CONTRIBUTIONS TO OUR KNOWLEDGE OF THE PYLORIC CÆCA IN THREE FAMILIES OF FRESH-WATER INDIAN FISHES (OPHICEPHALIDÆ, NOTOPTERIDÆ AND MASTACEMBELIDÆ), TOGETHER WITH SOME REMARKS ON THEIR PROBABLE FUNCTIONS

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With 1 Plate and 4 Text-Figures

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1. Introductory

REFERENCES to up-to-date literature revealed that so far no regular work has been attempted on the pyloric cæca in the fresh-water fishes of India, and it is for this reason that my former teacher and colleague, Professor

The term pyloric cæca is retained throughout, though actually these structures arise from the duodenum.

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B. K. Das of the Osmania University, suggested to me that it would be worthwhile to work out fully and to make a thorough comparative and systematic study and survey of these organs (and later on their physiology) in fishes of our own waters. From certain stray accounts it has been gathered that these structures have just been casually mentioned to be present in some 31 families of Indian fishes, including nearly 76 genera and about three times as many species, most of which are marine, some estuarine and a few fresh-water forms.

After consulting the relevant literature one would find that the structure (and to some extent the physiology) of the pyloric caeca has been briefly described by a handful of workers only, amongst which the most notable ones are Rosenthal (1824), Hyrtl (1864), Blanchard (1882), Stirling (1884), Fr. Day (1887), Bondouy (1897-99), Johnson (1907), Kostanecki (1913) and Dharmarajan (1936), whose works have been reviewed in this paper. Acting on Professor Das’s suggestion I have first of all worked out the structures of these caeca in four species of the family Ophicephalidae, and then one of Notopteridae and three of Mastacembelidae, thus making a total of eight species of fresh-water fishes commonly met with in Hyderabad, and the results of nearly a year’s work of mine are embodied in the following pages.

2. Historical Summary

There are but a few small papers dealing with the account of the pyloric caeca in teleostean fishes:

In 1824 Rosenthal has just touched upon the condition of the pyloric caeca in the Sword-fish without giving any figure. Hyrtl (1864) has shown a very curious disposition and the mode of opening of the bile duct actually into the “appendices pyloricae” in Fistularia, Aulostoma and Acanthurus—there being a single caecum in Fistularia, two in Aulostoma and six in Acanthurus. The account given by Johnson (1907) is, however, an interesting one in which he has referred to “The individuality and variation of the pyloric caeca of the Centrarchidae”. The main object of his contribution is just to show that the pyloric caeca of certain members of this particular family, viz., the Sun-fish, Lepomis, Black Bass, Micropterus, etc., are not similar, as generally assumed, but that they differ considerably in number and form: in other words, they show a lot of individual variations in a single family, that is to say, the pyloric caeca have an individuality of their own in every species of fish. Here the caeca vary in number, usually from 6 to 19, but in Micropterus they may be considerably branched, and these branches may be as many as 28.
In every case fresh material for histological study was obtained after pithing the live fish. In order to have a perfect fixation and preservation, both internally and externally, the two pyloric caeca were first of all injected with Bouin's fluid until they were quite turgid from the oesophageal side with the help of a small syringe after cutting off the oesophagus and inserting the nozzle at its distal end, and then finishing off the operation by giving two ligatures after fluid had run inside the whole length of the alimentary canal quite satisfactorily—one knot was tied at the remote end of the oesophagus and the other at the proximal end of the ileum slightly behind the caeca. The caeca and the associated parts of the gut were then removed and preserved in the same fluid for 8–24 hours. After having carefully dissected out the caeca from the surrounding tissues, each, as a rule, was cut into three portions, viz., the proximal, the middle and the distal segments (except in the case of the Mastacembelidae, in which the two caeca, being very small and very closely situated together, have been treated as a whole). Each piece of the caeca as also other parts of the alimentary canal were imbedded separately in paraffin blocks, and serial sections (both transverse and longitudinal), from 6 to 8 \( \mu \) thick, were cut. They were variously stained, such as, for instance, in picro-indigo-carmine, Mallory's triple, Heidenhain's iron-haematoxylin, and Delafield's haematoxylin counterstained with eosin. Several freehand and camera lucida sketches were made, and many photomicrographs have also been taken and compared.

It is my most pleasant duty to record my sincere thanks here to Professor Dr. A. Subba Rau, B.A., D.Sc. (London), F.R.M.S., Principal and Head of the Zoology Department of the Central College, Bangalore, for his kindly going through the MS. and making some very useful suggestions as well as for accepting the paper for publication in this journal. I am very grateful to Professor R. Gopala Aiyar, Director of the Madras University Zoological Research Laboratory, for his kind help and friendly criticisms. I am also grateful to Professor B. K. Das for his help and guidance. I am very thankful to Professor A. B. Misra of the Benares Hindu University for certain valuable advice.

4. The Pyloric Caeca of Ophicephalus striatus Bl. as a Type

(a) Topography and Morphology.—As an example of the typical condition of the pyloric caeca, mention may first of all be made of Ophicephalus striatus Bl., the “Murrel” (the second largest member of the Fam. Ophicephalidae), a fish which is very commonly found in Hyderabad. In this fish, there are two fairly large caeca (right and left, Text-Fig. 1, a and b, Bla
Text-Fig. 1 (a). Dissection of *Ophicephalus striatus* from the ventral aspect, showing the pyloric cæca *in situ* ($\times 1\frac{1}{2}$). 1 (b). Alimentary canal of the same fish unravelled, showing the disposition of the cæca ($\times 1\frac{1}{2}$).  

Text-Fig. 2. Anterior portion of the alimentary canal of *Notopterus notopterus* unravelled, showing the disposition of the cæca ($\times 2$).  

Text-Fig. 3. Alimentary canal of *Mastacembelus armatus* unravelled, showing the disposition of the cæca ($\times 2$).  

Text-Fig. 4. Ditto of *Fistularia villosa*, showing the disposition of the single cæcum ($\times 3$).
R. cae. and L. cae.) which are tubular, digitiform structures arising just from the commencement of the small intestine; that is to say, immediately behind the pylorus (Pyl.) which is quite short. The bile-duct (Bl. dc.) often opens immediately behind the origin of the right cæcum, or sometimes in the very narrow interspace between the right and the left cæca. The right cæcum is usually somewhat smaller in size than the left one. The intestinal orifice of each cæcum is quite distinct though very small, but, unlike that of the rectal gland of Selachian fishes where there is a valve, it is unguarded by any valvular structure.

The cæca are invariably filled with some semi-digested food-material mixed up with a small quantity of mucous, and in certain rare cases some bile also. There is a large amount of fat (F.tis.) that conceals the greater portion of these cæca.

The intestine of this carnivorous fish, as one would naturally expect, is of a simple type and bears two loops—one at the anterior end (Ant. lp.) and the other at the posterior end (Post. lp.). Further, it is interesting to compare the relative lengths of the various parts of the alimentary canal with those of the cæca, and the ratios may be stated as follows:

Cæca : Intestine, and Cæca : whole length of the alimentary canal

\[ \frac{1:3.9}{1:3.2} R \] \[ \frac{1:5.2}{1:4.2} L \]

respectively, where R denotes the right cæcum and L the left cæcum, and the length of the cæcum (either of the right side, or of the left side) has, in each case, been taken to represent as a unit.

(b) Blood- and Nerve-Supplies.—The blood-supply is quite interesting in a way that the coeliaco-mesenteric artery arises from the right side of the dorsal aorta and divides into three main branches:

1. Gastric artery going to the stomach.
2. Cæcal artery bifurcating into two smaller twigs, and supplying the right and the left cæca.
3. Anterior mesenteric artery supplying the proximal part of the intestine.

The blood is returned from these cæca by means of two factors, viz.,

1. The cæcal vein draining blood from the right and left cæca and emptying itself into the Hepatic Portal vein. Into each of these cæcal factors veins from the stomach also open.
2. A small vein arising independently from the right cæcum and dipping into one of the tributaries of the Hepatic Portal vein.
As regards the nerve-supply it is worthy of note that the visceral branch of the right Vagus divides into four small branches, viz., the cardiac, gastric, intestinal and cæcal, supplying the heart, stomach, intestine and the two cæca respectively, whereas the left visceral has no cæcal branch, but in other respects it is exactly like its right counterpart.

(c) Histology.—After a careful examination and study of a large series of transverse and longitudinal sections of the pyloric cæca the following histological details add a great interest to our knowledge, and may be briefly mentioned thus—here the figures of *Ophicephalus marulius* Ham. have been given merely for the sake of convenience:—

(1) Roughly speaking, the internal structure of the proximal region of the pyloric cæca (Pl. IV, Fig. 2) is pretty similar to and built upon the same general plan as that of the small intestine (Pl. IV, Fig. 1).

(2) The cæcal villi (Pl. IV, *Cæ. vil.*, *i.e.*, the folds of the mucosa of the cæcum) are, as a rule, very prominent and extend for a considerable distance inside the cæcal lumen.

(3) The various layers which compose the wall of the cæcum, from without inwards, are (Pl. IV, Fig. 2):—

(i) Serous coat = visceral peritoneum (*Ser.*).

(ii) Layer of longitudinal muscle-fibres (*Long. musc.*) = thin envelope.

(iii) Layer of circular muscle-fibres (*Circ. musc.*) often twice or three times as thick as No. (ii).

(iv) Sub-mucosa (*Sub. muco.*) consisting of connective-tissue, some blood-capillaries (*Bl. cap.*) and nerve fibres.

(v) Mucosa usually consisting of a two- or three-cell deep layer, made up mostly of columnar or stratified epithelial cells amongst which a large number of goblet cells are also to be found. It is thrown into a very large number of deep folds which form finger-like structures (or the "cæcal villi", *Cæ. vil.*) penetrating into the cæcal lumen—the central core of each "cæcal villus" is highly vascular, having many fine blood-capillaries which traverse and extend up to its distal end, and probably thus increase the absorptive surface of the cæcum.

Curiously enough, in the distal region of each cæcum (Pl. IV, Figs. 3 & 5) the "cæcal villi" grow in size and multiply tremendously, interdigitate and fuse with one another thus presenting the appearance of a sort of spongy structure (or what has been designated here as "spongy-tissue", *Int. dig.*
muc. fl.) filling up and practically obliterating the whole of the caecal lumen (Cæ. lum.) in other words, this sort of excessive branching and highly folded arrangement of the "caecal villi" evidently provides greater area for the absorption of the digested soluble food in this region of the caecum.

5. Condition of the Cæca in Some other Fresh-Water Indian Fishes

(A) Other Species of the Family Ophicephalidae:

In the other three species of the family Ophicephalidae which have been investigated, viz., Ophicephalus marulius Ham. (the largest species), O. punctatus Bl., O. gachua Ham. (the smallest species), the general structure of the cæca (together with their blood- and nerve-supplies) is practically just the same as that described for O. striatus Bl., but there are a few minor variations which may be very briefly pointed out as follows:—

(1) The pyloric cæca are club-shaped in O. punctatus, whereas they are of a tapering nature in O. gachua.

(2) The various ratios of the cæca for the other three species, as those described above for O. striatus, are:—

(i) O. marulius = \( \frac{1:6.2}{1:5.2} \) R and \( \frac{1:8.7}{1:7.3} \) L respectively,

(ii) O. punctatus = \( \frac{1:6.6}{1:4.8} \) R and \( \frac{1:8.6}{1:6.2} \) L respectively, and

(iii) O. gachua = \( \frac{1:7.1}{1:5.7} \) R and \( \frac{1:8.5}{1:6.8} \) L respectively.

(R and L, wherever being used, always signify right and left cæca as in the case of O. striatus.)

(3) The "caecal villi" of O. punctatus are relatively very large—they are nearly twice the size of the "intestinal villi".

(4) The simplest type of "caecal villi" are to be found in the smallest species of this family, viz., O. gachua, in which they do not multiply and fuse together in the distal region of the cæcum (Pl. IV, Fig. 4) as they do in all other species of the Ophicephalidae as well as in most other fishes that I have studied so far.

(B) Notopterus notopterus (Pallas):

(a) Topography and Morphology.—In this fish the whole of the alimentary canal is relatively very short (Text-Fig. 2). The intestine (Int.) lies below the large gas-bladder and is thrown into a semi-circular loop with the
convex surface directed upwards. There are two curved conical caeca,* one of which is dorsal in position (D. ca.), and the other ventral (V. ca.), the former being bigger than the latter, and both lying hidden between the globular stomach (St.) and the intestine (Int.), and running closely parallel to the latter. The pylorus (Pyl.) is very small.

The ratio of the lengths of the dorsal and the ventral caeca: intestine = 1:2.5 and 1:4 respectively (the length of either of the caeca being taken as a unit). Ditto dorsal and ventral caeca: whole length of the alimentary tract = 1:3 and 1:5 respectively.

(b) Blood- and Nerve-Supplies.—(1) The cæliaco-mesenteric artery gives off three branches:—

(i) Intestinal—supplying the whole of the intestine.
(ii) Gastric—supplying the stomach and also sending a small branch to the posterior part of the dorsal caecum.
(iii) Cæcal artery divides into two branches: one going to the dorsal caecum and the other to the ventral.

(2) The blood is drained from the cæca by two ways:

(i) Two cæcal veins bring back blood independently from the dorsal and the ventral cæca and ultimately join the Hepatic Portal vein.
(ii) Small veins draining blood from the posterior ends of both the cæca and falling into the intestinal factor of the Hepatic Portal.

As regards the nerve-supply it may be mentioned that the visceral branch of the left Vagus, unlike the previous case, innervates the stomach and the two cæca, whereas its right counterpart sends off twigs to the intestine and the dorsal caecum only.

(c) Histology.—The salient features in the histology of the caecum of Notopterus as distinguished from those of the ophicephalids are as follows:

(1) Elongated digitiform “cæcal villi” and several large goblet cells are present in the cæcal epithelium towards the Proximal and the Mid-regions of the caecum.

(2) In the distal region of the cæcum, however, the “villi” do not proliferate so copiously as they do in the Ophicephalidæ, but most of them penetrate inwards towards the centre of the cæcal lumen, and some of them also unite with one another (Int. dig. muc. fl.—Pl. IV, Fig. 5), forming many narrow inter-communicating passages or channels (Ch.) inside the cæcal

* In this figure the cæca are displayed after being straightened out.
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lumen—all these modifications are evidently meant to increase the absorptive surface of the cæcum.

(C) Various Species of the Family Mastacembelidæ:

Three members of this family, viz., Rhynchobdella aculeata (Bloch), Mastacembelus armatus (Lacep.) and M. pancaless (Ham.) have been studied, but here I shall confine myself in describing the condition in Mastacembelus armatus (Text-Fig. 3) as a typical case, which agrees with the other two species practically in all essential respects.

(a) Topography and Morphology.—In M. armatus (as also in the other two species of this family) there are two cæca (right and left, Text-Fig. 3, R. cæ. and L. cæ. respectively) which are relatively very small as compared with those of Notopterus notopterus (Pall.) and the several species of the Fam. Ophicephalidæ. They are short, stumpy, finger-like structures originating from the junction of the duodenum with the pylorus (Pyl.) and to some extent adhering to the sides of the latter. They are practically equal in size, but sometimes the left cæcum may be just slightly bigger than the right one.

The ratio of the length of any one of the two cæca (right or left—both being regarded to be of equal size): intestine = 1:14.6, and the cæcum: whole length of the alimentary tract = 1:25:0 (length of either cæcum representing a unit as in previous cases).

(b) Blood- and Nerve-Supplies.—(1) The cœliaco-mesenteric artery gives off 4 branches:

(i) Gastric—supplying the stomach.
(ii) Intestinal—supplying the intestine.
(iii & iv) Two independent cæcal arteries, and supplying the right and the left cæca.

(2) The blood is returned from both the right and the left cæca by a single cæcal vein which joins the intestinal factor of the Hepatic Portal vein.

Regarding the nerve-supply it may be mentioned that the right visceral branch of the Vagus, as in the Ophicephalidæ, sends off small branches to both the cæca, the stomach and the intestine, whereas its left counterpart mainly innervates the stomach and the mesentery.

(c) Histology.—In the distal region of the pyloric cæca of the Fam. Mastacembelidæ the "cæcal villi" (Pl. IV, Fig. 6) are comparatively more developed than in the Notopteridæ: here they form a lot of infoldings and interdigitation and are all compacted together, having the "villi" massed up side by side in a slightly oblique manner, and roughly presenting the appearance
of a small gland. Not infrequently, however, the mucous folds also unite with one another, chiefly towards the posteriormost part of the cæcum, as observed in other fishes, thus increasing its absorptive surface. Another noteworthy fact is that only a few goblet cells are present along the lumen epithelium of this group.

As far as histological structures are concerned in the other two species, viz., _M. pancalus_ and _R. aculeata_, it is worthwhile to remember that there is no deviation from the typical condition as just described above in the case of _M. armatus_.

6. Discussion

Here, I will just deal very briefly with the nature and significance of the pyloric cæca in a summarised form as they exist in various groups of fishes in general:

(1) The pyloric cæca are absent in Cyclostomata, Dipnoi, and practically in all Elasmobranchs, but there is a considerable variation as to the number, form and structure of these cæca in various members of the Teleostomi, some of which are already described in most of the text-books on fishes. A very good summarised comparative account of these cæca in fishes, found outside India, is given in _Handbuch der Vergleichenden Anatomic der Wirbeltiere_, Vol. III (1937), by Pernkopf, Lehner and Jacobshagen.

(2) For instance, amongst the Ganoids the pyloric cæca are absent in the Bow-fin (_Amia_). In the "Bichir" (_Polypterus_) there is a single cæcum whereas in other members of this group, viz., Sturgeon (_Acipenser_), Spoon-bill (_Polyodon_), and Gar-pike (_Lepidosteus_) the cæca are very well developed.

(3) Again, in certain groups of Teleosts, the cæca are entirely absent as, for example, in the Cat-fishes (_Siluridae_), Pikes (_Esocidae_), Toothed-carps (_Cyprinodontidae_), Wrasses (_Labridae_), Plectognathi including the Globe-fishes, the Porcupine-fishes and lastly in the Pipe-fishes (_Syngnathidae_).

(4) Whilst in some others, including both the European as well as the Indian types, the cæca may be very numerous (i.e., at least more than 50) as, for example, in Salmon (_Salmo_), whiting (_Gadus merlangus_), Mackerel (_Scomber scombrus_), and certain Clupeidae. They may be many in number as in the "White Pomfret" (_Stromateus sinensis_), _Sphyraena_, the "Hairstail" (_Trichurus_), the "Pompano" (_Caranx_), etc.; moderate number (e.g., 16) in the so-called "Bombay Duck" (_Harpodon_); 5-7 in _Acanthurus_; 3-5 in certain Pleuronectids; only a few (3, for example) in _Premnas_ and _Tetradrachnum_ (Fam. Glyphidodontidae); two in _Notopterus_, Ophicephalids, Sand-eels (_Mastacembelidae_), the "Gourami"; (_Osphronemus_), etc.;
and only one in *Fistularia villosa* (Fam. Fistulariidae, Text-Fig. 4), and besides these, there are, of course, several other genera and species that are not mentioned here—it would be too cumbersome a list to deal with all of them in the limited space at present.

(5) It is also very interesting to note that in certain extreme cases, *e.g.*, Sturgeon, Whiting and Tunny (*Thunnus thynnus*) where the cæca are not only numerous, but most of them (or in some cases, all of them) are also united together by means of connective tissue to form a compact, gland-like mass communicating with the intestine, either by a *single* wide duct (as in Sturgeon) or by *several* small orifices as in other examples. Such a condition of the pyloric cæca would naturally lead to the assumption that probably they have some sort of secretory function, supplementing the actions of the digestive glands, such as the liver and the pancreas. At any rate one might say that such cæca must be of some important use in connection with the digestive functions of the fish in which they occur and have assumed such a compact, gland-like character. In other words, in such cases they may be said to represent aaccessory digestive glands.

7. Summary and General Conclusions

(1) The pyloric cæca are true outgrowths of the *proximal* portion of the small intestine (*i.e.*, the duodenum), as has been corroborated by their histological structure, and hence the name pyloric cæca is really a misnomer: the correct name for them should be "intestinal cæca".

(2) They should not be mixed up with the "cæcal" or "rectal gland" of Selachian fishes, which has been so thoroughly worked out by Miss D. R. Crofts in recent years (cf. P.Z.S., 1925). *That is to say they are not homologous with the "cæcal" (or "rectal gland") of Selachian fishes, nor with any other cæcal outgrowth of other vertebrates, because all such latter structures take their origin between the large and the small intestine, whereas the pyloric cæca are given off immediately behind the pylorus as true outgrowths of the first part of the ileum.*

(3) From the presence and nature of the semi-digested liquid food-contents inside the lumen of the pyloric cæcum and the opening of the latter into the ileum as well as in due consideration of a fairly large amount of vascular supply (particularly the drainage of the blood into the portal system) and also in due recognition of the significance of the very structure of those copiously distributed digitiform "cæcal villi", comparable to the true intestinal villi, the following physiological functions may possibly be attributed to them:—
(a) Might serve as accessory food-reservoirs in these fishes—the intestine in most of these fishes being of shorter lengths (so far investigated), but this fact could not be generalised yet until a very large number of fishes has been thoroughly examined.

(b) Probably a part of digestion might take place.

(c) Some absorption of the digested food may probably also take place (cf. from the nature of the highly vascular "caecal villi").

(d) According to some authors (Mordacai, 1882; Blanchard, 1882; Stirling, 1884; and Bondouy, 1897 and 1899), who have worked on the physiology of pyloric caeca in certain other fishes, the following probable functions have been assigned to them:

That they are said to produce diastatic and trypsin-like enzymes which effect some digestion of the carbohydrates and the proteids, and thus help and supplement the digestive processes of other juices poured into the alimentary canal. (I have, however, no sufficient physiological data at my disposal just at present to fully test and justify the validity of this statement and, at any rate, I am presently engaged in carrying on a series of physiological experiments and biochemical tests on the contents of the pyloric caeca, and my results will shortly be communicated in later papers.

(e) It is not yet quite certain if diet has really any marked effect or influence on the relative size and structure of these caeca, and this point can only be definitely settled when a very large number of fishes, belonging to various families and living in different environment (and having different diet) has been thoroughly investigated, especially from this point of view—at this stage, in absence of any further data, it would rather be too hazardous to speculate anything.

(f) It is also very doubtful whether the number and nature of the pyloric caeca are of any taxonomic value in the study of fishes—this point could also be elucidated after a thorough systematic examination of a very large number of different species and families of fishes with which I am engaged at present.

REFERENCES TO LITERATURE


Pyloric Cæca in Three Families of Fresh-Water Indian Fishes


Bridge, T. W. .. Fishes, C. N. H. Series, 1922.


Dawes, Ben .. "The Histology of the Alimentary Tract of the Plaice (Pleuro-nectes platessa)," Q.J.M.S., 1930, 73, No. 290.


Kyle, H. M. .. The Biology of Fishes, 1926.

Norman, J. R. .. A History of Fishes, 1931.


Panicker, M. K. N. .. "Histology of the Alimentary tract of Therapon quadrilineatus;" in MS.


**EXPLANATION OF PLATE**

Fig. 1. Camera lucida sketch of a part of the transverse section of the intestine of *Ophicephalus marulius*, showing the very prominent "intestinal villi".

Fig. 2. Ditto of the proximal region of the pyloric caecum of the same fish, showing the very prominent "caecal villi".

Fig. 3. Photomicrograph of the transverse section of the distal region of the pyloric caecum of the same fish, showing the tremendous interdigation and fusion of the "caecal villi" to form a sort of "spongy tissue".

Fig. 4. Camera lucida sketch of the transverse section of the distal region of the pyloric caecum of *Ophicephalus gachua*, showing very simple arrangement of the "caecal villi".

Fig. 5. Photomicrograph of the transverse section of the distal region of the pyloric caecum of *Notopterus notopterus*, showing the fusion of the "caecal villi" and the formation of the intercommunicating channels.

Fig. 6. Ditto of *Mastacembelus armatus*, showing the compact gland-like arrangement of the "caecal villi".

**EXPLANATION OF THE ABBREVIATIONS USED IN THE TEXT-FIGURES AND THE PLATE**

*Abd. cav.*, Abdominal cavity; *Ant. lp.*, Anterior loop; *Bl. cap.*, Blood capillaries; *Bl. dc.*, Bile duct; *Ca.*, Caecum; *Ca. lurn.*, Caecal lumen; *Ca. pr.*, Proliferating "villi" of the caecum; *Ca. v.*, The so-called caecal villi; *Ch.*, Inter-communicating channels inside the caecal lumen; *Circ. musc.*, Layer of circular muscle fibres; *D. Ca.*, Dorsal caecum; *F. tis.*, Adipose tissue; *Gl. bl.*, Gall-bladder; *Int.*, Intestine; *Int. dig. muc. fl.*, Interdigitation and fusion of the mucous folds of the caecum; *Int. vil.*, the so-called intestinal villi; *L. Ca.*, Left caecum; *Liv.*, Liver; *Long. musc.*, Layer of longitudinal muscle fibres; *Mus.*, Muscles; *Oes.*, Oesophagus; *Ov.*, Ovary; *Post. lp.*, Posterior loop; *Pyl.*, Pylorus; *R. Ca.*, Right caecum; *Ser.*, Serosa; *St.*, Stomach; *Sub. muco.*, Sub-mucosa; *V. Ca.*, Ventral caecum.