2. An unknown Lemur from the Lushai Hills, Assam.

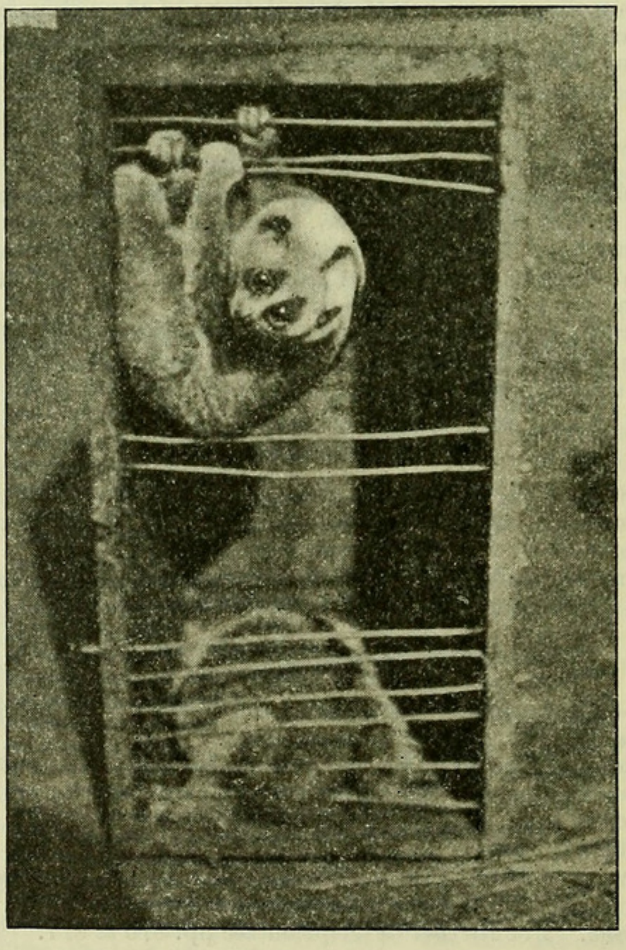
By N. ANNANDALE, D.Sc., C.M.Z.S., Superintendent, Indian Museum.

[Received November 3, 1908.]

(Text-figure 173.)

Mr. T. D. La Touche, of the Geological Survey of India, has recently shown me a remarkable photograph taken by himself during the Lushai Expedition of 1889–90. It represents two individuals of a small mammal evidently allied to the Slow Lemurs (*Nycticebus*), but differing from all known Asiatic species of the order in possessing a thick, bushy tail. The photograph is not clear as regards the tail, but Mr. La Touche assures me that it was present.

Text-fig. 173.



An unknown Lemur from Assam.

The new Lemur is white in colour, with a narrow black mid-dorsal stripe extending from the occiput to the base of the tail, a dark triangular patch round each eye, and the anterior surface of the ears dark. The tail is apparently very thick and cylindrical, shorter than the head and body, and without definite markings. The limbs are comparatively short and stout. The head is large and round, the face flat, the muzzle small, the ears short and rounded ; the eyes are perhaps a little smaller than those of *Nycticebus tardigradus*, but are separated by less than their own diameter. The fur is apparently close and woolly.

Hab. "Caught near Fort Lungleh, Dec. 1889" (*La Touche*). Evidently an inhabitant of dense jungle on the outer ranges of the Lushai Hills, Assam.

Mr. La Touche tells me that the individuals he photographed were caught in the jungle and escaped from captivity after a short confinement. They were habitually so slow in their movements that no precautions were taken to prevent their escape; but when once they had got out of their cage they vanished rapidly. They were fond of hanging upside down, as the upper animal of the photograph (text-fig. 173) is doing. It will be noticed that in this position the tail does not hang down but is supported against the side of the box. Possibly it is prehensile, but this is not clear. The lower animal in the photograph is evidently asleep. It sits with its head tucked in under its chest, much as *Nycticebus* does; the tail is also tucked in under the body.

Possibly on examination the skull of this interesting Lemur would show further differences from the known Indian genera, *Nycticebus* and *Loris*. *Nycticebus* and *Loris* have a rudimentary tail or no tail at all ; *Tarsius*, the only other Asiatic genus, which is the type of a separate family and only occurs in the Malay Archipelago, has a long, thin tail with a tuft at the end. The closest extra-Asiatic allies of *Nycticebus* and *Loris* are the Pottos (*Perodicticus*) from W. Africa, which have short or rudimentary tails. Even the type of coloration of La Touche's Lemur, however, so closely resembles that of the Indian forms that it is impossible that the new genus is widely separated from them. Among the Madagascar genera, moreover, *Indris*—like *Tarsius*, the type of a separate family—has a rudimentary tail; and even in the genus *Perodicticus*, as it is now defined, there is a considerable difference in the length of this organ in different species.

[Since the above was written I learn from Col. E. W. Loch that the tailed Lemur of the Lushai Hills is well known to him. I defer the publication of a technical description and the naming of the genus until it has been possible to examine specimens.—January 5, 1909.]

December 15, 1908.

Dr. HENRY WOODWARD, F.R.S., Vice-President, in the Chair.

The Secretary read the following report on the additions made to the Society's Menagerie during the month of November 1908 :—

The number of registered additions to the Society's Menagerie during the month of November was 91. Of these 50 were acquired by presentation, 18 by purchase, 12 were received on deposit, 10 by exchange, and one was born in the Gardens.

The number of departures during the same period, by death and removals, was 190.

Amongst the additions special attention may be directed to :—

Two Walruses (*Odobænus rosmarus*) from Franz Josef Land; purchased on Nov. 23rd.

One Sumatran Civet (*Viverra tangalunga*) from Sumatra; presented by A. R. Heath, Esq., on Nov. 24th.

Two Pardine Genets (*Genetta pardina*) from Warri, Southern Nigeria; presented by E. G. Stevens, Esq., on Dec. 13th.

Mr. Frederick Gillett, V.P.Z.S., gave an account of his recent Hunting Trip to the Thian Shan, illustrated by lantern-slides.

Mr. R. I. Pocock, F.L.S., F.Z.S., Superintendent of the Society's Gardens, exhibited photographs of a Sumatran Tiger, recently purchased by the Society, and made remarks upon this animal and upon the other Tigers at present living in the Gardens. He said:—"This Tiger, a male, was one of a litter obtained by Mr. Pinckney at Deli in Sumatra. Its ground-colour is noticeably darker and duller in hue than in the Indian and Siberian Tigers in the adjoining cages. The stripes are numerous, closely placed, and broad, nearly all of those on the sides of the body, behind the shoulders, and on the hind-quarters, being looped or reduplicated. The shoulder is scantily striped, and the outside of the fore leg nearly unstriped, except for one or two narrow stripes across the wrist and a few abbreviated stripes along the back of the leg below the elbow, which are continuous with those on the inner side of this limb. The inner sides of both fore and hind limbs are fully striped to the feet. The pale areas over the eyes, on the cheeks, chest, belly, and inside of the limbs are only dirty white and not sharply defined from the yellow-brown hue of the rest of the body. The yellow-brown hue of the muzzle extends over the whisker-area down to the black patch round the corner of the mouth and separates the white patch on the front of the upper lip from the white of the cheek.

Except for the multiplication and duplication of the stripes, this specimen seems to agree with other Sumatran Tigers that have been described. In his Monograph of the Felidæ, for example, Elliot remarks that Sumatran Tigers are smaller than Indian examples and do not exhibit any white about the face and throat, those parts being buff, while the general colour is dark red, but with the stripes distributed in the typical style.

Text-fig. 174.

Sumatran Tiger (from a specimen now living in the Society's Gardens).

Our Sumatran Tiger is also small. His age is uncertain, however, and he may be no more than about three years old. His weight is probably only about half that of our large Indian Tiger. He stands about 29 inches at the shoulders.

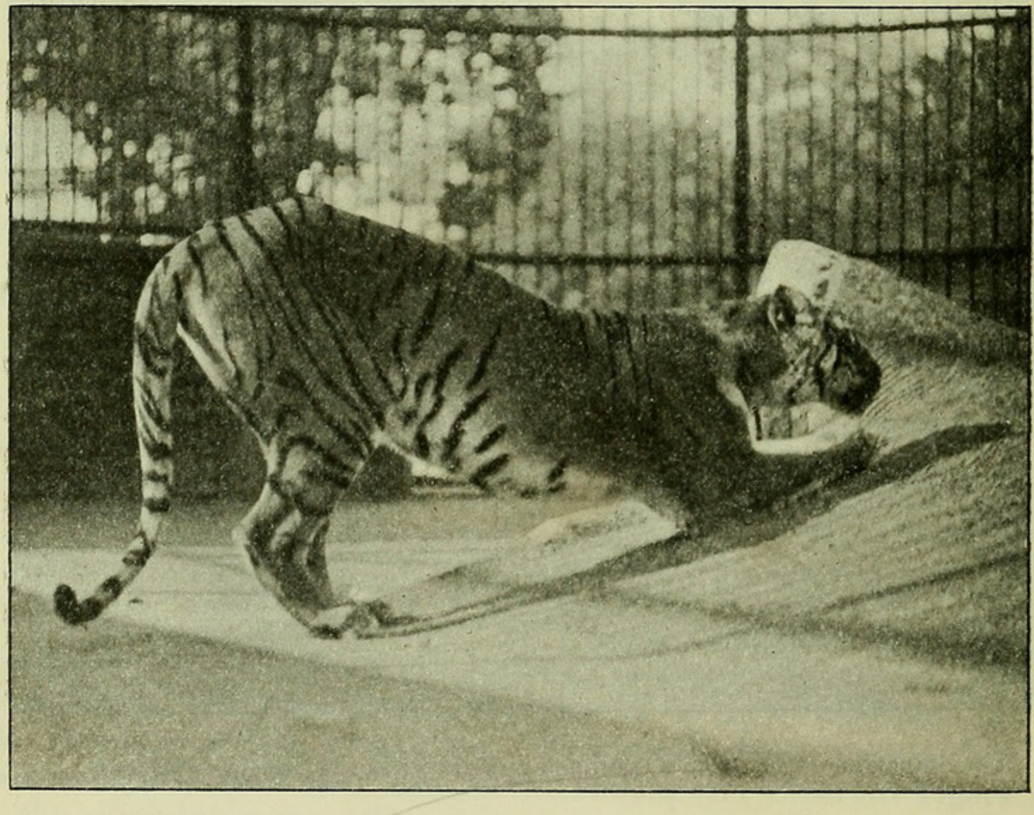
The Sumatran Tiger was originally named *Felis tigris nigra* by Lesson (Nouv. Tabl. R. Anim., Mamm. p. 50, 1842.) But since no description was subjoined, *nigra* must be regarded as a *nomen nudum*. Fitzinger subsequently described it as *Tigris sondaica* (SB. kais. Akad. Wien, lviii. pt. i. p. 454, 1868), and this name has been universally and correctly adopted.

Our Sumatran specimen resembles in the nature of its stripes the Persian Tiger described and figured by Dr. Heck (Lebende

Bilder etc. p. 157), but may be at once distinguished by the indistinctness and small extent of the white areas of the head and body, by the absence of the fringe of hair on the belly, and the shorter hair of the cheeks and throat. The Persian race has been named *F. tigris virgata* by Matschie, in allusion to the completeness of the pattern of stripes.

Of Indian Tigers the Society possesses at the present time three examples: one large male from Mysore, presented by A. Forbes, Esq., C.S.I., and two females from Nepal, presented by H.R.H. the Prince of Wales. The latter are remarkable for the reduction both in number and length of their stripes, of which scarcely any

Text-fig. 175.



Nepalese Tiger (from a specimen now living in the Society's Gardens).

show a sign of looping. The greater part of the shoulder, the outside of the fore leg, and a large portion of the costal area of the thorax are without stripes; while on the inner side of the fore leg the only stripe that persists is the brachial stripe, a constant feature in many species of *Felis*. On the hinder part of the body and on the hind-quarters the stripes show a strong tendency to abbreviation, in addition to being comparatively thin and widely separated. From their general appearance I am convinced that these two specimens came from the same litter, a conclusion which lessens the systematic value one might be inclined to attach to the features they have in common. Be it noted, moreover, that another Tigress which came at the same time from the same country was as fully striped as our other Indian Tiger, though much less so than the individual from Sumatra; and that a thick-coated Siberian specimen in the British Museum is as poorly striped as the two Nepal specimens here described. These Nepal Tigers do not develop a thick winter coat, although they are kept in the open all through the cold weather. Indian Tigers are regarded systematically as typical representatives of *Felis tigris*.

Of Mantchurian Tigers the Society has a fine pair presented by the Duke of Bedford. From their facial similarity I should say that they undoubtedly came from the same litter. Beyond the fact that they were shipped from Vladivostock, their exact locality is unknown. They seem to be typical members of the Mantchurian race, and differ from our Indian Tigers in having a considerably greater extent of white and a correspondingly lesser extent of yellow on the body, head, and limbs. They also develop a thick coat in the winter. The male stands about 38 inches at the shoulder.

The race to which these Tigers belong was named *F. tigris mongolica* by Lesson (Nouv. Tabl. R. Anim., Mamm. p. 50, 1842); but since the name was unaccompanied by a diagnosis, it cannot stand, although it has been adopted by Matschie, Trouessart, and Lydekker, who at the same time reject the name *nigra* given by Lesson to the Sumatran race. I adopt, therefore, the name *longipilis* proposed by Fitzinger (SB. kais. Akad. Wien, lviii. pt. i. p. 455, 1868).

The four described races of Tigers may be briefly characterized and contrasted as follows:—

a. Pale areas of the head, body, and limbs dirty to buff white and small in extent; size small or medium .... *sondaica*.

a'. Pale areas of the head, body, and limbs clean white, sharply defined and greater in extent.

- *b*. A copious mane on the cheeks and throat and along the belly; size medium .... *virgata*.
- *b'*. Mane on cheeks shorter; practically none on throat and belly.
  - *c*. White on belly, face, and inside of legs considerably more extensive; winter coat thick and woolly ... *longipilis*.
  - *c'*. White on belly, face, and inside of legs much less extensive; winter coat short and not markedly longer and thicker than that of the summer .... *tigris*.

The following papers were read :—

1. Some Notes on the Muscular and Visceral Anatomy of the Batrachian Genus *Hemisus*, with Notes on the Lymph-Hearts of this and other Genera. By FRANK E. BEDDARD, M.A., F.R.S., F.Z.S.

[Received October 23, 1908.]

(Text-figures 176–190.)

The existing knowledge of this genus of Frogs is limited, so far as I am aware, to the external characters *, the osteology, and certain points in the anatomy of the tadpole †. I therefore take the opportunity afforded by the death of the only example of a species of *Hemisus* (*H. guttatum*) ever possessed by the Society to lay before the Meeting a few notes upon the structure of the "soft parts" of the adult, as a further ‡ contribution to the anatomy of the Engystomatidæ.

As I have had only one individual for examination, my account of the anatomy of *Hemisus* cannot aim at being comprehensive. I have, however, been able to get together a considerable number of facts upon the anatomy of many organs and systems of organs in this Frog, which I treat of in the following order :—

Dorsal Musculature, p. 894.
Ventral Musculature, p. 898.
Hyoid and its Musculature, p. 907.
Musculature of the Thigh, p. 912.
Abdominal Viscera, p. 913.
Thymus Gland, p. 915.
Posterior Lymph-Hearts and Sacs, p. 916.
Posterior Lymph-Hearts of *Xenopus*, p. 924.
Lymph-Hearts of *Rana guppyi*, p. 930.
Résumé of Characters of *Hemisus*, p. 932.
Résumé of principal new Facts, p. 933.

§ *Muscles of the Dorsal Surface.*

Contrary to what is found in *Breviceps* and *Rhinoderma*, the *depressor mandibulæ* of *Hemisus* is quite large and well developed. It arises in the ordinary way from the fascia dorsalis overlying the latissimus dorsi and crosses the scapula on its way to its insertion on to the lower jaw. Of this muscle the outer margin is thicker than the rest, though there is no abrupt break dividing the muscle into two sections.

* Boulenger's Cat. Batr. Sal. B. M. 1882, and literature therein cited ; Gadow, in Cambridge Natural History. vol. viii. 1901, relating to Reptiles and Amphibians.

† Bles, "Notes on Anuran Development, &c.," Budgett Mem. Vol., Cambridge.

‡ "On the Anatomy of *Breviceps*," P. Z. S. 1908, p. 11. "On the Anatomy of *Rhinoderma*," P. Z. S. 1908, p. 678.

The *latissimus dorsi* is a large muscle, the origin of which commences some way behind the scapula and extends forward to a point about on a level with its posterior border. It arises from the middle line of the back and underlies the fascia dorsalis which is closely adherent to it. It should be mentioned in considering this muscle that the humerus is not free from the body. It is closely connected with the fascia covering the body and a strongish band connects the fascia dorsalis with the very elbow. This state of affairs must necessarily, one would suppose, have influenced the adjacent musculature. In any case, the latissimus dorsi blends early with the infraspinatus, and indeed it is difficult to distinguish between the two muscles anywhere. The conjoined muscles narrow rapidly to form a thick muscle a little way from the insertion on to the humerus.

The *cucullaris* is a very massive muscle and is attached up to the very tip of the suprascapula, along its anterior border.

When the latissimus dorsi is cut and reflected I can find no muscle comparable exactly to the transversely running rhomboideus (or retrahens scapulæ) of *Rhinoderma*. The position of that muscle is occupied by fascia binding the suprascapula to the middle line of the back, in which no muscular fibres can be detected on dissection. The cutting and reflection of the latissimus dorsi, and the fact that the suprascapula thus exposed is a narrow plate of cartilage with a concave posterior boundary-line, brings into view certain muscles connecting the transverse processes of the third and fourth vertebræ with the scapula and suprascapula, which have received various names in *Rana*.

Inasmuch as these muscles have not been described in the large female *Rana guppyi*, where they are naturally peculiarly clear, and in which Frog they appear to differ slightly from the corresponding set of muscles in *Rana esculenta*, it will not be useless to describe these muscles before proceeding to deal with those of *Hemisus*.

In *Rana guppyi* the muscles in question, which obviously resemble, as has been pointed out, the serratus group of muscles of higher animals, can be divided into two groups :—those which are inserted on to the under surface of the suprascapula and those which are inserted on to the under surface of the scapula. The direction of the two sets of muscles is totally different, and their course indeed lies nearly at right angles. The broad cartilaginous edges of the suprascapula nearly completely cover this system of muscles. The group which are inserted on to the suprascapula consist of four muscles, of which one, the *rhomboideus*, has been already described by myself in this species *.

The second is a large flat muscle arising from the free end of the transverse process of the fourth vertebra, which I take to be the *retrahens scapulæ* of Ecker (with which therefore I was wrong in identifying the rhomboideus in my description of *Pipa* quoted

* *Cf.* memoir on *Pipa*, P. Z. S. 1895, p. 835.

below) and which is perfectly distinct from the rhomboideus of *Rana guppyi* to which I have just referred. The muscle is inserted on to a considerable area of the suprascapula and is in contact in front with the insertion of the rhomboideus, which is in its turn in contact with the insertion of the cucullaris. At its origin the muscle is connected with the tendinous intersection of the longissimus dorsi as well as with the transverse process of the fourth vertebra. Between this muscle and the next to be mentioned lies the anterior lymph heart which is described on another page *. This next muscle arises from the end of the transverse process of the third vertebra and is distinctly composed of two parts. Each of these is a flat sheet of muscular fibres.

The two sheets are perfectly distinct at their origin. For the outer of the two does not extend so far along the surface of the cartilage posteriorly as does the inner muscle. At their insertion, however, close to that of the retrahens scapulæ, there is no distinction between the several layers of this muscle, which must therefore be regarded as simply double-headed. It differs therefore from the *transverso-scapularis tertius* or *serratus* (Ecker) of *Rana esculenta*, with which I believe it to be homologous. The insertion of this muscle is in contact with that of the retrahens scapulæ. The fourth muscle is not a flat muscle like the last two, but is narrow and more or less oval in transverse section. It arises independently of the last muscle from the anterior edge of the free end of the transverse process of the third vertebra, and is inserted quite away from the serratus near the anterior border of the suprascapula outside of the insertion of the levator anguli scapulæ. This muscle is not mentioned by Ecker, unless, indeed, it is this which is the transverso-scapularis tertius.

The remaining muscle of the "serratus" series is obviously the homologue of the *transverso-scapularis major* (Ecker) of *Rana esculenta*, and is the only muscle of the series which is inserted upon the scapula. As in *R. esculenta*, it arises by two heads, one from each transverse process of vert. 3 & 4. That arising from the transverse process of the fourth vertebra is very much the larger and both heads are entirely fleshy. The insertion of this muscle on to the scapula lies between the insertions of the sterno-cleidomastoid and the protrahens scapulæ, which are the two head muscles of the scapula corresponding to the single head muscle of the suprascapula referred to above †.

When in *Hemisus* the latissimus dorsi has been cut through and reflected, two muscles belonging to the serratus series are exposed throughout their entire length and a third very nearly so. The two which are fully exposed belong to the suprascapula, and the third is very obviously the equivalent of the transverso-scapularis major which is inserted on to the scapula.

* *Vide* p. 930.

† The sternocleidomastoideus of *R. guppyi* really consists of two parts, a much larger part and a smaller which is inserted separately by a longish tendon.

The two muscles belonging to the suprascapular series of the serratus group arise respectively from the transverse processes of the third and fourth vertebræ. That arising from the fourth vertebra, and which therefore represents the *retrahens scapulæ* of *Rana*, is much the more slender of the two. It is a flat strap-shaped muscle of much the same diameter throughout. It is inserted on to the end of the suprascapula by a flat tendon. The shorter and wider muscle arises from the transverse process of the third vertebra and is inserted on to the suprascapula along a wider line of insertion than that of the last-described muscle, but in contact with it at its extremity. It corresponds, as I imagine, to that double-layered muscle in *Rana guppyi* which I have identified provisionally with the *transverso-scapularis tertius* of *Rana esculenta*. The chief reason which leads me to this inference is that the anterior lymph-heart lies between it and the retrahens scapulæ just described. Moreover, the muscle is distinctly composed of two layers, or rather it may be better to speak of the lower layer as a distinct muscle, since it is more oval in section than the superjacent layer. In this case the deeper layer may be really the equivalent of the third "serratus" muscle described above in *Rana guppyi*. The two muscles (or three) which have been just described run in a direction which is not far from parallel to the longitudinal axis of the body, being directed obliquely inwards from behind forwards to that axis, and they constitute those muscles belonging to the serratus system which are inserted upon the suprascapula. There is also besides the cucullaris, which has been already referred to, another head muscle, the *levator anguli scapulæ*, which is also attached to and beneath the suprascapula.

There now remain certain muscles of the serratus complex which are inserted upon the scapula. Of these there is first of all the obvious homologue of the *transverso-scapularis major* of *Rana*. This consists, as in *Rana*, of two heads arising respectively from the transverse processes of the third and fourth vertebræ. The two heads are entirely fleshy and more equal in size than in *Rana*; they combine to form a single muscle which is inserted low down on the scapula. The direction of this muscle is quite at right angles to that of the suprascapular series of the serratus complex. A second large muscle lies in front of that which has just been described, and its fibres run about parallel with those of the transverso-scapularis major, and are inserted on to the junction of the scapula and the suprascapula if the junction is fixed by the change of direction of the bony scapula from the chiefly osseous, partly cartilaginous supra-scapula; indeed, perhaps the bulk of the fibres are really attached to the suprascapula. This muscle arises well in front of the third vertebra, but its origin is not covered by the suprascapula. I suppose that it may be compared with the transverso-scapularis minor (Ecker) of *Rana esculenta*; but the origin is different and the muscle actually and relatively much larger.

When the abdominal viscera are removed or pushed aside, the internal surface of the ilia and their muscles are exposed, as I have recently figured * in the genera *Megalophrys*, *Rana*, *Pelobates*, and *Ceratophrys*. The conditions observable in *Hemisus* when a dissection of this kind is made are more like those of *Ceratophrys* than those of any of the other genera to which I have just referred. The ilium is exposed for the greater part of its length and devoid of muscular covering, for the *ilio-coccygeal* origin does not extend at all over the ventral surface of the bone.

The *ilio-lumbaris* arises towards the anterior end of the ilium, exactly in the way in which I have figured it in *Ceratophrys*. It is, however, a rather more solid muscle and passes up to the origin of the œsophageal muscle † without a break except for tendinous intersections which correspond to the transverse processes of the successive vertebræ. Moreover, it abuts closely upon the centra of the vertebræ, at any rate anteriorly. There is no long lateral slip of this muscle as in the Pelobatidæ ‡.

§ *Ventral Musculature.*

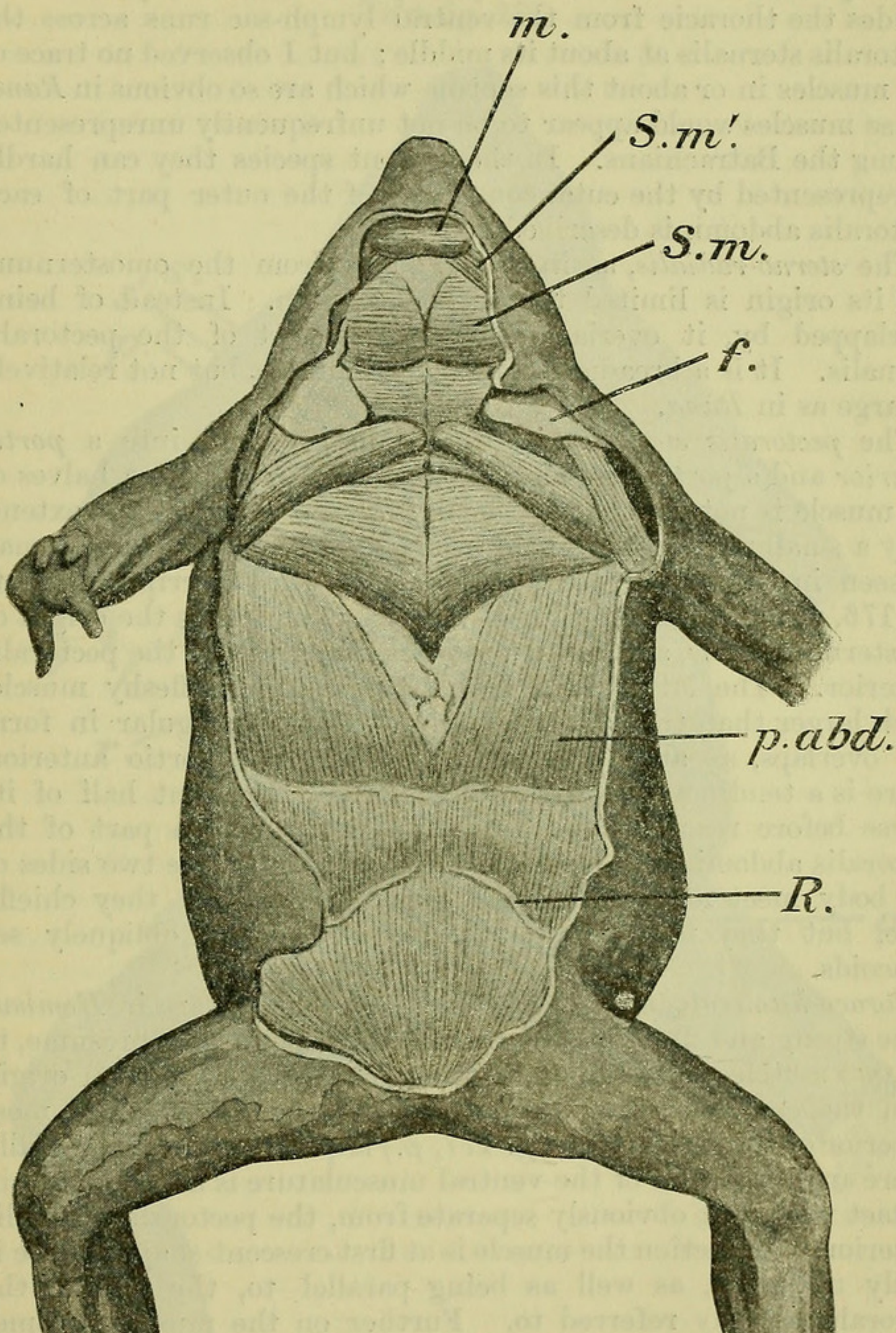
The two *pectorales abdominis* differ from those of many Frogs in that they meet in the middle line ventrally. The rectus abdominis absolutely ceases to be visible with their origin, and is, in fact, anteriorly to this line covered by them, a peculiarly strong inscriptio tendinea forming the boundary line between the two muscles. Another peculiarity of this inscriptio tendinea besides its strength and toughness, which is doubtless in relation to the importance of the pectoralis attached to it, is the fact that this tendinous seam is firmly attached to the skin. So firm and so direct (*i. e.* not through a special septum such as those which divide the other subcutaneous lymph-spaces) is this connection that some fibres of the muscles concerned have the appearance of arising from the skin. The two pectorales abdominis are not only continuous at their origin from this tendinous seam and septum, their fibres are nearly in contact for some little space in front of this; for there is a prolongation forwards of the seam at right angles to the rest, from which the innermost fibres of each pectoralis abdominis arise. This is not, however, continued far towards the sternal region. A triangular or, indeed, almost V-shaped space is left between these two pectorales abdominis and the pars sternalis anteriorly, as is shown in the figure (text-fig. 176), which is uncovered by any muscular layer and where the posterior region of the pectoralis sternalis is exposed.

In the middle ventral line of the body the septum between the pectoralis abdominis and the rectus abdominis is pretty well at right angles to the longitudinal axis of the body. Laterally the line of origin of the pectoralis curves more and more anteriorly, so that at the sides of the body the origin of the

* P. Z. S. 1907, p. 332, text-fig. 93, p. 333, text-fig. 94, &c.
† For which see p. 915.
‡ P. Z. S. 1907, p. 905.

pectoralis abdominis is not far from the armpit. Furthermore, in this region the fibres of the muscle very distinctly arise from

Text-fig. 176.



Ventral musculature of *Hemisus guttatum*; the skin has been largely removed, but no muscles have been cut and reflected.

f. "Thymus gland." *m.* Submentalis muscle. *R.* Rectus abdominis muscle; the letter points to the first inscriptio tendinea. *p.abd.* Pectoralis abdominis *S.m.* & *S.m.'* Two portions of submaxillaris muscle.

the skin itself and entirely from the skin, not merely by a few fibres here and there as may be the case towards the middle line of the body.

The *pectoralis cutaneus* is completely absent. The septum which divides the thoracic from the ventral lymph-sac runs across the pectoralis sternalis at about its middle; but I observed no trace of the muscles in or about this septum which are so obvious in *Rana*. These muscles would appear to be not unfrequently unrepresented among the Batrachians. In the present species they can hardly be represented by the cutaneous fibres of the outer part of each pectoralis abdominis described above.

The *sterno-radialis*, as in *Rana*, arises from the omosternum, and its origin is limited to the omosternum. Instead of being overlapped by, it overlaps the anterior part of the pectoralis sternalis. It is a broadish strap-shaped muscle, but not relatively so large as in *Rana*.

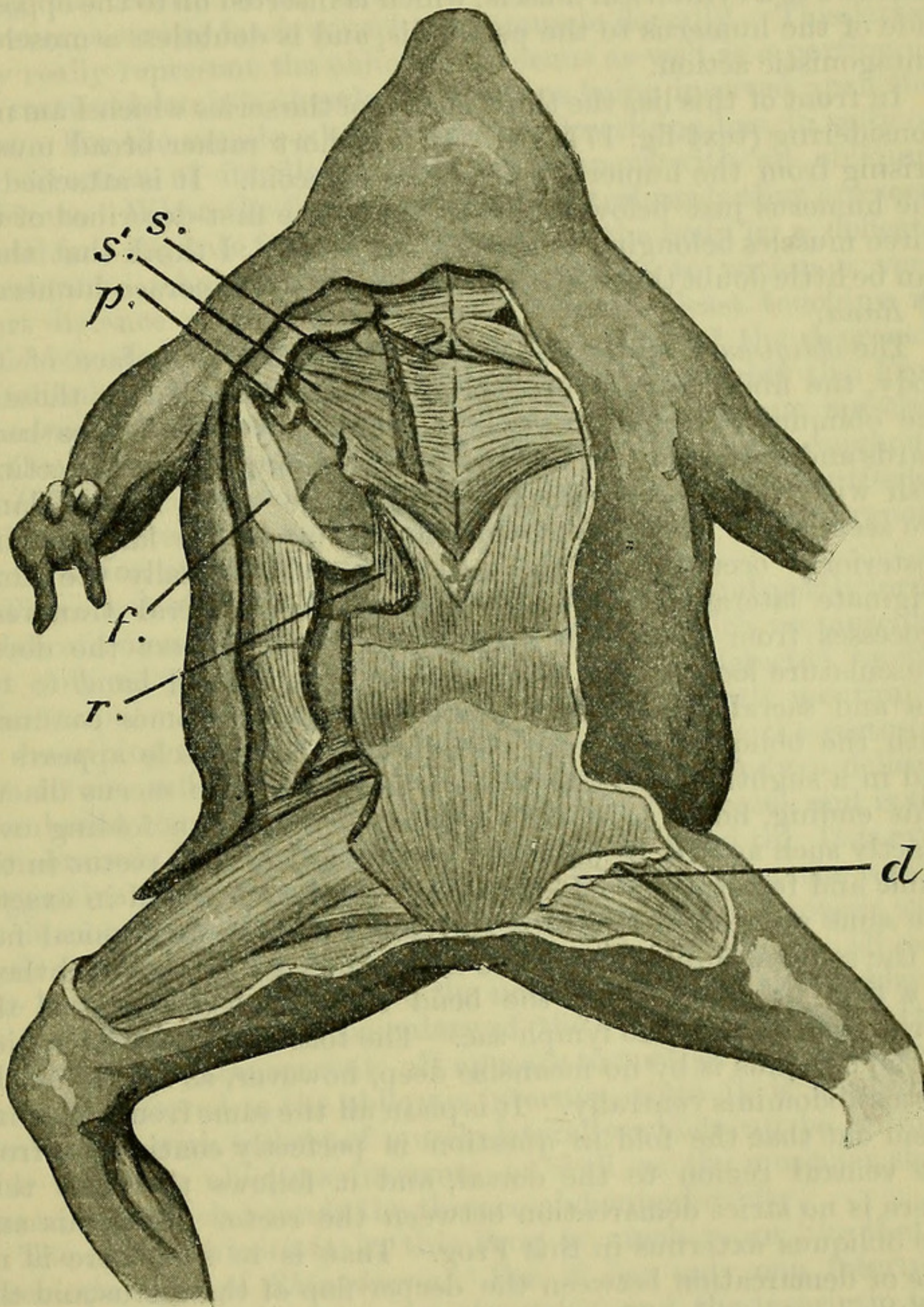
The *pectoralis sternalis* is divided, as in *Rana*, into a *portio anterior* and a *portio posterior*. The first of these two halves of the muscle is not visible superficially for the whole of its extent. Only a small part appears before any dissection is made, as may be seen in the text-figure accompanying this description (text-fig. 176, p. 899). The origin of most of it underlies the origin of the sterno-radialis, and some underlies the origin of the pectoralis posterior. The latter is a very large and deep fleshy muscle, much larger than the portio anterior. It is triangular in form and overlaps, as already stated, a part of the portio anterior. There is a tendinous seam running along it for about half of its course before reaching the humerus, on to which a part of the pectoralis abdominis is inserted. The muscles of the two sides of the body meet at a tendinous seam from which they chiefly arise, but they take origin also from the very obliquely set coracoids.

Coraco-humeralis and *pectoralis minor*.—There are in *Hemisus* three strong and fleshy muscles which correspond, as I presume, to the two muscles thus named in *Rana* (*R. guppyi* *) to their origin from the coracoid; they lie one behind the other. The most posterior of the series (text-fig. 177, *p.*) is quite visible superficially before any dissection of the ventral musculature is made. It is in contact with, but obviously separate from, the pectoralis sternalis posterior. In section the muscle is at first crescent-shaped, since it partly underlies, as well as being parallel to, the part of the pectoralis already referred to. Further on the muscle becomes flatter, and is inserted upon the humerus by a flat strap-shaped short tendon immediately ventral of the insertion of the pectoralis abdominis. It may be that this muscle is really referable to the pectoralis sternalis rather than to the coraco-humeralis; but in any case it is perfectly distinct from the pectoralis from origin to insertion.

* See Beddard, "Anatomy of *Pipa*," P. Z. S. 1895, p. 837.

Immediately underlying the last-described muscle (when the animal is viewed in the ordinary position of dissection) is a much broader muscle which I take to represent that muscle which I

Text-fig. 177.



Ventral musculature of *Hemisus guttatum*, with the skin removed and some of the superficial muscles cut and partly removed.

f. Fat-mass, lying within a lymph-sac covered by pectoralis abdominis and floored by a delicate layer of muscle (*r*) partly belonging to the rectus abdominis and partly to the obliquus internus. *d*. Fibrous wall of femoral lymph-sac cut irregularly near to its origin from the reflected border of the rectus abdominis. *p*. Muscle (cut across) which is perhaps part of the coraco-humeralis. *s*. Coraco-humeralis. *s'*. Pectoralis minor.

have just referred to in *Rana guppyi* and *Pipa* * as the *pectoralis minor*. It arises (text-fig. 177, *s.'*, p. 901) from the more internal part of the coracoid not only below the pectoralis sternalis, but from the opposite (*i. e.* the dorsal) side of the coracoid bone. It arises by several partly separate strands, is fan-shaped, and rapidly narrows to a cylindrical muscle, which is inserted on to the opposite side of the humerus to the pectoralis, and is doubtless a muscle of antagonistic action.

In front of this lies the third muscle of the series which I am now considering (text-fig. 177, *s.*). It is a short rather broad muscle arising from the humeral half of the coracoid. It is attached to the humerus just below the insertion of the first-described of the three muscles belonging to the present series. I think that there can be little doubt that it really corresponds to the coraco-humeralis of *Rana*.

The *obliquus* is quite extensive on the dorsal surface of the body, the fibres having precisely the same direction as those of the obliquus externus in *Rana*, *i. e.* obliquely from before backwards and outwards. When the animal is pinned in a dissecting-dish with the ventral side downwards, the whole of the flanks are seen to be occupied by this muscle up to the large vacuity posteriorly occupied by the saccus iliacus. Dorsally the fibres originate laterally of the ilia and expanded sacral transverse processes from the tough aponeurosis which covers the dorsal musculature loosely, and is attached by a downward band to the ilia and sacral transverse processes before it becomes confluent with the obliquus externus. Posteriorly the muscle appears to end in a slightly thickened concave margin at the saccus iliacus. This ending, however, is only apparent; there is a folding over exactly such as will be described in the case of the rectus in the pubic and femoral region, but less in extent, and caused in exactly the same way, or, at any rate, correlated with an anatomical fact of the same nature. For in the muscle now being described there is a firm insertion along the bend of the muscle-layer of the dorsal wall of the iliac lymph-sac. The fold in this dorsal region of the obliquus is by no means so deep, however, as is that of the rectus abdominis ventrally. It is plain all the same from following them out that the fold in question is perfectly continuous from the ventral region to the dorsal, and it follows therefore that there is no strict demarcation between the rectus abdominis and the obliquus externus in this Frog. That is to say, there is no line of demarcation between the deeper flap of the rectus and the obliquus externus. The superficial flap of the rectus, as already said, ends upon the skin. The two parts of the muscle are thus nearly at right angles here, and the posterior sheet runs almost dorso-ventrally, forming the anterior boundary of the iliac lymph-sac and exposed by cutting open one of the septa

* A redissection of the muscles in question in *Rana guppyi* shows the presence of the "*pectoralis minor*" in that Frog, as I have asserted.

of the lymph-sac. When the dorsal part of the muscle now under description is cut through by an incision running parallel with the long axis of the body, it can be plainly seen to be a single though fairly thick layer of muscle. There is no layer underneath it. There is, in fact, in this region, that is along the entire back, but one obliquus muscle. There is, however, a strong fascia covering the muscle dorsally. This latter may really represent the obliquus externus as well as a portion of the rectus abdominis already described as being inserted upon the skin. For the muscle which I am now describing has, in spite of the direction of its fibres, more in common with an obliquus internus. When the fibres are traced ventralwards they are seen to end in a digitate fashion on the sides of the body in a delicate membrane. Anteriorly the muscle extends to within a very short distance of the scapula, but not in the least touching it. It is bounded, in fact, anteriorly by the origin of the depressor mandibulæ. It is interesting to notice how thoroughly this Frog *Hemisus* differs from its ally *Breviceps* in the oblique muscles. In the latter they are both well developed and fleshy throughout. In *Hemisus* the muscles are largely defective as muscular tissue; and on the ventral side there is only the delicate membranous continuation of the obliquus.

This sheet of the body-wall is partly muscular and partly forms a delicate membrane of connective tissue, in which no muscular but only wavy connective-tissue fibres can be detected by the microscope. As to the latter tract, I shall presently mention it in describing the rectus abdominis muscle. When the rectus is cut across, reflected in the middle region of the body, a delicate membrane comes into view which underlies the rectus and is the membranous part of the obliquus internus referred to. It is even suggestive of an omentum, such is its freedom from the rectus. It is not, however, attached to the viscera which it covers, save here and there by an emergent blood-vessel. It extends all over the body-cavity right back to the neighbourhood of the bladder—in fact, to the posterior boundary of the abdominal cavity. It is quite thin and transparent. It appears to me that this membrane must be referred to the obliquus internus, since it is absolutely continuous with a sheet of muscle laterally which can be nothing else than the obliquus internus, as well as the muscular sheet anteriorly which bounds the thoraco-abdominal cavity.

The *rectus abdominis* in this Frog is much more like that of *Breviceps* than of *Rhinoderma*. For it has only one inscriptio tendinea between its origin at the pubes and the inscriptio tendinea to which the pectoralis abdominalis is attached. The fibres too are arranged in a fan-shaped way like those of *Breviceps*, and do not run only in an anterior direction parallel with the long axis of the body as in *Rhinoderma* and many Frogs. In the middle line of the body the fibres run postero-anteriorly; laterally they are quite oblique in direction. Furthermore, it will be noticed from the drawings (text-figs. 176 & 177, pp. 899, 901) that, as in *Breviceps* *, the boundary-line between the thigh ventrally and the trunk ventrally is entirely occupied by these muscles, a separate obliquus externus not being visible on this view of the animal. Whereas in *Rana*, when the skin is reflected from the abdomen and thigh, the obliquus externus as well as the rectus are seen to form the boundary-line between limb and trunk. There is another important difference which this muscle shows and in which it resembles *Breviceps*. The rectus abdominis overlaps a considerable portion of the thigh, to the extent indeed of 6 mm. or so. Under the free edge of the muscle laterally a seeker can be pushed. There is, however, a plain distinction laterally between the rectus abdominis and the obliquus muscle (for the moment I leave it undecided whether it is to be regarded as externus or internus), which is not merely the lateral and dorsal extension of the rectus. It will be noticed that the one inscriptio tendinea (see text-fig. 177) which exists behind the origin of the pectoralis abdominis, and along the course therefore of the rectus abdominis, does not reach the edge of the muscle which overlaps the thigh musculature and towards which it tends. In this region then it is impossible to discriminate between rectus and obliquus, on the assumption, that is, that we have here reached the border-line of the two. I am disposed, however, to think that this lateral extension of the rectus is wholly rectus; for a careful dissection shows that it ends by being inserted upon the skin and its fibres are not continuous with those of what is obviously the obliquus muscle described above as originating from the dorsal aponeurosis.

When the pectoralis abdominis is cut through and reflected the anterior portion of the rectus abdominis is brought into view. This lies at a much lower plane than the posterior region of the muscle. For there is a deep cavity between it and the covering pectoralis abdominis. This cavity is not merely a lymph-space. It contains an elongated body which I describe later in connection with the thymus †. This cavity then is floored (examined in the ordinary position of these muscles when dissected from the ventral surface) by a delicate layer of muscles (text-fig. 177, *r.*) which is by far thinner than the rectus abdominis of which it is the forward continuation from the anterior inscriptio tendinea. The muscular fibres, however, do not extend over the whole of the cavity thus exposed. Towards the middle line the muscular fibres form an area which is not only thicker in its muscular tissue than more laterally, but definitely arises from the inscriptio tendinea. Laterally there is no such origin from the inscriptio tendinea where the rectus abdominis and the pectoralis abdominis meet, and this sheet has been described as a part of the obliquus internus.

The lateral portion of the *rectus abdominis*, under which, when it covers the thigh, a probe can be passed, as already mentioned, demands a more detailed consideration. It is to be noted, in the

* P. Z. S. 1908, p. 16, text-fig. 3.

† See p. 915.

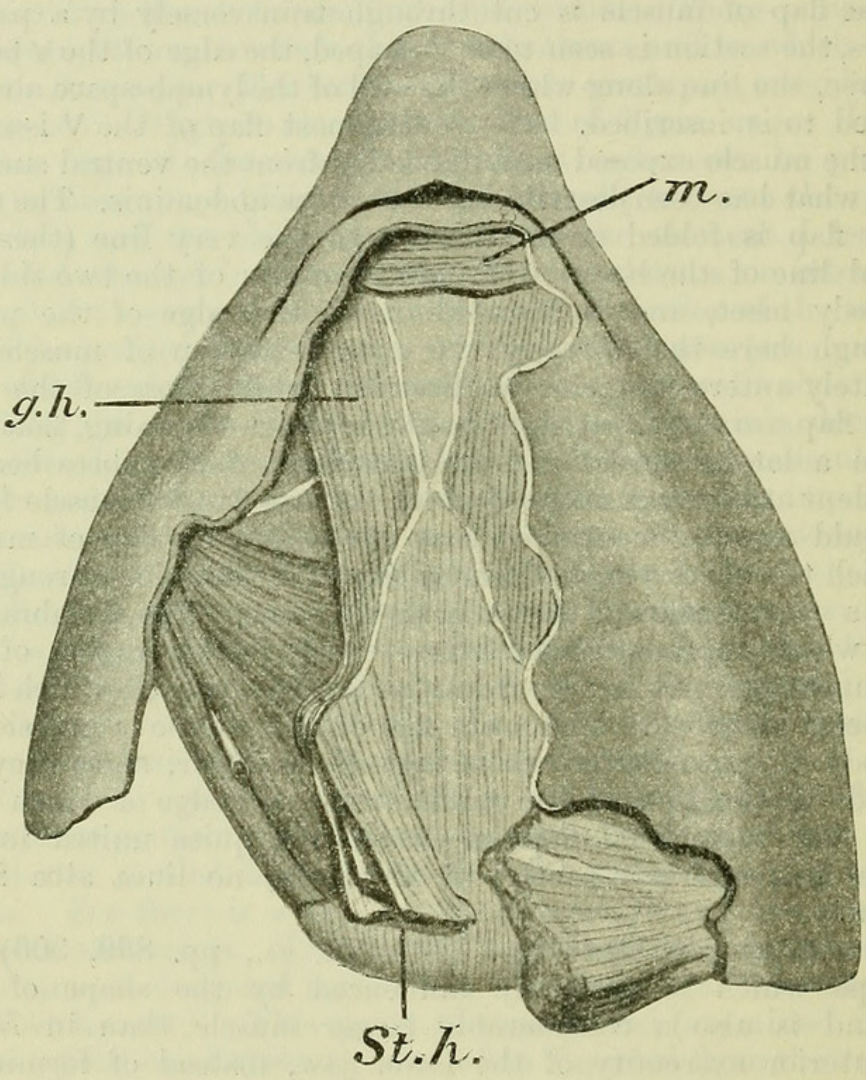
first place, that there is here not simply the matter of a muscle extending loosely over the proximal region of the thigh during its relaxed condition. The edge of the rectus which lies upon the thigh is bound down to the skin of the leg by a septum of connective tissue (text-fig. 177, *d.*) which forms the wall of a lymph-sac belonging to the system of femoral lymph-sacs. When this septum and the flap of muscle is cut through transversely by a pair of scissors, the section is seen to be V-shaped, the edge of the V being, of course, the line along which the wall of the lymph-space already referred to is inscribed. The ventralmost flap of the V is naturally the muscle exposed on a dissection from the ventral surface, and is what has been described as the rectus abdominis. The more dorsal flap is folded under this up to the very line (the mid-ventral line of the body) where the muscles of the two sides of the body meet, and is inserted on to the edge of the pubis. Although here the fibres of the superficial flap of muscle are accurately antero-posterior in direction, while those of the subjacent flap are exactly at right angles to them—running, that is to say, in a lateral direction—the directions of the fibres become coincident at the apex of the V which the two flaps of muscle form. It should now be mentioned that the deep-lying flap of muscle of which the fibres are consistently lateral in direction throughout is not a continuation of the obliquus internus. The membranous sheet which represents the latter muscle in this region of the body underlies and is free from the layers of muscle which have just been described. The lower flap of the muscle of one side of the body is quite distinct from that of the other, since they are divided by the line of the pubis from each edge of which they arise. The superficial flaps are, however, quite united in the middle line, and posteriorly, at any rate, no linea alba is to be seen.

The *submentalis* (text-figs. 176, 178, *m.*, pp. 899, 906) has a shape which is evidently influenced by the shape of the jaw and is also a considerably larger muscle than in *Rana*. The anterior extremity of the lower jaw, instead of forming a uniform curve as in *Rana*, has a perfectly straight or square region anteriorly, which is shown in the accompanying text-figure (text-fig. 178). The breadth of the jaw here is fully 5 mm., and the length of the submentalis is therefore only a little less and it has not in so marked a degree as in other Frogs a lenticular shape. It has the form of a cylinder tapering to both extremities. Its fibres can be seen to run straight across from one side of the jaw to the other in the middle region of the muscle. At both ends they curve upwards and are inserted into the angle of each mandibular ramus where the straight anterior portion of each, which is at right angles to the longitudinal axis of the body, passes into the side of each ramus. I have described in *Rhinoderma darwini* * a pair of triangular muscles lying behind the submentalis which I compared to the *genioglossus*. It might perhaps—though at

* P. Z. S. 1908, p. 686, text-fig. 146 *a*.

present any suggestion as to the homology of the muscles lacks a firm base upon comparative anatomy—be more reasonable to regard the muscles in question as a part of the submentalis. In any case, I do not find the least trace of this muscle in *Hemisus*.

Text-fig. 178.



Ventral musculature of neck-region in *Hemisus guttatum*.

m. Submentalis muscle. *g.h.* Geniohyoid; the white lines dividing the two lateral parts of the muscles from the median practically unpaired portion represent the hypoglossal nerve. *St.h.* Sternohyoid muscles; the three separate muscles are shown. To the left of these are seen the petrohyoidei.

Submaxillaris.—Although *Hemisus* differs from *Rhinoderma* in the matter just referred to, the two agree in the specialization of the submaxillaris proper (not including the subhyoideus, which was formerly regarded as being a part of this muscle) into two regions. The conditions observable in *Hemisus* are shown in the figure referred to above (text-fig. 176, p. 899). The main mass of the muscle, which is all that exists in *Rana* and many other Batrachians, is indistinguishable posteriorly from the subhyoideus. Each muscle is divided from its fellow in the middle line of the throat by a considerable tendinous interval anteriorly. This non-muscular interval diminishes in breadth posteriorly until it practically disappears in the region of the subhyoideus. In addition to this the *submaxillaris* consists of an anterior layer of fibres on each side which are comparable to an almost similarly placed layer of fibres in *Rhinoderma*. A thin layer of fibres runs on each side from the fascia covering the submentalis to the ramus of the jaw in an oblique direction, and overlies almost at right angles the section of the submaxillaris which is contiguous. This is clearly shown in text-figure 176, *s.m.'*, and needs no more elaborate description.

The *subhyoideus* is of about the same proportions as in *Rana*, and passes behind the ramus of the lower jaw on its way to the cornua of the hyoid. That it is attached to the cornua of the hyoid and not to the wall of the skull is quite apparent. An examination of text-figure 176 would seem to show an additional muscle belonging to the series which form the floor of the mouth, and arising on either side from the anterior extremity of the sternum. I am unable, however, to give any further details about this muscle than are displayed in that figure. It may of course be merely an anterior slip of the pectoral series (including the sterno-radialis).

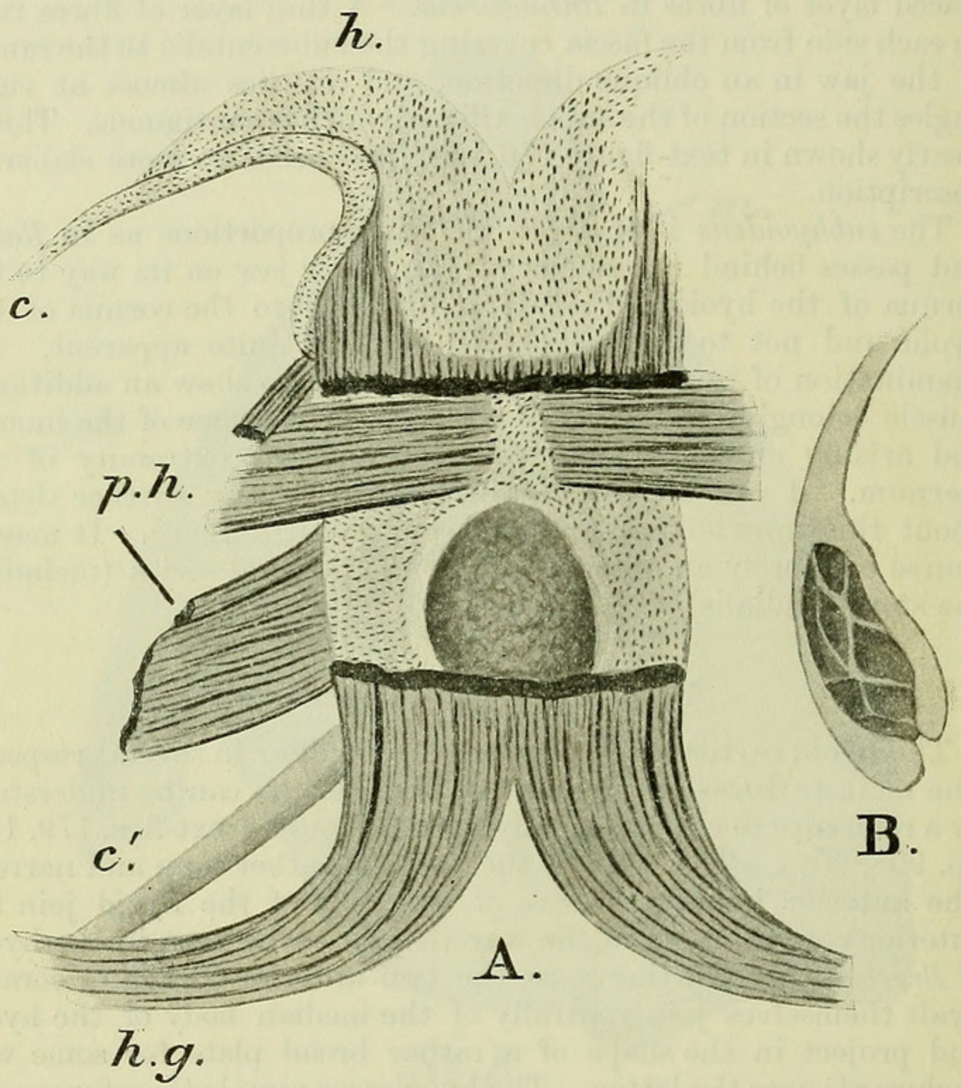
§ *Hyoid and its Musculature.*

The hyoid cartilages of *Hemisus* are peculiar in several respects. The main features of this part of the skeleton can be understood by a reference to the accompanying text-figures (text-figs. 179, 180, pp. 908, 909). The body of the hyoid is rather long and narrow. The anterior hyoid processes of the body of the hyoid join the anterior cornua much in the way that is to be seen in the hyoid of *Breviceps* *. Furthermore, the two anterior cornua or cerato-hyals themselves join ventrally of the median body of the hyoid and project in the shape of a rather broad plate for some way backwards over the latter. The hyoglossus muscle therefore passes through an actual foramen in the hyoid, which it completely fills. It is evident, however, that this hyoglossal foramen is not absolutely homologous with that of *Xenopus* †, but is more comparable to the nearly complete foramen seen anteriorly in the hyoid of *Pelodytes* ‡. For the foramen in *Xenopus* is an actual perforation of the body of the hyoid, whereas in *Hemisus* the foramen is produced beyond the end of the body of the hyoid and by the approximation of the origins of the anterior cornua of the hyoid. Were there a complete foramen in the hyoid of *Pelodytes punctatus* it would be more comparable to that of *Hemisus* in that the anterior cornua enter into its formation. It would not, however, be strictly homologous; for in *Pelodytes* and *Pelobates* there are a pair of

* P. Z. S. 1908, p. 12, text-fig. 2.
† See Ridewood, Journ. Linn. Soc., Zool. vol. xxvi. pl. 8. fig. 1, *h*.
‡ Ridewood, P. Z. S. 1897, pl. xxxv. fig. 10.

lateral foramina as well as the median notch nearly converted into a foramen in these genera (and, it may be added, in *Megalophrys* *). I take it that in *Hemisus* the single median foramen embraces

Text-fig. 179.



A. Ventral surface of hyoid of *Hemisus guttatum* partly cleared of muscle (the geniohyoids are removed and the hyoglossus cut through twice and the middle part removed).

c. The anterior cornu of one side. *c'*. The posterior cornu in which the absence of dotting indicates bone. *h*. Thin portion of anterior cornua, which meet in the middle line to form a ventral and backwardly projecting sheet of cartilage, with a rounded posterior margin which partly covers the hyoglossus (divided just behind the edge of this cartilage). *h.g*. Posterior region of hyoglossus. *p.h*. Sternohyoideus posterior; the anterior petrohyoideus is seen anteriorly to be inserted on to the body of the hyoid, where it nearly meets its fellow in the middle line; above this is seen the insertion of the anterior of the sterno-hyoids.

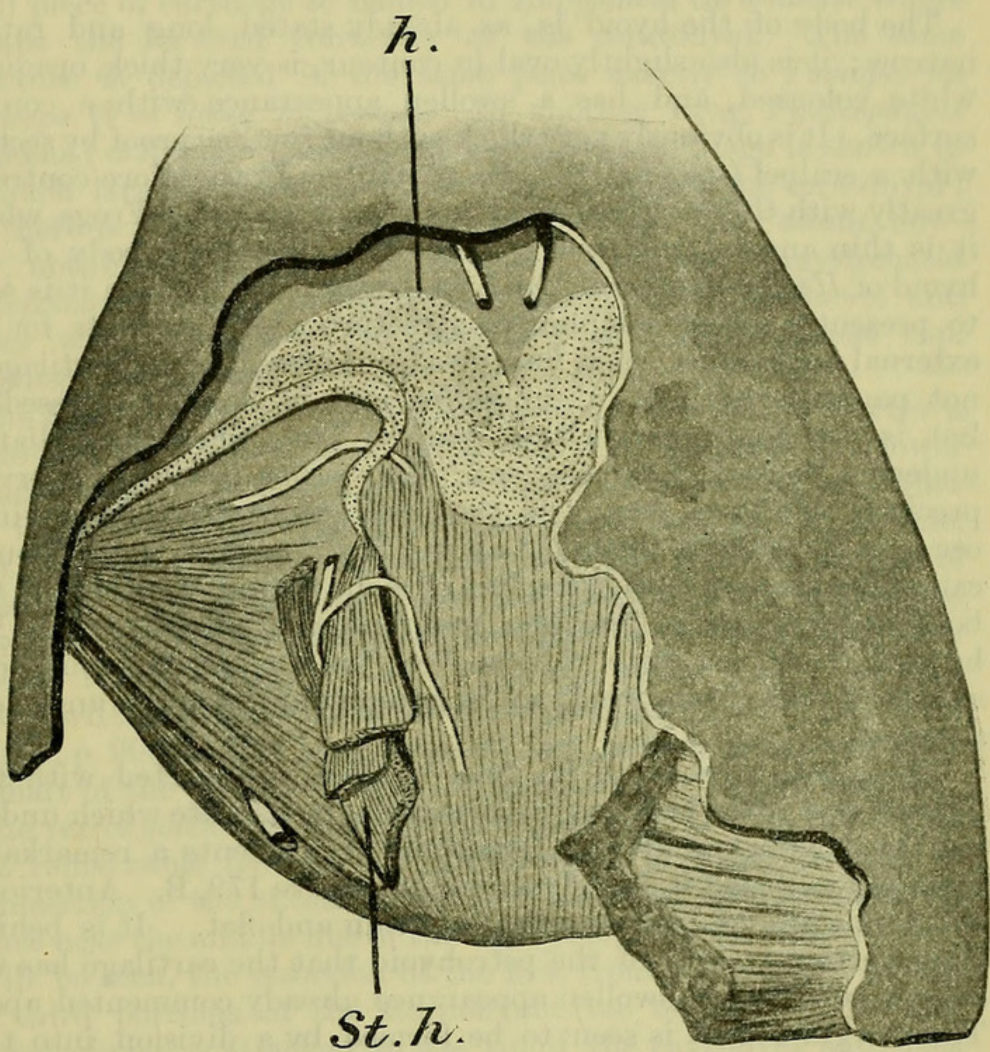
B. Section through body of hyoid in a longitudinal direction.

these lateral foramina as well as the median notch, since it is bounded laterally, not only by the roots of the anterior cornua,

* Beddard, "On Pelobatidæ," P. Z. S. 1907, p. 895, text-fig. 237.

but also by the anterior lateral processes of the body of the hyoid. It is perhaps possible to compare the lateral foramina in the hyoid of *Breviceps* with the lateral foramina of *Pelodytes* and *Pelobates*.

Text-fig. 180.



Hyoid of *Hemisus guttatum* and its musculature. Ventral aspect.

h. Anterior border of hyoid: the letter points to the plate formed by the union of the thinner portion of the anterior cornua which underlie the hyoglossus muscle, which muscle passes above them through the foramen thus formed. *St.h.* Sternohyoid muscles (3), over which the hypoglossal nerve is seen to pass and to supply, by one branch, the hyoglossus muscle. To the left of the figure are seen the petrohyoidei.

The anterior cornua near to the wall of the skull are bars of translucent cartilage of approximately equal diameter throughout. Towards its attachment to the body of the hyoid each bar gets much wider, as is shown in text-figure 179. The wider region of each cornu is due to the existence there of a semilunar tract of cartilage reinforcing the outer edge of the bar and becoming excessively thin along its anterior convex border. This cartilage is perfectly continuous with each cornu, but has the appearance of an extrinsic addition to it, because of its lack of translucency. This part of the hyoid cartilages is, in fact, whiter and more opaque than the bluish translucent cornu. This is not so evident where it is so very thin (*i. e.* at and near to its free edge) as it is where the two tracts of cartilage fuse to form the hood which has already been spoken of.

The body of the hyoid is, as already stated, long and rather narrow; it is also slightly oval in contour, is very thick, opaquely white coloured, and has a swollen appearance with a convex surface. It is obviously very thick without further proof by section with a scalpel (text-fig. 179, B., p. 908). It therefore contrasts greatly with this cartilage in, at any rate, many other Frogs, where it is thin and flat and even translucent. When the body of the hyoid of *Hemisus* is divided up by a longitudinal incision it is seen to present a rather complicated structure which accounts for its external appearance when uninjured. Anteriorly the cartilage is not particularly thick; it underlies and is closely adpressed to but is not continuous with a plate of bone which immediately underlies the wall of the pharynx. This is not, it will be observed, precisely the same thing as the ossifications which sometimes occur in the body of the hyoid among Batrachians *, nor obviously can it be compared to the splint of bone found underlying the body of the hyoid in *Pelodytes* and figured by Ridewood †. We have in *Hemisus* a plate of bone overlying the cartilaginous body of the hyoid, from which it is completely separate and non-adherent.

This plate of bone in its turn is closely connected with the ventral wall of the pharynx. The cartilaginous plate which underlies this bone when divided longitudinally presents a remarkable appearance, which is also shown in text-figure 179, B. Anteriorly the cartilaginous plate is relatively thin and flat. It is behind the insertion upon it of the petrohyoid that the cartilage has the convex outline and swollen appearance already commented upon. This turgid region is seen to be formed by a division into two plates of the cartilaginous hyoid which do not absolutely meet but come into the closest contact possible short of fusion posteriorly. Imbedded in the space between the two layers of the dichotomously divided sheet of cartilage is a lenticular mass of a softish consistency and a spongy appearance. I am unable to suggest what this is, unless it is developing bone. Though the above description is incomplete in this, it is obvious from the facts which I have been able to ascertain definitely that the hyoid complex in *Hemisus* is very remarkable.

There are other Frogs than the Engystomatid in which the hyoid apparatus is in certain respects like that of *Hemisus*. I have already directed attention to the likenesses shown in the hyoid of *Breviceps*. The thin layer of rather different-looking

* E. g., *Rappia* sp., *Cyclorhamphus marmoratus*, &c., Parker, Phil. Trans. 1881.
† *Loc. cit.* pl. xxxv. fig. 10.

cartilage fixed on to the ceratohyals and extending backwards in *Hemisus* to form a ventral hood over the hyoglossal muscle is represented in other Engystomatid Frogs though to a less degree; for I identify this cartilage with that termed "extra-hyal" by the late Prof. W. K. Parker*. This anatomist has figured a small piece of cartilage so named in *Engystoma carolinense* where it caps the forward convexity of the ceratohyal. The same structure is depicted in the same place exactly in *Tomopterna breviceps* (? = *Rana breviceps*). In another Frog, *Pyxicephalus rufescens* (= *Rana rufescens*), the extra-hyal cartilage is shown to be much larger, extending for a long way down the ceratohyal; but there is nothing like the hood of *Hemisus*. In *Callula*, however, nothing of the sort is figured. But the Engystomatid *Diplopelma ornatum* differs from its congener *D. berdmorei* and agrees with *Engystoma* in possessing this cartilaginous cap. *Phryniscus* also seems to want this structure.

The *hyoglossus* is a very thick muscle, as is usual; it forms a single muscle for the most part where it traverses the lower surface of the body of the hyoid. But a distinct slip on either side is quite distinguishable from the main body of the muscle, from the very origin of the muscle from the posterior cornua of the hyoid. The fibres of origin of the hyoglossus can be stripped away from the shaft of the posterior cornu, with which bone they have no relation except at the very tip, where they arise contiguous with the insertion of the petrohyoideus posterior (see text-fig. 178, p. 906). The hyoglossus, in fact, merely covers ventrally the shaft of the posterior cornu; it is not at all wrapped round it.

The *petrohyoideus* is shown in text-figs. 178, 179, & 180. The most remarkable feature about this series of hyoid muscles is the insertion of the anterior part of the muscle upon the ventral surface near the middle line of the basihyoid. This muscle divides, as will be seen, the insertion of the first from those of the second and third portions of the sternohyoid (see text-fig. 179). The last petrohyoid is attached to the tip of the thyrohyal and does not extend beyond it on to the larynx.

The origin of the *sternohyoideus* I am unable to describe fully. But the greater part at least seems to be derived from the under surface of the conjoined coracoids. Whether any of it is formed as a direct continuation of the rectus abdominis I do not know. In any case the muscle is divisible from at least very near to its origin into three distinct slips, which run forwards in close contact and as one muscle. Whether these three separate slips correspond or not to the three muscles in *Breviceps*, of which I have referred two to the sternohyoid and one to a derivative of the obliquus which I have termed in that Frog "hyoabdominal"†, I am uncertain; but their insertion one after the other in both Frogs is in favour of this comparison. Moreover, the origin of the hyoabdominal in *Breviceps*, a little way behind and to the outside

* Phil. Trans. 1881.

† P. Z. S. 1908, p. 12, text-fig. 2, *Hy.abd.*, and p. 23, text-fig. 5, *hy.abd.*

of the sternum, may be covered over in *Hemisus* by the greatly modified coracoids, and thus cut off from its relations with the obliquus. The insertions of the sternohyoid are shown in text-fig. 179, p. 908. They lie one behind the other to the outside of the hyoglossus. It is clear that in the disposition of this muscle *Hemisus* is nearer to *Breviceps* than to *Rana*.

The *geniohyoideus* (see text-fig. 178) has the two usual insertions posteriorly which exist in other Batrachia Salientia. They are divided from each other for a long way up the muscle (towards the mouth) by the main anteriorly running branch of the hypoglossal nerve. The lateral insertion on to the body of the hyoid of the geniohyoideus is preceded by a gathering together of the fibres of the muscle into a thick strap-shaped band which curves round the insertion of the sternohyoid (the most anteriorly inserted slip of that muscle) and is inserted below it—out of sight in the ordinary position of dissection from below. The inner portion of the muscle is a very delicate layer of fibres which with its fellow of the opposite side completely covers the hyoglossus and extends to the very end of the hyoid apparatus. In this the muscle resembles that of *Breviceps*, but, as pointed out in my description of the latter genus *, the peculiarity is not important. The *omohyoid* appears to be completely absent, as in *Breviceps*. I could discover no trace of that muscle in *Hemisus*.

§ *Musculature of the Thigh.*

When the skin is removed from the inside of the thigh the following muscles are brought into view, which are named in order from the anterior border of the thigh, viz., the vastus internus, adductor longus, sartorius, adductor magnus, rectus internus major, and rectus internus minor.

There is therefore nothing particularly striking so far about these muscles, which resemble those of *Breviceps* and even *Rana*. It is to be noted, however, that the *adductor longus* is hardly at all exposed and is almost completely covered by the *sartorius*. In this feature *Hemisus* differs from *Breviceps* † and is nearer to *Rhinoderma* ‡ and *Rana*.

In describing the anatomy of *Breviceps* § I have directed special attention to the partial origin of the *rectus internus minor* from the skin. The same characteristic feature occurring also in *Rhinoderma* is a bond of union between these two, in some other respects, not very closely allied genera. This peculiar attachment of the muscle in question to the inner surface of the skin of the leg is also noticeable in *Hemisus*, but not nearly to so marked an extent as in *Breviceps*. The insertion upon, or origin from, the skin of the thigh of a few fibres of the muscle was, however, plain enough.

The *semitendinosus* is formed by the union of two fleshy heads.

* P. Z. S. 1908, p. 14.
† P. Z. S. 1908, p. 25, text-fig. 6.
‡ P. Z. S. 1908, p. 691.
§ P. Z. S. 1908, p. 26.

When the thigh-muscles are viewed from the outside more muscles are visible without dissection than in the corresponding view of *Rana*. Several of these are shown in text-fig. 183, p. 919. The *rectus anticus femoris* is a thin and slender muscle as in *Rhinoderma* *, and broadening out it ends on the surface of the vastus internus, the head of origin of which is also visible on the present view. On the same side of the glutæus the *ilio-psoas* is also visible without any further dissection. The *vastus externus* is not at all of unusual size as it is in *Breviceps* † ; and the *biceps*, which comes next, is perhaps rather large. The *pyriformis*, distinctly broad, is as usual inserted dipping down between this muscle and the last of those belonging to the dorsal series, which is, of course, the *semimembranosus*.

§ *Abdominal Viscera.*

The *liver* consists of three lobes and is rather different from that of *Breviceps*. In the first place, it does not in the very least conceal the heart. Secondly, it does not only possess three lobes as in *Rana*, but the right half of the liver is much smaller than the two lobes which together constitute the left half of the gland. These two lobes are not completely separated. The *gall-bladder* is large and spherical and almost hidden by the right lobe.

The gastro-hepatic ligament shows an interesting structural feature which may or may not be common to other Frogs. The ligament in question is, of course, part of the ventral mesentery of the alimentary canal. The ligament does not extend far forward along the stomach; it is limited to about the last one-third of an inch of the stomach before it bends abruptly to join the duodenum. In this course four gastrohepatic vessels, which later join to form two, and which are separated by a nearly if not quite anangious section of the membrane from that close to the duodenum which carries the main portal vein.

The *stomach* (text-fig. 181, *st.*, p. 914) when cut open is seen to be marked internally by thick rugæ, of which I counted eleven near to the end of that organ. It is noteworthy that in this region at any rate five or six of these rugæ are to some extent connected by transversely running folds, a coarse network being thus formed. The remaining plicæ of the internal surface of the stomach are completely detached folds without any connecting folds. These simple separate folds occupy the ventral surface of the organ ; the others are dorsal, and the internal surface of the stomach is fairly evenly divided between them. As in *Rhinoderma*, the stomach does not end where it bends sharply to the right and narrows. It is thus V-shaped and its lining ends very abruptly where the duodenum begins.

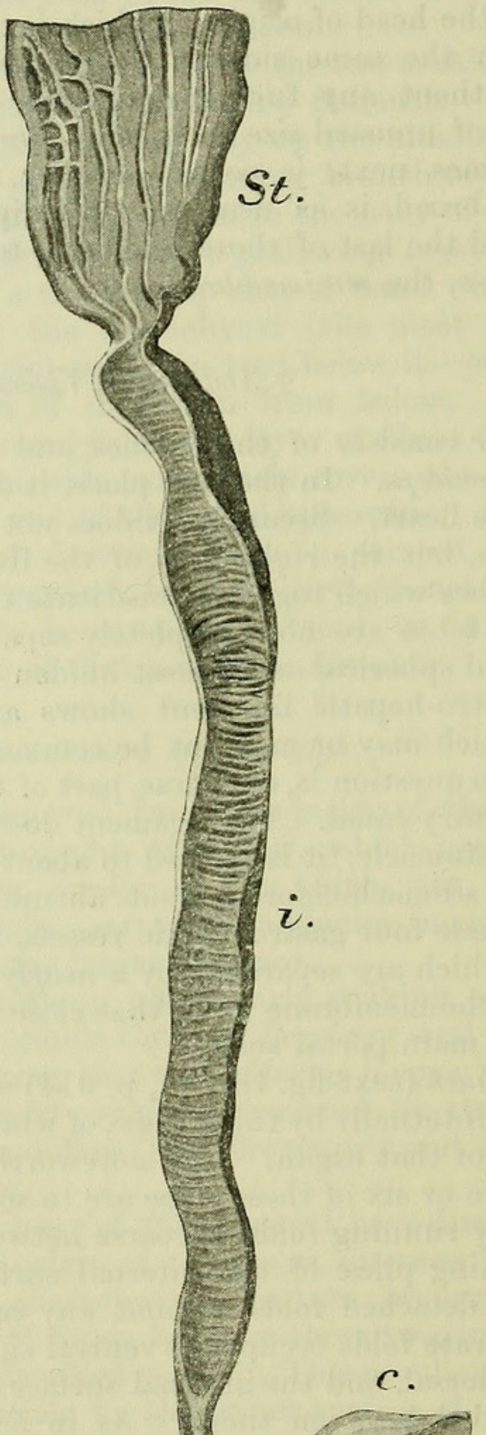
The *duodenum* (text-fig. 181, *i.*) is marked by very fine and transverse delicate folds or valvulæ conniventes. There is no

* P. Z. S. 1908, p. 691.

† P. Z. S. 1908, p. 26.

intermediate region between these and the strong longitudinal folds of the stomach. Moreover, the thickness of the walls of

Text-fig. 181.



Alimentary tract of *Hemisus guttatum* opened to show the varying characters of the lining membrane in different regions.

c. Colorectum. *i.* Small intestine. *St.* Stomach.

the stomach is at once diminished at the commencement of the duodenum. Thus the pyloric region almost projects in a valve-like fashion into the duodenum. The small intestine measures when stretched out 55 mm. Throughout its whole course the small intestine is occupied by rather closely set valvulæ conniventes, and nowhere can I detect any distinct reticulate arrangement of the folds such as I have figured in *Rhinoderma*. Here and there faint indications of such are present, but nothing that can be seriously compared to the reticulations found in *Rhinoderma* or at the commencement of the duodenum as figured in *Rana esculenta*. The *colorectum* (text-fig. 181, *c.*), into which the ileum opens, suddenly projecting indeed into its interior, is marked by longitudinally running folds. There is a remarkable resemblance to the stomach in that on one side of the gut the folds are simple, while on the other side there are transverse folds connecting them, and thus a network is formed.

The *kidneys* are of considerable length; the right kidney measures 19 mm., which may be compared with the total body-length of 60 mm.

The *oviducts* are thick and very much coiled. The straight piece which intervenes between the funnel and the coiled region is very short. The oviducal funnel lies behind the root of the lung. It is unusually long, and that of the right side at any rate measured 7 mm. It is an open groove and is attached all along to the cervical aponeurosis, the layer of the obliquus internus which closes the abdominal cavity anteriorly.

The *lungs* hang quite freely into the abdominal cavity; they are only attached to the liver quite at the root as in *Rana guppyi* *.

The *diaphragm* or *œsophageal muscle* is not an extensive muscle in *Hemisus*. In this it agrees with its allies. It appeared to me also that, as in *Breviceps* †, the muscle is entirely inserted upon the œsophagus.

§ *The Thymus Glands.*

In describing the anatomy of *Breviceps* I have pointed out the large size, compared to those of *Rana*, of the thymus glands. In the Batrachian with which I deal in the present communication, a pair of bodies which I take to be the thymus glands are much larger still, proportionately as well as actually. In *Rana esculenta* they are described and figured as being about 3 mm. in length. In the specimen of *Hemisus* upon the dissection of which the present paper is based, and which measured 60 mm. ($2\frac{1}{3}$ inches about), each thymus consisted of two discrete portions; the larger on each side was quite 7 mm. across at its greatest diameter. The position and size of the organs are shown in text-figure 176, *f.*, p. 899. They lie on each side behind the subhyoideus muscle and in front of the sterno-radialis and upon the deltoid, to which especially they are attached by flat bands of connective tissue. Each gland is flat and plate-shaped, of rounded contour; from the middle of the ventral surface a

* P. Z. S. 1907, p. 349, text-fig. 99, *m.*

† P. Z. S. 1903, p. 27.

process arises which runs forward as far as the angle of the lower jaw, which has almost the appearance of a duct, but which is, of course, no such thing. The glands are white and appear to be chiefly composed of fat.

In addition to these structures there is on each side of the body another "gland" of the same general appearance, but smaller, which I refer to the same category. These are flat circular bodies 2·5–3 mm. in diameter. These lie on either side well behind the head and just behind the scapula, covered over by the fascia which is continued into the depressor mandibulæ, and have a special relation to the thickened lateral edge of that muscle, as is described elsewhere *. Their position is considerably more posterior than the thymus glands of *Rana* and than the additional glands of *Hemisus* already described. It is well known † that among the Amphibia there are in the adult various remains of bodies derived from cells belonging to the branchial system of the tadpole, which have been termed "postbranchial bodies," "Epithelkörperchen," &c. I take it that in *Hemisus* these various structures which have just been described are also to be referred to the same category. They are, however, unquestionably much larger relatively as well as actually than in at least some other Amphibia Salientia.

§ *Posterior Lymph-Hearts and Associated Sacs.*

The enormous size, actual as well as relative, of the posterior lymph-hearts of *Breviceps* ‡ is at present an unique fact in the anatomy of the Batrachia Salientia. On grounds of affinity the existence of equally or nearly as large posterior lymph-hearts might have been expected in *Rhinoderma darwini*; but a careful search convinced me that *Rhinoderma* § was unlike *Breviceps* in this important and remarkable peculiarity. In *Hemisus*, however, I find an equivalent of this structure, which is very different in its character, though retaining certain features which lead to the inference that we have in this genus a modified and degenerate homologue of the enormous posterior lymph-heart of *Breviceps verrucosus*.

As is the case with *Breviceps*, though not to so great an extent as in that Frog, the thigh of *Hemisus* is fairly enclosed within the contour of the body. The body does not, however, extend beyond the tip of the coccyx as it does in *Breviceps*.

There is thus in *Hemisus*, as in *Breviceps*, a space left dorsally on each side of the posterior region of the vertebral column, behind the oblique muscles, which is floored by the muscles of the proximal region of the thigh. This space is cut off from the lymph-spaces covering the rest of the thigh by a transverse and

* *Cf.* p. 894.

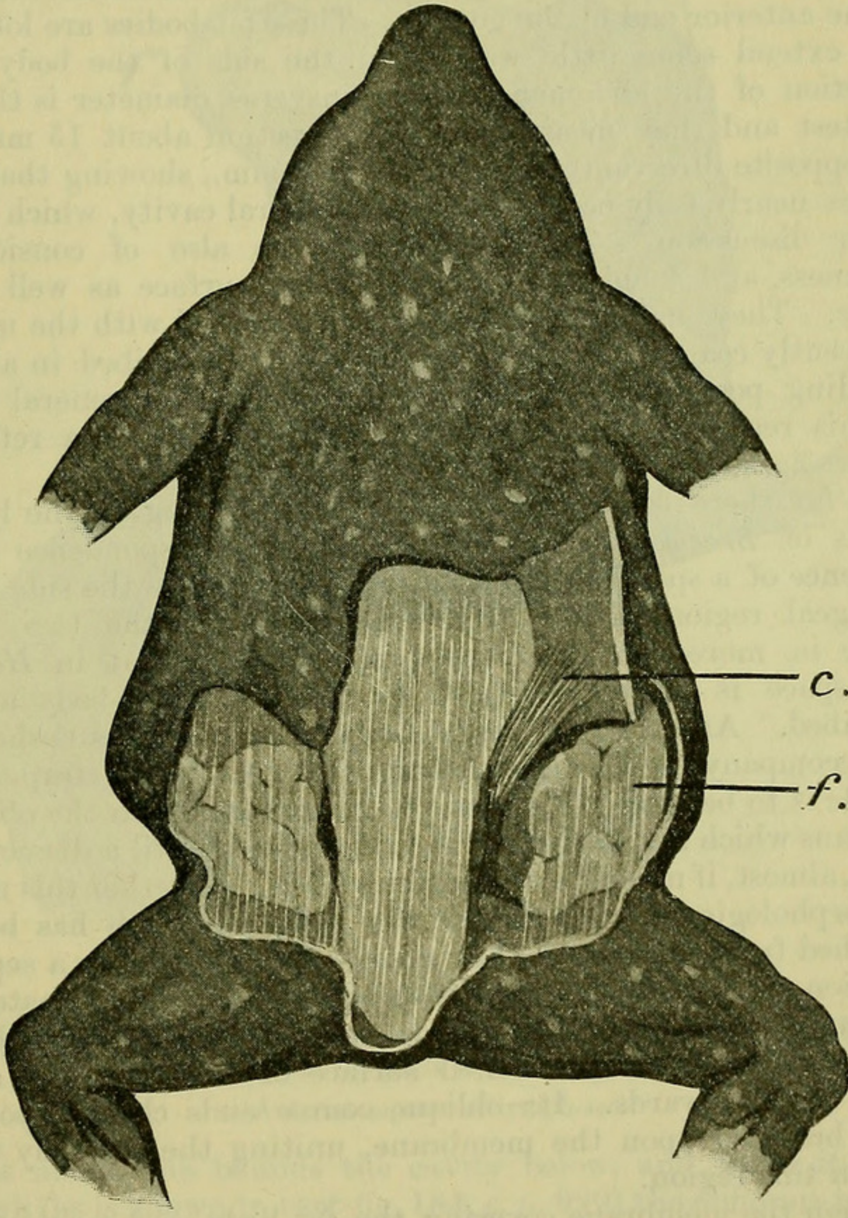
† Maurer, "Schildrüse, Thymus und Kiemenreste der Amphibien," Morph. Jahrb. xiii. 1888, p. 298.

‡ Beddard, "Anatomy of *Breviceps*," P. Z. S. 1908, p. 33.

§ *Id.*, "On *Rhinoderma*," P. Z. S. *t. c.* p. 678.

oblique septum starting in the neighbourhood of the coccyx. The length of this space is some 11 mm., the total length of the body being, from snout to tip of coccyx, 58 mm. It is therefore proportionately smaller than the corresponding space in *Breviceps*, which contains the lymph-heart; the greater size in *Breviceps* is, however, effected by the extension of the body behind the tip of

Text-fig. 182.



Dorsal view of *Hemisus guttatum*, with the skin of the back partly removed.

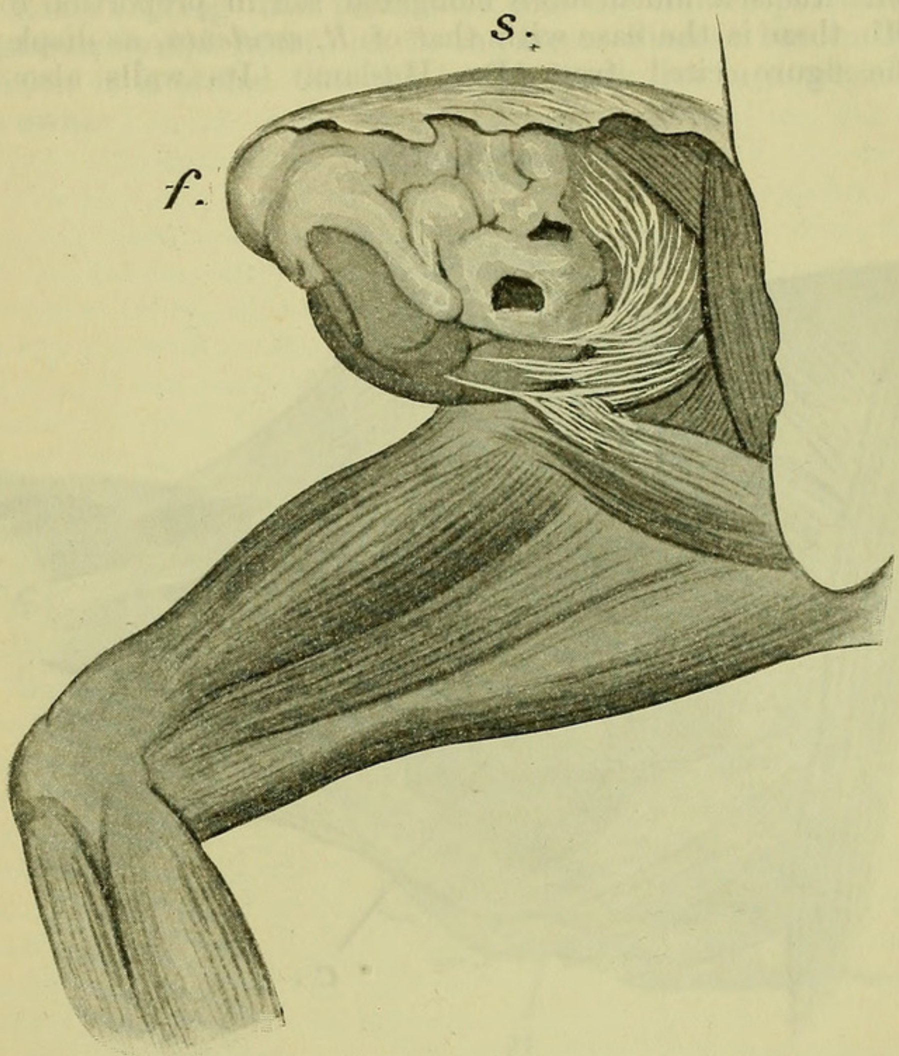
f. Fat-body lying in saccus iliacus and covered by a membranous wall.
c. Cutaneous muscle.

the coccyx. This cavity is exposed by the removal of the skin, which is particularly thick and glandular on the dorsal surface of the body generally in this Frog. To the wall of the greater part of the cavity the skin is not adherent and can be, therefore, removed without tearing the structures which it covers. When this has been done (see text-fig. 182, *f.*, p. 917), a transparent and toughish membrane is revealed, which completely covers the cavity and is continuous with the septum bounding it on the side of the leg, to which reference has been already made. Anteriorly and laterally, however, the membrane described is adherent to the skin. Below this membrane, and of course perfectly visible through it, is a large fat-body quite similar in appearance to the structure which I have termed the thymus gland and to the abdominal fat-bodies at the anterior end of the gonads. These fat-bodies are lobulated and extend some little way down the side of the body in the direction of the abdomen. The transverse diameter is thus the greatest and they measure in this direction about 15 mm. In the opposite direction the diameter is 8 mm., showing that these bodies nearly fully occupy the suprafemoral cavity, which is now under discussion. These fat-masses are also of considerable thickness, and lobulated upon the lower surface as well as the upper. They are by no means to be confused with the mass of apparently coagulated lymph which I have described in a corresponding position in *Breviceps verrucosus*. The general aspect of this region of the body will be understood after a reference to text-figure 182.

So far there is nothing exactly corresponding to the lymph-hearts of *Breviceps*. There is merely a correspondence in the existence of a space lying above the thigh and to the side of the coccygeal region of the vertebral column in the two Frogs. There is, moreover, the important difference that in *Hemisus* this space is largely occupied by the bulky fat-body already described. Anteriorly to the fat-body on each side, as is shown in the accompanying drawing (text-fig. 182, *c.*), a broad strap-shaped muscle is to be seen; this is not to be confused with the obliquus externus which lies in front of it, and, indeed, until a dissection is made, almost, if not quite, in contact with it. Whether this muscle is morphologically a portion of the obliquus which has become detached from the rest of that muscle and diverted to a separate function is another matter; it is not in any case in anatomical continuity with it. This muscle arises from the ileum below, passing upwards to the dorsal surface of the body and at the same time outwards. Its oblique course ends chiefly upon the skin, but also upon the membrane, uniting the fat-body to the skin in this region.

When the membrane covering the fat-body, and connecting it with the mass of bone and muscle constituting the caudal and pelvic regions of the body, is cut and the fat-body pushed aside towards the side of the body (away from the middle line) it is seen (text-fig. 183) to fill but loosely the space in which it lies and from which it is, indeed, partly cut off by membranes which cover it below. This membrane is largely fenestrated, so that the space which contains the fat-body is not shut off completely from the space lying below it. It is also attached by flat strands of membrane to another membrane lying beneath and rather in front of the fat-body and partly covered over by the strap-shaped cutaneous muscle already in part described.

Text-fig. 183.



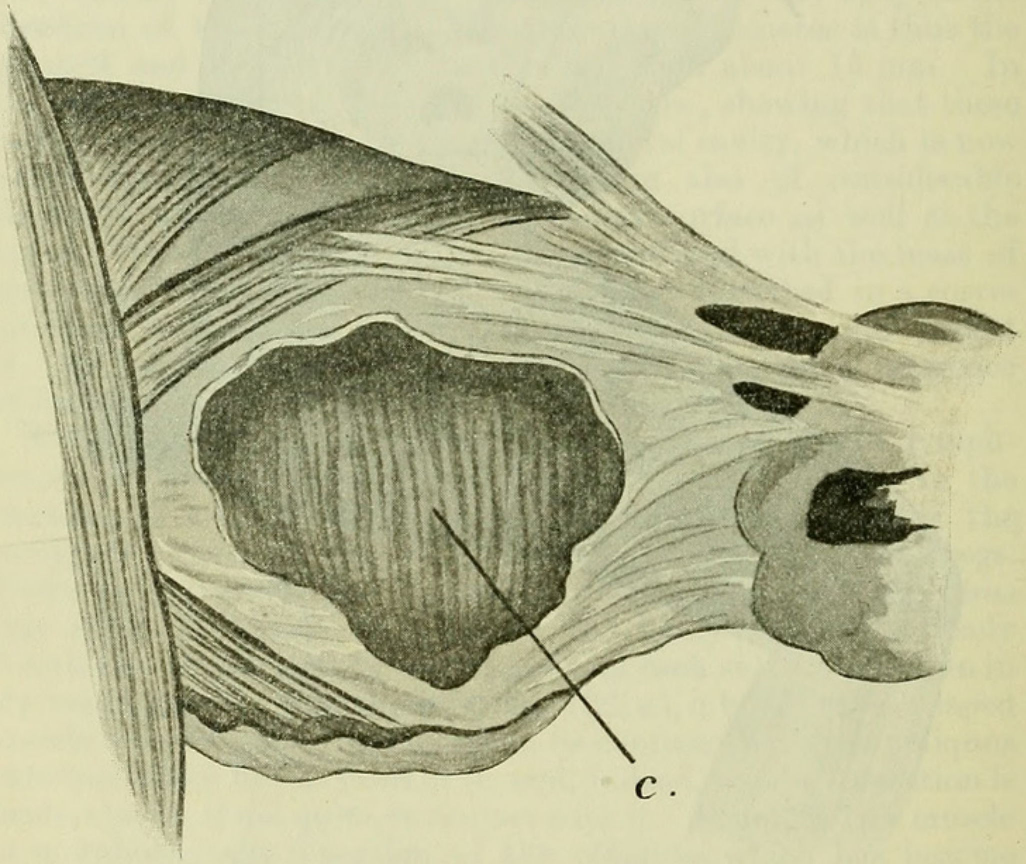
Saccus iliacus of *Hemisus guttatum*.

The fat-body (*f*) has been pushed over to the left; strands of connective tissue uniting it with the walls of the sac are shown.

s. Anterior septum of lymph-sac.

This membrane bounds the cavity below, and when it is cut through (as is shown in text-fig. 184, *c*, p. 920) the obliquus muscle is exposed; but as the membrane is quite free of the muscle it would seem to be really the dorsal wall of a subsidiary sac lying on the obliquus. It seems to me to be clear that this large sac, almost filled up by the fat-body already described, and in which also lies—as will be described presently—the lymph-heart, corresponds to the saccus iliacus of the Frog, *Rana esculenta*. Furthermore, the muscular slip which I have referred to as traversing the sac in *Hemisus* near to its anterior wall appears to me to be probably the musculus cutaneus iliacus of *Rana*. This sac and the muscle is figured in the edition of Ecker's 'Frog' which has been translated by Dr. Haslam*. There is a fuller account of the lymph-sacs of the Common Frog in the more recent edition of Gaupp. I figure here (text-fig. 185) for purposes of comparison with *Hemisus* the saccus iliacus in the large female of *Rana guppyi*. It is a much more elongated sac in proportion to its breadth than is the case with that of *R. esculenta*, as displayed in the figure cited from Dr. Haslam. Its walls also are

Text-fig. 184.



Saccus iliacus of *Hemisus guttatum*.

The fat-body is pushed to the right; the strands of connective tissue connecting it with the walls of the sac are shown.

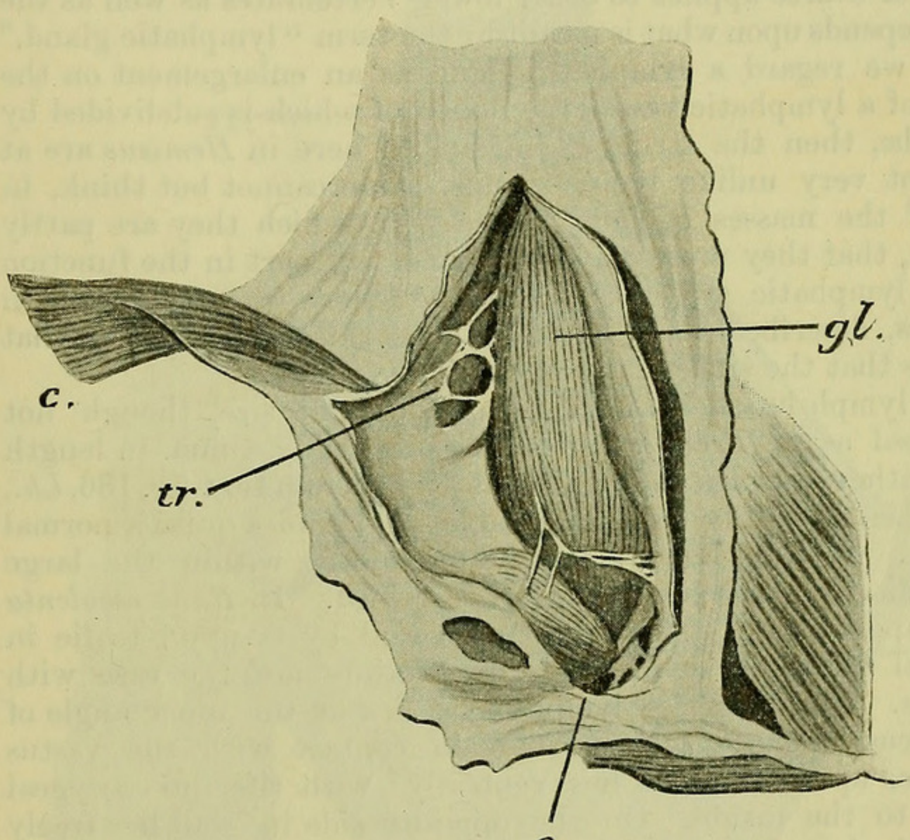
c. Obliquus muscle revealed by cutting open the floor of the sac.

attached by branched threads of stout connective tissue, which present the exact appearance, as will be seen in the figure, of the chordæ tendineæ of the valves of the mammalian heart. There are two of these branched stays between the dorsal and ventral walls of the sac. Gaupp mentions these structures as occurring in the lymph-sacs of *Rana*, but does not particularize their existence in the saccus iliacus. They are not represented in the figure, to which I have referred, of the sac in *Rana esculenta*. This sac communicates by a wide orifice

* Fig. 173, p. 259.

with the abdominal cavity at a point corresponding to that of the ostium in *Rana esculenta*, and also at its posterior extremity where it dips underneath the sac lodging the posterior lymph-heart. A seeker pushed through each ostium eventually appears at the same place in the abdominal cavity. In Haslam's edition of Ecker's 'Frog' it is mentioned that the hinder portion of the posterior lymph-heart lies in the saccus iliacus; but in Gaupp's edition it is stated that the lymph-heart lies in a special sac of its own.

Text-fig. 185.



Saccus iliacus of *Rana guppyi* opened.

c. Cutaneous muscle. *gl*. Glutæus. *O*. Ostium, leading into abdominal cavity. *tr*. Trabeculæ connecting walls of the lymph-sac.

The latter statement is clearly correct for *Rana guppyi*, where the lymph-heart lies just in front of the pyriformis muscle in a special sac, which is at least not in open communication with the saccus iliacus, and which indeed overlies it. There is thus an obvious difference between *Hemisus* and *Rana* in that the posterior lymph-heart of the latter lies in a special sac of its own, whereas that of *Hemisus* is contained in the saccus iliacus, as is plainly shown in text-fig. 186 (p. 923), where the posterior boundary of that sac touches the posterior wall of the heart. There is a further difference in that the interior of this lymph-sac is largely divided by trabeculæ, in the interstices of which is lodged the large lobate fat-body already described and figured (text-figs. 182, 183, pp. 917, 919). At the same time it will be noted that the "chordæ tendineæ" of the lymph-sac of *Rana* would seem to foreshadow (or to be the remains of) this trabecular system. The mass of trabeculæ and contained fat-mass is carried to an extreme in the opposite direction in the case of *Xenopus*, where (see p. 924) a tough mass of connective-tissue fibres and interspersed fat surrounds the lymph-hearts.

It is said, and in a sense correctly, that there are no lymphatic glands in the Frog. The absolute truth of this generalization (which of course applies to other lower Vertebrates as well as the Frog) depends upon what is meant by the term "lymphatic gland." For if we regard a lymphatic gland as an enlargement on the course of a lymphatic vessel the lumen of which is subdivided by trabeculæ, then the structures described here in *Hemisus* are at least not very unlike lymph-glands. One cannot but think, in view of the masses of fatty tissue with which they are partly plugged, that they must play some important part in the function of the lymphatic system; and the existence of fatty masses in *Xenopus*, described below *, strengthens this supposition in that it shows that the structure is not unique.

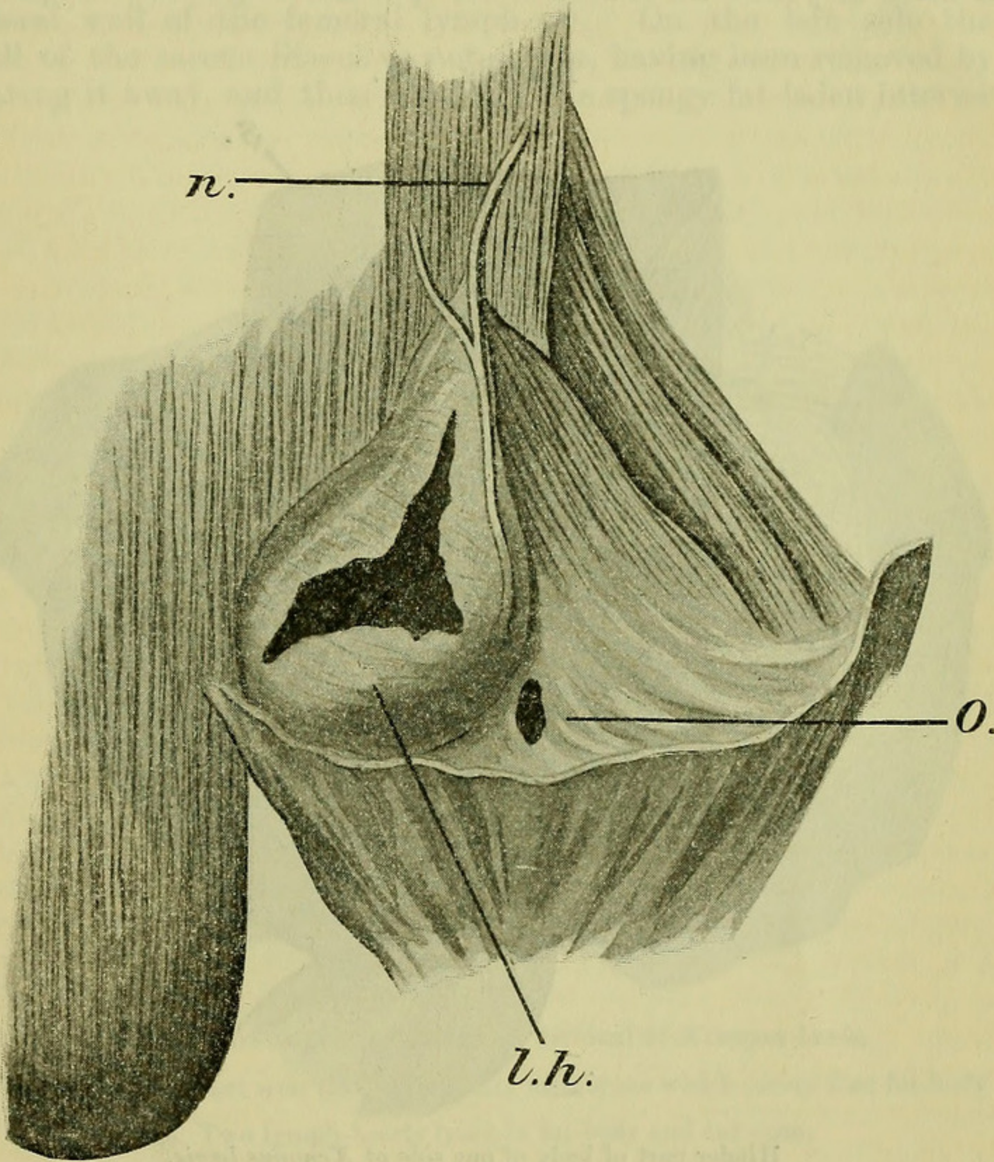
The lymph-heart itself is of considerable size, though not so colossal as in *Breviceps*. It measures fully 4 mm. in length and is rather elongate in form. It is displayed in text-fig. 186, *l.h.*, from which it will be seen that the heart occupies quite a normal position. It lies, however, quite definitely within the large saccus iliacus which has just been described. In *Rana esculenta* the lymph-heart of the same pair is said by Gaupp † to lie in a special sac of its own. This is certainly not the case with *Hemisus*. The posterior lymph-heart lies at the inner angle of the saccus iliacus. The heart is in contact with the vastus externus, upon which it lies ventrally; with the ilio-coccygeal muscle to the inside. On the opposite side its wall lies freely within the lymph-sac already mentioned and described at length. It is in front of the pyriformis muscle. It is not very closely related to the glutæus muscle. The septum bounding the saccus iliacus posteriorly is attached along the vastus externus and ends on the wall of the heart, or at least is firmly attached to the posterior wall of the heart at this point. Just in the angle where the septum in question and the heart meet is a smallish circular ostium (text-fig. 186, *O.*), which I take to be a communication between the saccus iliacus and the heart. A small blood-vessel, as is shown in the figure (*n*), runs along the outer side of the heart forwards, dipping down to the glutæal muscle; it is possible that this is the vein into which the heart opens. The heart is rather pear-shaped and lies with its long axis parallel to the long axis of the body. The narrow end is anterior. The heart is easily to be distinguished from the posterior septum of the saccus iliacus

* See p. 924.

† See his edition of Ecker's 'Frog.'

which is attached to it, and from such septa generally, by its yellowish colour, due of course to the fact that its walls are muscular and not formed of connective tissue. The outer wall of the heart is quite smooth and has a bronzy appearance, due to its muscular walls; the internal surface is sculptured into raised

Text-fig. 186.



Lymph-heart (posterior) of *Hemisus guttatum* and associated structures.

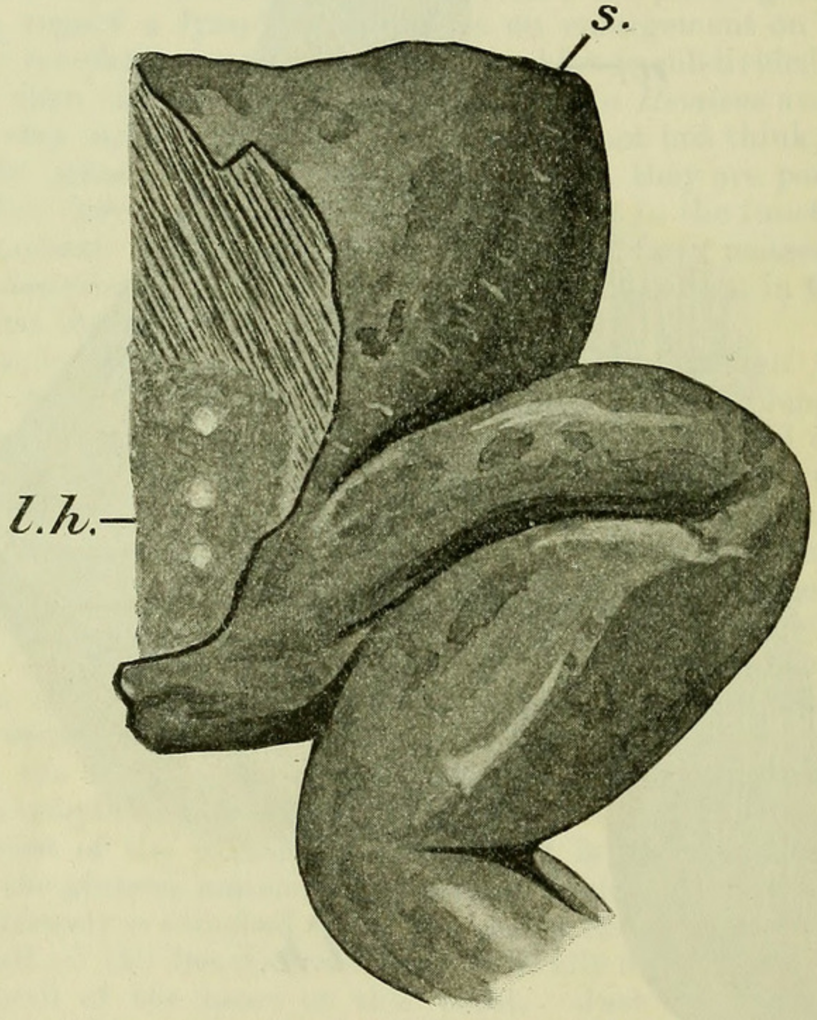
l.h. Lymph-heart cut open to show its interior. *n.* Vein referred to in the text. *O.* Ostium referred to in the text.

muscle-masses here and there with, of course, depressions between. The fibres in the outer wall of the heart run largely, as I have convinced myself by a microscopic examination, across its long diameter.

§ *The Posterior Lymph-Hearts of* Xenopus.

The posterior lymph-hearts of this genus are not, so far as I am aware, known. As I have dissected them in two individuals of this African Frog, and as they present certain remarkable differences from those of other Frogs, I think it worth while to append to my account of these structures in *Hemisus* some notes upon the lymph-hearts of *Xenopus*. When the animal is dissected, a mass of yellow fat is seen to lie upon the thighs and to spread

Text-fig. 187.



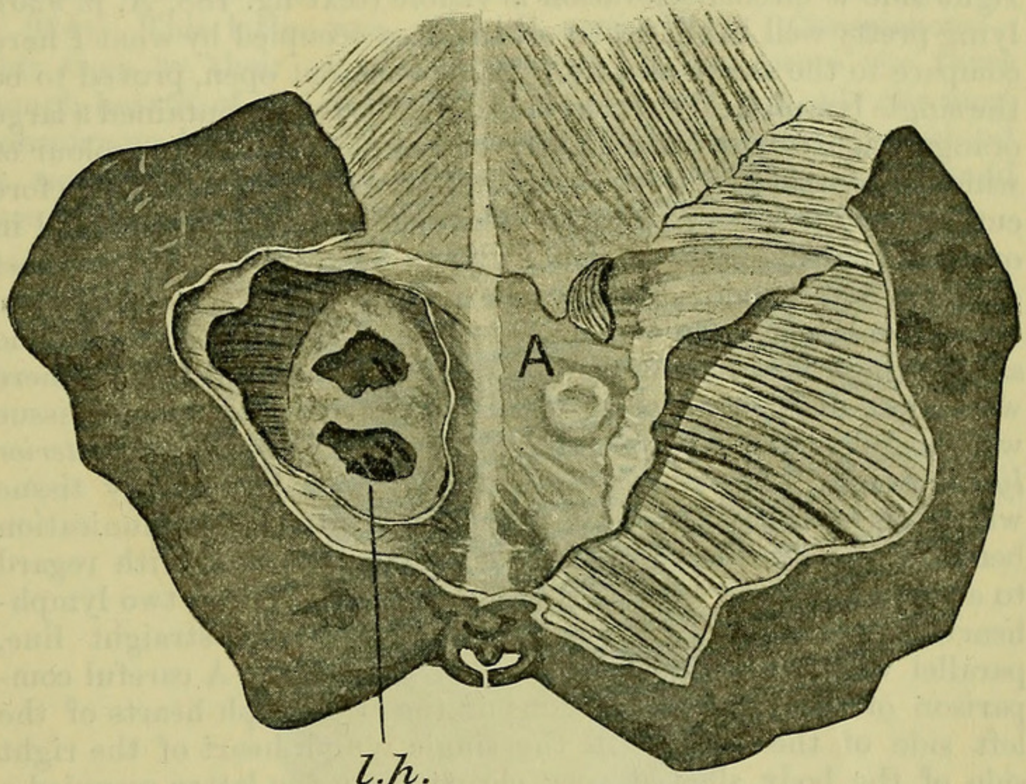
Hinder part of body of one side of *Xenopus lævis*.

l.h. Mass of fat in which lie lymph-hearts—distinguished as light circles.
s. Sense-organs of lateral line.

upwards for some way on to the back. The mass of fat upon the proximal region of each thigh is, as is to be seen in the annexed figures (text-figs. 187, *l.h.*, & 188, *l.h.*), of roughly circular outline. It is seen on excavation by the scalpel to be of some depth, and I regard the space in which it lies as representing the saccus iliacus of the lymph-system of *Hemisus* and other Frogs. There is, however, no empty sac here. The fat entirely fills the cavity. The actual fat itself is contained in a very close meshwork of fibres of connective tissue. When this is cut into and pressed the actual fat readily escapes and floats up to the surface of the water in the dissecting-dish.

The figure to which reference has been made (text-fig. 188) shows the saccus iliacus and adjacent structures intact on the right side save for the removal of the skin. The thin membrane covering the saccus iliacus is left intact. The cut edge of the membrane lying further to the right and continuous with this is the inner lateral wall of the femoral lymph-sac. On the left side the wall of the saccus iliacus is not shown, having been removed by tearing it away, and thus exposing the spongy fat-laden interior

Text-fig. 188.



Hinder part of body of another individual of *Xenopus lævis*.

A. Single lymph-heart seen through delicate membrane which covers iliac fat-body

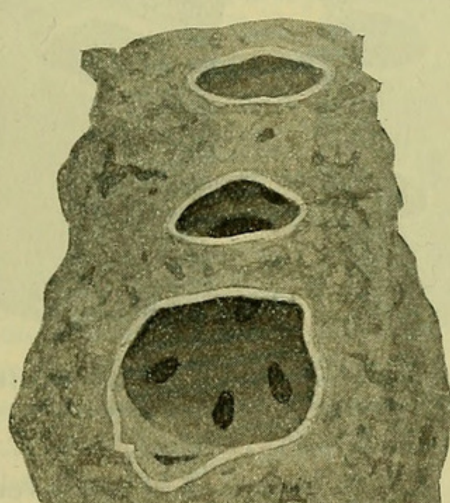
l.h. Two lymph-hearts lying in fat-body and cut open.

of the lymph-sac in question. This wall does not fit loosely, but is intimately connected with the fat-holding reticulum below, so that it has to be removed in fragments. The border-line between the two sacs is shown by a depression running along the membrane; it is along this line that the boundary between the sacci iliacus and femoralis is fixed. At the inner upper corner of the saccus iliacus, where it abuts upon the middle line of the body, a triangular flap of the covering of the saccus iliacus is cut and reflected. This shows a portion of a muscle which is presumably to be regarded as the cutaneus iliacus, and which has already been described in *Hemisus* and *Rana guppyi*.

It will be noted that, as in *Hemisus*, this muscle lies within the saccus iliacus, and that it is entirely attached to the wall of that sac at its insertion, and does not reach the skin at all. In *Hemisus* some of the fibres of the corresponding muscle are thus intercepted, but the rest reach the skin. In *Rana* all of the fibres of the muscle reach the skin. It is noteworthy that the wall of the saccus iliacus, as is clearly shown in the figure, is distinct from the overlying skin and not fused with it as are the dorsal walls of other lymph-spaces such as the adjoining femoral to the lateral septa, to which reference has already been made. On the left side the attachments of the septa bounding the femoral lymph-sac are shown in their attachments to the skin. On the right side a circular elevation is visible (text-fig. 188, A, p. 925), lying pretty well in the centre of the area occupied by what I here compare to the saccus iliacus. This, when cut open, proved to be the single lymph-heart of that side of the body; it contained a large orange-coloured clot (presumably of lymph), the darker colour of which, as compared with the surrounding tissues, was obvious before cutting into the lymph-heart. The clot was roughly spherical in outline, slightly flattened from above downwards. Its greatest diameter was 4 mm. Thus the heart itself may be considered to be a little larger. On the opposite side of the body there was no single lymph-heart corresponding to that of the right side. There were most distinctly visible, when the surrounding spongy tissue was carefully cut away, *two perfectly detached and separate posterior lymph-hearts*. Between them was some of the spongy tissue which fills up the lymph-sac, and there was no open communication between the two hearts, whatever may be the facts with regard to a communication by means of finer tubes. These two lymph-hearts lay one behind the other in a perfectly straight line, parallel with the longitudinal axis of the body. A careful comparison of the relative positions of the two lymph-hearts of the left side of the body with the single lymph-heart of the right side of the body, showed very clearly that the latter occupied a place midway between the anterior wall of the anterior and the posterior wall of the posterior left lymph-hearts. It would thus appear to correspond to the two of them—that is, the single right lymph-heart has been produced from a concrescence of two originally separate lymph-hearts, or it has given rise by division to two lymph-hearts on the left side. Of these two lymph-hearts of the left side the anterior was distinctly the larger, which is not very well shown in the figure referred to (text-fig. 188). This larger left lymph-heart, moreover, contained a blood-clot which was not to be seen in the interior of the hinder and smaller lymph-heart of the left side. This suggests, of course, that the systole and diastole of the two consecutive hearts are not synchronous, but that one is in systole, while the other is in diastole. The remains of the lateral line which are so prominent in *Xenopus* as stitch-like along the sides of the body did not appear to me to have any exact relation to the series of lymph-hearts of the left side, that is, they did not accurately overlie them. The hearts lay to the inside of the lateral line, as is also shown in the figure.

The soft and yet toughish and even sticky tissues which form the fat-holding plug which nearly, or quite, fills the saccus iliacus, and in which the hearts are imbedded, are not altogether easy of dissection, and the exposure of the lymph-hearts with much neatness is very difficult. It is possible that in the specimen which has just been described I have overlooked a lymph-heart; for in two others which I have dissected *there were undoubtedly three pairs of posterior lymph-hearts.* In one of these, which happened to be rather a small individual, the hearts, at any rate of one side of the body, were distinctly visible directly the skin was removed and the fatty mass exposed (see text-fig. 187, p. 924). This latter was, as usual, very yellow. Conspicuous—this time by their paler and browner colour—were the three lymph-hearts, of which the most anterior was not only the most conspicuous but the largest. The other two lying in a row behind it were, however, quite evident, though probably they would escape the attention of anyone not aware of their existence.

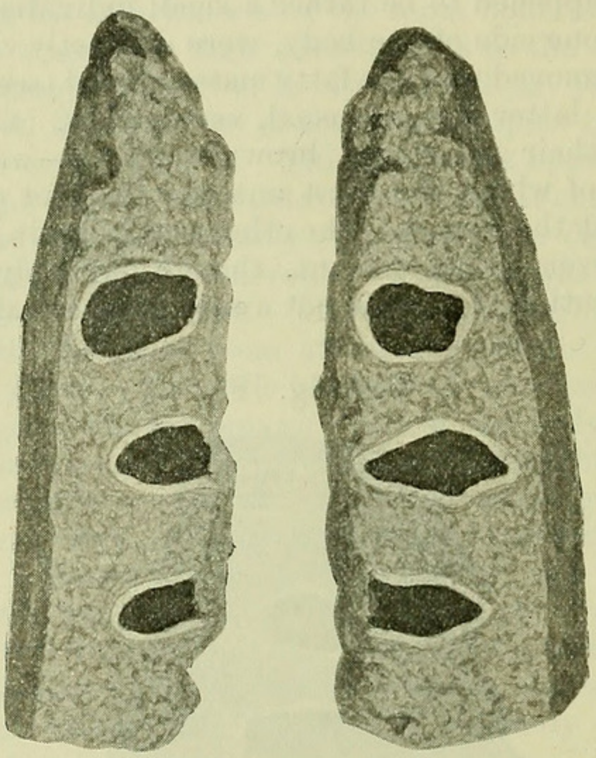
Text-fig. 189.



Iliac fat-body of *Xenopus lævis* dissected to show three lymph-hearts.

Indeed, it was after the discovery by dissection of three lymph-hearts on each side of the body of a third specimen, that I noted the external appearance of these lymph-hearts in the small specimen to which reference has just been made. In this latter specimen the three lymph-hearts of the right side are represented, as seen by dissection, in text-figure 189, the upper wall of each heart having been removed in order to display the interior. It happened that this particular specimen was especially favourable for displaying the structures in question. The preservative alcohol had hardened the hearts and the surrounding tissue in such a way as to render them very tough and had decolorized the hearts, while rather deepening the yellow of the fat-mass. It was thus found convenient to cut through with a pair of scissors the fat-mass of the left side of the body along a line presumed to pass through the hearts. Text-figure 190 shows that this was successfully accomplished, and represents the two sides of the cut whereby the mass of fat and the contained lymph-hearts were divided longitudinally.

Text-fig. 190.



Iliac fat-body of *Xenopus lævis* cut longitudinally into two halves to show cavities of lymph-hearts.

This longitudinal section passed, I believe, very nearly through the middle of each lymph-heart. It will be seen that they are not all of them of exactly the same size, though the differences between them are not very great. In the dissection (text-fig. 189, p. 927) of the hearts on the right side of the same Frog it will be noted that the last of the three hearts is considerably the largest of the three, perhaps twice as large as either of the others. This did not appear to be the case on the left side of the body. What is particularly striking about these hearts when seen evenly divided, and in section, is the great thickness of their walls. This is not exaggerated in the drawing to which reference has been made. The dissection of the corresponding hearts on the opposite side of the body (text-fig. 189) of this specimen shows the apertures in the walls of the hearts which presumably admit lymph into their interior. The thickness of the walls is also shown in this drawing. It is doubtless partly owing to the strong contraction of the hearts at the moment of death.

I am not aware that the posterior hearts of *Xenopus* have been described. The pectoral lymph-hearts, however, of this Frog are described and figured by Dr. Bles in his beautiful memoir * upon the larval development of *Xenopus*. There is but a single pair, and each is enveloped in a lymph-sac of its own. Dr. Bles remarks that the early development of these structures in *Xenopus* is remarkable, since in *Rana temporaria* and *Bufo calamita* the author found that the pelvic lymph-hearts do not appear until after the metamorphosis. This, however, does not argue that these structures are new formations and not comparable with the lymph-hearts in Urodeles. It is hardly likely that the anterior and posterior lymph-hearts are not parts of the same series, and therefore the early development of the pectoral hearts in *Xenopus* is to be set off against the late appearance of the pelvic hearts in certain Frogs, including, as it is to be supposed, *Xenopus* itself.

Inasmuch as the lymph-hearts of *Rana* are connected with veins supplying the fore and hind limbs respectively, a suggestion may be made as to the retention (or, if my opinion be not accepted, the multiplication of these hearts) of three pairs of posterior lymph-hearts in *Xenopus*. While in most Frogs, indeed in all, the hind limbs are the powerful swimming-organs of the animal, and exceed in size the relatively feeble fore limbs, the disproportion reaches its maximum in *Xenopus*. Of this Frog Dr. Bles justly writes:—"The size of the arm is altogether out of proportion to the size of the leg, which is an extremely powerful swimming-organ. The limbs of *Xenopus* as a Frog are paralleled by the limbs of *Macropus* as a Marsupial" †. The excessive size of the hind limbs in *Xenopus* bears some relation to the triple lymph-hearts. It is true that I have not succeeded in finding the veins into which the hearts open. But it can hardly be doubted, from the position which they occupy, that their orifices are into veins connected with the legs.

Attention may be drawn to the variability of these posterior lymph-hearts in *Xenopus*. This fact, as it appears to me, is of itself evidence, though naturally not of a positive character, that the structures in question are not a new formation, but are derivatives of the chain of lymph-hearts in certain Urodeles. The variability affects, as I think, the number of the hearts, which does not only differ in individuals, but from side to side of the same individual. But even if I am mistaken in this and have simply failed to find the supposed missing hearts in those specimens where only one or two appear to exist, there still remains the variability in point of size. There is, I hope, no

* "The Life-history of *Xenopus lævis* Daud.," Trans. Roy. Soc. Edinb. vol. xli. pt. iii. 1905, p. 789.

† Trans. Roy. Soc. Edinb. *tom. cit.* p. 819.

doubt whatever about this. An inspection of my figures, which were drawn quite independently of any directions from myself, will settle this matter. It is well known that variation is apt to affect organs or series of organs undergoing reduction. And, therefore, I dwell upon this fact as bearing upon the view upheld here, that in this Frog we have a persistent multiplicity of lymph-hearts, such as that which characterizes certain Urodeles, but which is considerably reduced.

The interest attaching to these facts concerning the posterior lymph-hearts of *Xenopus* is not only that they are—so far as I am aware—a contribution to the anatomy of that Frog. Their chief interest centres in the possibility of comparing them with the multiple lymph-hearts of certain Urodeles. With regard to this matter Dr. Wiedersheim sums up as follows in his 'Vergleichende Anatomie der Wirbelthiere' * :—"Bei *Salamandra maculosa* und *Siredon pisciformis* sitzen zahlreiche Lympherzen längs des *Sulcus lateralis* unter der Haut und zwar entfallen bei dem erstgenannten Thier auf dem Schwanz (beide Seiten zusammengerechnet) 10–12, auf den Rumpf mindestens ebensoviel. Bei *Siredon pisciformis* finden sich jederseits 8 rhythmisch pulsirende Lympherzen die wie bei *Salamandra maculosa* aus ovalen, von quergestreifter Muskulatur umwickelten Bläschen bestehen." These facts were first discovered by Weliky †.

§ *The Lymph-Hearts of* Rana guppyi.

Although it is usually stated in books and memoirs dealing with the anatomy of *Rana* that the posterior lymph-heart is a single structure on each side, this is not the universal view. Hoyer ‡ has given an account, with figures in the text, of the lymph-heart of *Rana esculenta*. A longitudinal section of one of the hearts given by him shows three distinct cavities, of which the hindermost is the larger. It is to be noted, however, that this figure is hardly convincing of itself as to the existence of three separate hearts, such as we have seen exist in *Xenopus*. For the muscular wall shown in Hoyer's figure extends without a break over the three cavities; there is no such complete separation as is indicated in text-figure 189 (p. 927) of the present communication. And so far, therefore, Dr. Hoyer's figure bears out the statement of Oehl (which is quoted by him), viz. "Das Herz gelappt ist," and that of Ranvier (also quoted by him), who observed that each apparently single posterior lymph-heart was divided by partitions into several divisions. Weliky, however, according to Hoyer, found that each heart "aus 3 gesonderten Abtheilungen besteht: dass also 3 hintere Lympherzen jederseits vorhanden sind." This, of course, agrees precisely with the facts which I have detailed in the present paper with regard to *Xenopus*. At the same time it cannot be disputed that the conditions obtaining

* Zweite Auflage, Jena, 1886.

† Zool. Anz. 1884.

‡ Bull. Acad. Cracovie, 1904, p. 228.

in *Xenopus* are more primitive than those found by the above writers to occur in *Rana*. The hearts are larger and, extending as they do over a larger area of the body, are more widely separated, and thus more completely distinct than can be the case with *Rana*, when so small a cleft contains the three hearts—or the trifid heart,—which are not indeed difficult to overlook altogether. Whatever may be the case with *Rana esculenta*, I found in a specimen of *Rana guppyi* a single lymph-heart on each side posteriorly, and measuring about 6 mm. in length; it lay in quite the usual position in front of the pyriformis muscle, but well behind the glutæus, separated from it, in fact, by the posterior end of the ilium.

The direction of the heart is rather obliquely outwards, very nearly parallel to the pyriformis muscle. Although each heart may be accurately described as a single heart, the cavity is completely divided across its major length (*i. e.* transversely to the long axis of the pyriformis muscle) by a septum of the same appearance and texture as the general parietes of this lymph-heart into two quite separate chambers. This division, however, is merely a septum; there is no question of any separation of the obviously single heart into two hearts. Nor is there any external constriction of a marked character which could fairly justify a statement that there were two consecutive lymph-hearts present on each side. I may say that the lymph-hearts on both sides of the body of this Frog were identical. This, it may be observed, is a very different condition of the posterior lymph-heart to that which has just been described in *Xenopus*. In the latter genus, I repeat, there are three distinct lymph-hearts on each side, in *Rana guppyi* only a single heart the cavity of which is divided *.

I may take this opportunity of calling attention to the anterior lymph-heart in *Rana guppyi*, where it is very conspicuous on account of its large size. It is quite 9 mm. long (when slightly stretched perhaps) and lies in a lymph-sac completely covered by the suprascapula, which has to be lifted up in order to display it. The sac and the contained heart are bounded by the longissimus dorsi and the retrahens scapulæ on the inside, and by the transverso-scapularis tertius on the outside †. The greater part of the lymph-heart consists of a single chamber, in which there is no trace of any septa. At the inner side, however, an incomplete septum partly separates off a very small chamber, which is about 1·5 mm. in breadth. This contains, I believe, the orifice into the vein. It would be better perhaps to describe the incomplete septum as a valvular flap which regulates the flow of blood and lymph. In any case, there is no complete division of this anterior lymph-heart into two chambers, such as has been described in the posterior lymph-hearts of the same Frog.

* Mr. Burne kindly allows me to quote a letter in which he informs me that the posterior lymph-hearts in a specimen of this Frog in the College of Surgeons Museum are quite similar.

† For these muscles, *v. supra*.

§ *Résumé of principal Muscular and other Characters of* Hemisus.

The principal characteristics of the genus *Hemisus* which I have been able to elucidate in the foregoing pages, are as follows:—

(1) The rectus abdominis has but one inscriptio tendinea. It cannot be distinguished laterally from the obliquus externus and is folded over itself at edge of the abdomen, where it joins the thigh, in a remarkable way.

(2) The obliquus internus consists of a thick layer of muscles, arising mainly from the dorsal aponeurosis to the outside of the ilia, which end upon a thin membrane which represents the ventral portion of this muscle. It is uncovered for the greater part by the obliquus externus.

(3) The sternohyoid consists of three distinct muscles inserted separately and behind each other on to the hyoid body.

(4) There is no omohyoid.

(5) The submaxillaris appears to be specialized into three tracts on each side, of which the fibres run at different angles to each other.

(6) The dorsal portion of the depressor mandibulæ is present.

(7) The latissimus dorsi has an origin extending considerably beyond (behind) the scapula and joins early with the infraspinatus.

(8) There is no rhomboideus muscle.

(9) There are altogether four "serratus" muscles on each side of the body; 1 and 2 arise respectively from the transverse processes of vertebræ 3 and 4; 3 arises from the transverse processes of both those vertebræ; 4 arises from the neck laterally in front of the third vertebra.

(10) In the thigh the rectus internus minor partly arises from the skin.

(11) There are two pairs of large fat-masses lying in lymph spaces and another pair corresponding in position to the thymus lying beneath the skin.

(12) The stomach is elongate, with a narrower portion bent to form a U with the major portion.

(13) The small intestine is traversed throughout by closely set transverse folds.

(14) The fat-bodies are very large.

(15) The oviducts are much coiled and with a long drawn out gutter-like funnel.

(16) The lymph-sacs are not particularly large and in the usual position.

(17) The hyoid has large extra-hyals anteriorly which fuse ventrally below the hyoglossus muscle, and the body of the hyoid is very thick, with a bony plate distinct from and overlying the convex and swollen cartilaginous layer.

The above 17 characters appear to me to be the chief anatomical distinguishing features of *Hemisus*, besides certain osteological and external peculiarities which I do not deal with here. Of the former there are more that are peculiar to *Hemisus* than of those which ally it to its allies. *Hemisus* is peculiar, so far as is at present known, in Nos. (1), (2), (3), (6), (7), (11), (13), (17)—that is, in nearly one-half of those which I have selected.

Hemisus agrees with both of its allies, *Breviceps* and *Rhinoderma*, in (5)—at any rate, as to the fact that there are various additional muscles, not present in *Rana*, upon the floor of the mouth ; there is, however, no detailed agreement between the three genera in the disposition of these muscles. In (10), (12) *Hemisus* agrees with *Rhinoderma*, and differs from *Breviceps* in (16). *Hemisus* agrees with *Breviceps* and differs from *Rhinoderma* in (4), (8), (14). I am not quite certain as to the remaining features of the anatomy, which I have made use of as indications of closer or more remote affinity. These facts, and indeed others which will be found in the foregoing pages, do not, as it seems to me, permit of a very decisive placing of *Hemisus* with regard to the two remaining genera of Engystomatid Frogs whose anatomy is known. The particular likenesses which *Hemisus* shows to *Breviceps*, as opposed to *Rhinoderma*, may be increased by the addition of the fact of the partial inclusion of the limbs within the area of the trunk, and by the division of the rectus abdominis muscle by only a single inscriptio tendinea. But *Breviceps* remains, after all, an extremely specialized type in many ways. General reflections upon the arrangement of these Frogs will, in fact, be better deferred until more anatomical facts have been collected.

§ *Résumé of principal new Facts.*

It may be convenient to extract from the foregoing account of *Hemisus*, and of *Xenopus* and *Rana*, the following principal new facts which I have been able to ascertain :—

(1) *Hemisus* is characterized by the existence of three pairs of large-lobed fat-bodies, of which one pair correspond in position to the thymus in other Frogs, the second lie in a cavity (? a lymph-sac) behind the shoulder-girdle, and the third pair are contained in a sac partly overlapping the thigh, which is to be compared with the saccus iliacus of *Rana*. The prerenal fat-bodies are also very large.

(2) *Xenopus* has a similar pair of fat-bodies in the representative of the saccus iliacus, the fatty tissue, however, straying further forward on to the back.

(3) The saccus iliacus in *Hemisus* and *Xenopus* is divided by trabeculæ in the interstices of which lies the fat-body; the commencement of such a division of the saccus iliacus is seen in *Rana guppyi*. It is possible to compare these structures with lymph-glands.

(4) *Hemisus* has a single pear-shaped posterior lymph-heart, which, unlike that of *Rana*, lies in the saccus iliacus.

(5) *Xenopus* has a chain of three perfectly distinct posterior lymph-hearts on either side of the body, which lie in the saccus iliacus.

(6) In *Rana guppyi* the single posterior lymph-heart of each side is completely divided into two consecutive chambers.

(7) Neither in *Hemisus* nor in *Rana guppyi* is there any division of the anterior lymph-heart.

(8) *Hemisus* possesses a hyoid which is remarkable in several ways and unlike that of other Batrachians. The extra-hyals are large and meet in the middle line below and not in contact with the body of the hyoid ; the latter consists of a cartilaginous plate continuous with the corona, which is greatly thickened posteriorly by a nucleus of laxer tissue, and above which lies a plate of bone—not imbedded in it, but distinct from it.

(9) A comparison of *Hemisus* with *Breviceps* and *Rhinoderma* allows of the extraction of certain characters apparently distinguishing the Engystomatidæ, *i. e.* specialization of muscles of floor of mouth, division of sternohyoid, connection of rectus internus minor with skin.

(10) *Hemisus*, though a burrowing and ant-eating genus like *Breviceps*, shows comparatively few special structural likenesses to it. The principal resemblances are: partial inclusion of limbs within the trunk; (?) absence of omohyoid and rhomboideus ; great strength of muscles attached to the shoulder and fore limb, which, however, are not entirely the same muscles in the two types; the modifications of the muscles of the hyoid and the floor of the mouth, which are to some extent similar in the two types. But the many differences in the abdominal and dorsal musculature obscure and outweigh the special likenesses, which might be referred to similarity in habits and mode of life.

2. Description of a new Species of *Lacerta* from Persia. By G. A. Boulenger, F.R.S., V.P.Z.S.

[Received October 13, 1908.]

(Plate LXVII.*)

Lacerta chlorogaster.

Head moderate, once and three-fifths to once and three-fourths as long as broad; snout moderately long, obtuse. Rostral not touching the nostril; one postnasal; a single anterior loreal; four (rarely five) upper labials anterior to the subocular; a complete series of granules between the supraocular and the

* For explanation of the Plate see page 936.