THE CRANIAL ANATOMY OF
GLYPHOGLOSSUS MOLOSSUS (GÜNTHER).

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In a previous paper (10) the cranial osteology of the endemic Engystomatid genera, *viz.*, *Cacopus*, *Kaloula* and *Microhyla*, was reported with the object of estimating the correct position of this presumably primitive group of Anura. A large number of primitive features in the organization of these three narrow-mouthed toads has been described. The object of this paper is to place on record the salient features in the cranial osteology of the interesting Engystomatid, *Glyphoglossus molossus*, and to note if there are any points of difference or comparison between this and the other three genera previously described. It is to be noted, however, that *Glyphoglossus* is not indigenous to Mysore and therefore the study of it becomes all the more important in establishing the relationship of the group Engystomatidae as a whole. A single specimen of *Glyphoglossus* was secured by Boulenger (1) from Irrawady delta and Pegu, which seem to be its natural place of occurrence. Specimens have also been reported from Siam.

Among the earliest workers on the cranial osteology of Anura, mention must be made of Gaupp (5) whose 'Anatomie des Frosches' is an invaluable aid in the study of Anuran osteology. Recently, however, Dr. Villiers has studied the South African Brevicipitidae and the aglossal anura chiefly from the aspect of the cranial characteristics. In the Brevicipitid *Caco sternum* (16) Villiers recognizes the predominating Ranid features and remarks that 'there is however very good reason to believe, that *Caco sternum* is a Ranid as well.' Similarly M. Smith (11) after a careful scrutiny of the skulls of *Phrynella* and *Kaloula* with regard to the differences between the palatine and the vomer, has since abandoned treating them together. Further, in a single genus itself as noticed by Parker* for *Microhyla* the palatine is present in some while wanting in

others. The absence of the palatine has been observed in *Microhyla rubra* by me.

I am indebted to Prof. A. Subba Rau for a fairly adult specimen of *Glyphoglossus* from his collection, for which act of kindness I am thankful to him. My warmest thanks are due to Prof. C. R. Narayan Rao for guidance and direction.

The head was decalcified in 70 per cent. alcohol containing 1 per cent. nitric acid. Sections 10 microns thick were cut and stained in Bismark brown, picro-indigo-carmine, Haemalum-eosin and Mallory.

At the outset it must be pointed out that *Glyphoglossus* stands apart from the other members of the group *Engystomatidae* in very many features. Both the prenasal cartilages, the superior and inferior, are present and support the premaxilla.

**THE OLFACTORY CAPSULE.**

The cartilaginous framework of the nasal region is simple and possesses the characteristic structures described by Gaupp for *Rana*. However, from the cartilago obliqua depends the plica and the characteristic Gauppian wulste is absent. A vestigial recess saciformis may be noticed. In *Cacosternum* (16) where a well-developed recess is present the septomaxillary forms a capsule for it. But, in forms like *Phrynornerus* (15) and *Glyphoglossus*, since the recess is vestigial the septomaxillary bears no relation to it. Whether the septomaxillary is separated from the superior lamina or not, is not possible to be made out in my sections since my preparations do not show it clearly on account of long preservation in alcohol. At any rate the position of the septomaxillary and the vestigial nature of the recess could be easily made out. The other features are exactly as those described by Gaupp for *Rana*. The cavum inferior bears a thickened part towards the septum nasi which has been compared with the organ of Jacobson. The olfactory nerve innervating this part of the nasal organ passes through a groove or canal in the septum nasi. This feature is, however, peculiar to *Glyphoglossus* and not noticed in *Kaloula, Microhyla* and *Cacopus*. Further the septum nasi is extraordinarily thick in *Glyphoglossus* and unlike *Cacopus* no trace of ossification can be noticed in it.

In fact a feature of difference which is apparent at the first sight between *Kaloula* and *Glyphoglossus* is the thickness and the passage of the nerves in the septum in the latter, while
in the former the nerves run in close companionship with the glandula nasalis medialis. At about the same region in *Glyphoglossus* the thin investing nasals make their appearance. In a slightly posterior region the nasals are large and they never extend laterally towards the maxilla. Even the planum terminale which is thick and short, is uncovered by the nasal in which feature *Glyphoglossus* differs from *Microhyla* and resembles *Rana*.

It is to be remarked, however, that the cavum inferius opens either directly into the buccal cavity or through the intervention of a separate chamber, called the prechoanal sac. Both these features are noticed in the South Indian Eungystomatidae as already reported. In the tadpoles of *Cacopus* the choanae open into the prechoanal sac in which character they resemble the tadpoles of the South African *Phrynomerus* (15), and when they assume adult conditions the choanae bear no relation whatsoever to the vestigial prechoanal sac. On the other hand, the tadpoles of *Microhyla* and possibly those of *Kaloula* also, possess no anlage of a prechoanal sac, while in the adults of these examples and also of *Phrynomerus* (15), the cavum inferius opens into two sacs which have been compared to the buccal division of the organ of Jacobson, and these sacs ultimately open into the buccal cavity. While these relationships of the opening of the narial chambers are so complicated in these examples, in *Glyphoglossus*, it is extremely simple. The cavum inferius opens directly into the buccal cavity (see Fig. 1) and it is not possible to say if it opened into an anlage of a prechoanal sac in the larval conditions since I have not been able to study the tadpoles. In possessing no prechoanal sac therefore, *Glyphoglossus* diverges totally from its South Indian and South African congeners and resembles *Rana*. But in *Rana* the eminentia olfactoria is flat and is unsupported.
by a cartilaginous axis; in *Glyphoglossus* the eminentia is thick and supported by broad cartilaginous axis which is an extension of the solum nasi.

At the base of the solum nasi the vomer makes its appearance and unlike the Brevicipitidae and *Microhyla* no extension of the vomer seems to embrace the choanae in *Glyphoglossus*. The antorbital cartilage is invested by the palatine near the choanal end and towards the maxillary is noticed the pterygoid bone on the dorsal aspect of the cartilage. Moreover towards the recess lateralis also, in the antorbital region and also where the antorbital cartilage unites with the tectum nasi another investment is noticed similar to the pterygoid investment. In the sections taken in the hinder region, it is noticed that this ventral investment joins the pterygoid bone and remains as an internal investment of the pterygoid cartilage. Such an investment I have not noticed in the South Indian Engystomatidae that I have examined.

The frontoparietals appear just when the choanae commence to disappear from the sections. They are very well developed and are closely apposed, supporting thereby the statement of Boulenger that the Engystomatidae are devoid of a fontanelle. But Villiers describes the presence of a frontoparietal fontanelle in most of the South African forms.

The ossification in the ethmoid region is extremely feeble. It may almost be said that the os en ceinture is absent from my specimen of *Glyphoglossus* while the extensive ossification in the ethmoidal region is greatly manifest in *Cacopus* and *Kaloula* and this abbreviation is noteworthy in *Glyphoglossus*. Figure 2 shows the frontoparietals, the three pieces of cartilage dorsally and a large one ventrally,—all the four being derivatives of the trabecula. This ventral trabecular derivative divides the os en ceinture into a right and a left half in the South Indian Engystomatidae. Since the ossification is itself feeble in *Glyphoglossus* such a division is not possible to be made out. Except for two patches of ossification in the cartilage on either side of the brain in this region, no other ossification can be noticed.
Such a feeble ossification should not excite surprise since no sphenethmoid or os en ecutence is noticed in the case of Probreviceps (20).

THE EAR REGION.

The otic region presents certain peculiarities which I have not noticed in the other Engystomatid examples that I have examined. The occurrence of a hidden tympanum and the 'extraplectral' cartilage and also the incomplete annulus seem to be a distinguishing feature of the group Engystomatidae, though in a Ranid example Arthroleptella (13) Villiers has noticed the presence of an incomplete sickle-shaped annulus tympanicus.

Three Figures (3, 3a & 3b) are drawn to represent the middle ear and the associated structures. In the region where the extraplectral has made its appearance a sickle-shaped annulus tympanicus can be seen. Moreover dorsal to the annulus, the paraquadrate ossification can also be seen. The pterygoid which is to a side is noticed to invest the pterygoid cartilage. The quadratomaxillary which in previous sections is completely osseous is seen in this region (Fig. 3) investing the quadrate cartilage. Soon, the paraquadrate is seen to
invest the extended quadrat cartilage and the quadrato-maxillary has disappeared from the sections (Fig. 3a). The last Figure (3b) shows the union of the pterygoid cartilage and the quadrat. The figure also shows the ventral end of the annulus tympanicus, the small middle ear and the pars externa plectrum. Ventral to this pterygoquadrat cartilage is the Meckle's cartilage. The dermarticular investment is absent from sections in this region. Section 3c shows the opening of the Eustachian tube and the pars media plectrum. This appearance of the opening of the Eustachian passage is due to the fact that the middle ear seems to take a slight bend before it opens by the said passage. The ventral end of the annulus tympanicus in Kaloula establishes a connexion with the crista parotica by means of a cartilage. This cartilage and also the commissural one between the crista and the pars externa called the pars ascendens are both wanting in Glyphoglossus.

The attachment of the pars media plectris with the otic capsule is interesting. In Figure 4a the pars media has attached itself to the wall and its maximal attachment is noticed in Figure 4b, where the sheath-like appearance of the columella (pars media) is lost. In Figure 4c, the operculum (stapes) makes its appearance and the knob to which the opercular muscle is attached is shown in Figure 4d. The conditions enumerated here closely correspond to what has been described for Phrynomerus (15) by Villiers.

**THE LOWER JAW.**

The lower jaw in the South Indian Engystomatidae and in Glyphoglossus conforms to a common plan. At the symphisial
region a little ossification (possibly the prorostral) is noticed. The mentomeckelian ossification is very extensive in *Glyphoglossus* (Figures 5, 5a & 5b) and rather feeble in *Microhyla* (Figures 6 & 6a), *Cacopus* (Figure 7) and *Kaloula*. From the mentomeckelian no backwardly directed process can be observed in these forms as described by Villiers for *Phrynomenorus* (15) and *Breviceps* (19). No sooner the mentomeckelian bone disappears from the section, a rod-like cartilage other than the one invested by the dentary and the angular is noticed at this region in the sections. To this part of the Meckelian cartilage is attached the submental is muscle. A reference to the presence of a rod-like cartilage running parallel with the lower jaw has been made by Devanesan (2) and it is now shown definitely that it is a lateral epiphysis of the Meckie's cartilage uniformly occurring in the Engystomatidae. The dentary is independent of the mentomeckelian bone and establishes no connexion with it. Dorsal to this ossification is seen an unconnected piece of cartilage in *Glyphoglossus* whose exact significance I am not able to determine.

The muscle submental is excessively enlarged and the M. geniohoides is therefore pushed up and the M. hyoglossi assume a lateral position. The exaggerated development of these two former muscles which are believed to be responsible
in opening and closing the mouth and narial apertures, is to be closely correlated with the life habits of these narrow-mouthed toads. Cacopus at least lives for six months during the year buried under the earth while Kaloula and Microhyla live in wet earth and very little is known about the habits of Glyphoglossus. Mention must also be made along with these terrestrial habits of the Engystomatidae, the well-developed operculum in Glyphoglossus. This is possibly in response to the terrestrial habits as propounded by Varsluys (12).

In the posterior region of the mouth, Boulenger (1) mentions the presence of a denticulated ridge in Glyphoglossus and two in Cacopus. The region posterior to the second ridge in Cacopus is lamellated and is called the ‘pharyngeal organ’ by Devanesan (2). The presence of a similar modified tract in the pharyngeal wall is also noticed in Glyphoglossus. The histology of the organ is described by Devanesan for Cacopus and the same is also true of Glyphoglossus. The ciliated mucous epithelium extends over the filiform basement membrane core in the form of long lamella. The major part of the lamella is composed of large ovoidal secreting cells while the terminal part is composed of columnar cells with oval nuclei. Devanesan (2) believes that this organ is responsible in secreting a sticky fluid which enables the tongue in capturing the prey. In fact normally, the maxillary glands are attributed with this function of secreting the sticky fluid. He points out that the maxillary glands are absent in Cacopus and therefore the function is transferred to the pharyngeal organ. But the sections in the anterior region of the head of Cacopus show the presence of large maxillary glands opening into the mouth. Similar glands are also
noticed in *Glyphoglossus*. Therefore what exactly the function of the modified pharyngeal region is, it is difficult to say.

Moreover in *Glyphoglossus* Boulenger (1) mentions the presence of a papilla in the posterior region of the mouth. A section of the papilla is drawn in Figure 2. The histology of the papilla is merely a mass of loose connective tissue covered over by the pharyngeal epithelium.

**SUMMARY.**

1. A vestigial recess sacelliformis is present.
2. The absence of prechoanal sac is noteworthy.
3. The feeble ossification in the sphenethmoid region is recorded.
4. The pars ascendens is absent.
5. The presence of an extraplectral cartilage and a well-developed operculum with a knob are noticed.
6. The "pharyngeal organ" is described. The secretory function of the organ as described by Devanesan is questioned.

**LITERATURE CITED.**

3. Ecker .. "Frog." (Translated by Haslam). 1898.


KEY TO THE ABBREVIATIONS USED IN THE TEXT.

A.  Angulare (Dermarticulare).
Ant.  Antorbital cartilage.
A.t.  Annulus tympanicus.
C.  Cartilage whose significance is not determined.
c', c", c"'.  Dorsal, lateral and ventral derivatives of the trabecular cartilage.
Ch.  Choana.
D.  Dentary.
d. f. v.  Ductus fenestra vestibuli.
E.  Extrapleural cartilage.
e. olf.  Eminentia olfactoria.
E. T.  Eustachian tube.
F. P.  Fronto-parietal.
f. o.  Fenestra ovalis.
hy.  Anterior cornu of the hyoid.
L. l.  Lower lip of the otic capsule.
L. c.  Lymph cavity.
M.  Meckle's cartilage.
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<thead>
<tr>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>M. a.</td>
<td>Meckle's cartilage and the Angular.</td>
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<tr>
<td>Max.</td>
<td>Maxillary.</td>
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<tr>
<td>Md.</td>
<td>Mundwinkeldrüse.</td>
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<td>M. c.</td>
<td>Middle ear.</td>
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<td>M. epi.</td>
<td>Meckelian epiphysis.</td>
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<td>M. m.</td>
<td>Mentomeckelian ossification.</td>
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<td>mus.</td>
<td>Muscle.</td>
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<td>m. sub.</td>
<td>Muscle submentalis.</td>
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<td>N.</td>
<td>Nasal.</td>
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<td>op.</td>
<td>Operculum.</td>
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<td>P.</td>
<td>Palatine.</td>
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<td>Pa.</td>
<td>Paraquadrate.</td>
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<td>pap.</td>
<td>Papilla.</td>
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<td>Par.</td>
<td>Parasphenoid.</td>
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<td>P. e.</td>
<td>Pterygoid cartilage.</td>
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<td>pmp.</td>
<td>Pars media plectris.</td>
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<td>P. Q.</td>
<td>Paraquadrate cartilage.</td>
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<td>Pt.</td>
<td>Pterygoid bone and cartilage.</td>
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<td>Qm.</td>
<td>Quadrate cartilage and the Quadratomaxillary.</td>
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<tr>
<td>q.</td>
<td>Quadrate cartilage.</td>
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<td>S. N.</td>
<td>Solum Nasi.</td>
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<td>Sy. o.</td>
<td>Symphisial ossification.</td>
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<td>T. c.</td>
<td>Transitional cartilage.</td>
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<td>V.</td>
<td>Vomer.</td>
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<td>W. o.</td>
<td>Wall of the otic capsule.</td>
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