and finally the other end gets attached to the outer rim of the fossa of angular that receives the condyle of quadrate.

The ligament is found only on the blind side. In P. blochii it is absent even on the blind side.

8. Intermaxillary ligament

It connects the lateral faces of the heads of the maxillae of both the sides. A pair of such ligaments has been observed in the presently studied fishes (Figs. 91, 92).

1) A wide band of transverse ligament running on the outer aspect of maxillae, connecting both the maxillary spines.
ii) Relatively narrow transverse band of ligament running on the inner aspect of maxillae, connecting both the premaxillary processes.

9. Inter premaxillary ligament

This ligament runs transversely between the heads of the premaxillae of both sides. Two such ligaments have been observed in the present group of fishes (Figs. 91, 92).

i) A transverse band of ligament running between the anterodorsal part of both the premaxillae.

ii) A relatively thick transverse band of ligament running between the ventral aspect of the heads of both the premaxillae.

10. Intermandibular ligament

It is a wide band of ligament running transversely between the inner aspect of the anterior end of both the mandibles (Fig. 76).

/Ligaments between opercular apparatus and jaws/

11. Angular-interopercle ligament

This is an elongated band of ligament present on the ventral side of the lower jaw. It runs between the anteroventral aspect of the interopercle and the ventral margin of angular (Fig. 7). However, a part of this ligament also remains attached to the ventral part of dentary.

This ligament is relatively well developed on the blind side (Fig. 8). In P. blochii this ligament is lacking on the ocular side.
12. Retroarticular-interopercle ligament

This is a strong, cylindrical ligament connecting the retroarticular with the anterior face of interopercle (Fig. 7). This ligament lies dorsal to angular-interopercle ligament.

The ligament is relatively strong on the blind side (Fig. 8).

/Ligaments of the opercular apparatus/

13. Opercle-preopercle ligament

It is a short but strong ligament connecting the anterolateral part of opercle with the posterior aspect of preopercle (Figs. 7, 8). It is similar on both ocular and blind sides.

14. Opercle-interopercle ligament

This is a thin membranous ligament connecting the anterodorsal part of interopercle with the anteroventral margin of opercle (Fig. 7). The ligament becomes wide towards the opercle.

It is relatively strong on the blind side (Fig. 8).

/Ligaments between opercular apparatus and suspensorium/

15. Opercle-hyomandibular ligament

This is roughly a rectangular band of ligament which connects the opercle with the hyomandibular (Figs. 7, 8). The ligament runs in a forward and downward direction from the small elevation present on the anterodorsal process of opercle to the posterior aspect of hyomandibular. It is identical on both the sides of head.
16. Autopalatine-maxilla ligament

It is a long, coarse, thread-like ligament connecting the head of maxilla with the anterior end of autopalatine. This ligament is present only on the blind side of the head (Figs. 87, 89).

In P. blochii the above ligament is very feebly developed.

17. Autopalatine-premaxilla ligament

This is a long, thin ligament which connects the dorsal side of head of premaxilla with the anterior end of autopalatine (Figs. 86, 88). The ligament becomes gradually wide towards the premaxilla. Near its attachment with autopalatine the ligament gets fused with the autopalatine-prevomer ligament.

This ligament is found only on the ocular side.

18. Quadratet-mandible (angular) ligament

It is a strong band of ligament connecting the quadrate and angular of the respective side (Figs. 86, 88). The ligament runs in a dorsoventral direction from the inner lateral surface of the condyle of quadrate to the inner lateral border of the articular facet of angular.

This ligament is relatively strong on the blind side (Figs. 87, 89).

19. Pterygoid-first infraorbital ligament

This ligament connects the pterygoid (ectopterygoid and endopterygoid) with the first infraorbital.
On the ocular side this is represented by a thin membranous ligament connecting the anterolateral part of the outer aspect of pterygoi with the first infraorbital (Fig. 86). However, this ligament is lacking on the ocular side of *C. bilineatus* (Fig. 88).

On the ocular side it is represented by a strong ligament (Fig. 87).

In *C. bilineatus* (Fig. 89) and *C. lingua* this ligament is attached to a lateral prolongation of ectopterygoid.

20. Pterygoid-lateral ethmoid ligament

This ligament is present only on the blind side of *C. bilineatus* (Fig. 89) and *C. lingua*. In *C. bilineatus* it is a strong ligament connecting the distal end of the lateral prolongation of ectopterygoid with the lateral ethmoid. In *C. lingua* the ligament is less prominent and is partly fused with the lateral ethmoid-first infraorbital ligament.

21. Pterygoid-prevomer ligament

It is a well-developed band of ligament connecting the anterior part of the inner aspect of pterygoid (ectopterygoid and endopterygoid) with the lateral groove of prevomer (Figs. 87, 89).

The ligament is present only on the blind side.

22. Autopalatine-ethmoid ligament

This is a moderately developed ligament connecting the anterior part of autopalatine with the ethmoid (Fig. 86).

On the blind side this ligament is relatively short in length (Fig. 87).
23. Autopalatine-lateral ethmoid ligament

It is a very short ligament connecting the head of autopalatine with the lateral ethmoid (Figs. 86, 87).

Though the ligament is present on both the sides of head, it is more prominent on the ocular side.

24. Autopalatine - prevomer ligament

It is a short but strong ligament running in between the anterior end of autopalatine and the lateral groove of prévomer (Fig. 86).

The ligament is absent on the blind side of the head (Fig. 87).

/Ligaments between hyoid apparatus and suspensorium/

25. Interhyal-hyomandibular ligament

It is a thin, membranous ligament which runs between the inner aspect of interhyal and the symplectic end of hyomandibular (Fig. 56).

The ligament is relatively strong on the blind side.

26. Interhyal-metapterygoid ligament

It is also a thin ligament like the previous one (Fig. 56). It runs between the inner aspect of both interhyal and metapterygoid. Towards its attachment with the interhyal it is fused with the interhyal hyomandibular ligament.

The ligament is relatively strong on the blind side.
In *P. blochii* the dorsal and ventral pairs are fused as a result only one pair of ligaments are present.

31. Interhyal-epihyal ligament

On the ocular side this ligament interconnects the interhyal with that of the epihyal on their inner aspects (Fig. 56). It is of similar nature on the blind side.

32. Basihyal-hypohyal ligament

It is a coarse, thread like ligament running between the anterior part of the ventrolateral aspect of basihyal and the outer aspect of the upper hypohyal of the respective side (Fig. 56). The nature of the ligament is similar on the blind side.

33. Inter upperhypohyal ligament

It is a short transverse band of ligament connecting the upperhypohyals of either side (Fig. 56). The ligament passes transversely over the antero-dorsal part of basibranchial.

34. Inter lowerhypohyal ligament

It is also a short, transverse band of ligament connecting the lowerhypohyals of both the sides (Fig. 57). The ligament passes transversely below the anteroventral part of basibranchial.

35. Hypohyal-sixth branchiostegal ligament

This is a long, narrow, thread like ligament connecting the ventral aspect of lower hypohyal with the head of proximal end of the anterior most ray or the sixth branchiostegal ray (Fig. 57). The ligament runs along the ventral side of ceratohyal. The nature and disposition of the ligament is similar on the blind side.
These are the ligaments which remain associated with the different bony elements of branchial apparatus. It may be further mentioned here that these ligaments exhibit bilateral symmetry.

36. Basibranchial₁ - hypobranchial₁ ligament

It is a strong, elongated band of ligament connecting the postero-lateral side of the ventral prolongation of basibranchial₁ with the ventromedian part of hypobranchial₁ (Fig. 57).

37. Basibranchial₁ - hypobranchial₂ ligament

This is a long, narrow thread like ligament present on the ventral side of the branchial basket (Fig. 57). It connects the ventral prolongation of basibranchial₁ with the anterior prolongation of hypobranchial₂.

38. Basibranchial₁ - basibranchial₂ ligament

This is a small ligament connecting the posteroventral end of basibranchial₁ with the anteroventral side of basibranchial₂ (Fig. 59). In P. blochii the ventral prolongation of basibranchial₁ is tightly fitted to the anteroventral side of basibranchial₂ and hence the above ligament is not discernible.

39. Hypobranchial₁ - hypobranchial₂ ligament

It is a strong strap like ligament connecting the hypobranchial₁ with the hypobranchial₂ of either side (Fig. 56). The ligament runs between the inner middle part of hypobranchial₁ and the outer aspect of the proximal end of hypobranchial₂.
40. Hypobranchial\textsubscript{1} - hypobranchial\textsubscript{2} ligament

It is also a strap-like ligament present on the ventral side of the branchial basket (Fig. 57). The ligament runs between inner lateral aspect of hypobranchial\textsubscript{1} with the anterior prolongation of hypobranchial\textsubscript{2}. Near its attachment with the hypobranchial\textsubscript{2}, the former fuses with the basibranchial\textsubscript{1}-hypobranchial\textsubscript{2} ligament.

41. Hypobranchial\textsubscript{2} - hypobranchial\textsubscript{3} ligament

It is a thin membranous ligament which connects the inner lateral aspect of hypobranchial\textsubscript{2} and hypobranchial\textsubscript{3} (Fig. 56).

42. Interhypobranchial\textsubscript{3} ligament

This is a small transverse band of ligament present on the ventral side of the branchial basket (Fig. 57). It runs between the inner lateral aspect of the hypobranchial\textsubscript{3} of either side. The ligament passes below the posterior end of basibranchial\textsubscript{3}.

43. Epibranchial\textsubscript{2} - ceratobranchial\textsubscript{3} ligament

It is a small strap-like ligament connecting the distal elevation of epibranchial\textsubscript{2} with the proximal part of ceratobranchial\textsubscript{3} (Fig. 56).
Table 3. Comparison of cranial ligaments of ocular side and blind side of the fishes under the present investigation (Transverse ligaments and the unpaired ligaments have been spared with).

Present - *, Absent - X, Present but stronger - **

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<thead>
<tr>
<th>Name of the ligament</th>
<th>Ocular side</th>
<th>Blind side</th>
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<tbody>
<tr>
<td>Lateral ethmoid - first infraorbital ligament</td>
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<tr>
<td>Maxilla - ethmoid ligament</td>
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<td>*</td>
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<tr>
<td>Maxilla-first infraorbital ligament</td>
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<tr>
<td>Premaxilla-first infraorbital ligament</td>
<td>*</td>
<td>X</td>
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<tr>
<td>Cleithrum-basioccipital ligament</td>
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<tr>
<td>Maxilla-mandible ligament (Absent in P. biochii)</td>
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<td>Angular-interopercle ligament</td>
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<td>Retroarticular-interopercle ligament</td>
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<td>Opercle-preopercle ligament</td>
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<td>Opercle-interopercle ligament</td>
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<td>Opercle-hyomandibular ligament</td>
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<td>Autopalatine-maxilla ligament</td>
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<td>Autopalatine-premaxilla ligament</td>
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<td>Quadratus-mandible (angular) ligament</td>
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<tr>
<td>Pterygoid-first infraorbital ligament (Absent on the ocular side of C. bilineatus)</td>
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<td>Pterygoid-lateral ethmoid ligament (Absent in G. prol and P. biochii)</td>
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<td>Pterygoid-prevomer ligament</td>
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<td>Autopalatine-ethmoid ligament</td>
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<td>Autopalatine-lateral ethmoid ligament</td>
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<td>Autopalatine-prevomer ligament</td>
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<thead>
<tr>
<th>Name of the ligament</th>
<th>Ocular side</th>
<th>Blind side</th>
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<tbody>
<tr>
<td>Interhyal-hyomandibular ligament</td>
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<td>Interhyal-metapterygoid ligament</td>
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<td>Epiphyal-interopercle ligament</td>
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<td>Hypohyal-hypobranchial₁ ligament</td>
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<td>Urohyal-hypobranchial₁,₂ ligament</td>
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<td>Urohyal-hypobranchial₂ ligament</td>
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<td>Basibranchial₁-hypobranchial₃ ligament</td>
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<td>Hypobranchial₁-hypobranchial₂ ligament</td>
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<td>Hypobranchial₁-hypobranchial₃ ligament</td>
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<td>Hypobranchial₂-hypobranchial₃ ligament</td>
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<td>Epibranchial₂-ceratobranchial₃ ligament</td>
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Different views of cranium of C. arel (Bl. 320 mm) and C. bilineatus (Bl. 320 mm) showing the nature and disposition of bones and ligaments.

Figs. 86 and 87 - Ocular and blind sides respectively of C. arel.
Figs. 88 and 89 - Ocular and blind sides respectively of C. bilineatus.
Fig. 90 - Ventral view of basioccipital of C. arel showing the ligaments.
Figs. 91 and 92 - External and internal view respectively of upper jaw of C. arel showing the nature and disposition of bones and ligaments.
Fig. 93 - Disposition of urohyal-hypohyal ligament of C. arel.

/Abbreviations/[a.sy] - anterolateral projection of symplectic
[al.sy] - anterolateral wings of symplectic
[c.a.a] - condyle for articulation with angular
[c.b.l] - cleithrum-basioccipital ligament
[c.s] - cartilaginous strip
[e] - ethmoid
[imx.l] - intermaxillary ligament
[ipm.l] - interpremaxillary ligament
[l.e.f.i.l] - lateral ethmoid-first infraorbital ligament
[la] - lacrymal
[m.r.c] - median rostral cartilage
[mpt] - metapterygoid
[mx.e.l] - maxilla-ethmoid ligament
[mx.f.i.l] - maxilla-first infraorbital ligament
[mx.mm.l] - maxilla-mandible ligament
[p.e.l] - autopalatine-ethmoid ligament
[p.l.e.l] - autopalatine-lateral ethmoid ligament
[p.mx.l] - autopalatine-maxilla ligament
[p.pm.l] - autopalatine-premaxilla ligament
[p.pv.l] - autopalatine-prevomer ligament
[p.sy] - posterolateral projection of symplectic
[pm.f.i.l] - premaxilla-first infraorbital ligament
[pt.f.i.l] - pterygoid-first infraorbital ligament
[pt.pv.l] - pterygoid-prevomer ligament
[q.mm.l] - quadrato-mandible ligament
[t.c] - third condyle of hyomandibular
[uh.hh.l] - urohyal-hypohyal ligament

[As the ethmoid is not visible from the blind side, so it has been shown in a hypothetical diagram]
A review of the relevant available literature reveals that very little work has been done till now on the cranial ligaments of fishes in general and the flatfishes (family - Cynoglossidae) in particular. Yazdani (1967, 1969) described some of the jaw ligaments of different groups of flatfishes including the family Cynoglossidae and tried to correlate them with their adaptations. But his findings are incomplete and incomprehensive. The present investigator has made a very sincere attempt to study all the cranial ligaments of the fishes under present study and to correlate them with their adaptations. An attempt has been made here to lay more emphasis on the ligaments which are directly or indirectly involved in the feeding of the fishes.

The snout of the fishes belonging to the genus Cynoglossus and Paraplagausia are employed to plough the sandy or muddy bottom to secure their food (Menon, 1977). The snout on the other hand is strengthened by the erisma and the anterior pseudointerneural spine, the latter supporting the former from below. But curiously enough the anterior pseudointerneural spine is fixed loosely on the frontal bones (Menon, 1977). So to strengthen the anterior pseudointerneural spine, ethmoid-anterior pseudointerneural spine has developed.

Yazdani (1969) reported the presence of first infraorbital (lacrimal) and the ligaments associated with it only on the blind side of Cynoglossus sp. Contrary to the observation of Yazdani (1969), the present investigator could record the presence of first infraorbital and its associated ligaments on the ocular side as well as on the blind side of the head of C. arel, C. lingua and P. blöckii. But it is noteworthy that first infraorbital is lacking on the ocular side of C. bilineatus even though the associated ligaments are present.
The cup shaped head of premaxilla of ocular side bears the rostral cartilage and the latter rests completely on the prevomer (vide Chapter I - osteology part). So to keep the premaxilla of the ocular side in proper position, premaxilla - first infraorbital ligament is present only on the ocular side. The presence of other ligaments associated with the first infraorbital like, lateral ethmoid - first infraorbital, maxilla - first infraorbital and pterygoid - first infraorbital ligament were also observed earlier in Solea solea and on the blind side of Cynoglossus sp. by Yazdani (1969). An analysis of the table 3 reveals that the ligaments like lateral ethmoid - first infraorbital ligament, maxilla - first infraorbital ligament and pterygoid - first infraorbital ligament of the blind side are stronger than their counter parts of the ocular side. This shows that the suspensorium and the jaw of the blind side are bound more strongly with the neurocranium. The presence of maxilla-ethmoid ligament was recorded by earlier workers like Dutta (1975) and Bandyopadhyay (1980'). The present finding that the ligament is present only on the blind side of the head receives support from the earlier findings of Yazdani (1969). The presence of such a strong ligament only on the blind side indicates that the maxilla of the blind side is bound very rigidly with the neurocranium which is essential as the former is expected to receive more stress during feeding. Presence of pterygoid-lateral ethmoid ligament on the blind side of C. bilineatus and C. lingua in addition to the presence of pterygoid-prevomer ligament on the blind side of all the fishes under present investigation reinforces the attachment of suspensorium with the neurocranium. Yazdani (1969) found only a single ligament running between the lateral faces of heads of maxillae. But meticulous observation by the present author has revealed the presence of one pair of such ligaments. While Yazdani (1969) maintained silence regarding the ligaments running between the heads of premaxillae, the present
The presence of maxilla-mandible ligament in different groups of fishes has been established by earlier workers like Liem (1970), Dutta (1968) and Bandyopadhyay (1980). Yazdani (1969) showed the presence of such ligament only on the blind side of tongue sole. Winterbottom (1974) stated that with the complete freeing of the maxilla from the cheek and a more mobile premaxillae, the maxilla-mandibular ligament becomes well consolidated. The present finding falls in line with the earlier finding of Yazdani (1969) and Winterbottom (1974).

The presence of a quadrate-angular ligament in the fishes has become an established fact. The stronger nature of such ligament on the blind side helps to hang the lower jaw more effectively from the quadrate. Such modification is required, as more pressure is likely to be exerted on the quadrate angular joint during the process of feeding.

The mandible-interopercle ligament was reported earlier in the teleosts by Yazdani (1969), Liem (1970), Datta (1972) and Bandyopadhyay (1980). Yazdani (1969) showed the presence of two such ligaments on the blind side and a single on the ocular side. However, the present investigator found the presence of a pair of such ligaments on both the sides except in P. biocchii where a single ligament is present on the ocular side. The investigations also reveal that the ligaments on the blind side are stronger which is very much required for the effective movement of the lower jaw of the blind side.

The presence of intermandibular ligament draws support from the earlier finding of such ligament in the Indian Cyprinodonts by Kulkarni (1948).

Opercle-preopercle ligament and opercle-hyomandibular ligament are symmetrical on both the sides and are of usual nature and as such
needs no further discussion.

The presence of opercle-interopercle ligament has been confirmed in different groups of teleosts by the earlier workers like Liem (1970), Datta (1972) and Bandyopadhyay (1980). The presence of a stronger ligament on the blind side helps to pull the interopercle of the blind side more effectively towards the opercle.

The presence of interopercle-epihyal, epihyal-interhyal and interhyal-hyomandibular ligaments were reported earlier in different teleosts by Liem (1970), Dutta (1968) and Bandyopadhyay (1980). The findings of the present investigator confirms the earlier reports. However, the present investigator shows that the interhyal-hyomandibular ligament is attached to the symplectic end of hyomandibular than to the cartilaginous block present below the hyomandibular as reported by the earlier workers.

The importance of urohyal-hypohyal ligament is obvious (Dutta, 1968; Datta, 1972 and Liem, 1970), but no body had examined the exact nature of the ligament till Bandyopadhyay (1980) examined it in detail. The present findings on the attachment of the ligament tallies more or less with the earlier findings of Bandyopadhyay (1980).

The presence of a hypohyal-sixth branchiostegal ray ligament is perhaps a new record and its role in binding the sixth branchiostegal ray is important since the latter remains unattached to the ceratohyal.

Though the branchial arches play a major role in the feeding and respiration of the fish, the study of the ligaments of this region was not made till recently when Bandyopadhyay (1980) investigated the branchial ligaments of some teleosts. The present investigation reveals that, the branchial ligaments are mostly strong strip like structures fastening different arches together. The present
investigation also reveals that, the branchial ligaments exhibit bilateral symmetry. This finding can be correlated with the earlier findings on bones and muscles of the branchial region which also exhibit bilateral symmetry (vide Chapters I and II).

To put the whole discussion in a precise form it can be said that the cranial ligaments connected with the suspensorium, jaws and opercular apparatus are better developed on the blind side than on the ocular side. It is worth mentioning here that the study of cranial osteomyology (vide Chapters I and II) has shown that the osteological elements of the jaws and suspensory apparatus are stronger on the blind side and the jaws of the blind side are provided with stronger muscles. Thus it can be said that the jaws of the blind side which are provided with teeth are extremely modified and best suited for feeding activities than that of the jaws of the ocular side which lack the teeth.