CHANGES IN THE INTERNAL STRUCTURE OF THE AIR-BLADDER OF *PANGASIUS PANGASIUS* (HAM.) DURING GROWTH.

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In the course of his taxonomic studies, Dr. S. L. Hora[1] found considerable variation in the form of the air-bladder of *Pangasius pangasius* (Ham.), and from an examination of the material in different stages of growth he was able to reconcile the divergent accounts of its structure by Taylor,[2] Day,[3] and Bridge and Haddon.[4] Further, when dealing with the correlation between the disposition of the liver and the kidney and the form of the air-bladder in *Pangasius*, he[5] indicated that under the pressure of the growing kidneys, the form of the air-bladder undergoes a series of changes. Dr. Hora's studies were, however, limited to the modifications in the external form of the air-bladder, but he recognised the need for a detailed study of the internal structure of the organ during growth. Being unable to devote much time to morphological work, Dr. Hora very kindly entrusted his material to me, and helped in collecting material of other stages from the Calcutta markets. I have thus been able to dissect specimens ranging in length from 91 mm. to 885 mm. In the following account of the structure of the air-bladder, I have followed the terminology of Bridge and Haddon. All the drawings reproduced here were made by me with the help of a Camera Lucida.

I am very grateful to Dr. Baini Prashad, Director, Zoological Survey of India, for affording me the necessary facilities for work in his department. The work has been carried out under the supervision and guidance of Dr. S. L. Hora, to whom I am indebted for the material, valuable suggestions and constant encouragement. My thanks are also due to Dr. T. N. Poddar, Professor of Biology, Carmichael Medical College, Calcutta, for his help in procuring a part of the material, and to Babu D. N. Bagchi, the senior Artist of the Zoological Survey of India for helpful suggestions in connection with the preparation of the illustration.

DESCRIPTION OF THE MATERIAL.

1. *Size of specimen : 91 mm. in total length.* (Text-fig. 1, *a* and *b*).

The air-bladder of a specimen 91 mm. in total length (fig. 1) consists of a large anterior portion which is like a normal bladder, and also of a posterior portion which is in the form of a caecum. The anterior portion is broad in front and oval behind. The posterior portion is very small

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[1] Dr. Hora very kindly allowed me to see his manuscript on the revision of the Schilbeidae which is to be published in the *Records of the Indian Museum.*

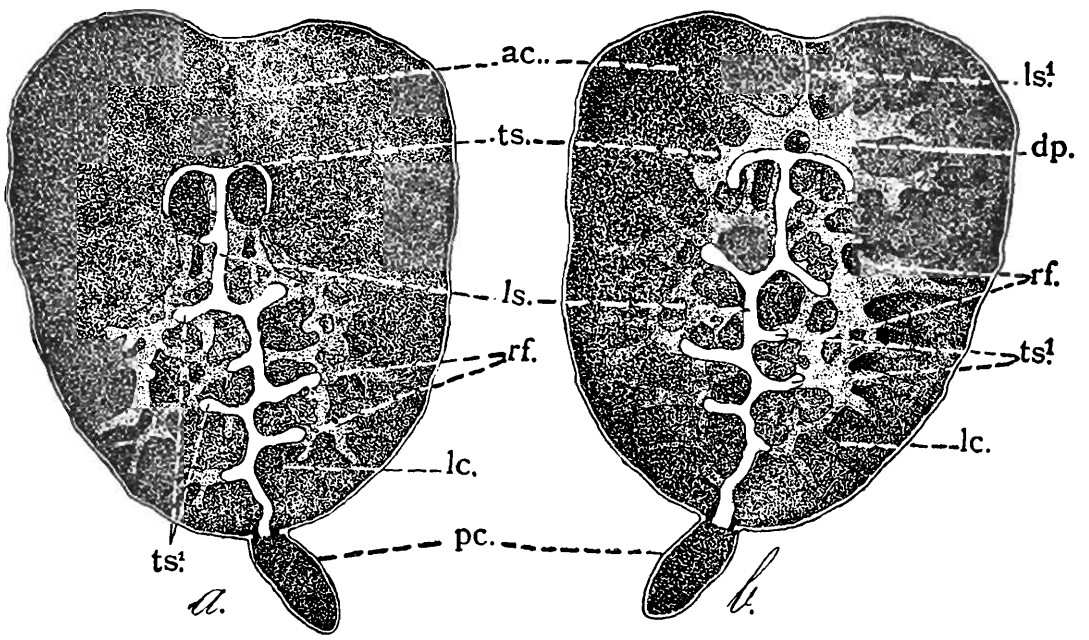
[2] Taylor, *Gleanings in Science*, p. 171 (1830).

[3] Day, *Proc. Zool. Soc. London*, p. 709 (1871).

[4] Bridge and Haddon, *Trans. Roy. Soc. London* (B) CLXXXIV, pp. 214-219 (1894).

[5] Hora, *Proc. Nat. Inst. Sci. India*, III, pp. 31-43 (1937).

and is covered dorsally by the kidneys but exposed ventrally. The anterior portion is divided internally into one short but broad anterior chamber (*ac.*) situated in front of the transverse septum (*ts.*) and two lateral chambers, (*lc.*) one on either side of the longitudinal (*ls.*) septum.



TEXT-FIG. 1.—Air-bladder of a specimen of *Pangasius pangasius* (Ham.) 91 mm. in total length. ×4.

a. Dorsal half. *b.* Ventral half.

ac.=the anterior chamber; *ar.*=annular ridges; *dp.*=opening of the ductus pneumaticus into the bladder; *lc.*=lateral chamber; *ls.*= primary longitudinal septum; *ls.*¹=secondary longitudinal septum; *pc.*=caecum; *rf.*=root-like bundles of fibres; *ts.*=primary transverse septum; *ts.*¹= secondary transverse septa; *vp.*=vertical pillars.

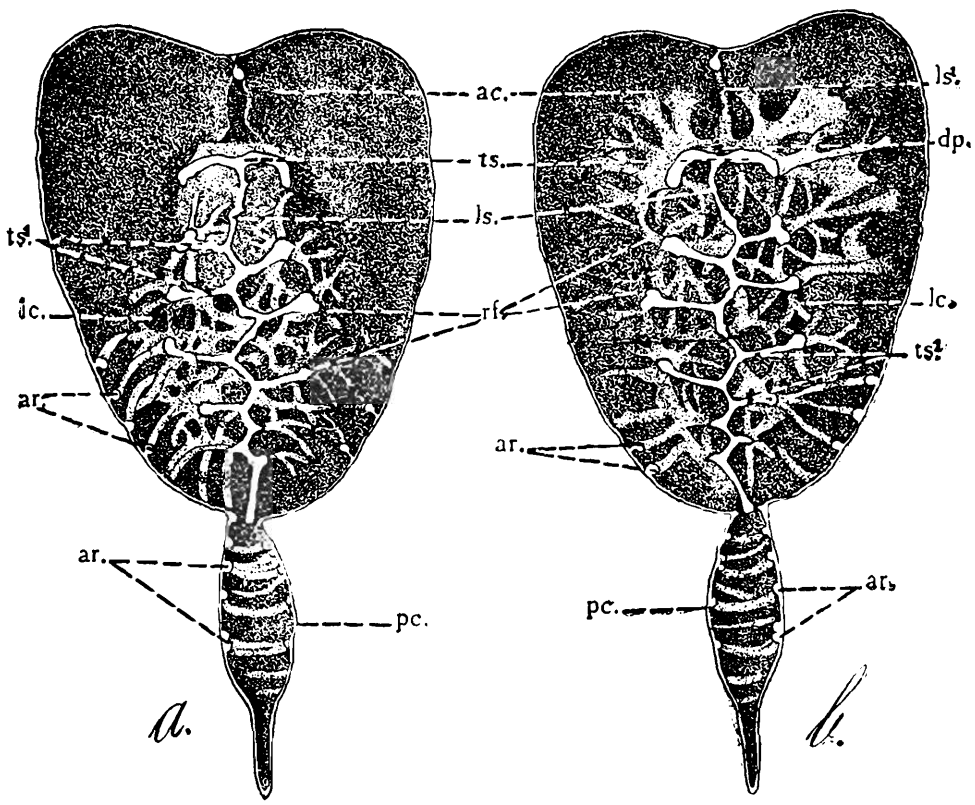
From the thick transverse septum, another thin longitudinal septum (*ls.*¹) grows forward and meets the anterior wall of the bladder. This new septum is confined to the ventral half of this portion of the bladder, and hence it does not bring about a division of the anterior chamber into two. This structure, which may be termed the secondary longitudinal septum, is not recorded by Bridge and Haddon. There is in addition a hollow pneumatic duct which connects the bladder with the oesophagus. The duct (*dp.*) opens into the bladder on its ventral wall just in the middle and in front of the primary transverse septum. The cavities of the two lateral chambers are subdivided and greatly broken up by the formation of numerous secondary transverse septa (*ts.*¹) which grow out from the sides of the primary longitudinal septum and laterally terminate before reaching the outer walls of the chambers. The secondary septa are further strengthened, and the spaces they enclose additionally sacculated by the growth of root-like bundles of fibres (*rf.*) which extend in between the septa. The growth of the root-like fibres is more vigorous in the ventral half of the bladder (fig. 1 *b*) than in the dorsal. In the ventral half very little space is left free, as most of the area is occupied by septa and fibrous tissue.

The posterior portion of the bladder, *i.e.*, the caecum (*pc.*), communicates anteriorly with both the lateral chambers but terminates blindly

behind. The communication is effected by two holes, one on either side of the longitudinal septum. The walls of the caecum are free from ridges or any other thickenings. It may also be noted that the walls of the posterior portion of the bladder are somewhat thickened and more opaque. The two antero-lateral pockets bulge dorsally and possess transparent walls. At this stage, the walls of the air-bladder are in contact with the lateral cutaneous areas, there being no layer of fat between the two. Anteriorly the right half of the bladder is a little longer than the left. The kidneys extend along the sides of the bladder to more than half of its length.

2. *Size of specimen : 143 mm. in total length* (Text-fig. 2, *a* and *b*).

The anterior portion of the air-bladder of a specimen 143 mm. in total length is similar in shape to the one described above, with the exception that the number of the secondary transverse septa (*ts.*[1]), which arise from the longitudinal septum (*ls.*), and of the root-like bundles of fibres (*rf.*) at the ends of the secondary transverse septa is greater.



TEXT-FIG. 2.—Air-bladder of a specimen of *Pangasius pangasius* (Ham.) 143 mm. in total length. ×3⅛.

a. Dorsal half. *b*. Ventral half.

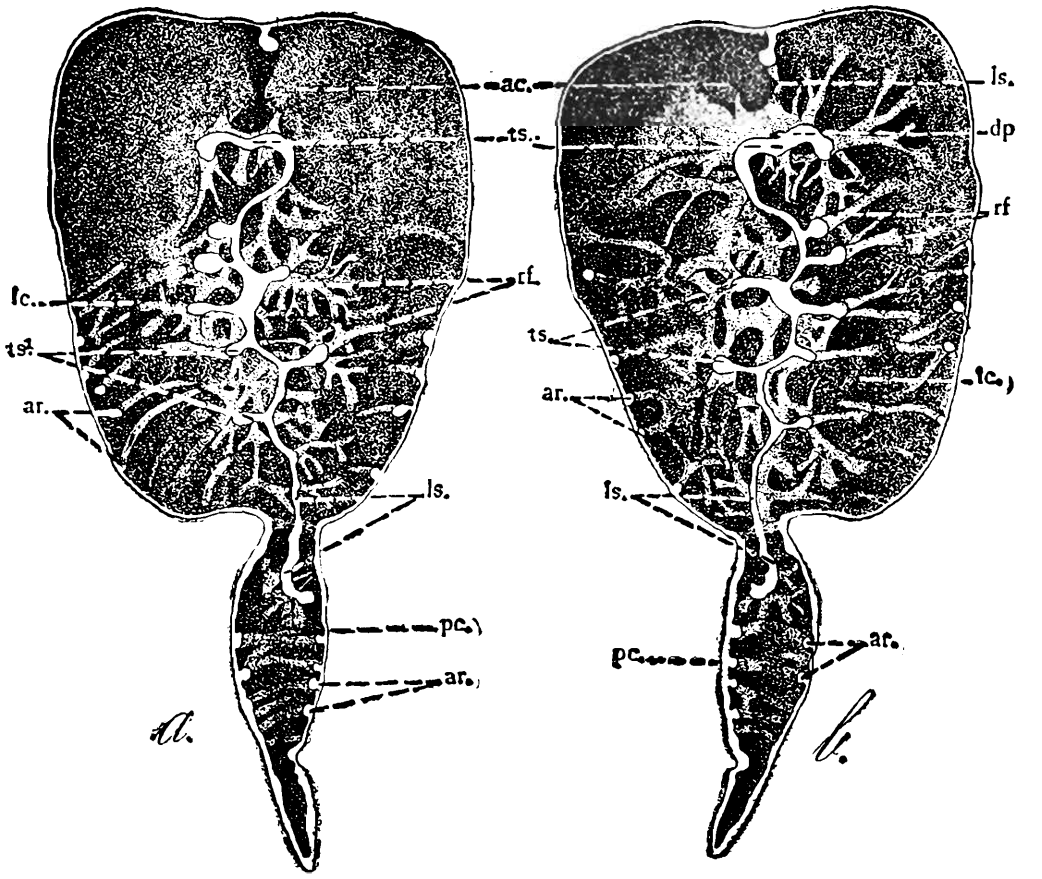
For lettering see explanation of text-figure 1.

These root-like bundles of fibres along with the few annular ridges (*ar.*), which are dorsoventrally placed along the sides of the bladder towards its posterior end, contribute to the obliteration of the space inside the bladder. The secondary longitudinal septum (*ls.*[1]), which was just noticeable in the earlier stage described above, is more prominent. It is in the form of a ring, placed dorsoventrally in the median portion of the anterior wall.

The posterior portion of the bladder (*pc.*) is now considerably longer and its posterior end almost extends to the base of the ventral fins. The tubular caecum is enclosed by the kidneys on the sides, but is exposed ventrally. It could also be seen at least in one place dorsally. The longitudinal septum does not extend into the caecum. The caecum is no longer a simple structure as its cavity is being filled up and the walls are further thickened and strengthened by a few annular ridges (*ar.*). Besides these ridges, there are other fibrous thickenings which arise from the ventral and dorsal walls. Towards the posterior end, the caecum is suddenly narrowed. The narrow region is devoid of ridges. There is very thin layer of fat between the bladder and the lateral cutaneous areas towards the posterior end of the latter, but towards its anterior end the fat layer is absent, and consequently the skin comes in contact with the bladder in that region.

3. *Size of specimen : 181 mm. in total length* (Text-fig. 3, *a* and *b*).

In the anterior portion of the bladder, there are a number of secondary transverse septa (*ts.*[1]) and root-like fibrous growths (*rf.*). The annular ridges (*ar.*) along the sides are more numerous. Practically everywhere,



Text-fig. 3.—Air-bladder of a specimen of *Pangasius pangasius* (Ham.) 181 mm. in total length. $\times 2\frac{7}{10}$.

a. Dorsal half. *b*. Ventral half.
For lettering see explanation of text-figure 1.

the walls of the bladder are thickened. Even the anterior chamber (*ac.*) is invaded by the fibrous roots of the primary transverse septum (*ts.*). In this stage the primary longitudinal septum (*ls.*) arises from the left extremity of the transverse septum, and not from the middle

of it, as is generally the case. The longitudinal septum, at this stage, extends into the cavity of the caecum for a very short distance.

The tubular caecum (*pc.*) originates entirely from the left half of the bladder instead of from the median point. It is covered on the sides by fairly thick layers of fat and extends as far as the base of the ventral fins. The walls of the caecum are strengthened by a number of annular ridges (*ar.*). A short distance in front of the posterior end, the wall on one side of the caecum is constricted. This may be an indication for the formation of an additional chamber.

There is a thin layer of fat between the walls of the bladder and the lateral cutaneous areas so that the walls are not directly in contact with the skin. There is an uneven layer of fat which covers the whole of the ventral surface of the bladder and a portion of the dorsal surface as well. The posterior half of the anterior portion of the bladder is somewhat compressed, probably owing to the lateral pressure exerted by the kidneys.

Judging from Bridge and Haddon's[1] description of the bladder, it seems probable that they had a specimen intermediate in size between the last two stages described above.

4. *Size of specimen : 205 mm. in total length.*

The air-bladder of a specimen 205 mm. in total length is similar in shape to the one described above, with the exception that the transverse septa, root-like fibres, and the length of the caecum are more pronounced. The tubular caecum extends backward to a fourth of the length of the anal fin and is externally divided into three chambers. The caecum is very much strengthened by annular ridges.

Day's[2] description of the air-bladder appears to correspond with the above description to a great extent.

5. *Size of specimen : 303 mm. in total length* (Text-fig. 4, *a* and *b*).

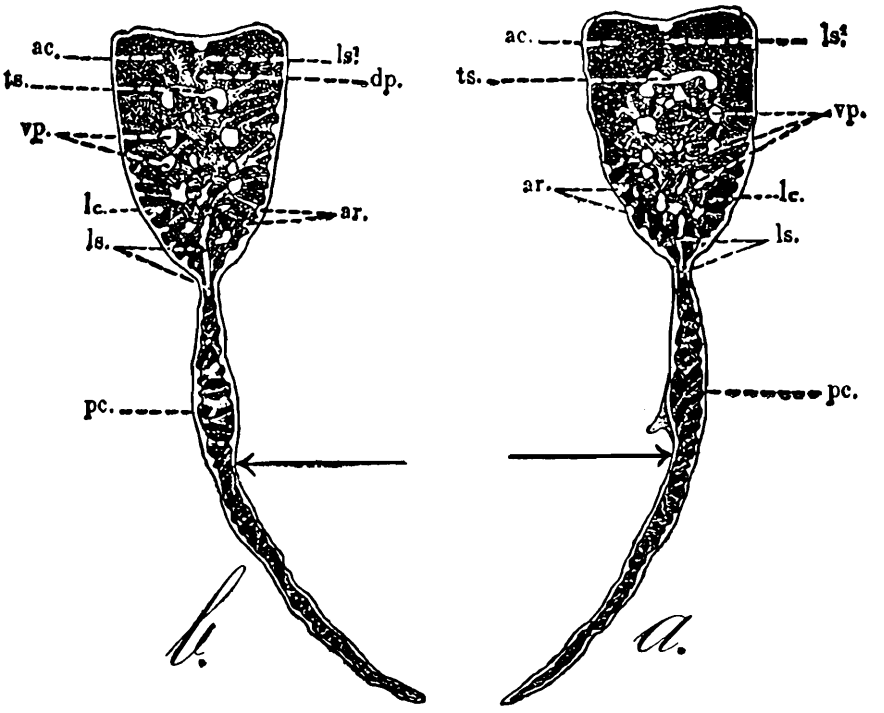
In a specimen 303 mm. in length, the air-bladder is long and narrow ; its walls are thick and hard. The anterior chamber (*ac.*) is very narrow and the lateral chambers (*lc.*) are filled with annular ridges (*ar.*) and fibrous thickenings. The longitudinal septum is absent as such, but it is broken up into a number of vertical pillars (*vp.*) which fill up the space inside the bladder. The longitudinal septum (*ls.*) is present only near the junction of the two portions of the bladder.

The tubular caecum is very long, about twice the length of the anterior portion of the bladder. The posterior half of the caecum is lodged within the ventral caudal musculature and the end of the caecum extends backward to more than a fourth of the length of the anal fin. The cavity of the caecum is almost filled by annular ridges, transverse and longitudinal thickenings.

There is a thin layer of fat between the walls of the bladder and the lateral cutaneous areas. A layer of fat is also present on the ventral surface of the bladder. The caecum gives off a spine-like projection from its dorsal wall, at about its middle. The dorsal half of the bladder

[1] Bridge and Haddon, *Trans. Roy. Soc. London*, (B), CLXXXIV, pp. 214-219 (1894).
[2] Day, *Proc. Zool. Soc. London*, p. 709 (1871).

(fig. 4, *a*) is comparatively less invaded by the fibrous thickenings and annular ridges.



TEXT-FIG. 4.—Air-bladder of a specimen of *Pangasius pangasius* (Ham.) 303 mm. in total length. ×⅘. The portion of the caecum, beyond the arrow is accommodated in the caudal muscles.

a. Dorsal half. *b*. Ventral half.
For lettering see explanation of text-figure 1.

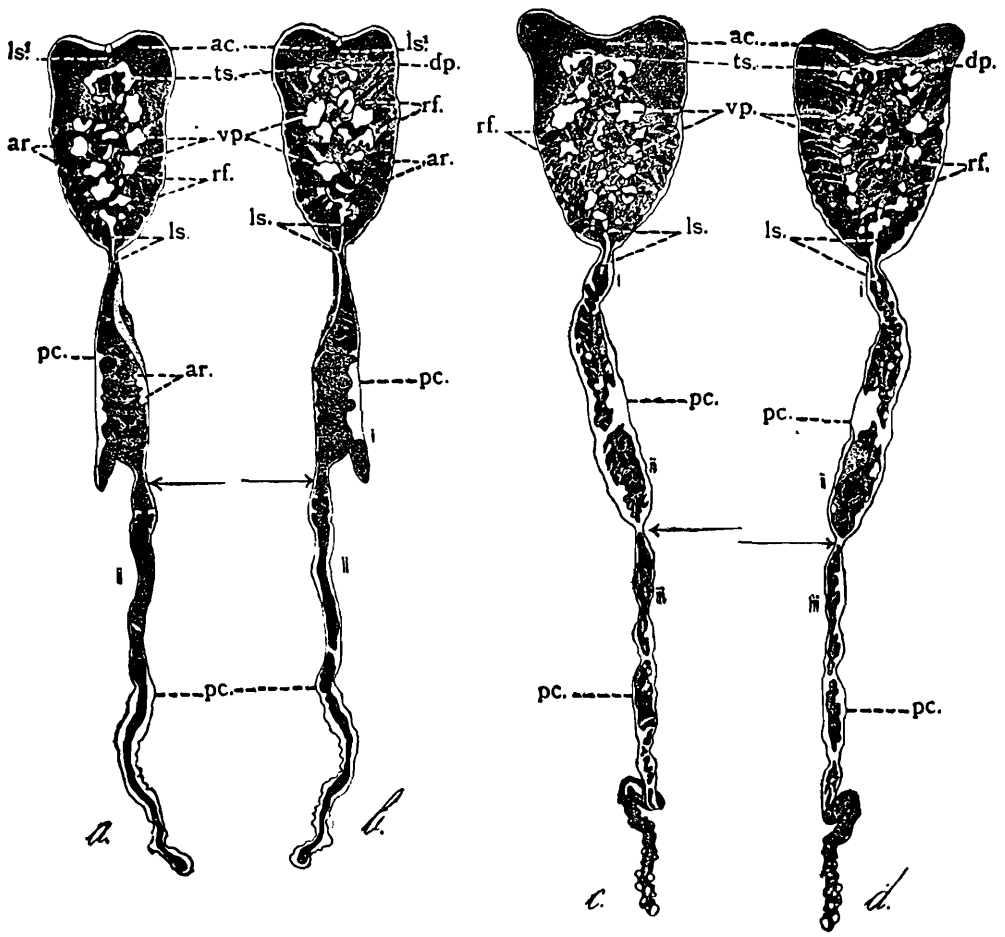
6. *Size of specimen : 353 mm. in total length.*

The air-bladder of this specimen is similar in all details to the one described above with the exception that the tubular caecum is definitely divided into two separate chambers by a constriction of the walls of the caecum. The caecum, which is folded on itself towards the posterior end, as shown in the case of the last stage, extends backward as far as the posterior end of the anal fin. The portion of the caecum, which is lodged in the muscles of the tail, is comparatively harder than the rest of it.

7. *Size of specimen : 460 mm. in total length* (Text-fig. 5, *a* and *b*).

The anterior chamber (*ac.*) is very narrow. The primary transverse septum (*ts.*) is very broad, and including its fibrous roots it is nearly as broad as the anterior chamber. There are no lateral compartments as such, for the space is filled by stout vertical pillars (*vp.*). These vertical pillars are roughly arranged in three rows, and probably represent the longitudinal septum in the middle and the end portions of the secondary transverse septa at the sides. A small portion of the longitudinal septum (*ls.*), the only remaining representative of the original primary longitudinal septum, extends into the caecum. The secondary longitudinal septum (*ls.*¹) is still represented here in a degenerating stage. The fact that it is degenerating is clearly shown by its absence in a bladder of a larger specimen, as shown below. There are very stout annular ridges (*ar.*) along the sides which strengthen the walls of the

bladder. In the dorsal half of the bladder (fig. 5, *a*) there are two regions along the sides, towards the anterior end which have a free space. These



TEXT-FIG. 5. *a.* & *b.*—Air-bladder of a specimen of *Pangasius pangasius* (Ham.) 460 mm. in total length. × ⅔. *a.* Dorsal half. *b.* Ventral half.

c. & *d.* Air-bladder of another specimen of *Pangasius pangasius* (Ham.) 885 mm. in total length. × $\frac{3}{10}$. *c.* Dorsal half. *d.* Ventral half.

The portion of the caecum, beyond the arrow is accommodated in the caudal muscles.

For lettering see explanation of text-figure 1.

portions bulge upward and are accommodated in bony recesses on the sides of the vertebral column.

The tubular caecum (*pc.*) is covered by a layer of fat for about half of its length, and extends as far back as three-fourths of the length of the anal fin. About the middle of its length, it gives off a short blind caecum towards the right side. The caecum at this stage is much complicated and is divided into more than one chamber. Of these chambers, only the first two (i and ii) are connected internally with each other and with the anterior portion of the bladder as well. There are numerous annular ridges (*ar.*) and other thickenings on the walls. The caecum is very long, shallow and tough, with the walls greatly thickened. Towards its posterior end, there are two places where the caecum is somewhat compressed.

There is a layer of fat between the walls of the bladder and the lateral cutaneous areas. The ventral surface of the bladder is covered by a

thick layer of fat which extends to half of the dorsal surface as well. The cavity of the pneumatic duct towards the oesophageal end is almost obliterated by the development of fibrous tissue from its walls. The bladder is relatively narrower and harder.

8. *Size of specimen : 536 mm. in total length.*

The structure of the air-bladder of a specimen 536 mm. in total length agrees, more or less, with the above description, except that the secondary longitudinal septum is altogether absent, and the caecum is definitely divided into two separate chambers, one broad and the other narrow. The whole of the narrow chamber is lodged in the caudal muscles. The caecum extends backward to about four-fifths the length of the anal fin. The walls of the bladder and the caecum are very hard and tough.

9. *Size of specimen : 885 mm. in total length* (Text-fig. 5, *c* and *d*).

The anterior wall of the bladder has a tendency to fatty degeneration. The anterior portion of the bladder is oval in shape with posterior end slightly narrower. The short, but broad anterior chamber (*ac.*), is greatly reduced. The primary transverse septum (*ts.*) is not fully developed and lies immediately behind the anterior wall of the bladder. The secondary longitudinal septum is absent. The walls of the bladder are strengthened by annular ridges (*ar.*) and are very hard to the touch. A small length of the greatly reduced longitudinal septum (*ls.*) extends into the cavity of the caecum.

The posterior portion of the bladder (*pc.*) is very long and reaches almost to the end of the tail region. It is accommodated in the ventral caudal muscles which are very closely applied to it. The walls of the caecum are very thick and the cavity inside is nearly filled by a number of strong and stout ridges which arise without any orderly arrangement. Towards the posterior end, the caecum is folded on itself, and the outer walls are covered with many stout and strong knobs. The caecum may apparently be divided into eight chambers; only the first three (i, ii and iii) are in communication with one another, and with the anterior portion of the bladder. The other chambers of the caecum are variously filled with fibrous growths.

There is a layer of fat between the walls of the bladder and the lateral cutaneous areas. The ventral wall of the bladder is closely attached to the dorsal wall of the abdominal cavity. The anterior portion of the bladder is white and shining while the caecum is dirty white in appearance. The oval plates of the "elastic spring" apparatus are well accommodated in the two hollow spaces developed on the anterior wall of the bladder. These spaces are very thin though the whole bladder is very hard to the touch. The pneumatic duct has an opening (*dp.*) into the bladder, but its opening to the oesophagus is not clear. However, a very small hole, not larger than a pinprick, is seen on the wall of the oesophagus.

Judging from Taylor's[1] description of the bladder, it seems probable that he had a specimen intermediate in size between the last two stages described above.

[1] Taylor, *Gleanings in Science*, p. 171 (1830).