CONTRIBUTIONS TO OUR KNOWLEDGE OF THE CRANIAL MORPHOLOGY OF SOME RANID GENERA OF FROGS.—Part II.

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Introduction.

In my previous paper (author, 1932) I described some aspects of the cranial morphology of some species of the two genera *Rhacophorus* and *Philautus*. It was pointed out that the examined species of *Philautus* could not be merged with *Rhacophorus* though some systematists like Smith maintain that a large number of species of *Philautus* are degenerate forms of *Rhacophorus*, or they are individuals that have been arrested in their development. The present communication is a contribution to our knowledge of the cranial morphology of three species of the genus *Rana*, commonly met with in South India. The object of this study is to place on record certain cranial characteristics of the South Indian Ranid forms and to compare them with those of the European forms like *Rana fusca* and *Rana esculenta* and also with the South African form, *Rana grayi*.

I have selected three thoroughly aquatic forms for study, *Rana hexadactyla* Lesson, *Rana cyanophlyctis* Schneid, and *Rana curtipes* Jerdon. According to Boulenger (1890) the first reference to *R. hexadactyla* is made in *Bdang. Voy. Ind. Or. Zool.*, p. 331 by Lesson, to *R. cyanophlyctis* in *Hist. Amph. i.*, p. 137 and to *R. curtipes* in *Journ. As. Sot. Bengal*, 22, p. 532, 1858. I am unable to comment upon the nature of description given about these forms, since I was not able to secure these papers for reference.

The earliest work on the development and morphology of the Batrachian skull is by Parker (1881). He records in this paper the cranial morphology of some Indian Ranid forms like *R. Kuhli*, *R. hexadactyla*, *R. gracilis*, *R. cyanophlyctis*, *R. pygmaea* and *R. tigrina*. Gaupp (1896–1904), on the other hand, describes the anatomy of the entire head of European forms like *R. fusca* and *R. esculenta* and his work is of classic importance though some points in his work require verification.
The adult Ranid specimens were all collected alive and fixed in Bouin's fluid. The heads were decalcified in 70% alcohol containing 3% nitric acid. Sections 12 microns thick were cut and stained in Hæmalum-eosin and Hæmalum-picroindigocarmine.

The Olfactory Region.

The cavities of the narial region of the three species of *Rana* are similar to the ones described for *Rana fuscata* by Gaupp. In the anterior region of the frogs studied by me, the sections show the presence of both the prenasal cartilages,—cartilago prenasalis superior and cartilago prenasalis inferior. The premaxilla invests both these cartilages. The cartilago prenasalis superior depends from the cartilago obliqua while the inferior cartilage depends from the cartilago obliqua. Judging by the weight of evidence in support of the obliquous suspension of the plica it may be generalised that in Anura, the plica invariably depends from the cartilago obliqua and not from the tectum proper.

The recessus sacciformis,—"a cavity which, on the one hand, communicates with the vestibulum, and on the other hand, with the infundibulum and the cavum medium where these two latter cavities communicate with each other" is absent from the three species of *Rana* studied. The presence of a recessus sacciformis is prominently noticed in the European species of *Rana*, in which the disposition of the organ conforms with the description given above.

The disposition of the laminal cartilages is normal and in close association with the superior laminal cartilage, the septomaxillary bone makes its appearance. The septomaxillary is usually considered as a membrane bone appearing as an investment of the superior laminal cartilage. The bone is separated from the cartilage by the intervening connective tissue. This view is accepted by Goodrich (1930), de Villiers and all modern anatomists. But Lapage (1928), working on the septomaxillary of Urodela and Anura reports that the bone is definitely cartilaginous in origin. This view, though not accepted by all modern anatomists, is not altogether obsolete. In forms like *Kaloula pulchra*, Gray (*K. pulchra taprobanica*, Parker, 1934), the bone
makes its appearance as an ossification in the superior laminal cartilage thereby supporting the observations of Lapage. William K. Parker (1881) in his monograph on the structure and development of the skull in Batrachia (Part III) refers to the occurrence or otherwise of this bone in a large number of Anuran forms. He describes that in the specimen of *Rana hexadactyla*

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**Fig. 1A.** Trans-sections in the region of the septomaxillary bone of *R. hexadactyla*.

- *an. ty.* Annulus tympanicus.
- *b.e.* Buccal epithelium.
- *b.v.* Blood vessel.
- *c.a.* Cartilago alaris.
- *ch.* Choana.
- *c.m.* Cavum medium.
- *c.par.* Crista parotica.
- *c.p.ot.* Cartilaginous projection from the otic capsule.
- *c.pre.* Cavum principale.
- *c.s.* Cartilaginous support for the eminentia.
- *c.str.c.* Cristal portion of the transitional cartilage.
- *d.n.l.* Ductus nasolacrimalis.
- *e.t.* Eustachian tube.
- *f.p.* Frontoparietals.
- *gl.* Glands surrounding the cavum principale.
- *inf.* Infundibulum.
- *l.n.g.* Lateral nasal glands.
- *l.s.* Lamina superior.
- *max.* Maxilla.
- *Md.* Mundwinkeldruse.
- *me.* Middle ear.
- *mus.* Muscle.
- *nas.* Os nasale.
- *n.s.* Septum nasale.
- *me.* Nerve.
- *o.e.* Otic capsule.
- *op.* Ocreum.
- *op.gl.* Opening of the glands surrounding the cavum principale.

- *op.R.* Opening of the Rachendrüse.
- *ot.p.* Processus oticus.
- *ot.c.* Otic portion of the transitional cartilage.
- *parq.* Paraquadrate.
- *pars.* Paraphenoid.
- *pal.* Palatine.
- *p.a.* Pars ascendens plectri.
- *p.bas.* Processus basalis.
- *p.e.* Pars externa plectri.
- *p.m.p.* Pars media plectri.
- *p.q.* Processus quadratus.
- *pf.* Foramen prooticum.
- *prot.* Prootic bone.
- *p.t.* Planum terminale.
- *ptg.* Pterygoid bone.
- *ptg.b.* Processus basalis invaded by the pterygoid bone.
- *ptg.1.* Processus basalis invaded by the pterygoid bone.
- *Q.* Quadrat cartilage.
- *Qm.* Quadratomaxillary.
- *R.* Rachendrüse.
- *s.e.c.* Subethmoidal cartilage.
- *sk.* Skin.
- *sph.* Sphenethmoid.
- *s.n.* Tectum nasi.
- *t.p.* Tonsillar patch.
- *tr.c.* Transitional cartilage.
- *u.* Vomer.
- *w.p.* Worm parasite.
- *V.ne.* Branch of the trigeminal nerve.
examined by him there is "a small septomaxillary on the right side only, but the nasal angle in its ascent has a solid bony mass formed in it." In the other Indian and extrapeninsular species examined by him, viz., *Rana Kuhli, Rana gracilis, Rana pygmea* and *Rana tigrina* the absence of septomaxillary is noted, while in *Rana cyanophlyctis* "a small sigmoid septomaxillary" is reported by him. The same author also describes the occurrence of ossifications in the laminal cartilages of other examples, as the septomaxillary. Having examined the sections of *R. hexadactyla, R. cyanophlyctis, R. curtipes* and also that of *R. tigrina*, I have come to the conclusion that the observations of Parker (1881) with regard to *R. hexadactyla* and *R. tigrina* are not borne out by my studies. In my sections no lopsided development of the septomaxillary is noticed in *R. hexadactyla*, nor is the complete absence of the investing bone observed in *R. tigrina*. In *Rana hexadactyla* the bone appears as a small oval piece (Fig. 1A, smx.) above the lamina superius (l.s.) more towards the epidermal side of the cavum medium (c.m.). Posteriorly, the bone becomes hollowed out and one end of it invests the lamina superius while the other end bends over the infundibular (inf.) part of the cavum principale. Slightly posterior to the region where the infundibulum opens into cavum medium the septomaxillary is trifid (1B, smx.); one investment is noticed on the lamina superius while the other is seen on the lamina inferius and the third is situated externally to the infundibulum and internally to the glandula nasalis lateralis (l.n.g.). The investment noticed on the lamina superius disappears first; while the others unite to form a single piece at the region the cavum medium disengages a part from it as the nasolacrimal duct (d.n.l.). The bony piece referred to above also disappears from sections at the region where the planum terminale is fully formed. This description of the septomaxillary corresponds to that given for the South African form *Rana grayi* by du Toit (1933). The disposition of the bone in the other two species of *Rana* is almost similar to the one described for *R. hexadactyla*. In *R. cyanophlyctis* the bone appears as a single piece on the dorsal aspect of the lamina inferius. Posteriorly two more limbs make their appearance; a large one is added internally to the first and a smaller one is noticed under the lamina superius. The two external ones unite to form a forked single piece and the superior laminal investment remains the same (Fig. 2A, smx.); in the region of the infundibulum the forked external piece united with the internal one to form a single investment. Fig. 2B is drawn to show the disposition of the bony pieces in the region where the infundibulum gains access into the cavum medium. After the formation of the ductus nasolacrimalis, the investment on the lamina superius disappears, while a small portion of the septomaxillary persists in
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Trans-sections in the region of the septomaxillary bone of *R. cyanophlyctis*.

(Abbreviations as under Fig. 1.)

a few sections on the lateral aspect of the planum terminale (Fig. 2C, p.t.).

In *R. curtipes* the bone is feebly developed and is disposed on the laminal cartilages as in *R. hexadactyla*.

In the anterior region of *R. grayi*, du Toit (1933) describes the occurrence of a small prechoanal sac in the roof of the mouth. The sac is, however, absent from *R. hexadactyla*, *R. cyanophlyctis* and *R. curtipes*.

The next structure to engage our attention is the eminentia. The eminentia olfactoria in the Ranid forms is usually flat. This feature is noticed in the European form (Gaupp, 1904), in *R. grayi* (du Toit, 1934) and in some South Indian Ranid genera (author, 1934). In *R. hexadactyla* and *R. cyanophlyctis* the eminentia is elevated on account of the fact that the solum projects into the eminentia in the form of a large supporting cartilage (Figs. 3A and B, c.s.). In *R. curtipes*, on the other hand, there is no supporting cartilage and therefore, the eminentia is flat (Fig. 3C, c.s.). It is usually surmised that in Anuran forms which have adapted themselves largely to a terrestrial life, the eminentia is high or elevated. This view is borne out by examples like *Kaloula, Microhyla, Cacopus* (*Euperodon*) (author, 1932), *Glyphoglossus* (author, 1932 a), *Phrynomerus* (de Villiers, 1930), *Cacosternum* (de Villiers,
Figs. 3 A, B and C.—Transsections in the region of choana of *R. hexadactyla*, *R. cyanophlyctis* and *R. curipes* respectively.

(Abbreviations as under Fig. 1.)

1931), *Breviceps* (de Villiers, 1931 b) and *Probreviceps* (de· Villiers, 1933). Now, the explanation advanced for the development of an elevated eminentia becomes untenable, since purely aquatic forms like *R. hexadactyla* and *R. cyanophlyctis* have developed it, while it is absent from the other aquatic species, *R. curipes*. Therefore, the elevation of the eminentia has probably nothing to do with terrestrial adaptations of the Anura. It may, however, be said that the structure increases in area purely in response to the sensory requirements of the individual.

A brief reference may be made to the glands occurring in the narial region of the frogs examined by me. Gaupp (1904) describes the disposition
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of the glands in the European species of *Rana*. The latest account of the glands in the anuran head is by Müller (1932) who divides the glands under the following three heads:

(a) the intermaxillary glands,
(b) the palatal glands (Rachendrüse)
and (c) the tongue glands.

In the South Indian forms the disposition of the glands is almost identical with the description given by Müller. In *R. hexadactyla*, *R. cyanophlyctis* and *R. curtipes* the intermaxillary glands appear as tripartite structures, a median and two lateral groups. The lateral ones are situated externally to the premaxilla. Posteriorly, the intermaxillary glands also appear between the superior and inferior cartilages of the premaxilla and therefore, the glandular areas are five in number in this region. The areas again assume a tripartite appearance and finally, the bony separations disappear and the single large intermaxillary gland is seen. The openings of these glands are situated posteriorly and they open into the buccal cavity.

There is a set of glands surrounding the cavum principale (Fig. 2A, gl.), being disposed on the dorsal aspect of the lamina superior and they open by several long ducts into the cavum principale (Fig. 1A, op.gl.). They are very prominent in *R. hexadactyla* and *R. cyanophlyctis* and are not at all developed in *R. curtipes*. These glands of the cavum principale disappear at the region where the cavum medium gives off the ductus nasolacrimalis. The glandulae nasalis medialis make their appearance in the anterior region where the fenestra nasobasalis appears in sections. The intermaxillary glands situated ventrally to the fenestra, sometimes extend into the fenestra and surround the recessus medialis of the cavum inferius as in *Acris*, *Riacophorus* and other forms (Müller, 1932). In *R. curtipes*, the intermaxillary glands penetrate through the fenestra into the recessus medialis region of the cavum inferius. In *R. hexadactyla* and *R. cyanophlyctis* the penetration of the gland through the fenestra is not noticed. The glandulae nasalis lateralis (Figs. 1 and 2, l.n.gl.) and the Rachendrüse (see Figs. 3A, B and C, R.) are disposed as in the European form. Like the other glandular areas, the Rachendrüse are very poorly developed in *R. curtipes*.

The mundwinkeldrüse was for the first time described by de Villiers in *Anhydrophryne* (1931 c). Fuchs (1931) described the same gland in some amniotes (*Podocnema expansa*) and some amphibian examples (Bombinator, Dondrobates) under the name of “bursa oris angularis”. In *Rana grayi* the occurrence of the gland has been noticed by du Toit (1933). Müller (1932) also refers to this gland in his paper and remarks that it is not a typical gland, but only an accumulation of nuclei. In *R. hexadactyla* alone the
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gland is very well developed. The gland, as in the other forms of Anura examined, makes its appearance between the maxilla (Fig. 4A, max.) and the pterygoid (ptg.) and has a very small lumen; in close association with this, blood and lymph vessels are noticed. Posteriorly, it opens into the buccal cavity. In the region where the mundwinkeldrüse leads into the buccal cavity, the quadratomaxillary (Qm.) is also seen. In R. cyanophlyctis, on the other hand, the gland makes its appearance as two or three irregularly scattered areas of lymphocytic aggregations dorsally to the maxilla and pterygoid (Figs. 4B and C, Md.); in association with these lymphocytic aggregations, blood and lymph vessels and nerves are seen. It is extremely difficult to identify this structure as a "mundwinkeldrüse", but for the relative positions occupied by the lymphocytes, blood vessels and lymph channels (see Figs. 4B and C). Moreover, there is no opening of these lymphocytic areas into the buccal cavity. Perhaps, Müller's view of the non-glandular nature of the mundwinkeldrüse is largely borne out by R. cyanophlyctis. In R. curitis a different state of affairs is met with. A transversely elongated aggregation of lymphocytes, makes its appearance between the maxilla (Fig. 4D, max.) and the pterygoid (ptg.). This transverse elongation is largely due to the presence of a worm parasite (w.p.) occupying the space between the lower portion of the eye and the maxilla. The parasite is found on either side in identically the same place and is surrounded by a large number of chitinous cysts. The gland, however, opens into the buccal cavity by a small duct. I am unable to say at present what exactly the function of the gland is like.

I shall make here a brief reference to the other lymphocytic areas (tonsillar patches) found in the anterior region of the cranium. The subject of Batrachian tonsils has been studied by a large number of workers like
Kingsbury (1912), Jolly (1919)* and Myers (1928). Discussing the structure of the Anuran tonsils, Kingsbury (1912) notes that in essentials the structural features of the Anuran tonsils resemble those of mammals, though at the end he cautions by saying that the “homologization of the amphibian tonsils with those of other groups is regarded as unsafe.” He describes in detail the structure of the proglottidean, lateral and sub-lingual adenoid patches. Myers (1928) referring to Jolly’s work (1919) mentions that in the examples investigated by the latter author, “lymphoepithelial” masses are found only in *R. temporaria* and palatine tonsils in both *R. esculenta* and *R. temporaria*.

In *R. hexadactyla* and *R. cyanophlyctis* a large number of lymphocytic aggregations are noticed and *R. curtipes* is peculiarly free from these adenoid

patches. In *R. hexadactyla* and *R. cyanophlyctis* the numerous adenoid patches are disposed in the roof of the mouth, on the tongue and below it. The areas that are found just below the tongue and also far away from it (i.e., those that are situated above the mandible) are all labelled by Myers as sublingual tonsils. More correctly, the ones situated just below the tongue should be called sublingual and the others nearer to the mandible must be labelled mandibular tonsils. Besides the areas described above where these tonsillar patches occur, lymphocytic aggregations also occur in the region of the cavum inferius. One pair of these tonsils opens into the cavum inferius and the other only surrounds the maxillary end of the cavum. In the two examples referred to above there is also a large adenoid area just below each eye. These may be designated the subocular tonsils.

**The Membrane Bones of the Anterior Region.**

Included under the membrane bones of the olfactory region are the premaxillæ, maxillæ, vomer (prevomer), palatine and septomaxillary. A reference has already been made to the septomaxillary bone. The premaxillæ, maxillæ, vomer (prevomer) and palatine are represented as in the European form *Rana fusca* (Gaupp, 1904). In all the species of *Rana* examined by me, the lateral square of the premaxilla is longer than the median one. The premaxilla, maxilla and vomer (prevomer) are dentigerous. The nasal bone is disposed uniformly in all the species of *Rana* studied. Anterior to the planum terminale the nasal bones invest the tectum and
posterior to the planum they protect the cavum principale. In the antorbital region, investing the dorsal aspect of the antorbital cartilage is noticed the posterior portion of the nasal (Figs. 3A, B and C, *nas.*); the bone is thick and muscles are inserted into it.

**The Ethmoidal Region.**

The sphenethmoid (os en ceinture, Cuvier) is a girdle-shaped bone which may or may not be divided into a right and left half by means of a median cartilage. In some examples, however, the ethmoidal region is not at all ossified. To this latter category belongs *R. curtipes* (Fig. 5A). In *R. cyanophlyctis*, on the other hand, the sphenethmoid is very well developed.
and is not separated ventrally into lateral halves by a median cartilage. In
sections in the anterior ethmoidal region, the occurrence of a small piece of
cartilage (Figs. 5B and C, s.e.c.) between the sphenethmoid (sph.) and
parasphenoid (pars.) is noticed, whose exact significance, it is not possible
to say. This subethmoidal cartilage (s.e.c.) is also noticed in *Rana grayi*
(du Toit, 1933). In *R. hexadactyla* the sphenethmoid is well ossified as in

![Anterior and posterior sphenethmoidal regions of *R. hexadactyla.*](image)

*Fig. 5D.* *Fig. 5E.*

Anterior and posterior sphenethmoidal regions of *R. hexadactyla.*

(Abbreviations as under Fig. 1.)

*R. cyanophlyctis.* The frontoparietals in this region are thick and massive as
in *R. hexadactyla* and *R. cyanophlyctis*; in *R. curtipes* the bones are thin.

**The Otic Region.**

The otic region in all the three species of *Rana* that I have examined
follows a common plan. The paraquadrate (squamosal) bone is the first
to make its appearance in sections and posteriorly to it the middle ear and
annulus tympanicus are seen. In the region where the middle ear makes
its appearance in *R. hexadactyla*, the annulus tympanicus with the ventrally
situated maxilla and quadrato-maxillary are also seen. This extension of
the maxilla posteriorly seems to be a common condition among the Ranids
and it is also noticed in *Rana grayi* (du Toit, 1933). The membrane bones
and the associated cartilages in the middle ear region are drawn in the series
of Figs. 6A, B and C. It will be noticed that the arrangement of bones and
cartilages are not essentially the same as the descriptions given either for
European species of *Rana* or the South African form, *Rana grayi* (du Toit,
1933). In *R. hexadactyla*, in the region where the prootic bone has not yet
made its appearance the middle ear, annulus tympanicus and the paraquadrate bone are all noticed. In this region the circular pars externa plectri (the extrastapedial process) is also present, and therefore, it appears more anteriorly than it is noticed in the other Ranids. In posterior sections, the transitional cartilage (Fig. 6A, tr.c.) which appears internally to the

![Diagram](image-url)

**Fig. 6A.**
(abbreviations as under fig. 1.)

The paraquadrate (parq.) unites with the otic process (ot.p.) and the cristal end (Fig. 6B, c.tr.c.) of this combined cartilage unites with the ossified otic capsule posterior to figure 6B. Moreover in Fig. 6A, it is noticed that a small anterior portion of the processus basalis (p.bas.) also appears being invested by the pterygoid (ptg.). Peculiarly, however, in posterior sections the processus basalis (Fig. 6B, p.bas.) which arises from the processus oticus (ot.p.) is partially invaded by the pterygoid (ptg.). Both in 6A and B, the pars media is seen in close association with a cartilage which is the pars ascendens plectri. The pars ascendens plectri establishes a connection between the circular pars externa plectri on the one hand, and the cartilaginous ventromedial portion of the crista on the other. The occurrence of the maxilla and the quadratomaxillary in close association with the ventral portion of the annulus tympanicus are also shown in Figs. 6A and B. In Fig. 6C, where the eustachian tube opens into the buccal cavity, the ossified otic capsule (o.c.) is noticed and this gives rise ventrally to a large cartilaginous projection (c.p.ot.), which gives articulation to the posterior
Consecutive trans-sections in the middle ear region of *R. hexadactyla*.

(Abbreviations as under Fig. 1.)

portion of the processus basalis (*p.bas.*). The pars ascendens plectri (*p.a.p.*) is seen very close to its place of attachment with the crista. The dorsal
portion of the annulus tympanicus is also seen in the same figure as a projection from the crista (e.par). The quadratomaxillary is noticed ventrally to the ventral portion of the annulus tympanicus.

In the opercular region there is a small pars interna plectri and the operculum (stapes) is saucer-shaped. It depends from the upper part of the cartilaginous otic capsule. Posterolaterally, it has a knob for the attachment of a muscle.

In the suspensorial region the quadratomaxillary invades the quadrate cartilage and the paraquadrate extends laterally over the quadratomaxillary. No fusion between the paraquadrate and the quadratomaxillary is noticed as in one of the specimens of *Rana grayi* studied by du Toit (1933).

In *R. cyanophlyctis*, as in *R. hexadactyla*, even before the appearance of the prootic bone, the pars externa plectri which is a rounded cartilage makes its appearance. The processus basalis is not met with in this region.

Fig. 7.
Trans-section in the processus basalis region of *R. cyanophlyctis*.
(Abbreviations as under Fig. 1.)
In a slightly posterior region, the transitional cartilage unites with the processus oticus as in *R. hexadactyla* and the cristal part (Fig. 7, c.tr.c.) of this united cartilage fuses with the ossified extension of the otic capsule posterior to Fig. 7. The processus basalis (p.bas.) makes its appearance anterior to the opening of the eustachian passage, being invaded by the pterygoid (ptg.) and it is noticed that the cartilaginous portion of the processus basalis is considerably minimised. Moreover the pterygoid also invades the extension (o.tr.c.) of the oticus cartilage (ot.p.). At the region where the eustachian passage opens into the buccal cavity, the processus basalis invaded by the pterygoid bone, is noticed to articulate with a projection from the bony otic capsule. This condition of the articulation of the basal process is also met with in *R. hexadactyla*. In the same region on the left side of the animal, the bony pars media plectri gives rise to a small cartilaginous portion towards the paraquadrate, which in posterior sections disengages itself from the columella and disappears from the sections. This cartilaginous piece, perhaps, represents the pars ascendens plectri which is so prominently noticed in *R. hexadactyla*. The pars interna becomes manifest in posterior sections only.

The operculum is saucer-shaped and depends from the bony otic capsule. Posterolaterally there is a small knob for the insertion of a muscle.

The suspensorial region is as in *R. hexadactyla*. In *Rana cyanophlyctis* the quadratomaxillary invades the quadrate cartilage almost completely.

![Fig. 8. The suspensorial region of *R. cyanophlyctis.*](image)

(Abbreviations as under Fig. 1.)

Again, an extension of the paraquadrate over the quadratomaxillary is met with, as in *R. hexadactyla*.

In *R. curtipes*, where the paraquadrate and the middle ear appear in sections, the quadratomaxillary is not visible. The crista (Fig. 9A, c.par.)
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is very prominent and is cartilaginous. The processus basalis, however, has not yet made its appearance. Long before the appearance of the basal process, the united transitional \((tr.c.)\) and processus oticus \((ot.p.)\) cartilage establishes a connection with the crista \((c.par.)\). Thus in this case the oticus connection of the palatoquadrate with the cranium is very short; in \(R. hexadactyla\) and \(R. cyanophlyctis\), on the other hand, the connection is lengthened. This is on account of the fact that in the latter two examples the crista is an extremely long cartilaginous piece while in \(R. curtipes\), it is highly abbreviated in length. Posteriorly, the processus pterygoideus \((Fig. 9A, p.ptg.)\) cartilage fuses with the oticus cartilage \((ot.p.)\) and the large processus basalis \((Fig. 9B, p.bas.)\) is given off from this. It is noticed that a part of the processus basalis cartilage is invaded by the pterygoid bone as in \(R. hexadactyla\) and \(R. cyanophlyctis\). In Fig. 9C, the pars externa plectri is drawn and this is the first to make its appearance of the plectral

FIG. 9A.
Consecutive trans-sections of the middle ear region in *R. curtipes*.

(Abbreviations as under Fig. 1.)
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apparatus. The large pars externa (p.e.p.) gives rise internally to a pars ascendens plectri; this ascendens cartilage fuses with the crista, as in *R. hexadactyla*. The pars media is only superficially ossified with a feeble core of cartilage, thereby exhibiting the cartilaginous origin of the columella. The dorsal portion of the annulus tympanicus extends from the crista (c.par.) as in *R. cyanophlyctis*. It is obvious from the figure that there is no projection from the ventral portion of the cartilaginous otic capsule for the articulation of the posterior part of the processus basalis (p.bas.) as in *R. hexadactyla* and *R. cyanophlyctis*.

The small operculum which is crescentic in appearance depends from the upper wall of the otic capsule, and posterolaterally possesses a knob for the insertion of a muscle. The fenestral opening is small.

The suspensorial region is as previously described for *R. hexadactyla*. The invasion of the quadrate cartilage by the quadratomaxillary is very feeble in *R. curtipes*.

**Summary.**

1. The plica obliqua depends from the cartilago obliqua and not from the tectum nasi.
2. A recessus sacciformis is not present in the forms described.
3. A prechoanal sac is absent.
4. The shape of the septomaxillary in *R. hexadactyla* and *R. curtipes* differs from the same in *R. cyanophlyctis*.
5. The eminentia olfactoria is elevated in *R. hexadactyla* and *R. cyanophlyctis* and not in *R. curtipes*.
6. An unconnected piece of cartilage occurs in *R. cyanophlyctis* below the sphenethmoid.
7. The sphenethmoid is bony in *R. cyanophlyctis* and *R. hexadactyla*, whereas in *R. curtipes*, it is cartilaginous.
8. The “mundwinkeldrüse” in *R. hexadactyla* and *R. curtipes* are similar in structure; in *R. cyanophlyctis* the gland differs in shape and does not possess a lumen. It also does not open into the buccal cavity.
9. In *R. hexadactyla* and *R. cyanophlyctis* there is a large cartilaginos projection from the ventral portion of the otic capsule with which the posterior portion of the processus basalis articulates.
10. The crista parotica is very short in *R. curtipes*, while in *R. hexadactyla* and *R. cyanophlyctis*, it is comparatively long.
11. The pterygoid bone, in all the three species of *Rana* examined, invades the processus basalis partially.
12. A pars ascendens plectri which is a commissural cartilage between the crista and the pars externa plectri, is observed only in *R. hexadactyla* and *R. curtipes*.

13. The quadrate cartilage is feebly invaded by the quadratomaxillary bone in *R. curtipes*.

14. Since the operculum depends from the upper wall of the otic capsule, its movement must be considerably diminished in all the three species of *Rana* examined.

LITERATURE CITED.


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