

4. Contributions to the Knowledge of the Anatomy of the Batrachian Family *Pelobatidæ*. By FRANK E. BEDDARD, M.A., F.R.S., Prosector to the Society.

[Received September 26, 1907.]

(Text-figs. 229-240.)

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(1) INTRODUCTORY.

In a recent communication to this Society\* I dealt with a number of points in the anatomy of a Frog apparently identical with *Ceratophryne nasuta* of Schlegel (= *Megalophrys nasuta* auct.). I was unable at the time to compare this frog with any other member of the family *Pelobatidæ*, save only *Pelobates fuscus*. Since then Sir E. Ray Lankester has been so good as to entrust to me for study one example each of *Megalophrys montana*, *Xenophrys monticola*, and *Leptobrachium hasseltii*. I am able, therefore, in the present communication to the Society, to express some opinions with regard to the family *Pelobatidæ* and the inter-relationship of some of the genera or alleged genera belonging to that family. The three genera with which I deal in this contribution were admitted as such by Mr. Boulenger in his 'Catalogue of the Batrachia Salientia' †, and have been quite recently accepted (with the exception of *Xenophrys*) by Dr. Gadow in the volume of the 'Cambridge Natural History' devoted to Reptiles and Amphibia ‡. Mr. Boulenger himself, however, previously to the publication of the last-mentioned work, had expressed the view that it was impossible to retain both the genera *Xenophrys* and *Leptobrachium*, and therefore merged the former in the latter §. This alteration was due to the discovery of *Megalophrys feæ*, a frog showing the general structure of *Leptobrachium*. It was originally referred to *Megalophrys*, partly at least on account of the projections of horny skin above the eyes, which are met with in all of the previously known species of *Megalophrys*. Mr. Boulenger did not, however, as I understand him, combine all the three genera with which I deal in the present paper, viz. *Megalophrys*, *Xenophrys*, and *Leptobrachium*, into one genus. But my own observations upon *Megalophrys nasuta*, to which I have referred,

\* P. Z. S. 1907, p. 324.

† London, 1882, p. 443.

‡ Vol. viii. London, 1901, p. 161.

§ Ann. Mus. Genova, ser. 2, iv. p. 512, vii. p. 750.



seem to me to render desirable a revision of the anatomical characters of these various genera and species of Pelobatidæ. At present it would almost appear that *Megalophrys nasuta* is more different from *Megalophrys montana* than the latter is from either *Xenophrys* or *Leptobrachium*. The external resemblance too between the last three—particularly between *Megalophrys montana* and *Xenophrys monticola*—are quite as striking as the differences which all of them show to *Megalophrys nasuta*.

(2) SOME NOTES UPON THE ANATOMY OF  
*MEGALOPHRYS MONTANA*.

So far as I am aware, our knowledge of the structure of this frog is at present confined to the external characters, to such osteological characters as have been used for classificatory purposes by Cope and Boulenger, and to the sternum, which has been figured and described by Prof. Parker\*. Quite recently the tadpole has been reported upon by Mr. Laidlaw†, who quotes an account by Prof. Max Weber. The tadpole, with its curious funnel-shaped hood, has been figured by Dr. Gadow‡. As to the adult frog, I have been able to compare its structure with its congener (or, I perhaps ought to say, alleged congener) *Megalophrys nasuta*, on the anatomy of which I have lately contributed an account to this Society§.

The specimen upon which I report here was kindly placed in my hands by Sir E. Ray Lankester from the stores of the Natural History Museum. It shows in most respects the characters of the species as given by Mr. Boulenger in his 'Catalogue of the Batrachia Salientia'¶. I find, however, one rather important difference. Mr. Boulenger uses the phrase "tympanum hidden" as part of his generic definition of *Megalophrys*. This undoubtedly applies to *M. nasuta*¶, as I have been able to ascertain for myself. Subsequently\*\* Mr. Boulenger himself found a distinct tympanum in *M. longipes*. I have now to record that the tympanum is distinctly visible in *M. montana*, where, however, it is decidedly more obvious when the animal is dry. It is 4 mm. in diameter and is distant from the eye twice its own diameter.

Another rather salient difference between the two species which is hardly apparent from Mr. Boulenger's definition, concerns the tubercles of the body. I have no doubt that these may offer differences from individual to individual in *Megalophrys montana*; but, as I have already pointed out, there are some reasons for believing that these tubercles do not differ much in different specimens of *Megalophrys nasuta*: so that, in any case, they can

\* 'Monograph of the Shoulder-girdle,' Ray Society, 1869.

† "The Frogs of the 'Skeat' Expedition," P. Z. S. 1900, p. 890.

‡ 'Cambridge Natural History,' Reptiles and Amphibians, p. 60.

§ P. Z. S. 1907, p. 324.

¶ P. 442.

¶ I have carefully re-examined my specimen and find the barest indication of the tympanum.

\*\* P. Z. S. 1885, p. 850.



be contrasted in the two species. In *Megalophrys montana* they are much more numerous than in the other species. On the head, however, I only found two, and this is not very different from the three tubercles found on the head of *M. nasuta*. On the back and sides there are a considerable number in *Megalophrys montana*. They are perhaps rather less conspicuous than those of *M. nasuta*; but this is partly a matter of the smaller size of *M. montana*. Furthermore they present the appearance of sessile barnacles, owing to their variegated colour and radially arranged grooves; this, however, is possibly merely a matter of shrinkage of the skin.

#### § Abdominal Viscera.

The liver of this species is on the whole like that of *M. nasuta*. The right lobe is much the smaller, and the left lobe consists of two halves, of which the larger completely covers the more dorsally placed and smaller portion. In *Megalophrys montana* there is no distinct ring-like thickening, marking off the pyloric end of the stomach from the duodenum, such as occurs in *M. nasuta* and is there very pronounced. The alimentary viscera, however, do not vary greatly among the Pelobatidæ.

Certain features in the muscular anatomy of this Frog as compared with its alleged congener are dealt with in the ensuing section of the present paper, where they are more conveniently treated of. Broadly speaking, *Megalophrys montana* agrees with *M. nasuta* in those peculiarities of myology which I have already pointed out as differentiating *Megalophrys* from *Rana* \*.

#### § Lungs.

The lungs of this species are interesting from more than one point of view. In describing those organs in *Megalophrys nasuta* I pointed out that this Frog differs from *Rana* by the fact that the right lung is attached to the liver and the membrane bearing the bile-ducts &c., by a ligament which extends much further down the lung than it does in *Rana*. A portion of the lung, however, towards the free tip is not attached by a part of this ligament, which ceases at some little distance from the tip. *Megalophrys montana* shows a condition of the pulmonary ligament which is an exaggeration of the conditions found in *M. nasuta*. The pulmonary ligament in fact extends to the very end of the lung. Moreover, as in *M. nasuta*, there are two ligaments, of which one is attached as mentioned while the other is fixed to the dorsal body-wall. At their insertion on to the lung these two ligaments are continuous at one point. It follows, therefore, that a part at least of the lung is hidden away in a chamber of the cœlom which is cut off from the general cœlom of the abdominal cavity. This is obviously a step in the direction of the

\* P. Z. S. 1907, p. 348.



complete enclosure of the respiratory organs in their own coelomic chamber.

### § *Shoulder-girdle.*

The shoulder-girdle of my example of *Megalophrys montana* agrees generally with W. K. Parker's\* figure of the same. But there are differences to be recorded. The right coracoids overlap the left considerably more than they are represented to do in Parker's figure, and more than is the case with *Megalophrys nasuta* according to my own observations. The thin edge of the cartilage in question quite covers the pectoral muscles of the left side at their origin, which can be seen through the thin transparent blade of cartilage. The omosternum may be, perhaps, rather larger than Prof. Parker has figured, but it is distinctly more rudimentary than in *Megalophrys nasuta*, where it is calcified and has a more distinctly *Rana*-like form. However, slips of the muscular system of the shoulder are attached even to this flat and very thin omosternum in *Megalophrys montana*.

The sternum of the example of *Megalophrys montana* which I have examined does not agree in every detail with the figure by Parker of the same species. The bony style of which the sternum mainly consists is a much more slender style in my example than would be surmised by an inspection of Prof. Parker's figure. I find that the measurements of this part of the sternal apparatus are as follows:—The total length of the style is 13 mm. The diameter at the front end is 4 mm.; in the narrowest part of the style it is less than 1 mm. in breadth. The end of the sternum, where it terminates in a cartilaginous "epiphysis," is about  $1\frac{1}{4}$  mm. in diameter. It is clear from Prof. Parker's figure that the sternum of his example was distinctly different and stouter and shorter than my specimen. Still, on the whole there is plainly a substantial agreement. The cartilaginous end of the sternum is not at all rounded in my example. It ends squarely, and is of no greater diameter than the bony part immediately preceding it. There is absolutely no approach to the rounded cheesecutter-like end of the sternum, as it is portrayed in Prof. Parker's figure. In all of these points the present species differs markedly from *Megalophrys nasuta*.

The proportions of this part of the skeleton are, moreover, rather different in the two Frogs. The length of the sternum in *Megalophrys montana* has been mentioned. As the frog itself measures 72 mm. from the tip of the snout to the vent, the length of the sternum is very nearly one-sixth of that length. On the other hand, in *Megalophrys nasuta*, which measured at least 135 mm. in length, the sternum proper had a length of 36 mm. from end to end. The proportion is here obviously rather different. The sternum is plainly shorter and more like a quarter of the total body-length. As to the sternum itself, in *Megalophrys*

\* 'Monograph of the Shoulder-girdle,' Ray Soc. 1869, pl. vi. fig. 8. On p. 78 he says that "the *left*, normally, overlaps the *right*" (*italics mine*).



*nasuta* I have already described its general characters. The proportions of the length to the breadth of the bony shaft in its narrowest region do not appear to differ greatly from those of *M. montana*. The diameter was rather more than 1 mm., perhaps  $1\frac{1}{2}$  mm., about a twenty-fourth part therefore of the length. This is not widely different from the proportions exhibited by *M. montana*.

#### § *Hyoid and its Musculature.*

I reserve for later discussion \* certain facts relative to the hyoid cartilages and the muscles attached thereto. In this place the differences between the two Frogs assigned both of them to the genus *Megalophrys* will be considered. In examining the hyoid cartilages one obvious difference will be seen to distinguish the present species from *Megalophrys nasuta*. In the latter (cf. the figure illustrating my paper upon that Pelobatid †) the two *processus anteriores* of the body of the hyoid run anteriorly on the whole parallel to each other, with but a slight inclination towards the middle line, *i. e.* towards each other. Their extremities are in fact separated by quite 9 or 10 mm. across the middle line of the throat. In *Megalophrys montana* the processes in question, as in *Pelobates* and *Pelodytes* ‡, incline greatly towards each other and are finally only separated by the space of 1 mm. or but slightly more.

#### § *Œsophageal Portion of the Transversalis Muscle.*

This muscle is quite as conspicuously developed in *Megalophrys montana* (text-fig. 233, p. 886) as it is in *M. nasuta*. But there are certain differences in detail between these two species. Anteriorly at the septum defining the abdominal cavity (the cervical aponeurosis) its fibres lie side by side with those of the obliquus externus, and no line of division can be detected between the two muscles. Continuing on an imaginary line from the point where the two muscles are really distinct, it would appear that the transversalis is only inserted upon the œsophagus and is not connected with the cervical aponeurosis or the lungs at their root. The oviduct runs across it; but I cannot find that any of its fibres are deflected into the membrane supporting that tube. The muscle is pretty stout and fairly thick. Crossing the anterior end of the pelvis, and of course the ilio-coccygeal muscle arising therefrom, not far from its anterior end, as shown in the accompanying figure (text-fig. 233, p. 886), the fibres of the transversalis gather themselves together to form a thicker tract of the muscle like the laths in the handle of a fan. This is the origin of the muscle, and it passes back for a considerable distance completely free of the ilium, to be finally attached away from that

\* *Infrà*, p. 892.

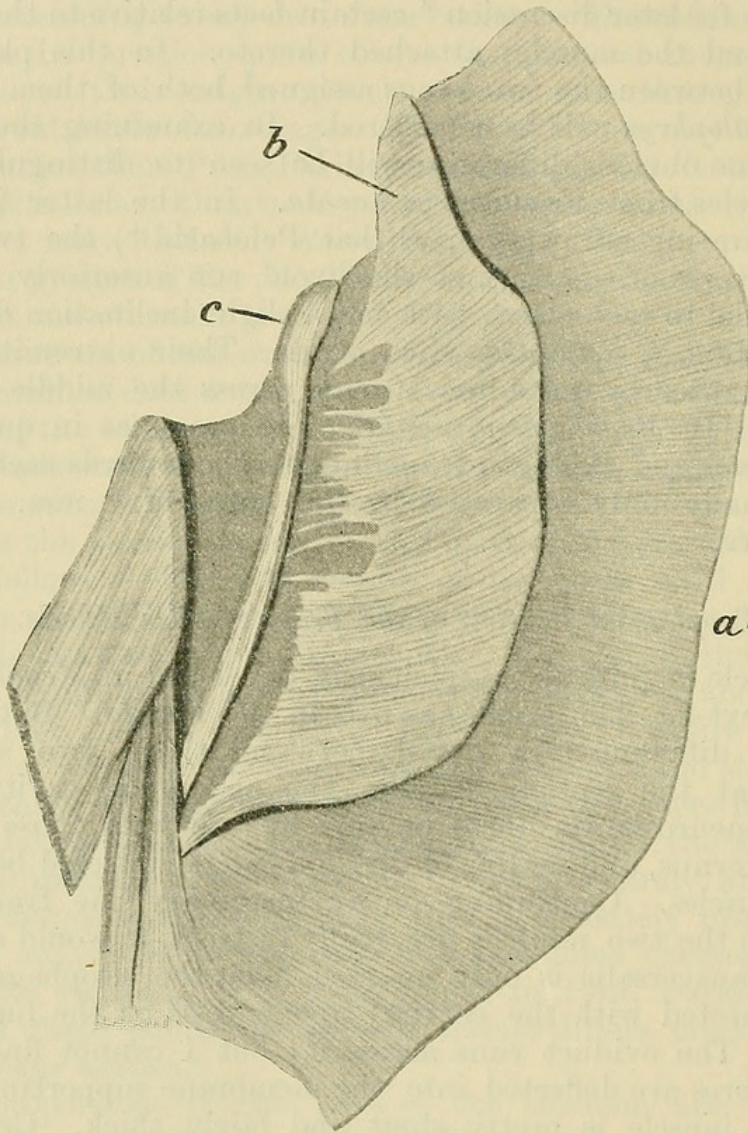
† P. Z. S. 1907, p. 341, text-fig. 97.

‡ See figs. by Boulenger in 'Tailless Batrachia of Europe,' and Ridewood, P. Z. S. 1897, pl. xxxv.



bone for a long way behind its anterior extremity. This appears to be the only origin of the œsophageal muscle; it has no connection whatever with the transverse processes of any vertebræ anterior to the ilium, so far as I have been able to ascertain. In re-examining *Megalophrys nasuta* for purposes of comparison with the present species, I find that my description is correct, but not sufficiently detailed for purposes of accurate comparison with the

Text-fig. 229.



Left ilium and adjacent musculature of *Megalophrys nasuta* from the ventral surface. The ilio-coccygeal muscle (to the left of the figure) is cut across obliquely.

*a.* Obliquus muscle. *b.* Œsophageal muscle. *c.* Long muscle of ilio-lumbar complex.

muscle of *Megalophrys montana*. In *Megalophrys nasuta* the transversalis muscle of the œsophagus arises from the pubis, as I have already stated. The exact mode of connection is shown in the figure annexed hereto (text-fig. 229), and will be seen to be not very different from that of *Megalophrys montana*.

The muscles in question are represented from the ventral



surface. The ilio-coccygeal is cut across obliquely. The ilium is seen clearly, and to the outside of it runs the narrow muscle belonging to the ilio-lumbar complex which I have had occasion to describe as probably characteristic of the Pelobatidæ. Outside of this again is seen the broad and thin transversalis muscle with its cut edge divided across its fibres, *i. e.* parallel to the long axis of the body of the frog. Outside this, again, is the obliquus muscle. It will be seen that the transversalis is not fan-shaped and that its fibres are nowhere collected into a thick bundle as in *Megalophrys montana*. On the contrary, the muscle obviously ends in a series of digitations near to the end of the obliquus fibres, and these are connected with the pubis only indirectly by the tendinous aponeurosis represented in the drawing referred to (text-fig. 229). The insertion of the transversalis on to the aponeurosis is a very long one: it reaches, in fact, a little way anteriorly to the pubis and back nearly as far as the symphysis.

In both species therefore the attachment of the transversalis muscle lies outside of the long ilio-lumbar muscle, which, I may take this opportunity of remarking, is just as well developed in *Megalophrys montana* as it is in *M. nasuta*. Nor is there, so far as I could see, any attachment to any vertebræ comparable to the equivalent of this muscle in *Rana*, *Ceratophrys*, &c. In fact, in *Megalophrys* the transversalis seems to have preserved a primitive arrangement as one of the covering sheets of the body unconnected directly (only through aponeurosis) with any bones. A further specialisation of this muscular sheet would lead to the conditions observable in *Rana* &c. on the one hand, and in *Pipa* and *Xenopus* on the other. There are in fact no reasons that I can detect from an examination of the transversalis and neighbouring muscles in *Megalophrys montana*, for separating it widely from its supposed congener *Megalophrys nasuta*.

The following is a tabular statement of the differences existing between the two species. The resemblances I shall point out later, when considering the allied forms *Xenophrys* and *Leptobrachium*.

*Megalophrys nasuta.*

- (1) Tympanum invisible.
- (2) Palpebral processes very large; "nose-leaf" present.
- (3) Conical tubercles on back only three.
- (4) Index finger considerably longer than second.
- (5) Vomerine teeth between choanæ.
- (6) Omosternum less rudimentary. Sternum one fourth body-length, with large posterior cartilaginous epiphysis.
- (7) Vertebræ procœlous.
- (8) Sacral vertebra completely fused with coccyx.
- (9) Anterior processes of hyoid parallel.

*Megalophrys montana.*

- Tympanum quite distinct.
- Palpebral processes small; "nose-leaf" rarely present.
- Conical tubercles numerous.
- Index finger only just longer than second.
- Vomerine teeth behind choanæ.
- Omosternum more rudimentary. Sternum one third body-length, with small posterior cartilaginous epiphysis.
- Vertebræ opisthocœlous\*.
- Sacral vertebra articulating with adjoining coccyx.
- Anterior processes of hyoid convergent.

\* I have verified these facts in the case of the specimen described here.



(3) ON *XENOPHRYS* AND *LEPTOBRACHIUM*.

Of these two genera I have examined, as already mentioned, the species *Xenophrys monticola* and *Leptobrachium hasseltii*. The external characters of both are described in some detail by Mr. Boulenger in his 'Catalogue,' and later in the 'Fauna of British India,' 1891, and I have identified upon my specimens every characteristic mentioned by him. There are, however, a few—very few—minutiae with which he does not deal. As already mentioned, the external resemblances between *Megalophrys montana* and *Xenophrys monticola* are very close. The interorbital region is, however, distinctly more concave in the *Megalophrys* than in the representatives of the two other genera. Mr. Boulenger has remarked the large triangular mark between the eyes (which does not exist in *Leptobrachium hasseltii*) in *Megalophrys montana* and *Xenophrys monticola*. I may add that this has a straight anterior margin in the latter species, but is deeply concave in *Megalophrys*. The "V-shaped linear raised fold on the nape" is very plain in *Xenophrys monticola*; but that species has also—and Mr. Boulenger\* does not mention this—on each side a lateral longitudinal fold, exactly as in *Megalophrys montana*. In the latter species the equivalent of the V-shaped glandular fold is accurately transverse†. But there is in these folds a close likeness between the two species referred to, and they are totally absent in *Leptobrachium hasseltii*. I have observed another minute feature in which my species of *Megalophrys* and *Xenophrys* agree to differ from the species of *Leptobrachium* which I have studied: in the last-mentioned frog the gape of the mouth only just reaches the anterior margin of the tympanum; in the other two it extends rather beyond this point. The example of *Xenophrys monticola* which I have examined and described does not, it would appear, quite agree with those examined by Boulenger at the time when he drew up his 'Catalogue.' He writes under the generic definition of *Xenophrys*: "Tympanum scarcely distinct," and again, under the specific description of *Xenophrys monticola*: "tympanum slightly distinct, vertically oval, about two thirds the width of the eye." In my example the tympanum was particularly distinct owing to its enclosure within a very strongly marked raised rim continuous above with the fold leading from the eye to the shoulder. Another feature of likeness between *Megalophrys montana* and *Xenophrys monticola* is in the metatarsal tubercle. Boulenger correctly states of both species that this tubercle is indistinct. This statement may be amplified by noting the additional fact that the metatarsal tubercle has the same elongate oval form and comparatively large size in both of these frogs, which is very different from the small and prominent and nearly round tubercle of *Leptobrachium hasseltii*.

An external character to which but little attention has been

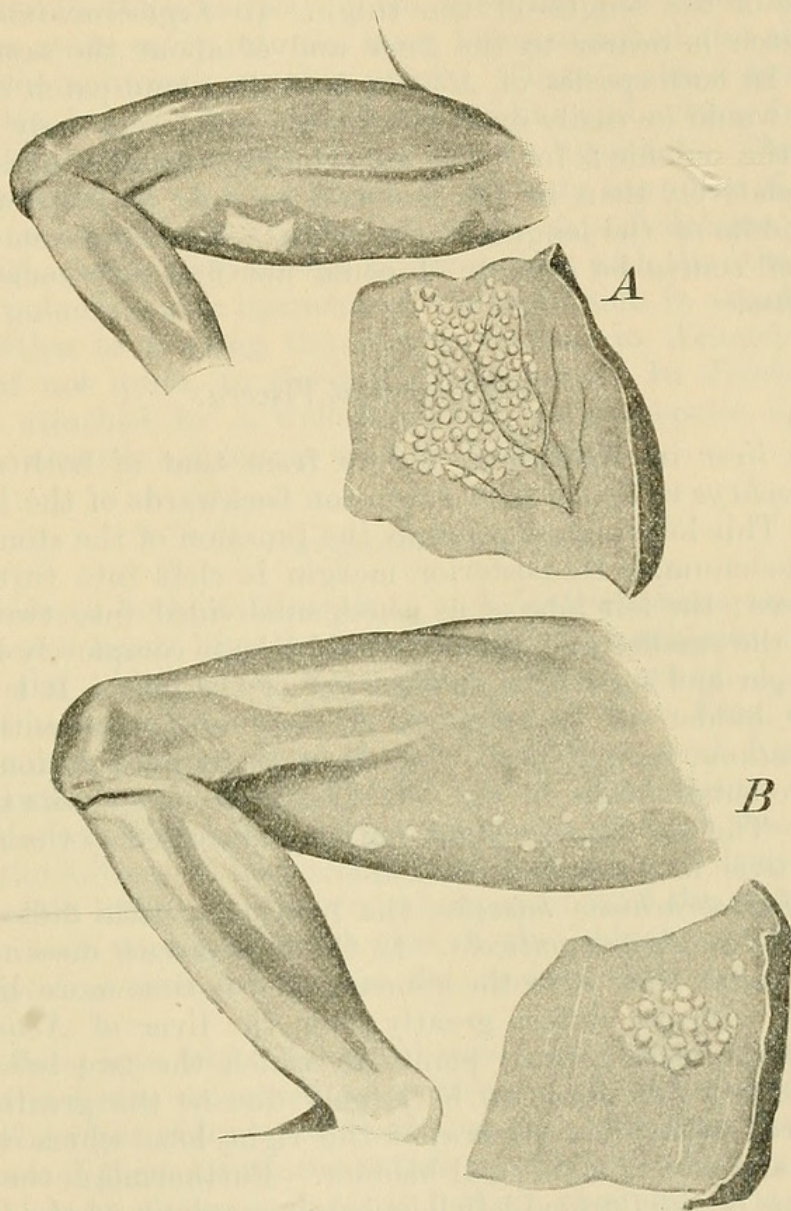
\* Dr. Anderson (P. Z. S. 1871, p. 201) appears to have noticed it.

† It is, however, V-shaped in *Megalophrys longipes* (P. Z. S. 1885, p. 850).



paid is a patch of glands upon the thigh \*. These are really not clear until the skin has been removed from the subjacent muscles

Text-fig. 230.



A. The thigh (upper figure) and detached fragment of skin more highly magnified (lower figure) of *Xenophrys monticola*, to show the "thigh-gland." In the upper figure the gland is shown as a large white patch with a few isolated and scattered glands near it. In the lower figure the composition of the gland from a number of aggregated simple glands is shown. It is here seen from the lower surface.—B. Corresponding parts of *Megalophrys nasuta* of the same proportional size.

and then inspected upon its lower surface. That is to say, the individual glands are not clear, for the patch as a whole is marked

\* Mr. Boulenger, in his more recent definition of *Xenophrys monticola* (Reptilia and Batrachia in 'The Fauna of British India,' 1890, p. 510), does not refer to the gland-patch on each thigh.



by its white colour contrasting with the surrounding brown integument. There are also scattered glands upon the thigh and elsewhere; but only this one large patch which lies on the dorsal surface near to the posterior border of the thigh. In *Xenophrys monticola* this aggregation is 7 mm. in length and is at about the middle of the length of the thigh. In *Leptobrachium hasseltii* the patch is nearer to the knee and of about the same relative size. In both species of *Megalophrys* the gland-patch is present, but it would be easily overlooked if the skin were only examined from the outside; for it is considerably smaller both actually and relatively than in the last two genera. It lies not far from the middle of the length of the thigh. These differences of size may of course be sexual. I could not find any such patch in *Pelobates*.

#### § Abdominal Viscera.

The *liver* in *Xenophrys* differs from that of both species of *Megalophrys* in the greater extension backwards of the larger left lobe. This lobe almost conceals the junction of the stomach with the duodenum. Its posterior margin is cleft into three conical processes; the left lobe is, as usual, subdivided into two lobes, of which the smaller and distinctly bifid lobe is completely hidden by the larger and superficial subdivision of the lobe. It is not completely hidden in *Megalophrys nasuta*, and apparently not in *M. montana*, though here what appears to be a fusion between the two subdivisions of the left lobe somewhat masks their relations. The *gall-bladder* is not entirely concealed by the right lobe of the liver in *Xenophrys monticola*.

In *Leptobrachium hasseltii* the liver is a little different from that of *Xenophrys monticola*. In the first place it does not extend nearly so far back over the stomach, and is thus more like *Megalophrys*. It also differs greatly from the liver of *Xenophrys* in the approximately equal points to which the two lobes extend posteriorly; this seems to be largely due to the greater size (as compared with other genera) of the right lobe which completely covers and conceals the gall-bladder. Furthermore, the two subdivisions of the (larger) left lobe barely overlap and the lower lobe is thus practically fully exposed. This is an exaggeration of what is met with in *Megalophrys nasuta*.

The *pancreas* of *Xenophrys monticola* agrees pretty closely with that of *Leptobrachium* and of *Megalophrys* as recently described by myself\*. I should mention that in these genera a slender branch of the pancreas lies in the fold of mesentery which connects the stomach and duodenum. In neither *Xenophrys* nor *Leptobrachium* could I detect any marked division between the stomach and duodenum, such as is found in *Megalophrys nasuta*.

\* P. Z. S. 1907, p. 349.



### § Lungs.

The suspension of the lungs in *Xenophrys monticola* is more like what is found in *Megalophrys nasuta* than in *M. montana*. On the right side, the lung is attached to the liver by a membrane which extends fully halfway down the lung and ends upon the vena cava at its entry into the liver, being attached also of course to the liver anteriorly to this point. There is also a membrane binding the lung to the dorsal median line and arising from the lung in common with the pulmo-hepatic ligament. The corresponding ligament on the left side of the body has a line of attachment of the same length to the left lung. *Leptobrachium hasseltii* agrees rather with *Megalophrys montana* than with the other types. For the pulmo-hepatic ligament of the right side is attached to a point further back along the vena cava than in *Xenophrys*, and almost, if not quite, to the end of the lung. In *Pelobates* the lung is attached by a well-developed pulmo-hepatic ligament, which however is not longer than in *Xenophrys*.

### § Uro-genital Organs.

The kidneys both of *Xenophrys* and *Leptobrachium* are smooth glands very much like those of *Rana*. I emphasise this fact because the kidneys of *Megalophrys nasuta*, which I did not describe in my account of the anatomy of that Frog, are very different in appearance from those of its allies. And, I may take this opportunity of stating, the kidneys of *Megalophrys montana* are on the whole like those of its congener. In both these species in fact the kidney is broken up into three or four large, almost disconnected lobes, and the general appearance of the organ therefore contrasts very much with that of the kidneys of *Xenophrys* and *Leptobrachium*, which are flat and smooth with an even surface.

The *Xenophrys* which I studied was a fully adult male, that is to say, the testes measured respectively 11·5 (right) and 9 (left) mm. The right kidney possessed four vasa efferentia, forming no rete; two of them bifurcated before reaching the kidney. In an adult *Pelobates fuscus* each testis had six vasa efferentia. It has been recorded that the male *Pelobates fuscus* has no vesicula seminalis. This structure is also absent from the ureter of *Xenophrys monticola*. It is known that the fat-bodies vary considerably in their degree of development in males of *Rana*. They were very greatly developed in the male *Pelobates* just referred to. In the *Xenophrys*, however, they were most feeble; there were only three digitations on the right side (and I think the same number on the left) which were not attached to the anterior end of the kidney, but to the membrane attaching it to the postcaval vein. In *Leptobrachium* the genitalia were immature. The fat-bodies had many digitations. The mesoarium was partly attached to the dilated end of the oviduct, as I have described in *Megalophrys*

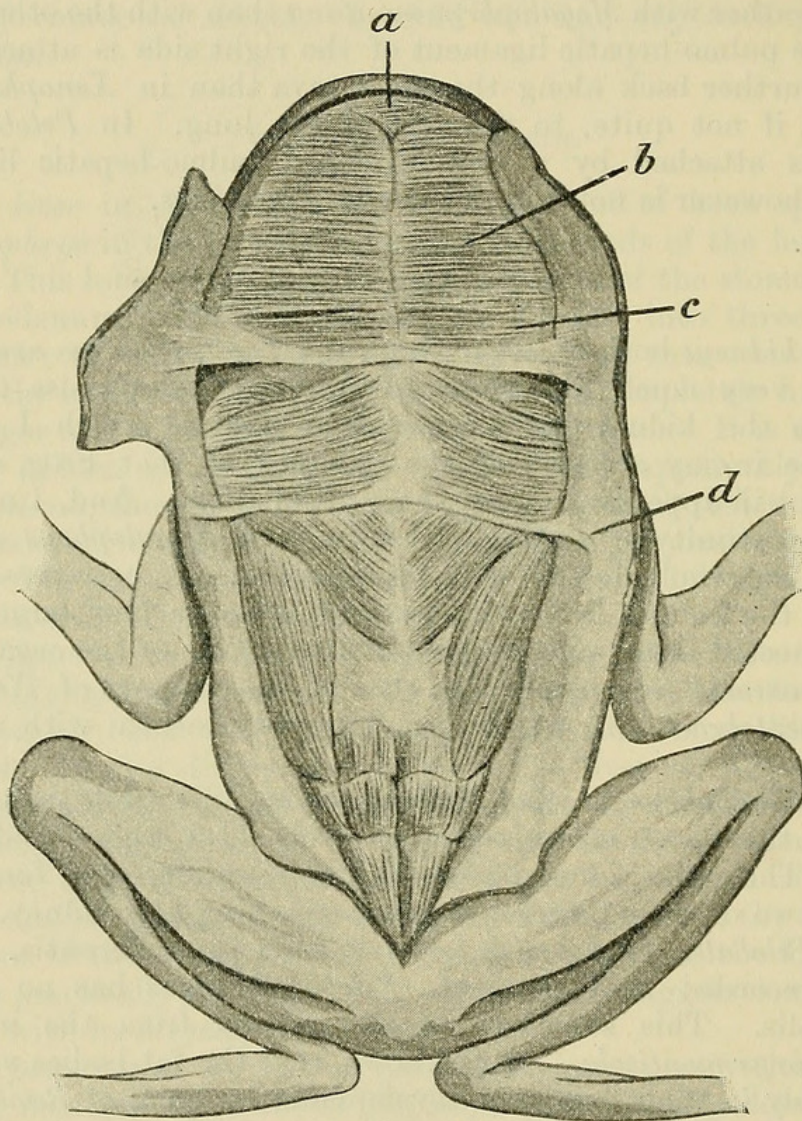


*nasuta*. I am uncertain whether a definite diverticulum of the expanded termination of the oviduct exists; there was, however, the appearance of such, accentuated doubtless and indeed perhaps caused by the taut condition of the ligament in question.

### § *Ventral Musculature.*

The ventral musculature of *Xenophrys* differs from both that of *Rana* and that of *Megalophrys nasuta*. The general disposition of the muscles, exposed by the removal of the skin of the ventral

Text-fig. 231.



Ventral musculature of *Xenophrys monticola*.

*a.* Submental muscle. *b.* Submaxillaris. *c.* Subhyoideus. *d.* Posterior septum of lymph-sac lying upon the pectoralis muscle.

surface, will be rendered plain by the accompanying figure (text-fig. 231). The abdominal portion of the pectoralis seems to be precisely as in *Rana* and *Megalophrys*. It is of considerable size



much larger than in *Leptobrachium* (to be described presently), and arises from the second tendinous intersection of the rectus abdominis, and from the fascia covering that muscle for some way anterior to that point. The pectoralis anterior (or pars epicoracoidalis) arises as usual from the surface of the coracoid cartilage. In front lies the pars episternalis of the deltoid, which also receives fibres from the small omosternum; nothing superficial can be possibly distinguished as a separate sterno-radialis such as is found in *Rana*. The pectoralis posterior (or pars sternalis) is more like that of *Rana* than it is like that of *Megalophrys nasuta*, for it extends in its origin down the whole of the bony shaft of the sternum up to the expanded xiphoid plate, which line of origin is of about the same length as that of the pectoralis anterior. In *Megalophrys nasuta* this muscle does not reach in its line of origin beyond the expanded anterior end of the bony sternum. With regard to these muscles I have also examined *Megalophrys montana*, though they were much hardened and stuck together and thus difficult to discriminate. I believe, however, that I am able to assert that this species presents characters which are intermediate between the two extremes already referred to. For the origin of the pectoralis posterior extends some way down the bony style of the sternum, in fact for about half its length.

I could find no pectoralis cutaneus in *Xenophrys monticola*, and in this the frog agrees with *Megalophrys nasuta*. The septum dividing the abdominal lymph-space from the pectoral was plain enough; but it was nowhere invaded by or connected with slips of muscle arising from or near the pectoralis abdominalis.

The considerable extension backwards of the sternum in *Xenophrys* as in *Megalophrys* reduces the posterior (*i. e.* poststernal) region of the rectus abdominis muscle. In *Xenophrys monticola* the third intermuscular septum of the rectus abdominis lies on a level with the end of the xiphoid cartilage of the sternum, there being thus only three segments of this muscle lying behind the sternum.

The throat region of *Xenophrys monticola* agrees more closely with the corresponding region in *Rana* than in the, in other respects, more nearly allied *Megalophrys*. The proportions between the submaxillaris, the subhyoideus, and the submentalis appear to me to be exactly as has been figured in *Rana esculenta*. I may mention that the subhyoideus of both *Megalophrys nasuta*\* and *M. montana* is relatively a much larger muscle. Furthermore, the median raphe between the two halves of the submaxillaris and subhyoideus is a mere streak.

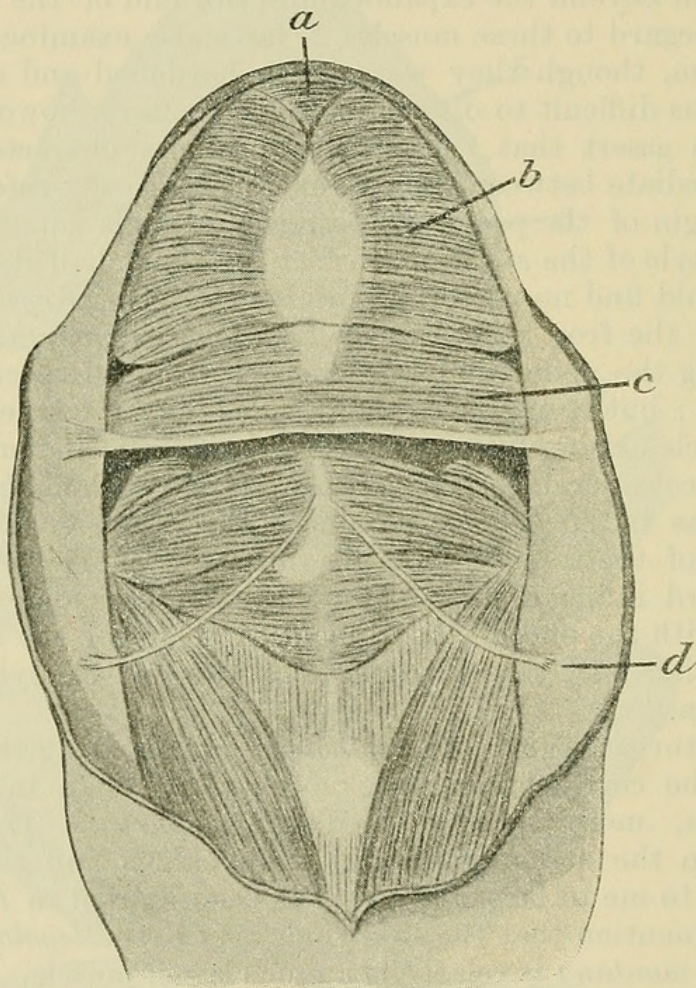
The ventral musculature of *Leptobrachium hasseltii* presents considerable differences from that of its ally *Xenophrys monticola*, and is in more than one respect much more like that of *Megalophrys*. It differs, however, from all these frogs in two very salient points which are visible when the ventral integument is reflected.

\* P. Z. S. 1907, p. 340.



The shortness of the sternum considered relatively to the length of the sternum in other genera results in a much longer post-sternal rectus abdominis, while the pectoralis appears to be short, again relatively speaking. The second point of difference concerns the course of the sheet of membranous tissue which separates the abdominal from the pectoral lymph-space. In *Xenophrys* and in *Megalophrys nasuta* this is almost transverse to the longitudinal axis of the body, being slightly convex anteriorly; it hardly reaches the pectoralis abdominis. In *Leptobrachium*, on the other hand, the attachment of this membrane is V-shaped with the apex of the V directed anteriorly; it passes over the pectoralis abdominis to near the middle of which it is attached.

Text-fig. 232.

Ventral musculature of *Leptobrachium hasseltii*.

Lettering as in text-fig. 231.

However, in this genus, as in those already treated of, there appears to be no pectoralis cutaneus. The pectoralis anterior seems to be exactly like that of *Xenophrys*, and I could detect no trace of a separate sternoradialis muscle. The pectoralis posterior, on the other hand, is not like that of *Xenophrys*. For it arises along a line which extends halfway down the bony style of the



sternum, and thus more closely resembles the same muscle in *Megalophrys montana*.

The throat musculature of *Leptobrachium* (text-fig. 232) does not agree entirely with that of either of the other two genera of Pelobatidæ with which I am concerned in the present communication. I have already pointed out that in the two species of *Megalophrys* (at any rate as commonly held) the subhyoideus is a large muscle as compared with the submaxillaris. The subhyoideus in *Leptobrachium* has exactly the same character. Furthermore, this species, i. e. *Leptobrachium hasseltii*, shows a likeness to *Megalophrys nasuta* in the submaxillaris. I have already pointed out that in *Xenophrys monticola* a mere seam separates in the middle line of the throat the two halves of the muscle. On the other hand, in both *Leptobrachium hasseltii* and *Megalophrys nasuta* this seam is expanded into a widish tendinous sheet. *Megalophrys montana* appears to agree with its congeners in this point. *Leptobrachium*, however, does not agree with *Megalophrys* in the arrangement of the submentalis muscle. In the former genus, and in both species, the submentalis is completely concealed by the fibres of the submaxillaris, the median tendinous interval ceasing some way behind the mandibular symphysis. The fibres of the submaxillaris have to be cut before the submentalis can be seen. The arrangement in both *Leptobrachium* and *Xenophrys* is different from this, and they agree entirely with each other. The submentalis is quite distinct anteriorly near to the symphysis of the lower jaws, not being concealed by muscular fibres of the submaxillaris. The greater part of the submentalis is thus visible; but not its insertions on to each mandible. Moreover, a distinct tendinous seam on each side is seen to divide its fibres from those of the submaxillaris. The two tendinous seams meet to form the median tendinous interval between the right and left halves of the submaxillaris.

So far, therefore, as concerns the superficial muscles of the ventral surface, *Leptobrachium* and *Megalophrys* are more nearly allied than either of them is to *Xenophrys*. The two former agree in (1) the reduced posterior pectoralis, (2) the distinctness and relatively large size of the subhyoideus, (3) the considerable tendinous interval between the right and left halves of the submaxillaris. On the other hand, *Leptobrachium* and *Xenophrys* are alike in the relations of the submentalis to the submaxillaris.

It is interesting to compare the Eastern genera, *Megalophrys*, *Xenophrys*, and *Leptobrachium*, with the essentially European *Pelobates* \*. The comparison shows an extraordinary uniformity, so far as the muscular peculiarities already dealt with are concerned, between *Pelobates fuscus* and *Xenophrys monticola*. The pectoralis muscle is identical by reason of the large size of the pectoralis posterior, which extends as far back in its origin as to the posterior end of the bony style of the sternum. The muscles on the floor of the mouth are also identical in the two genera. It is difficult to draw any boundary line between the submaxillaris

\* This genus only extends eastward as far as Asia Minor and Syria.

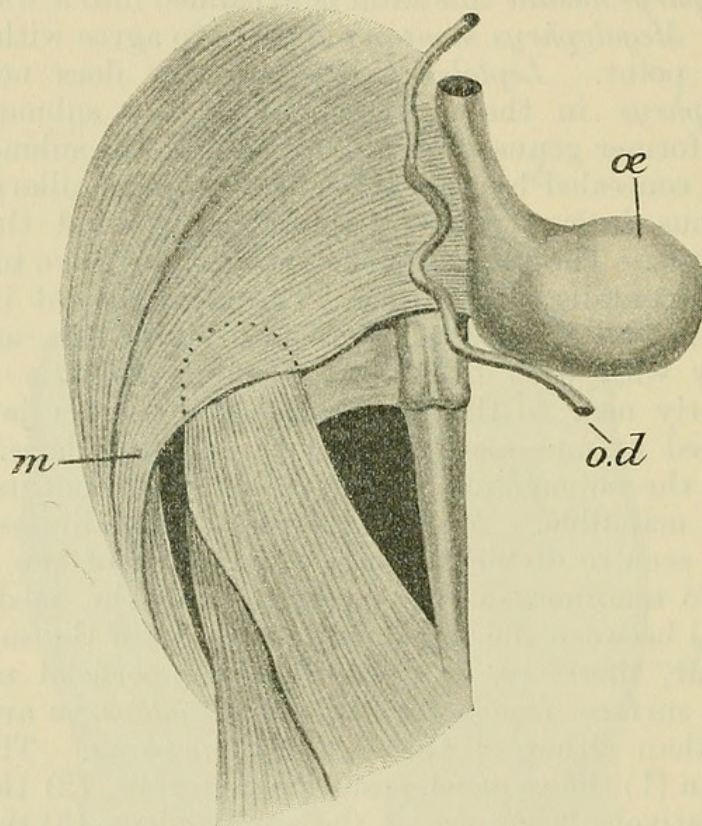


and the subhyoideus, such as is very obvious in the other two Oriental genera. A fine tendinous seam divides the right and left half of the submaxillaris. This seam also in *Pelobates*, as in *Xenophrys*, bifurcates anteriorly and partitions off the submentalis from the submaxillaris, which is therefore not covered by the latter as it is in *Megalophrys*.

§ *The Transversalis Muscle to Œsophagus.*

This muscle in its large size, place of origin, and insertion, is apparently peculiar to the Pelobatidæ. It becomes therefore of very great importance to ascertain its relations in the genera

Text-fig. 233.



Œsophageal muscle and neighbouring structures in *Megalophrys montana*.

- m.* The œsophageal muscle at first separate but towards the centre of the figure indistinguishable from the obliquus externus which lies above it; its posterior attachment to the œsophagus is seen to overlies the sacral vertebra, which latter is seen to be free from the ensuing coccyx. *od.* Oviduct. *œ.* Œsophagus.

*Xenophrys* and *Leptobrachium*. In *Xenophrys* the muscle is very obvious, and without further dissection appears to be precisely as in the genus *Megalophrys*. It occupies the anterior half of the abdominal cavity and has a curved, somewhat excavated posterior border a little in front of the kidney. It seems distinctly thinner in proportion than the same muscle in *Megalophrys montana* (text-fig. 233), a conclusion at which I arrive with greater confidence, since the two frogs were of the same size. I can see

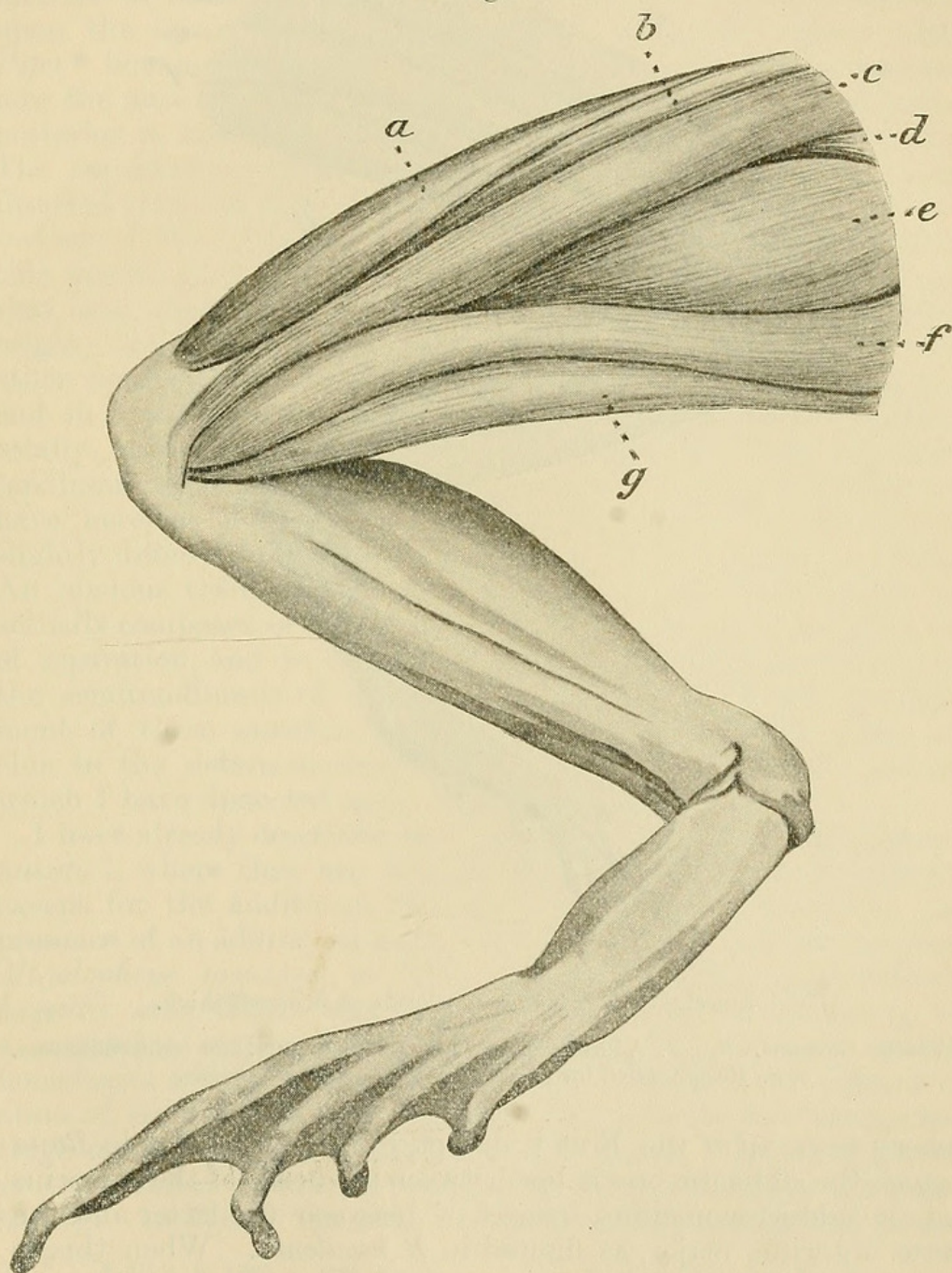


no features in the corresponding muscle in *Leptobrachium* which necessitate a particular description of that type. I may take this opportunity of remarking that the pelvic muscles in this region (long strip of ilio-lumbar, ilio-coccygeal, &c.) are in *Xenophrys* and *Leptobrachium* as in *Megalophrys*.

§ *Musculature of the Thigh.*

In comparing the thigh-muscles of the several genera of Pelobatidæ which I describe in the present communication, I have used

Text-fig. 234.



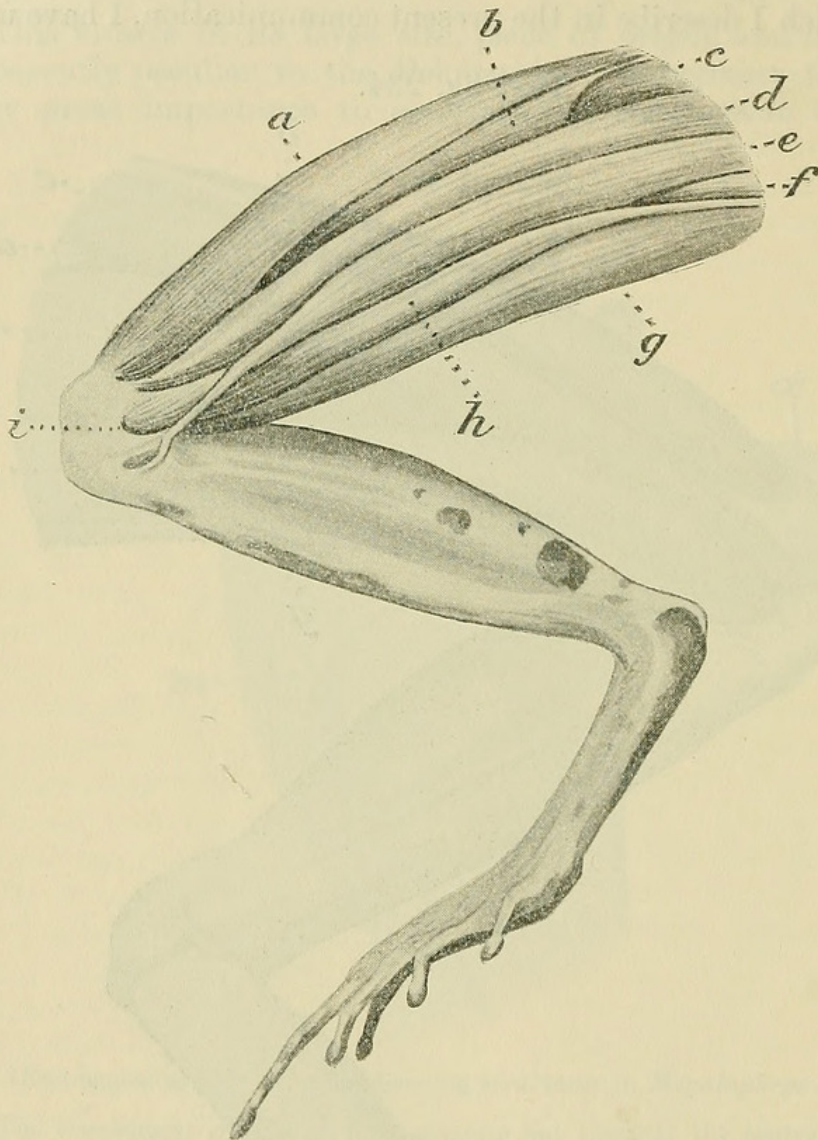
Thigh-muscles of *Rana guppyi* on the inside of the thigh.

*a.* Vastus internus. *b.* Adductor longus. *c.* Sartorius. *d.* Adductor brevis.  
*e.* Adductor magnus. *f.* Rectus internus major. *g.* Rectus internus minor.



the conditions obtaining in *Rana guppyi* as a basis of comparison. In using the same species for a comparison with *Pipa* I regret to find that I have made an error as to *Rana guppyi* in a paper communicated to this Society some twelve years since\*. There are six muscles visible (text-fig. 234) when the skin is removed from the inside of the thigh. These are precisely as figured in

Text-fig. 235.

Thigh-muscles of *Xenophrys monticola* on inside of thigh.

*a.* Vastus internus. *b, c, d.* Adductors. *e, f.* Sartorius or sart. and semitendinosus. *g, h.* Recti interni (or gracilis). *i.* Semimembranosus.

Ecker's work upon the Frog†, except for the fact that in *Rana guppyi* the adductor brevis lies between the heads of the sartorius and the adductor magnus, instead of between the latter and the rectus internus major, as figured in *R. esculenta*. When this is

\* P. Z. S. 1895, p. 837.

† Engl. Transl. by Haslam, Oxford, 1889, p. 98, fig. 81.



compared with *Xenophrys monticola* some differences are seen. The inner side of the thigh of the latter species is represented in the accompanying figure (text-fig. 235) and there is no doubt about the identification of the three adductors, the two recti interni and the vastus internus. This leaves for identification the two muscles which I have lettered "*i*" and "*e.f.*" The two heads of origin are plainly seen in the case of the latter muscle, while the insertion only of "*i*" is visible. The latter muscle seems to be without doubt the semimembranosus, which in the case of *Rana* does not appear upon the inside of the thigh at all but is quite restricted to the dorsal aspect. It is not without interest to note that in this appearance of the semimembranosus upon the inner surface of the thigh, *Xenophrys* agrees with *Pipa*\* but not with the Aglossan *Xenopus*†. There remains now the muscle "*e.f.*" This has two heads of origin, of which the posterior is much the smaller and soon joins the anterior head. The superficial position of the muscle and the fact that it is inserted onto the knee superficially to (*i. e.* ventrally to) the insertion of the recti interni, would seem to argue the identity of this muscle with the sartorius of *Rana*, from which it would in that case only differ by its two heads and its more posterior origin, and consequently different position in relation to the other muscles of the thigh. On the other hand, the two muscles end in a well-marked and longish strap-shaped tendon and are totally indistinguishable for some distance in front of their tendinous ending, which would fit in well with the view that we have here, as in *Rana*, a double-headed semitendinosus with a slightly different origin and insertion from that muscle in *Rana*. An obvious third view is to regard the two-headed muscle as actually composed of two muscles which are in course of fusion or of separation, and to compare them with both the sartorius and the semitendinosus of *Rana*. A consideration of the arrangement of these muscles within the family Pelobatidæ offers no clue to the determination of the homologies. For the genera which I have dissected agree with *Xenophrys*.

I have already described the muscles in question in *Megalophrys nasuta*‡, where they are practically the same as in *Xenophrys* except for the additional and slight complication caused by the presence of an additional head to the posterior of the two muscles. *Megalophrys montana* is like *Xenophrys*, and *Leptobrachium hasseltii* only differs very slightly, this difference consisting in a somewhat earlier fusion between the two muscles, whose homologies are under consideration. In *Pelobates* the differentiation of the two was even slighter. If, however, we consider the thigh-muscles in the Aglossa, it is possible, as I think, to arrive at a reasonable conclusion concerning these muscles in the Pelobatidæ. In *Pipa*§ the same two muscles that are present in the

\* P. Z. S. 1895, p. 838, fig. 4.

† *Ibid.* p. 844, fig. 3.

‡ P. Z. S. 1907, p. 343.

§ P. Z. S. 1895, p. 838, woodcut, fig. 4, 3, 4.



Pelobatidæ are present, and have the origin, course, and insertion as in *Megalophrys*, &c. They are completely superficial and visible on the internal aspect of the thigh only. There is no deeper muscle which could correspond to the semitendinosus of *Rana*. I find on a dissection of another example of *Pipa* that the insertion of the muscles (at any rate in that individual) is a little different from my description of the same in the paper already referred to. The two muscles are free from each other at their origin and also for the greater part of their course—and in this they differ from the corresponding muscles of the Pelobatidæ—but unite to form a common tendon which interposes itself between the two recti interni muscles (or gracilis), and is therefore inserted ventral of one and dorsal of the other. In spite of these differences, it is I think reasonable to assume that there is an homology between these muscles in *Pipa* and those which have just been described in the above-mentioned genera of the Pelobatidæ. This resemblance is in itself an interesting fact, and is to be added to those which I have already referred to and shall have occasion to refer to later.

My own observations upon the anatomy of *Pipa* and *Xenopus* and those subsequently published by Dr. Ridewood, which I have occasion to refer to several times in the course of the present communication, have certainly strengthened the opinion that there is a relationship between *Pipa* and *Xenopus* closer than that which ties either of these genera to any other genus\*, and that the group Aglossa is fully justified. It is not unreasonable, therefore, to compare the thigh-muscles in the two. I have again dissected *Xenopus* in case any error might have crept into my former account of that Frog, and find that the facts relating to the musculature of the thigh are as I there stated them†. I believe, moreover, that my interpretation of the thigh-muscles of *Xenopus* was more correct than of those of *Pipa*. The sartorius of *Xenopus* is largely fused with the semitendinosus, but has a separate insertion. The loss of this and the reduction in size of the sartorius (from before backwards) would bring about a state of affairs such as exists in *Pipa* and the Pelobatidæ, where the presumed sartorius is not only thinner but has a more posterior origin; the loss of the anterior portion of the muscle in *Xenopus* would obviously bring about such a result. These suggestions are of course based upon the supposition that there is likely to be a resemblance in the musculature of *Xenopus* and of *Pipa*. And in any case the views which I have ventured to express seem to me to be the most probable ones. On general grounds one might perhaps be tempted to look for a closer likeness between the Pelobatidæ and the Ranidæ than between the Pelobatidæ and the Aglossa; but the facts which have just been considered afford no basis for a comparison on these lines. Finally, as concerns the thigh-muscles, I may point out that the exposure of the insertion

\* Except of course *Hymenochirus*, the third genus of Aglossa.

† P. Z. S. 1895, p. 844.



of the semimembranosus on the ventral side of the thigh occurs in *Megalophrys*, *Leptobrachium*, and *Pelobates* as well as in *Xenophrys*.

The various facts concerning the musculature of the hind limb in the Pelobatidæ, which I have detailed in the foregoing pages, enable us to assign certain characters to that family as a whole, though the existing information upon the Anura generally does not allow at present of formulating a definition of the Pelobatidæ which shall differentiate them from other families, except possibly from the Ranidæ. As opposed to the Ranidæ, the Pelobatidæ, so far as we know them, are characterised by—(1) the appearance of the distal end of the *semimembranosus* (at its insertion) on the ventral surface of the thigh; (2) the fusion of the *sartorius* with the semitendinosus, if that is to say the homologies arrived at above are allowed; (3) the fact that the *semitendinosus* is either a single muscle or, if composed of more than one part (as in *Megalophrys nasuta*), the two heads arise side by side and not at different levels as in *Rana*, and that this muscle is quite superficial and not concealed by the *rectus internus major* or other muscles; (4) the tendon of insertion of the *rectus internus major* runs dorsally of the tendon of insertion of the *semitendinosus*.

#### § Sternum.

The sternums of *Xenophrys* and *Leptobrachium* are much like the sternums of *Pelobates*\* and *Megalophrys*†. There are, however, differences of detail which are worth recording as an assistance towards the determination of the mutual position of the various forms of Pelobatidæ to which generic rank has been given, and which are considered in the present contribution to the zoology of that family. I have already pointed out the great differences in the proportion of the body-length to the sternum in *Megalophrys nasuta* and *Pelobates fuscus*‡ and in the two species usually referred to the genus *Megalophrys*§. In *Xenophrys monticola* the total body-length from the tip of the snout to the vent was 68 mm.; from the anterior end of the omosternum to the extreme end of the sternum the length was 27 mm., and the true sternum measured 16 mm. In *Leptobrachium hasseltii* the corresponding measurements were 55 mm., 18 mm., and 10 mm. It appears, therefore, that in *Xenophrys* the proportions between these different lengths are not very different from those of *Megalophrys nasuta*; that is to say, the body-length of *Xenophrys*: length of entire sternum :: 10 : 4, while in *Megalophrys nasuta* the proportions are 10 : 4·5. Again, the body-length of *Xenophrys*: length of true sternum :: 10 : 2·3, and the corresponding proportions in *Megalophrys nasuta* are 10 : 2·7. Of *Leptobrachium*

\* Cf. Boulenger, 'Tailless Batrachia of Europe,' pt. i. p. 197, fig. 75.

† Beddard, P. Z. S. 1907, p. 329.

‡ *Id. ibid.* p. cit.

§ *Supra*, p. 874.



*hasseltii* the proportions of body-length to total sternal length (including omosternum) are 10 : 3·2, and of body-length to length of true sternum 10 : 1·8. *Megalophrys montana* clearly comes nearer to *Leptobrachium* than to its congener or to *Xenophrys*, for the two sets of proportions are (in the order adopted) 10 : 3·5 and 10 : 1·7. Translating these numbers into words, *Xenophrys monticola* and *Megalophrys nasuta* fall into one group characterised by a long sternum, while *Megalophrys montana* and *Leptobrachium hasseltii* agree with each other in possessing a short sternum.

In *Pelobates fuscus* the body-length was 47 mm., the total length of the sternal region including the omosternum 16 mm., and the length of the true sternum 9 mm. The actual proportions are therefore, as treated above in the Oriental Pelobatidæ, 10 : 3·4 and 10 : 1·9. These numbers hardly fill up the gap between the Pelobatidæ with a short sternum and those which possess a long sternum; they show that *Pelobates* is referable to the former group. I have already pointed out\* that the form of the sternum proper differs in *Megalophrys nasuta* and *M. montana*, especially in the form of the cartilaginous plate in which it ends posteriorly. *Xenophrys* and *Leptobrachium* agree with each other and with *Megalophrys nasuta*, *Pelobates*, &c. in that the xiphisternum is a wide cheesecutter-shaped cartilaginous plate, differing thus from that of *Megalophrys montana*. In neither *Xenophrys* nor *Leptobrachium* does the sternum extend so far as the end of the larger (left) lobe of the liver.

In dissecting the sternal musculature of *Xenophrys monticola* I have noticed a sheet of stiff fibrous tissue which extends laterally along each side of the sternum and overlies the sternohyoideus muscle. This is not an aponeurosis connected with that muscle or with any other muscle. The muscle is quite free from it and unconnected by any fibres. It seems to be an extension of the sternum itself laterally. It may indeed be regarded as morphologically part of the sternum; and, if this suggestion is correct, it brings the sternum of this Pelobatid more into line with that of some other Batrachia Salientia. A broad expanded sternum is, for instance, a character of the Aglossa. This is not urged, of course, as necessary evidence of special affinity with the Aglossa; for other genera belonging to the Phaneroglossa have also a broader sternum than is typical among the Pelobatidæ. It is not, however, at variance with such a view which other facts referred to support.

#### § Hyoid Muscles and Cartilages.

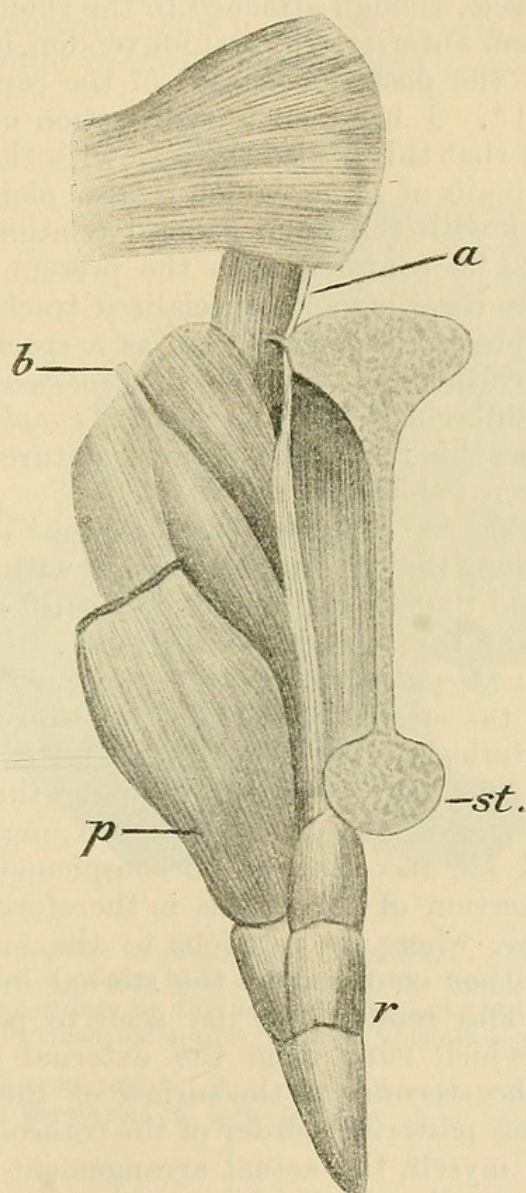
The relations of the rectus abdominis and the sternohyoideus in *Xenophrys monticola* are very unlike those of *Rana* and very like those of *Megalophrys nasuta*. When the pectoralis posterior

\* *Supra*, p. 874.



of *Rana guppyi* is cut across and reflected, the sternohyoid is exposed from its origin from the xiphoid end of the sternum up to where it dips under the shoulder-girdle anteriorly to reach the hyoid. In *Xenophrys* (text-fig. 236) the disposition of this muscle is as in *Megalophrys nasuta*, but with some slight differences of detail. When the pectoralis posterior is cut across

Text-fig. 236.

Sternum and adjacent musculature of *Xenophrys monticola*.

*a.* Specialised tract of rectus abdominis muscle attached by a tendon to border of coracoid. *b.* Scapular portion of obliquus. *p.* Pectoralis abdominalis cut across anteriorly. *r.* Rectus abdominis. *st.* Sternum.

and reflected, the sternohyoid is in the same way brought into view. The sternal portion of it, *i. e.*, that which arises from the xiphoid process of the sternum, runs anteriorly on each



side parallel to, and in contact with, the bony style of the sternum. Anteriorly dipping under the expanded anterior end of the sternum and joining the rest of the sternohyoideus, as in *Megalophrys nasuta*, it is covered by an aponeurosis inserted upon the latero-posterior border of the expanded anterior end of the sternum. This here joins the sternal attachment of a portion of the rectus muscle, which muscle I have also referred to as occurring in *Megalophrys*. The attachment of this latter muscle is strongly tendinous in *Xenophrys* as it is in *Megalophrys*. The tendon of this muscle, though attached to the rhomboidal expansion of the sternum anteriorly by a stout tendon, is continued on by this tendon to the posterior border of the cartilaginous and expanded coracoid\*. I have on a redissection of *Megalophrys nasuta* ascertained that this is also the case with that Frog. The portio omo-abdominalis of *Rana*, which is also plainly to be seen in *Xenophrys*, and with the same general relations that it has in *Rana*, is not to be confused with the present muscle, which, is, as I think, to be regarded as a specialised tract of the rectus abdominis, not represented (at any rate as a specialised muscle) in *Rana*. The corresponding muscles in *Leptobrachium hasseltii* seem to show no differences from those of *Xenophrys monticola*, and there is thus in this region of the musculature an agreement among these Eastern Pelobatidæ.

I have been able to compare these several muscles which agree so exactly among the Oriental Pelobatidæ with those of *Pelobates fuscus*. I find that this species of Pelobatid agrees with its Eastern relatives and thus disagrees with *Rana*. *Pelobates* agrees more closely with *Megalophrys nasuta* than with *Xenophrys monticola* in that the sternal portion of the sternohyoid is not inserted at all anteriorly upon the rhomboidal expansion of the sternum. It can be plainly seen to dip under this (*i. e.*, to pass above it dorsally), and appears to be quite unconnected with it by any fibres at all, and there is no conspicuous aponeurosis. The coracoidal insertion of the rectus is therefore much clearer than in *Xenophrys*, where its relations to the anterior end of the sternum are rather confused by the sternal insertion of the sternohyoideus. The tendon can be seen to pass through a tendinous sling, which runs from the external corner of the anterior end of the sternum to the surface of the rectus muscle just above it, to the posterior border of the coracoid. This is, as I have convinced myself, the actual arrangement in *Xenophrys* and *Megalophrys* as well as in *Pelobates*.

In describing the geniohyoideus muscle of *Rana esculenta*, Dr. Haslam translates† as follows from Ecker's work upon the Frog:—This muscle on each side of the throat "divides posteriorly into two portions. One of these, the median, is inserted into

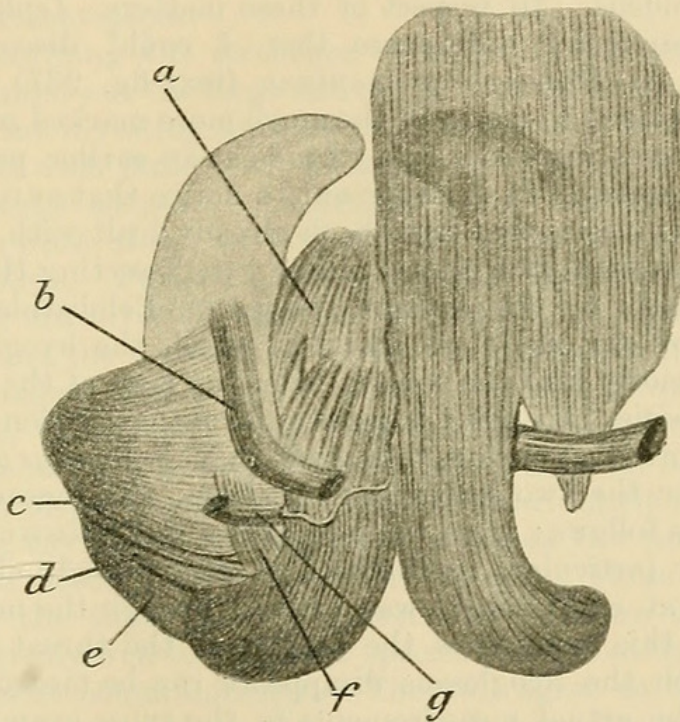
\* The principal attachment of the tendon is really to the coracoid. The attachment to the sternum is rather of a fibrous than a tendinous nature, as in *Pelobates*.

† 'The Anatomy of the Frog,' by Dr. Alexander Ecker. Transl. by George Haslam, M.D., Oxford, 1889, p. 64.



the inner border of the posterior horn of the hyoid bone, and is here attached to a fascia which covers the m. hyoglossus from beneath. By the same fascia the muscles of opposite sides are connected in the space between the two posterior cornua." I quote this description in full in order to emphasise the differences which *Rana* shows from all of the Pelobatidæ examined by myself and described in the present paper. In *Xenophrys monticola*, when the submaxillaris and subhyoideus are cut and reflected, a thin and broad sheet of muscle is seen to occupy the greater part of the area of the throat. This muscle is indistinguishable into two muscles; for, while in *Rana guppyi* (and *esculenta* as figured by

Text-fig. 237.



Some of the hyoid muscles of *Megalophrys montana*. On the right side the processus anterior of the basal cartilage of the hyoid is seen exposed; the corresponding cartilage on the left side (the right-hand of the drawing) is covered by the geniohyoid muscle, through which it appears dimly.

*a.* Hyoglossus. *b.* Sternohyoid. *c, d, e.* Subdivisions of posterior petrohyoid; the large anterior petrohyoid is seen in front of *c*. *f.* Part of geniohyoid. *g.* Omohyoid.

Ecker) a membranous median interval separates the right and left geniohyoid muscles, allowing the subjacent (*i. e.*, dorsally lying) hyoglossus to be seen through this transparent fascia, the geniohyoideus in *Xenophrys* is indistinguishable anteriorly into two halves, the fascia being represented by muscle. There is then no view of the hyoglossus muscle until the geniohyoid is divided and reflected. Furthermore, when the muscle of each side bifurcates to permit of the passage of the sternohyoideus (as in *Rana*), the two inner portions form a continuous sheet of muscle



which covers completely, and has to be dissected away to reveal, the underlying hyoglossus. This same arrangement of the geniohyoid is quite plain in *Megalophrys montana* and in *Leptobrachium hasseltii*, and apparently in *Megalophrys nasuta*.

The hyoglossus in *Xenophrys* is an extremely stout muscle, arising from the thyrohyals as usual. In cutting the muscle through longitudinally in that part of it which lies on the body of the hyoid, the muscle is seen to be separable into five superjacent layers very plainly distinct from each other. The muscle does not run so far forwards along the floor of the mouth as in *Rana*, and enters the tongue nearer the middle of that organ, which is more attached to the floor of the mouth in the Pelobatidæ than in many other Frogs. This greater adhesion of the tongue is perhaps connected with the spreading and greater extension of the geniohyoideus. In respect of these matters, *Leptobrachium* shows no particular differences that I could discover from *Xenophrys*. In *Megalophrys montana* (text-fig. 237) the only difference appeared to me to be the much more marked subdivision of the hyoglossus into rope-like strands at an earlier period than in the other genera. It is important to notice that as regards the two hyoidean muscles that have been already dealt with, *Pelobates* entirely agrees with its Oriental allies. In dissecting the muscles above described in the several species of Pelobatidæ, certain differences are obvious in the point at which the hyoglossus disappears anteriorly into the tongue from the floor of the mouth.

In some species this point is more anterior in position, in others more posterior. It is curious to remark that *Xenophrys* and *Leptobrachium* offer the two extremes in position. The measurements taken were as follows: from the middle of a line drawn connecting the posterior (articular) extremities of each mandibular ramus another line at right angles was drawn through the mandibular symphysis; this represents the length of the throat; and the point at which the hyoglossus disappears can be measured along this line. The actual measurements in the types examined were as follows:—

	Length of Throat.	Length of Hyoglossus.	Proportion.
<i>Xenophrys</i> .....	22 mm.	6 mm.	$\frac{3}{11}$ or .27
<i>Megalophrys nasuta</i> .....	42 „	26 „	$\frac{13}{21}$ or .538
<i>Megalophrys montana</i> ...	22 „	14 „	$\frac{7}{11}$ or .63
<i>Leptobrachium hasseltii</i> ...	19 „	12 „	$\frac{12}{19}$ or .63

It is also noteworthy that *Leptobrachium* and *Megalophrys montana* are nearer together than any other forms, and that the two *Megalophrys* are by no means identical.

The hyoid cartilages of *Megalophrys montana* have been already dealt with to some extent in this paper\* as assisting to distinguish

\* *Supra*, p. 875.



that species from *Megalophrys nasuta*, the hyoid cartilage of which I have already examined and figured \*. In comparing the two species alleged to be of the same genus, I pointed out a difference in the curvature of the basal cartilage which happens to be of morphological importance. It is most interesting to find that this undoubted likeness to *Pelobates*, shown by *Megalophrys montana* but not by *M. nasuta*, does not occur elsewhere among the species which I have had the opportunity of investigating. There is a very slight approach to the curvature exhibited by *Megalophrys montana* in the case of *Xenophrys*. But in *Leptobrachium* the *processus anteriores* are directed straight forward parallel with the long axis of the body of the Frog and without the slightest deflection towards each other, as in *Megalophrys nasuta*—not the first point of likeness between these two that I have pointed out in the present paper.

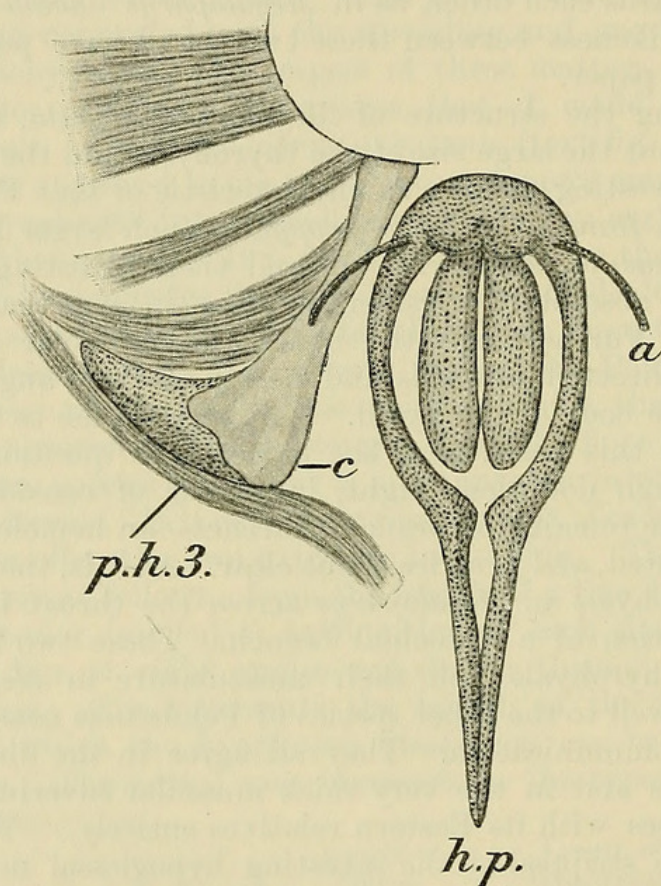
In describing the structure of *Megalophrys nasuta*, I particularly pointed out the large size of the thyrohyals and the immense mass of the investing muscles as characteristic of that Frog when compared with *Rana*. In *Rana guppyi*, a much larger Frog than *Megalophrys nasuta*, the thyrohyals and their investing mass of muscles were absolutely considerably less in size than in the *Megalophrys*. Furthermore, the bones and muscular sheath in question are directed upwards and nearly at right angles to the direction of the body of the hyoid. It appears to me to be justifiable to regard this position of the processes in question as some evidence, though doubtless slight, in favour of considering the processes as the remains of branchial arches—an homology which has been disputed, and is at least not clear. As it is, the direction of these thyrohyals in *Megalophrys* across the throat is, at any rate, the direction of a branchial branch. These two facts concerning the thyrohyals and their musculature in *Megalophrys* apply equally well to the other species of Pelobatidæ considered in the present communication. They all agree in the direction of these processes and in the very thick muscular covering. *Pelobates*, too, agrees with its Eastern relatives entirely. When the thyrohyals are stripped of the investing hypoglossal muscle, the bony shaft is very plainly marked off from the cartilaginous epiphysis, and the insertions of the petrohyoidei posteriores become obvious. In all the types that I have examined the thyrohyals are straight and with a "waist" in the middle. The epiphysis in *Megalophrys montana*, like that of *M. nasuta*, projects boot-like towards the petrous region of the skull. It differs, however, in some degree from the epiphysis of its alleged congener. In *M. nasuta* the epiphysis is attached distinctly to the side—the outer side—of the end of the thyrohyal. The latter bone is bony up to the actual posterior truncated edge. It is, however, cartilaginous at the inner posterior corner. Thus it comes about that the epiphysis is very easily detached. This is not at all the case

\* P. Z. S. 1907, p. 341, text-fig. 97.



with *M. montana*. In that Frog the epiphysis (which is straighter and not so curled as in *M. nasuta*) is continuous with the cartilaginous posterior border of the thyrohyal, and is not detachable. In *Xenophrys monticola* there is a slight difference; the cartilaginous epiphysis is easily detachable and is attached to the bony shaft, as is shown in the accompanying figure (text-fig. 238), partly to the side and partly to the posterior border of the thyrohyal. The thyrohyal of *Leptobrachium hasseltii* is quite different from any of the types just described. The bone is straight and narrow at the posterior end. It has not the hourglass-shape that it has

Text-fig. 238.

Laryngeal cartilages and adjacent structures of *Xenophrys monticola*.

Bronchial cartilage. *c*. Bony shaft of thyrohyal with cartilaginous epiphysis to left. *hp*. Hypopharyngeal processes of cricoid cartilages. *p.h.3.* Posterior petrohyoid.

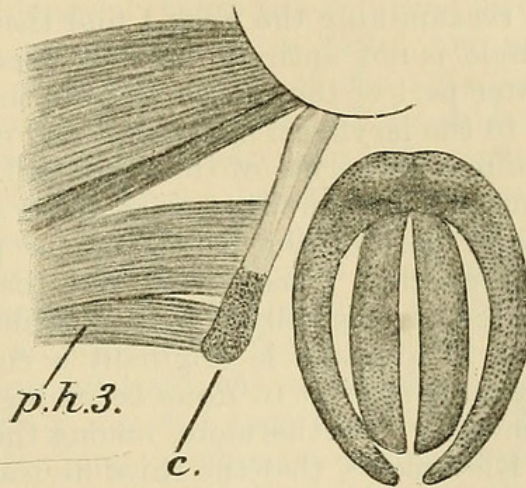
in the other genera. It ends in cartilage below, and from this latter is readily detachable by a slighter cartilaginous epiphysis. This region of the hyoid in *Leptobrachium* (text-fig. 239) differs much more from that of *Xenophrys* than the latter genus does in this respect from *Megalophrys*. A final peculiarity of the thyrohyal epiphysis distinguishes *Xenophrys* from both species of *Megalophrys*. In the two latter the epiphysis is distinctly posterior to the petrohyoideus posterior tertius muscle. In *Xenophrys*, on the other hand, this cartilaginous process lies as distinctly in



front of the same muscle, in fact between it and the petrohyoideus posterior secundus. I am not quite clear about the exact relations of the corresponding parts in *Leptobrachium hasseltii*.

The petrohyoidei muscles are all four of them present in such Pelobatidæ as I have dissected. The insertions of these (and of the hyoid muscles generally) in *Pelobates* and *Pelodytes* have been carefully figured and described by Ridewood\* and compared with those of *Rana temporaria*. He has observed that the fourth division of the petrohyoideus, *i. e.* the petrohyoideus posterior tertius, is absent from *Pelodytes*. As to *Rana* the current figures and descriptions of the hyoid musculature in *R. temporaria* and *R. esculenta* indicate four petrohyoideal† muscles; and I can confirm these statements as applying to *Rana tigrina*. Furthermore, it is plain from the illustrations cited below and from my own

Text-fig. 239.



*Leptobrachium hasseltii*.

*c.* Points to cartilaginous epiphysis of thyrohyal. *p.h.3.* Posterior petrohyoid.

dissections, that in these species of *Rana* the three portions of the petrohyoideus posterior are slender, of insufficient width to come into contact at their insertions on to the thyrohyal bone. It must not, however, be imagined that this is distinctive of *Rana*. For in *Rana guppyi* the petrohyoideus posterior is only formed of two separate muscles, which are, however, broad and fanshaped and nearly fill up the entire margin of the thyrohyal at their insertion. The anterior of the two muscles is the larger and clearly corresponds to the primus and secundus; but in two examples of the Frog in which I dissected these muscles I can find no evidence of the fusion of two muscles. In *Rana* generally the three (or exceptionally two) divisions of the petrohyoideus posterior are inserted

\* P. Z. S. 1897, pl. xxxv. figs. 10, 11.

† *E. g.*, Ridewood (*loc. cit.*); Wilder, Zool. Jahrb., Abth. f. Anat. ix. 1893, Taf. 20. fig. 35; Haslam in Ecker's 'Anatomy of the Frog,' fig. 60, p. 65. But Göppert (Morph. Jahrb. Bd. xxvi. 1898, Taf. 8. fig. 7) figures only three in *Rana temporaria*.



on to the bony thyrohyal, the anterior slip of the muscle straying only slightly if at all on to the body of the hyoid, as figured for instance by H. H. Wilder\*. On the other hand, I have already pointed out that in *Megalophrys nasuta* the first of the three slips of the petrohyoideus posterior arises mainly—and indeed I believe I may say, after a reexamination, exclusively—from the body of the hyoid at its junction with the thyrohyal†. In *Rana* a small slip of the petrohyoideus posterior tertius is not inserted with the mass of the muscle on to the thyrohyal but forms a part of the laryngeal musculature. I could see that this was the case with *Rana guppyi*, where nearly the whole muscle appeared to be inserted on to the thyrohyal, but a few fibres escaped beyond it and appeared to be inserted onto the ligament binding the posterior end of the thyrohyal to the cricoid; I did not trace them beyond this point‡. In *Megalophrys nasuta* I have described this muscle as passing beneath the end of the thyrohyal§ (i. e., beneath when the animal is examined in the ordinary position of dissection). In reexamining the Frog I find that this is the case, but that the muscle is not entirely inserted upon the thyrohyal. In fact, the greater part of the muscle escapes the thyrohyal and is inserted close to the laryngeal apparatus, and only a part is inserted onto the inner end corner of the thyrohyal. We have here in fact conditions precisely the reverse of those sometimes found in *Rana*, the major part of the petrohyoideus posterior tertius being a laryngeal muscle. I may point out that this fact is of some importance embryologically. For, as Wilder|| has shown, the petrohyoideus in question is originally a continuous muscle reaching the larynx, part of it in *Rana* becoming later separated as an intrinsic muscle. Furthermore, among the Aglossa it has been shown by Ridewood¶ that the third division of the petrohyoideus posterior (or rather the muscle believed to correspond thereto) is a purely laryngeal muscle, having no connection with the hyoid. Thus *Megalophrys nasuta* shows a distinct likeness in this anatomical relation—though it is doubtless a small one—to the Aglossa. These same peculiarities of the petrohyoid muscles occur also in the other Oriental Pelobatidæ upon which I am able to report in the present communication. The peculiarities therefore cannot be held to be in any way characteristic of sex. In *Leptobrachium hasseltii* (see text-fig. 239) the three posterior petrohyoidei are visible as perfectly distinct muscles. The petrohyoideus posterior primus is in contact with the petrohyoideus anterior. The petrohyoideus posterior secundus is larger than it and the following and last of the muscles, which latter passes under the cartilaginous epiphysis of the thyrohyal bone.

\* *Loc. cit.* and fig. *cit.*

† This does not appear to be the case with *Pelodytes*.

‡ According to Göppert's figure, however (*loc. cit.*, fig. *cit.*) the whole of the last petrohyoideus escapes the thyrohyal and is a laryngeal muscle.

§ P. Z. S. 1907, p. 339.

|| *Loc. cit.* p. 307.

¶ Journ. Linn. Soc., Zool. xxvi. 1897.



The slender petrohyoideus posterior primus seems to be attached to the body of the hyoid just above the articulation of the thyrohyal.

In *Xenophrys monticola* the petrohyoideus posterior primus is separated by a wide gap from the petrohyoideus anterior. The middle and posterior slips of the former are about equal in size; but the latter runs in quite a different direction, passing below the end of the thyrohyal as is shown in the accompanying figure (text-fig. 238, p. 898).

*Megalophrys montana* is so much like *M. nasuta* (text-fig. 240, p. 902) that a special description is hardly needed. The differences from the last two types will be obvious.

The subhyoideus and the petrohyoidei of *Pelobates fuscus* are different from those of the Oriental Pelobatidæ. Owing to the absence of the anterior cornua of the hyoid in *Megalophrys nasuta*, the subhyoideus is attached to the lateral walls of the skull. In *Pelobates*, on the other hand, as is shown in the figures of Ridewood\* and Boulenger†, there is a detached piece of cartilage, in shape like the sound-holes of a violin, on either side which represents the posterior region of the anterior cornu. To the posterior extremity of this is attached the subhyoideus, thus confirming the morphological views held with regard to that piece of cartilage. *Pelobates fuscus* has the usual four pairs of petrohyoideal muscles. Of these the petrohyoideus anterior needs no special comment. The three slips of the petrohyoideus posterior are slender muscles as in *Rana*, and, as is also partly the case in that genus, are all attached to the thyrohyals. And furthermore, again as in *Rana esculenta*, the petrohyoideus posterior tertius is practically entirely inserted upon the end of the thyrohyal. As in *Xenophrys*, the long cartilaginous epiphysis of the thyrohyal—inadequately represented by Boulenger‡ and Ridewood§—lies between the second and third divisions of the petrohyoideus posterior.

### § Larynx.

In my paper upon *Megalophrys nasuta* I did not deal with the larynx of that Frog. I desire therefore in the present place to supplement that deficiency by a few facts. The laryngeal cartilages present us with several differences from those of other Frogs. *Rana* has naturally been taken as the type of the Anuran larynx, and until recently Wiedersheim's|| figures of the same. These latter have, however, been shown by H. H. Wilder to be representations of a type "entirely unique"¶. The more

\* P. Z. S. 1897, pl. xxxv. fig. 12.

† Ray Soc. Monograph, p. 197, fig. 75.

‡ Loc. cit., fig. cit.

§ Loc. cit., fig. cit.

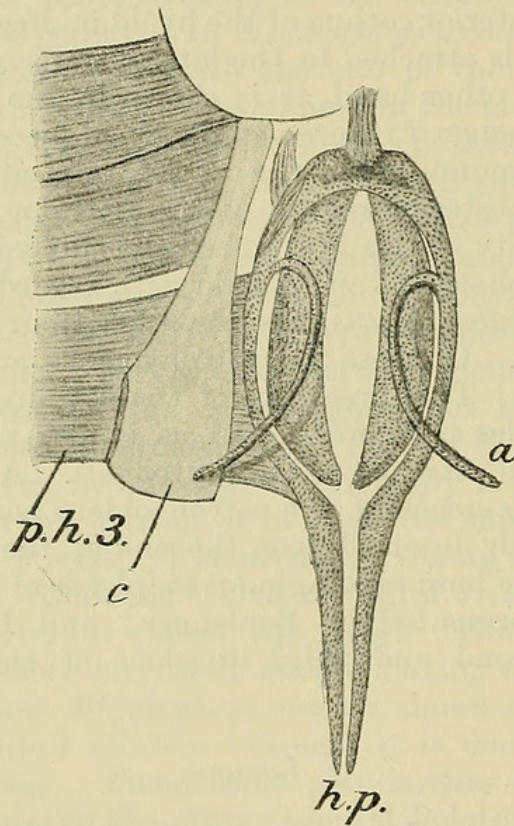
|| In the various editions of his two text-books.

¶ Zool. Jahrb., Abth. f. Anat. ix. p. 288.



ordinary arrangement is for the bronchial cartilages to be straight bars not fused and contorted to form "a fantastically shaped W." In all of the three types, however, figured by Wilder, the cricoid cartilage or "annulus" is represented as ending medianly in a pharyngeal process closely applied to the ventral wall of the œsophagus. This is termed by Haslam the "spine of cricoid cartilage." It might therefore be inferred that this spine was characteristic of the genus *Rana*\*. However, this is not the case; for in *Rana tigrina* there is the barest rudiment of this process. Otherwise there are no great differences between that species and "type II" of *Rana* as described by Wilder.

Text-fig. 240.

Laryngeal cartilage and adjacent structure of *Megalophrys nasuta*.

Lettering as in text-fig. 238.

In the figure of the laryngeal cartilages of *Rana esculenta* given in Haslam's translation of Ecker's work †, a stiff membrane is represented as filling up the interspace of the cricoid cartilage. This I find strongly developed in *Rana tigrina*. I mention this point with some emphasis, since in *Megalophrys nasuta* it is represented by an extremely delicate membrane. The two principal features that I have noticed in the structure of the larynx of *Megalophrys nasuta* which differentiate it from that of

\* It is very long in *Rana guppyi*.

† P. 313, fig. 204 M.



*Rana* are the following :—the bronchial cartilages are two very slender cartilages, one on each side. Instead of being stiff, straight, thick processes as in *Rana tigrina*, each is a very slender and arched cartilage, like a bronchial half-hoop, and corresponding of course to the point of opening of the lung into the larynx. I could see no arborescent outgrowths of these such as Ridewood has figured in *Rana* \*. Its slenderness and semilunar outline are distinctive as compared with the same cartilage in *Rana*. The second and more striking difference from *Rana* and from other Anura relates to the middle pharyngeal process of the annulus or cricoid cartilage. Instead of being a single median process, this is very distinctly composed of two pieces symmetrical with each other and lying closely side by side, being united by ligamentous tissue. These processes are very long. It seems to be difficult to avoid the conclusion that we have in this Frog a persistent embryonic condition in the separateness of the two halves of the cricoid. This second peculiarity of the larynx of *Megalophrys nasuta* (see text-fig. 240) is not, however, peculiar to that species or genus. I find exactly the same double median pharyngeal process of the cricoid in *Megalophrys montana* and in *Xenophrys monticola*. It would appear therefore to be unlikely that the disposition of these cartilages is in any way related to sex, for the *Xenophrys* which I examined was a male and the two *Megalophrys* were both females. In *Xenophrys monticola* the bronchial cartilage was arched like that of *Megalophrys nasuta*, but shorter and rather stouter.

In *Megalophrys montana* these cartilages are rather more of the type of *Xenophrys* than of *Megalophrys montana*. In all of these Frogs there is an agreement in the position of the point of origin of the bronchial processes in which they all differ from *Rana*. In the latter genus the bronchial cartilages arise from a point not far from being on a level with the posterior end of the thyrohyals. In *Megalophrys* and *Xenophrys*, on the other hand, these processes arise much more anteriorly where the cricoid and arytenoids come into contact to form a hood concealing the anterior end of the aditus laryngis. I have had occasion elsewhere in this paper to refer to differences between *Xenophrys* and *Leptobrachium*, which is interesting in view of their recent fusion to form one genus. I now find that in *Leptobrachium hasseltii* there is at any rate one very well marked difference in the larynx. This difference concerns the cricoid cartilage. These cartilages are not connected posteriorly, in which fact they agree with the other Oriental forms of Pelobatidæ. Moreover, the cartilages are very short and fail by a long distance to meet in the middle line posteriorly, there being of course no pharyngeal process or processes.

\* Journ. Linn. Soc., Zool. xxvi. pl. ix. fig. 7.



## (4) DEFINITION OF THE FAMILY PELOBATIDÆ.

There are not two opinions concerning the validity of the family Pelobatidæ, or respecting the justice of placing in that family all of the genera dealt with in the present communication. Among the matters that require settlement with regard to this family are: the limitations of the several genera which have been assigned to it, their mutual affinities, and the relationship of the Pelobatidæ to other Anurous Batrachia. I pretend to have brought forward in the present communication facts which bear upon the two important questions above set forth. The facts dealt with in the foregoing pages also permit of some extension in the definition of the family. At the present moment the only characters known which combine to define the Pelobatidæ are the following, viz.:—Teeth confined to upper jaw. Vomerine teeth usually present. Omosternum small and cartilaginous, rarely absent\*, or larger and calcified†; sternum mostly with an ossified style. Coracoids overlap ("arciferous" shoulder-girdle). Transverse processes of sacral vertebræ large and expanded. Coccyx occasionally fused with sacrum. Tongue round or oval, feebly nicked behind and free (except in *Asterophrys*). Pupil vertical.

These characters are not found collectively in any other family of Anura, though all of them singly or in some slight combination are found in other families. To these characters is sometimes added the condition of the tympanum—stated to be "indistinct." This does not appear to me to be a just character as defining the family. Furthermore, there are a certain number of negative characters, such as—ribs absent, no suckers on fingers and toes, &c.

To these may be now added two rather important characters—whose possible occurrence, however, in other families requires further demonstration. These are the reduction or even absence of the principal cornua of the hyoid complex, in formulating which I confirm and extend the opinion of Boulenger and Ride-wood; and the existence of a peculiarly large œsophageal muscle extending in its origin as far back as the middle of the pelvis. The non-union of the two halves of the cricoid and the double character of the often long hypopharyngeal process is characteristic of, though not universal in, this family, and it has not been recorded elsewhere.

The investigations described in the present paper and others referred to allow of the inclusion of a number of other characters, perhaps of minor importance, in the definition of the family Pelobatidæ. So far as we know at present, the thigh-muscles are peculiar in the absence of a deep-seated semitendinosus and the presence of two muscles closely related upon the inner surface of the thigh, which may correspond to the semitendinosus and the

\* In *Scaphiopus solitarius*.† In *Megalophrys nasuta*.



sartorius. Another feature is the absence of a superficial sterno-radialis muscle, the existence of a special slip of the rectus abdominis attached to the posterior border of the coracoid, the existence of a strong muscle extending from the ilium to the transverse process of the third vertebra belonging presumably to the ilio-lumbar complex (which is unrepresented in *Rana*, &c.), and the large size of the geniohyoid which covers the hyoglossus. It is possible also that the family will prove to be characterised by the numerous vasa efferentia not forming a rete, and by the absence of a vesicula seminalis.

Finally, the suspension of the right and left lungs up to or nearly to the posterior end by a ligament is, so far as we have gone, a character of this family.

#### (5) THE GENERA OF PELOBATIDÆ.

The next point for consideration is the limitation of the several genera treated of in this communication, which are for the most part allowed as valid by systematists. The only genus which is at the moment not generally allowed is *Xenophrys*, which has been included by Boulenger\* (whom others follow) in the genus *Leptobrachium*. So far as external characters go, *Megalophrys* might also be included, for *Leptobrachium fœæ* and *L. carinense* (occasionally) possess the processes over the eye which has given to *Megalophrys* its generic name.

Mr. W. L. Sclater has also in the paper referred to below† shown that *Leptobrachium carinense* may possess vomerine teeth, which were absent in the first individuals examined by Boulenger but subsequently found by him‡. This point is a further argument in favour of a coalescence of the genera *Xenophrys* and *Leptobrachium*, which were formerly distinguished by the presence in the former and the absence in the latter of these teeth. Again, the vomerine teeth of *L. carinense* are between or even slightly in front of the choanæ, which tends to throw doubt upon the use of this position of the teeth to distinguish *Megalophrys nasuta* from its congener and from *Xenophrys*. As to other characters, it has been pointed out that *Pelobates cultripes*§ varies in the fusion or non-fusion of the sacrum with the coccyx.

It is not, however, reasonable to decline to use as a character an anatomical peculiarity which may happen to vary. Indeed, if this were the case it would be hard to frame a considerable number of apparently useful specific and generic distinctions. In a similar fashion, the procœlous or opisthocœlous nature

\* Boulenger, Ann. Mus. Genova, loc. cit.

† W. L. Sclater, P. Z. S. 1892, p. 348.

‡ Ann. Mus. Genova (2) xiii. 1893, p. 344.

§ See Boulenger, 'The Tailless Batrachia of Europe,' Ray Soc. 1897, pt. i., and for references to statements made by others upon this anatomical variation which has not apparently been noted in *P. fuscus*.



of the vertebral centra has been shown to vary in one individual of *Xenophrys monticola* by Boulenger, and in other forms by others. If the three characters just shortly dealt with are disallowed as of classificatory value, I do not see how we are to escape from the inclusion in one genus not only of the Oriental, and doubtless closely allied, forms now named *Megalophrys*, *Xenophrys*, and *Leptobrachium*, but also of *Pelobates* and *Pelodytes*. *Scaphiopus* alone (of the genera that are tolerably well known) would escape this simplification in nomenclature. For the internal characters are not very decisive as evidence of generic delimitations. In one or two points, for example, *Xenophrys* stands rather alone, or is much nearer to *Pelobates* than to its more obviously related allies *Megalophrys* and *Leptobrachium*. Elsewhere *Leptobrachium* comes nearer to *Megalophrys nasuta* than to *Xenophrys*. If we were to arrange the different forms considered in the present communication by the mode of suspension of the lungs, *Leptobrachium* and *Megalophrys montana* would be placed together and contrasted with *Megalophrys nasuta* and *Xenophrys*. And other instances of cross-resemblance will be found to occur in the descriptions given in the preceding pages. These differences, however, though apparently unreliable as generic distinctions on account of their—so to speak—capriciousness of occurrence, are, taken in conjunction with the external and osteological characters already known, of sufficient importance in my mind to divide the Pelobatidæ considered in this paper into a number of genera. And I am distinctly of opinion, as far as the facts allow me to judge, that *Xenophrys* must be reinstated and a new genus formed for *Megalophrys nasuta*. On the other hand, it must be borne in mind that these Oriental Pelobatidæ which I distribute among four genera have certain points in common which distinguish them all and equally from *Pelobates*. These points are: (1) the general form of the larynx with its separate cricoids—a persistent embryonic condition as I imagine; (2) the more or less rudimentary condition of the metatarsal tubercle; (3) the less completely webbed hind toes; (4) the presence upon the thighs of a gland-patch; (5) the complete absence of the anterior hyoidean cornua.

Do these outweigh the osteological and other differences which have led to the separation of the Oriental forms into several genera? I am inclined to think not; for they appear to me to be less important even than characters which, if used for that purpose, would relegate *Pelobates* to the same genus as *Xenophrys* or *Pelobatrachus*. This view, however, which is in any case a matter of opinion, may be strengthened or weakened by the future collecting of fact.

The following table indicates the various points of anatomical likeness and unlikeness among the Oriental Pelobatidæ considered in the foregoing pages:—



	<i>Xenophrys.</i>	<i>Leptobrachium.</i>	<i>Megalophrys nasuta.</i>	<i>M. montana.</i>
<i>Metatarsal tubercle.</i> }	Elongate.	Small, circular.	Elongate.	Elongate.
<i>Ossifications in skin.</i> }	Not recognisable*.	Not recognisable*.	Very strong.	Not recognisable*.
<i>Tympanum</i> .....	Quite obvious.	Quite obvious.	Absolutely hidden.	Quite obvious.
<i>Vertebrae</i> .....	Procœlous.	Procœlous.	Procœlous.	Opisthocœlous.
<i>Sacrum</i> .....	Free from coccyx.	Free from coccyx.	Fused with coccyx.	Free from coccyx.
<i>Anterior processes of hyoid.</i> }	Slightly convergent.	Parallel.	Parallel.	Very convergent.
<i>Thyrohyals</i> .....	Hourglass-shaped.	Rod-like.	Hourglass-shaped.	Hourglass-shaped.
<i>Omosternum</i> .....	Rudimentary.	Rudimentary.	Fair-sized and calcified.	Rudimentary.
<i>Length of sternum as compared with body.</i> }	Long.	Short.	Short.	Long.
<i>Vomerine teeth.</i>	Behind choanæ.	Absent.	Between choanæ.	Behind choanæ.
<i>Liver</i> .....	Certain differences in form. (See text, p. 880.)			
<i>Lungs</i> .....	Pulmo-hepatic ligament extending halfway down lung.	Pulmo-hepatic ligament nearly to end of lung.	Pulmo-hepatic ligament halfway down lung.	Attached by pulmo-hepatic ligament for their whole length.
<i>Larynx</i> .....	Long hypopharyngeal processes.	No hypopharyngeal processes.	Long hypopharyngeal processes.	Long hypopharyngeal processes.
<i>Pectoralis posterior.</i> }	Extensive in origin.	Short.	Short.	Short.
<i>Submaxillaris</i> ...	With narrow tendinous median raphe.	With wide tendinous sheet in middle of throat.	As in <i>Leptobrachium</i> .	As in <i>Leptobrachium</i> .

\* *i.e.* to the feel when the frog is handled.

An analysis of this table shows that in the fourteen characters selected, *Xenophrys* is peculiar in only two characters; that it agrees with *Leptobrachium* and *Megalophrys montana* in four points; with *Leptobrachium* alone in no characters, and with *Megalophrys montana* alone in four characters. Of the remaining four characters, *Xenophrys* agrees with *Megalophrys* and *M. montana* in three. *Leptobrachium* is peculiar in four characters; it agrees with *Xenophrys* and *Megalophrys montana* in four characters, and with *Xenophrys* alone in none. With *Megalophrys nasuta*, *Leptobrachium* agrees in two characters. In short, the cross-likenesses and differences between these several types are such that no combination between any two or three of them as against two or one is possible. It shows with peculiar emphasis



that *Xenophrys* and *Leptobrachium* are not nearer to each other than any other two. With the addition of some further characters these genera may be described as on the following pages.

The genus *Xenophrys* will be thus characterised:—

*Skin with no conspicuous indurations. Aggregations of glands present on thighs. Tympanum fairly conspicuous. Vertebrae procoelous; sacral vertebra free from coccyx. Omosternum rudimentary, cartilaginous; xiphisternum ossified, ending in an expanded cartilaginous plate. Hyoid with anterior processes inclined towards each other; thyrohyals hourglass-shaped with long cartilaginous epiphysis separating the second and third petrohyoidei posteriores. Right lung supported for more than half its length by pulmo-hepatic ligament. Sternum long in proportion to body-length. Pectoralis posterior arising from whole of sternum. Submaxillaris fleshy throughout, with only a fine median tendinous raphe. Subhyoideus not very distinct from submaxillaris and slender. Larynx with long separate hypopharyngeal processes and short bronchial hoop.*

The following definition will indicate the chief characters of *Leptobrachium*:—

*Skin with no conspicuous indurations. Aggregations of glands present on thighs. Tympanum fairly conspicuous. Vertebrae procoelous; sacral vertebra free from coccyx. Omosternum rudimentary, cartilaginous; xiphisternum ossified, ending in an expanded cartilaginous plate. Hyoid with anterior processes strictly parallel, and not inclined towards each other; thyrohyals rod-like, without a laterally directed epiphysis. Lung supported for nearly its entire length by pulmo-hepatic ligament. Sternum short in proportion to body-length. Pectoralis posterior reduced in size. Submaxillaris with extensive tendinous centre. Subhyoideus very distinct and large. Larynx with no hypopharyngeal processes of cricoids, which remain separate.*

*Megalophrys* has the following characters:—

*Skin with no conspicuous indurations; with many tubercles. Aggregations of glands present on thighs. Tympanum fairly conspicuous. Vertebrae opisthocelous; sacral vertebra free from coccyx. Omosternum rudimentary; xiphisternum ossified, ending in a not expanded cartilaginous plate. Hyoid with anterior processes inclined towards each other; thyrohyals hourglass-shaped with long cartilaginous epiphysis lying behind posterior petrohyoidean muscle. Right lung supported for its entire length by pulmo-hepatic ligament. Sternum long in proportion to body-length. Pectoralis posterior reduced in length of origin. Submaxillaris with extensive tendinous centre. Subhyoideus distinct and large. Larynx as in *Xenophrys*.*

There remains the Frog which I have hitherto referred to under the name of *Megalophrys nasuta*. There is no doubt that



if the foregoing genera are allowed, and if *Megalophrys* is distinct from *Leptobrachium*, that that Frog will have to be placed in a distinct genus equivalent to these others. For this genus I suggest the name *PELOBATRACHUS*, which may be thus defined:—

*Skin with conspicuous indurations. A few large tubercles. Aggregations of glands present on thighs, but smaller than in allied genera. Tympanum invisible. Vertebrae procœlous; sacral vertebra fused with coccyx. Omosternum of fair size and calcified in part; sternum ossified with expanded cartilaginous xiphisternum. Hyoid with anterior processes parallel; thyrohyals hourglass-shaped with long cartilaginous epiphysis lying behind last petrohyoid. Right lung supported for half its length by ligament. Sternum short in proportion to body-length. Pectoralis posterior reduced in length. Submaxillaris with extensive tendinous centre. Subhyoideus large and distinct from submaxillaris. Larynx with long separate hypopharyngeal processes and long bronchial hoop on each side.*

The following characters are, so far as we know, peculiar or nearly peculiar to, and therefore to be used in the definition of, the genus *Pelobates*:—

*Skin without indurations. Vertebrae procœlous. Sacrum fused with coccyx; transverse process of sacrum formed from two vertebrae. Anterior processes of hyoid nearly meeting in middle line; anterior cornua of hyoid rudimentary and detached from the body of the hyoid. No gland on thighs. Toes webbed fully. Metatarsal tubercle a sharp-edged digging-organ. Larynx different in form from that of Oriental Pelobatidæ\*. Omosternum rudimentary, cartilaginous; xiphisternum ossified, ending in an expanded cartilaginous plate. Sternum short in proportion to body-length. Pectoralis posterior arising from whole of sternum. Submaxillaris fleshy throughout with only a fine tendinous raphe. Subhyoideus not very distinct from submaxillaris.*

The facts do not exist for a criticism of the numerous species that have been described and assigned to the genus *Leptobrachium*, and especially recently. It is clear, however, from these descriptions that external characters formerly regarded as distinctive of the genera *Megalophrys*, *Xenophrys*, and *Leptobrachium* respectively can no longer be allowed. For example, the species *Leptobrachium pelodytoides* † has an oval metatarsal tubercle presumably like that of *Megalophrys*, and therefore not like that of *Leptobrachium hasseltii*. *L. carinense* ‡ has horns on the eyelids as has *Megalophrys*, and the integument is hardened by stellate bony deposits. *L. fœæ* has the same characters, and, in addition, warts upon the body, the presence of which differentiated *L. monticola* which has them not, from *Megalophrys* which has them. The fact that these forms possess procœlous vertebrae does indeed

\* I reserve details for the present which I hope to furnish later.

† Boulenger, *Batrachia in 'Fauna of British India,' 1890, p. 510 &c.*

‡ Boulenger, *Ann. Mus. Genova*, xiii. 1893, p. 344.



differentiate them from *Megalophrys montana*, but not from *Megalophrys nasuta*. *Megalophrys longipes*\* has a V-shaped fold upon the nape which recalls that of *Xenophrys monticola*, and not that of *Megalophrys montana*.

A more satisfactory investigation of these various forms might perhaps break down the distinctions which I have endeavoured to set up between the four Oriental genera, and show that *Asterophrys* and *Batrachopsis* are to be placed with them. In the meantime, however, it is quite clear that the structure of the Pelobatidæ, as far as we know it at present, is quite in harmony with the geographical range of the different forms. There is no doubt that the four genera discussed here, which occur in the Oriental region, are much nearer together on the whole than any one of them is to *Pelobates*, which is Palearctic in range. It would appear also that the American *Scaphiopus* is quite as widely removed from either group, so far as we can judge from the osteological characters accumulated by Mr. Boulenger†. It is important to have been able to emphasise this relation between structure and geographical distribution.

#### (6) AFFINITIES OF THE PELOBATIDÆ.

A number of features, chiefly to be found in the hyoid and the fused sacral vertebræ, by reason of which the Pelobatidæ resemble the Aglossa, and especially *Pipa*, have been brought together by Dr. Ridewood‡. I am able in the present communication to add a few points of likeness between these two, at first thought, very dissimilar groups of Anura. It must be remembered, however, that the existing knowledge of the Anura is in so very rudimentary a condition that the following points of likeness between the Pelobatidæ and the Aglossa, though they are, as I hope, accurately stated, may not be confined to the Pelobatidæ; future dissection may show them to apply equally to other families or genera among the Phaneroglossa. In view of the fact that the Aglossa are an especially aquatic race, the members of which rarely leave the water, and are not capable of active progression upon the land, features of structural resemblance between them and the Pelobatidæ in the muscles of the leg are not without interest, for they can be hardly put down to a mere physiological cause. As far as I am aware, the Pelobatidæ are not as a family especially aquatic in their habits.

With regard to the hyoid, I can extend the facts dwelt upon by Dr. Ridewood as evidence of approximation in structure to the Aglossa; for in certain of the Asiatic Pelobatidæ there is the same tendency towards a union of the anterior processes of the body of the hyoid. As an absolutely new point of likeness between the Pelobatidæ and the Aglossa may be pointed out the condition of the most posteriorly lying Petrohyoideus muscle.

\* Boulenger, P. Z. S. 1885, p. 850.

† P. Z. S. 1899, p. 792.

‡ Journ. Linn. Soc. xxvi. 1897, p. 111 &c.



This muscle in the Pelobatidæ has retained its embryonic relations to the larynx, and has only in a very slight degree acquired the secondary relation to the thyrohyal. Precisely the same thing is figured by Ridewood for *Xenopus* and *Pipa*. The long extension backwards of the œsophageal muscle, universally characteristic of the Pelobatidæ (as far as our information goes), and its relation to the pelvis is possibly to be compared with the also very largely developed and apparently corresponding muscle in the Aglossa.

5. **Microlepidoptera of Tenerife.** By the Right Hon.  
LORD WALSLINGHAM, M.A., LL.D., F.R.S., F.Z.S.

[Received November 12, 1907.]

(Plates LI–LIII. and Text-figures 241–243.)

In the Annalen of the K.-k. Naturhistorische Hofmuseum (Vienna) Professor Dr. H. Rebel has published a series of very interesting and instructive papers on the Lepidopterous Fauna of the Canary Islands; I desire now to record the result of a short visit to Tenerife, during which I was able to devote a good deal of attention to the *Microlepidoptera* of the island: a large proportion of these having been bred, it is satisfactory to be able to add some information upon their food-plants and larval habits. In the last of the papers above referred to, published in Vienna in 1906, Prof. Rebel gives a revised systematic catalogue and enumerates 87 species of *Microlepidoptera* (10 of which are merely indicated without special names under the genera to which they belong), 4 out of the remaining 77 not being recorded from Tenerife; we have therefore a residue of 73 species, to which the additions following in this paper may now be made, raising the total to 173 species (of which 70 are here described) distributed among 84 genera (seven of which are new). It is proposed to add some critical notes upon Rebel's List, where these seem to be required through the acquisition of additional information: the species not met with are merely inserted to facilitate reference.

I desire to express my very grateful thanks to Dr. George Perez, and to Dr. O. Burchard, for the great assistance they gave me in naming many plants which I should otherwise have been at a loss to determine; as also to the Rev. A. E. Eaton for numerous additions to my cabinet included in this paper.

I had moreover the great advantage of being allowed to examine Mr. W. W. White's collection at Guimar, enabling me more fully to appreciate the value of Dr. Rebel's work; nor can I forget that that author had already most kindly dealt with some material originally submitted to him from my collection. Without the encouragement offered by the complete and systematic manner in





Beddard, Frank E. 1907. "Contributions to the Knowledge of the Anatomy of the Batrachian Family Pelobatid." *Proceedings of the Zoological Society of London* 1907, 871–911. <https://doi.org/10.1111/j.1469-7998.1907.tb06963.x>.

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