SEXUALLY MATURE LARVAL HEMIRAMPHIDAE FROM THE HAWAIIAN ISLANDS

BY
OTTO SCHINDLER

BERNICE P. BISHOP MUSEUM
BULLETIN 97

HONOLULU, HAWAII
PUBLISHED BY THE MUSEUM
OCTOBER, 1932

KRAUS REPRINT CO.
Millwood, New York
1974

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Printed in U.S.A.

Sexually Mature Larval Hemiramphidae from the Hawaiian Islands

By Otto Schindler[1]

INTRODUCTION

In the abundant collection of larval fishes which Dr. Victor Pietschmann brought to Vienna from his collecting trip in the vicinity of the Hawaiian islands in 1928, were found a great number of larval Hemiramphidae. These were kindly given by him to me to determine. It became evident in the course of this determination not only that these forms differ in many respects from *Hemiramphus brasiliensis* native to this locality, but also that as to their internal structure, very interesting conditions appear, deviating from those previously known, which seem to justify a detailed study of these Hemiramphidae.

However, before I begin the discussion of the results of this study I must express to Dr. Jan Versluys, director of the Second Zoological Institute of the University of Vienna, my sincere thanks for the privilege of working in the institute and especially for his valuable assistance and advice. Further I thank particularly Dr. Victor Pietschmann for the assignment of the material to me and his assistance during the development of the work. For special thanks I am also obligated to Dr. Heinrich Joseph who aided me in every respect in the most friendly manner, especially in histological questions and the production of microphotographs.

The exceedingly abundant collection, which contains some hundred specimens, is preserved in formol-alcohol which, as is almost always the case in material collected on expeditions, is not entirely adapted to delicate histological study, from which fact difficulties constantly resulted in the research. Approximately 30 specimens were minutely studied, about as many females as males; in all, however, for purpose of comparison in regard to body length, number of vertebrae, and number of fin-rays about 100 specimens were examined.

[1] Otto Schindler of Vienna presents the second paper of a projected series of publications resulting from investigations of Pacific faunas by Dr. Victor Pietschmann, Bishop Museum Fellow in Yale University 1927-28. The first paper is by Anton Böhm: "Distribution and variability of Ceratium in the northern and western Pacific": B. P. Bishop Mus., Bull. 87, 1931. The manuscripts of both papers were translated from the German by Margaret B. Edmondson.

The material originated from various localities all of which are leeward islands of the Hawaiian group, and was collected either by Dr. V. Pietschmann or William G. Anderson, captain of the fishing boat *Lanikai,* in the period from February to May, 1928. The localities are as follows: Pearl and Hermes Reef (lagoon), February 28, 1928 (Pietschmann), April 16-17, 1928 (Anderson); Lisiansky Island (lagoon, ¾ mile from shore), April 14, 1928 (Anderson); Laysan Island (lee side, ½ mile from the east shore and 1/3 mile west of the shore), May 6, 1928 (Anderson); French Frigates Shoal (lagoon), (1½ miles from Tern Island), May 11, 1928 (Anderson), (½ mile east of Tern Island) May 11-19, 1928 (Anderson). As is here shown, the greater part of the material was taken from lagoons. Only near Laysan Island, from which but a very small number of specimens originated, was the material collected on the open coast. The details of the collection will be given by Dr. Pietschmann himself in his description of the entire material collected on his expedition.

The exhaustive study of this material which was possible, made it appear to me to be well substantiated that the forms studied are specimens of two previously unknown species which I have described briefly under the names of *Hemiramphus praematurus* and *Hemiramphus pietschmanni* (17).[2]

Since a detailed study could not be carried out of objects preserved in 70% alcohol; these objects were stained in toto with picro- or borax-carmine, or haematoxylin, cleared with xylol and embedded for preservation in Canada balsam.

From the study it appeared, as already mentioned, that among the material two species of Hemiramphidae were to be distinguished which were dissimilar especially in the number of pre- and post-anal vertebrae and the number of rays of the anal fin. Even with the naked eye there was distinguishable in both species, whatever the size of single specimens, a certain difference between males and females, the females being always larger.

Right at this point I might mention that there were found among the females of both species not only those with very large, already far developed eggs, but also those whose eggs were yet relatively very small. The small eggs were naturally much less developed. Between these two stages of egg development were found in various specimens transitions in which in the posterior part of the ovaries already some very large eggs were to be seen, while the anterior region contained only quite small ones.

Abbreviations used in illustrations are as follows:

am. Arteria mesenterica.
aor. Anhangsorgan: appendage organ of the male reproductive system.
ao. Aorta.
bg. Bindegewebe: connective tissue.

[2] The numbers in parentheses refer to Literature Cited, p. 28

d. Darm: intestine.
dc. Ductus Cuvieri.
df. Dendritische Figuren: dendritic figures in the egg yolk.
fe. Follikelepithel: follicle epithelium.
gl. Glomerulus.
goe. Geschlechtsöffnung: opening of the reproductive system.
gr. Gerinnsel: clotted mass in the urogenital papilla.
hb. Harnblase: urinary bladder.
bd. Homogener Dotter: homogeneous egg yolk.
hz. Hornzähnchen: denticles.
kb. Kiemenblättchen: gill membranes.
kbl. Keimbläschen: germinal vesicle.
kg. Kiemengefäss: gill duct.
km. Kegelstumpfförmiger muskel: cone-shaped muscle.
le. Leber: liver.
lg. Luftgang: air duct of the swim-bladder.
ly. Lymphoid: lymphoid tissue.
m. Magen: stomach.
mst. Muskelstränge: muscle bands which bind the alimentary canal to the dorsal wall of the body cavity.
nk. Nierenkanal: urinary canal.
ov. Ovarium: ovary.
pa. Pankreas: pancreas.
pao. Palissadenepithel: palisade epithelium of the appendage organ of the male reproductive system.
rm. Rumpfmuskulatur: trunk musculature.
schbl. Schwimmblase: swim-bladder.
t. Testis.
ugp. Urogenitalpapille: urogenital papilla.
vc. Vena cardinalis.
vdf. Vas deferens.
vd. Vakuolärer Dotter: vacuole of egg yolk.
ws. Wirbelsäule: spinal column.
zr. Zona radiata.
* Beginning of the urogenital papilla.

HEMIRAMPHUS PRAEMATURUS

In this species the total length of females varies between 18 and 22.5 mm. and that of males from 14 to 18 mm. If one subtracts the length of the caudal fin, which varies in females between 1.1 and 1.6 mm., in males between 1 and 1.4 mm., then it follows that the body length of females measures 16.9 to 21.3 mm., that of males 13 to 17 mm. Naturally in these measurements it is to be borne in mind that in the larger specimens the caudal fin also is longer. Further measurements are as follows: body height of females, 1.2 to 1.4 mm., of males, 0.85 to 1 mm.; body width of females, 0.5 to 0.7 mm., of males, 0.4 to 0.6 mm.; length of head of females, 2 to 2.3 mm., of males, 1.7 to 2.1 mm. The diameter of eyes measures 0.6 to 0.7 mm.

From these body measurements the previously mentioned greatness of

difference between males and females stands out clearly, and also it is obvious that the body form is very greatly elongated. (See pl. 1, *A*.)

In the whole specimens cleared in xylol are to be recognized 37 to 39 vertebrae, of which the two last generally are not yet entirely developed. One can observe much more clearly in their external form that they are yet in course of development. They are somewhat shorter than the others and their periphery is not so clearly demarked from the surrounding tissue. Posteriorly the spinal column continues as a cartilaginous rod in which no indication of a differentiation into vertebrae is to be seen. At the caudal end this cartilaginous rod is somewhat dorsally curved. (See pl. 1, *A*.) The individual vertebrae are somewhat elongated and, so far as can be recognized, amphicoelous. An ossification or deposit of lime in the vertebrae is not present. In females the number of pre-anal vertebrae amounted to 24 to 25, in males 22 to 24. The number of post-anal vertebrae was between 11 and 14 in both sexes.

The anus lies in females below the twenty-fifth vertebra counted from the head, in males usually below the twenty-fourth, occasionally the twenty-third or twenty-second vertebra. It is found, then, in females one, occasionally two or three, vertebra lengths farther posterior than in males, so that the body cavity of females is somewhat longer than that of males. The very large ovaries obtain thereby a greater space than the less extensive male sex organs. The males exhibit a comparatively large urogenital papilla and are by this easily to be distinguished from the females in which this papilla is lacking. (See pl. 1, *A*.)

The ratio of length of the pre-anal to the post-anal portion (including the tail) in females is approximately as 2:1; in males the post-anal portion stands in slightly longer proportion to the pre-anal than in females, which is consistent with the previously given location of the anus. It does not need to be emphasized that the proportions of length here stated are not entirely constant, since the body proportions especially in larval fishes vary between individual specimens.

The entire body is unpigmented with the exception of a small dark brown to black spot in the level of the sixteenth or seventeenth vertebra and this is a pigment which is found on the caudo-dorsal part of the swim-bladder, to which I shall return later in the description of the latter. Moreover the eyes stand out clearly as black points in the yellowish-white preserved material. In freshly caught condition, so Dr. Pietschmann stated, the fishes appear clear as glass.

I might mention here that I state the place relationships of particular organs in their relation to the vertebrae, and not, as is the otherwise general usage, to the muscle segments. This has its ground in that the vertebrae are

always clearly visible while the muscle segments are often obscure. Consequently in the position with regard to the vertebrae the relationship is much more evident.

The extremely elongated, laterally somewhat compressed body possesses a pair of pectoral fins with 15 to 17 fin-rays. Ventral fins are lacking. The anal fin begins immediately behind the urogenital opening, which in males is developed to a distinct urogenital papilla. The anal fin possesses 11 to 13 rays of which the middle ones are longest, so that the fins appear highest in the middle. The length of the fin-rays decreases posteriorly. The dorsal fin with 16 to 20 rays lies above the anal and reaches, in accordance with the greater number of rays, farther craniad than the latter. The homocercal tail fin possesses 13 rays, which are segmented and, with the exception of the highest and lowest, also forked. Due to the preservation, the extremely thin fin-membrane is generally torn, especially on the dorsal and anal fins.

The number of observable myomeres from the head to the cranial end of the next to last vertebra is usually, according to the number of vertebrae present, 36 to 38. There is always present one myomere less than vertebrae. From the cranial end of the next to last vertebra caudad there is to be distinguished in most specimens no clear demarkation of the body musculature into myomeres. However, the number of myomeres is not always to be determined accurately, since, in the stained and embedded objects the myosepta in these sections of the body are so indistinct that their differentiation is accomplished with the greatest difficulty, and often is not at all possible. They are V-shaped with a short turned-back end piece, their dorsal and ventral ends lying consequently more caudad than the middle. (See pl 1, *A*.)

The teeth of *Hemiramphus praematurus* are conical, single pointed denticles, most of them somewhat hook shaped, curved backward. They stand in upper and lower maxilla in two or three rows without showing any definite arrangement. In addition to these are found similar conical or hook shaped, single pointed denticles, however only in very small numbers, on the dorsal and ventral walls of the pharynx. As is shown by section, they rest usually upon the cartilaginous skeleton of the pharynx. (See pl. 7, *B*.)

HEMIRAMPHUS PIETSCHMANNI

This species is ordinarily somewhat smaller than *Hemiramphus praematurus*. The total length of females varies between 15 and 20 mm., that of males betwen 11.5 and 17 mm. These measurements are both of females with large as well as those with exclusively small eggs, of which it is to be said that by no means are the specimens with large eggs also the longer, but rather that no constant relationship can be found between egg size and length of the female. Often relatively long females have very small eggs, while

those with large eggs often possess a very insignificant body length. The height and width of body are, in correspondence with the smaller size, also somewhat less than in *H. praematurus*. The diameter of the eyes measures between 0.5 and 0.6 mm. The length of head is contained 6.2 to 7.6 times in the body length (without the tail).

The length of the post-anal portion (including the tail fin) is in females only a little less than that of the pre-anal part. The ratio of length of the pre-anal to the post-anal portion is usually as 9:8. In most male specimens the post-anal portion (with the tail) exceeds the pre-anal somewhat in length, many times even more than a millimeter, which in the lesser total length of males constitutes a relatively large amount.

The number of vertebrae varies between 33 and 37, and here also it is shown that the one or two most caudal vertebrae usually differ from the others somewhat in their contour, since they have not yet acquired their final development. In general for the structure of the tail what has been said already of *H. praematurus* suffices. It is to be stressed however that variations in the proportion of pre- and post-anal vertebrae appear. While, namely, in females the number of pre-anal vertebrae varies between 17 and 20, that of post-anal between 15 and 19, in males there are to be determined 15 to 18 pre-anal and 17 to 20 post-anal vertebrae. In females there are more pre-anal than post-anal vertebrae while in males the opposite is the case, with which the previously given body dimensions agree. There appears also in *H. pietschmanni* a lengthening of the body cavity of females as compared with males. The urogenital papilla of males is very small and short (pl. 1, *B*, 1), often in the stained and embedded specimens only with difficulty to be distinguished, so that this mark of distinction between males and females is not so significant in *H. pietschmanni* as in *H. praematurus*.

The coloring of the body is the same as in *H. praematurus* except that the swim-bladder, which has the only pigment of the body other than that of the eyes, lies somewhat farther craniad. Its location varies somewhat in the different specimens and can be found in range of the thirteenth to sixteenth vertebra, from which it is easy to recognize that its length is the same as that of *H. praematurus,* and but slightly exceeds the length of one vertebra. In males of *H. pietschmanni* the swim-bladder appears, because the anus lies farther craniad than in females, to approach somewhat nearer to it. (See pl. 1, *B*.)

The number of fin-rays is as follows: dorsal, 15 to 18; anal, 14 to 17; pectoral, 15 to 17; caudal, 13; ventral, none. The dorsal lies opposite to the anal, the first ray of the dorsal being usually opposite to the anus. The fin-membrane is almost always torn.

The number of myomeres is usually, so far as this can be ascertained, about one less than the number of vertebrae. In addition, what has already been said of the myomeres of *H. praematurus* applies as far as the form is concerned.

The teeth are conical, single pointed, usually somewhat hooked backward. They stand in upper and lower maxillae in two or three rows.

In contrasting the two species of Hemiramphus it follows: that *H. praematurus* is ordinarily a little larger than *H. pietschmanni* in the same stage of development and possesses more vertebrae. The number of pre- and post-anal vertebrae in the two species is very different. *H. pietschmanni* has fewer pre-anal and more post-anal vertebrae than *H. praematurus,* which naturally expresses itself also in the comparison of length between pre- and post-anal body portions. The swim-bladder of *H. pietschmanni* lies somewhat farther craniad. Further, the number of fin-rays of the dorsal and anal fins is different in these two species. In *H. pietschmanni* the length of the dorsal fin is almost identical with that of the anal fin while in *H. praematurus* the dorsal is longer. Corresponding in the two species are the coloring and general features, particularly the shape of the skull and the number of rays of the pectoral and caudal fins. There is always shown in males in contrast to females, an elongation of the post-anal portion of the body at the expense of the pre-anal. As is clear from the descriptions, in both species the body proportions and the number of fin-rays and vertebrae vary between somewhat wide limits, which can make the impression that the distinction between *H. praematurus* and *H. pietschmanni* may often be obscure. This is however by no means the case. Both species are always clearly to be distinguished from one another, even if they are both very variant forms. This can be made clear especially by the larval condition.

Comparison with *Hemiramphus brasiliensis* (Linné) native to the vicinity of the Hawaiian islands showed that significant differences exist between the latter and the two species described by me. These differences cannot be completely declared from the larval state. One of the main reasons for my considering the two Hemiramphidae as new species was the difference in the number of pre-anal vertebrae, of which *H. brasiliensis* possesses 43, as I could determine in as yet unpublished X-ray photographs by Dr. Pietschmann. The number of fin-rays likewise differs very much, though there are here constantly modifications possible. There is, for example, as yet no ventral fin, which is always exhibited by Hemiramphidae. From the description of young Hemiramphidae it may be concluded, however, clearly, that the ventral fins appear very late. The pre-anal vertebrae are nevertheless already clearly developed and there are scarcely to be expected yet in them greater variations in number.

ANATOMY AND HISTOLOGY OF HEMIRAMPHUS PRAEMATURUS

PREPARATIONS

The results of detailed study of the anatomy and histology of *Hemiramphus praematurus* will now be described. It should be remarked at once, however, that of the females only those were studied in detail which possessed large eggs, no comparison being made as yet with forms having exclusively small eggs. For purpose of this study there were prepared from single parts, for example the gills, upper and lower jaws, special preparations which, like all the preparations, were stained and embedded in Canada balsam or glycerin. For fine anatomical or histological research, which was specially necessary, there were produced from the objects embedded in paraffin, transverse, longitudinal, and frontal sections. The thickness of sections measured 6-12 μ. The sections were stained, part with Delafield's haematoxylin and eosin or orange G., part with van Gieson's stain, thinner sections also with iron haematoxylin.

The sections which were treated with the stain specified by Prof. Dr. Joseph make very beautiful pictures. In the latter stain, just as in the iron haematoxylin method, they were pre-stained with iron oxydammon, quickly washed out with water, over-stained with Delafield's haematoxylin and differentiated with acid alcohol. This method furnishes a beautiful, bluish black stain, by which both connective tissue and other kinds of tissue, which in staining with simple Delafield's haematoxylin are not at all or only weakly colored, receive a blue tone and through it become clearly visible. Further, the so-stained sections are very well adapted to microphotography, which as everyone knows is not the case in many methods of staining.

THE HEART

The atrium and the ventricle of the heart lie, as is known only in young and embryonic stages, behind one another, in the long axis of the body, the atrium caudad of the ventricle. (See pl. 4, *C*.) They are separated from each other by a valve which allows the passage of blood only through a very small opening. The atrium possesses a relatively thin wall while the thick wall of the ventricle is composed of prominent reticulate musculature. Craniad the blood flows to the gills through the *conus arteriosus,* in which are clearly to be distinguished an inner longitudinal and an outer circular muscle layer. Noticeable in the heart, but especially in the blood vessels, is the extremely small number of blood corpuscles.

THE SWIM-BLADDER

The swim-bladder lies, both in males and females, ventral of the sixteenth and seventeenth, seldom of the fifteenth and sixteenth, vertebrae,

close under the spinal column. Its length exceeds only by a little that of one pre-anal vertebra. There occurs relative to its location ventral of two above-mentioned vertebrae less deviation, since it is at one time found more in the vicinity of the fifteenth or sixteenth, another time more in that of the sixteenth or seventeenth vertebra. Upon its dorsal side, with the exception of the most cranial sections, as previously mentioned, lies a dark brown to black pigment spot, with the exception of that of the eyes, the only pigment which appears in *Hemiramphus praematurus*. The phenomenon that the first pigment appears just in this caudo-dorsal portion of the swim-bladder has already been observed in many young fishes.

On the ventral side of the cranial end the air duct begins, at first composed of many fine ducts, which however during their progress craniad are reduced to one only, the ends of which finally blend in the body cavity.

THE GILLS

There are four pairs of gill-arches of which, however, only the two middle ones bear gills. The cartilaginous gill-arches are not curved but quite straight and bear the gill-membranes on their ventral side. Between the gill-membranes and the gill-arches the gill-ducts take their course, as one can see clearly in sections. (See pl. 7, *B*.) On the two outer gill-arches which bear no gill-membranes can clearly be observed, however, on the ventral side, a longitudinal blood vessel. The greater number of the gill-membranes fork close to their origin on the gill-arches distally into three short filiform branchlets. Toward the cranial end of the gill-arches and especially in their most cranial part, where the gill-arches are fused with the lower jaw, a gill-membrane exists only as a single filiform process. (See pl. 4, *D*.) Gill-membranes which are composed of two filiform processes fused together are few. On the third gill-arch, partly also on the second (counted from the oral aperture), are gill-membranes consisting of three filiform branchlets usually so placed that two successive ones have their distal ends turned in the opposite directions, one right and the next left of the gill-arch. (See pl. 4, *D*.)

On the dorsal side, all gill-arches bear a row of somewhat hook-shaped, curved, single pointed denticles, the points of which are directed somewhat backward. They resemble entirely the previously described denticles of the pharynx and comprise, together with these, a mechanism which serves to retain food.

Directly behind the eyes, dorsal of the cranial part of the gill-arches, is found, in a lateral indentation of the roof of the mouth, on each side, a gill, the filiform gill-membranes of which are directed medio-dorsally. These gill-membranes are more than twice as long as those of the gills previously

described. Their length in a cranio-caudal direction is approximately half that of a gill-arch. It is probably a question here of an opercular gill, as it is frequently described in young fishes.

THE ALIMENTARY CANAL

The digestive tract extends without coils quite straight from the oral aperture to the anus. This agrees with the description of the digestive tract of Hemiramphidae by Cuvier and Valenciennes (2, p. 3) that, "Le canal intestinal est en effet un simple conduit sans circonvolutions ni coecums."

It is noteworthy that I could find nowhere in the cranial part of the digestive tract mesenteries for its attachment in the body cavity. So far as this part of the digestive tract is concerned, I indicate here the oesophagus and the anterior part of the stomach, which appear to be connected with the spinal column by two transversely striated muscle bands and thereby to be fastened in the body cavity. As the stomach proceeds caudad it approaches the ventral body wall and the middle and posterior intestines lie quite closely against this wall, with the exception of the most cranial part of the middle intestine which is separated from the ventral body wall by the caudal part of the liver. The two muscle bands mentioned, to which the cranial part of the digestive tract is attached, both originate quite closely behind one another at the junction of the oesophagus and stomach on the dorsal side. These are the ones below the cranial end of the first vertebra where this borders on the occipital region of the skull. From the dorsal side of the digestive tract the first muscle band extends dorsad toward the spinal column, making a sharp angle with the digestive tract, and is attached in the middle of the first vertebra on its ventral side. Leaving the dorsal wall of the digestive tract closely behind the first, the second muscle band extends dorsad and is joined with the dorsal trunk muscles beneath the third vertebra.

The oral aperture continues without clear boundary into the gill-cavity (pharynx), in the ventral wall of which is found the thyroid in form of numerous small lobules. On its dorsal and ventral sides lie the previously mentioned denticles. From here the pharynx is contracted to the oesophagus, the epithelium of which is folded longitudinally, the lateral and dorsal walls having much greater folds than the ventral where the epithelium shows only small tufted elevations. The inner wall of the oesophagus is covered with many layered epithelium, two to three cell layers thick, the cell boundaries of which cannot be clearly discerned. One can, however, recognize from the position of the nuclei that the epithelium consists of several cell layers. The nuclei are elongated ellipsoid, their longitudinal diameter being at least twice as long as the transverse. Outside of this epithelium on the ventral

and dorsal sides lies a longitudinal muscle layer. The single muscle fibers of this layer which lie on the ventral side, as can be learned by cross section, are much thinner than those on the dorsal side. On the outside the epithelium and longitudinal musculature of the oesophagus are surrounded by a circular muscle layer.

The longitudinal muscle layer of the oesophagus, especially caudad, shows clearly the development of several muscle bands. From their position one can here distinguish in detail the development of two groups, one more dorsally placed, composed of two to four, and one more ventrally, of two muscle bands. Those more dorsally situated are united caudad into one single muscle band, which breaks through the circular muscle layer and forms the first of the two muscle bands by which the anterior region of the tube appears to be fastened to the dorsal wall of the body cavity. The two more ventrally situated longitudinal muscle bands unite now, proceeding likewise at the same time dorsad, and break through the longitudinal muscle layers, forming the second previously described muscle band which unites the digestive tract and dorsal trunk musculature.

Just behind the place at which the first muscle band breaks through the circular musculature, connective tissue passes between epithelium and circular muscle layers, into which simultaneously the longtitudinal muscle layer becomes reduced. The oesophagus here passes into the stomach without clear boundary. The connective tissue layer rapidly increases in content caudad and forms a thick layer between the epithelium which forms the inner wall of the stomach and the trunk musculature which forms the outer wall. I use here the term stomach, although I found no special stomach glands and though this portion of the tract does not seemingly appear at all specially designated. However, this section of the canal is to be distinguished by the histological composition of its wall from the other sections and corresponds well for the most part to the descriptions which have been given of the stomach of other Teleostei.

The stomach, the dimension of which at the transition from the oesophagus, just as that of the oesophagus, is much greater in transverse than in dorso-ventral direction, assumes caudad a cylindrical form. Instead of the epithelium, which, consisting of several layers, covers the inner wall of the oesophagus, appears a single layered more or less tall cylindrical epithelium, the oval nuclei of which lie at the base. In the entire length of the stomach there are deep longitudinal folds on all sides, a deeper alternating almost throughout with a shallower fold. (See pl. 5, *A-D, m.*) In the wall of the stomach, and best in the middle portion of its length, blood vessels are visible which lead from here into the liver in which they form a plexus of capillaries. In the middle stomach section, where almost regularly five

greater alternate with five smaller longitudinal folds of epithelium, there are to be seen, on sectioning, in the deeper sulsi, which are formed by the epithelial layer and which are packed with connective tissue, five blood vessels quite regularly arranged. In the cranial and caudal parts of the stomach is the arrangement neither of longitudinal layers nor of blood vessels so regular. The blood vessels are only found in the connective tissue from where they, breaking through the circular muscle layer, extend into the liver, but never into the inner epithelial layer.

Just in front of the opening of the *ductus choledochus* into the alimentary canal, that is, in the region of the fifth vertebra, the cylindrical epithelial cells that cover the inside of the stomach become higher while they at the same time press back the connective tissue, until finally in the vicinity of the opening of the *ductus choledochus* they displace the connective tissue except for quite trifling remnants. Shortly behind this point, which at the same time is to be accepted as the boundary between stomach and middle intestine, the connective tissue is no more to be identified. The canal wall consists now of a layer of very tall cylindrical epithelium, which on its free side, exposed to the lumen, possesses a ciliated border. Around the cylindrical epithelium is a very thin circular and longitudinal muscle layer, which is again surrounded by a very thin serosa. This composition of the canal wall continues to the anus.

Between middle intestine and colon, a circular fold intervenes, and is found one and one-half to two vertebrae lengths before the anus. The colon is rather short. The middle intestine runs as an approximately equal sized tube from the end of the stomach to the level of the swim-bladder. Here under the swim-bladder it diminishes somewhat in size. Then, rapidly increasing in dimension, it becomes in this most caudal part, that is, in the caudal part of the middle intestine and the colon, one and one-half to almost twice as thick as before. There appears in the section behind the swim-bladder, as far as the intestine form is concerned, however, a difference between males and females. While the intestine of males retains its round form, that of females becomes, owing to the large size of the reproductive organs, somewhat flattened and takes on, regarded in cross-section, an elliptical contour, the longer axis of which lies in a transverse direction. By this dorso-ventral flattening, more room is produced ventrally for the ovaries. In the colon of females the dorsal intestinal wall becomes yet more flattened until finally it is perfectly level.

Toward the caudal end of the stomach it is to be observed that the number of longitudinal folds of the epithelial layer decreases. This is to be noticed in increased measure in the cranial and middle parts of the middle intestine, where the folds of the epithelial wall are much reduced both in

number and also in height. In the caudal part of the middle intestine the growth of longitudinal folds increases again and is present in the colon in yet greater measure. In females, owing to the flattening of the canal in dorso-ventral direction, the folds are not so strongly formed. In the dorsal wall, moreover, the longitudinal folds are better developed than in the ventral and lateral walls. The cylindrical cells of the middle intestine and colon are distinguished very clearly from those of the stomach. They are, as already mentioned, much higher than the latter and possess on their free surface a ciliated border. Further, their cell boundaries stand out much more clearly, so that in many of the shrunken preparations the single cylindrical cells of the middle intestine appear to be separated by an interstice. The rather long ellipsoid nuclei lie approximately in the middle of the cylindrical cells. The cells of the dorsal and ventral walls exceed in height by far those of the lateral walls. The epithelial cells of the colon and of the caudal part of the middle intestine are much smaller in females than in males, which also conforms with the smaller dorso-ventral dimension of these sections of the canal.

THE LIVER

The liver consists of a single large lobe which begins at the level of the first vertebra, shortly caudad of the beginning of the stomach, and extends backward almost to the cranial end of the swim-bladder. In females the liver reaches somewhat farther back than in males. It lies ventral of and beside the stomach and cranial section of the middle intestine and begins in front with a lobe lying ventral of the stomach, which very quickly increases in size and fills up the entire space on both sides of the stomach. Somewhat in front of the entrance of the *ductus choledochus* into the alimentary canal, the part of the liver lying left of the stomach shrinks, while at the same time the stomach pushes somewhat toward the left side from its previous median position. In the vicinity of the entrance of the *ductus choledochus* the left part of the liver completely disappears, and the ventral part also is very greatly reduced, so that by further reduction of the ventral portion finally only a right liver lobe remains. (See pl. 8, *A*.) In the entire section of the cranial middle intestine only a right liver lobe is found. Due to the right sided position of the liver, the middle intestine is also pushed to the left side of the body.

The liver possesses numerous tubules. The tubules, on cross-section, are composed of three to six liver cells, which join closely against each other with broad facets. The liver cells are polygonal, often somewhat elongated, and possess a large roundish or ellipsoid nucleus which always lies close to one facet. As already mentioned, numerous blood vessels lead from the stomach into the liver where they form a plexus. From their union arise the hepatic veins which flow forward into the *sinus venosus*.

THE PANCREAS

The pancreas, the tubules of which exhibit only an extremely small lumen, reaches from the beginning of the middle intestine to somewhat behind the caudal end of the swim-bladder. It is divided into a great number of small lobes and extends in its most cranial part right from the middle intestine, the bile-duct enclosed between these, and after a longer course spreads itself dorsally from the canal, sending off one lobe on the left dorsal side of the intestine. This left lobe is divided into several smaller lobes. Behind the caudal end of the liver the pancreas reaches its greatest enlargement. It occupies here for a short distance the room right of the alimentary canal which the liver filled craniad and extends here also to both sides dorsal of the intestine as a ribbon-like flattened tissue. After this maximal enlargement the pancreas tapers off in the region of the swim-bladder and possesses finally in its caudal part no more than one or two lobes lying to the right of the intestine (pl. 8, *B*) until it finally ends one-half to one vertebra length behind the caudal end of the swim-bladder.

The secretion of the liver and the pancreas is carried off by the bile-duct, or the *ductus choledochus*, which empties below at the right side into the alimentary canal. This point of discharge designates the boundary between stomach and middle intestine. The bile-duct takes a course within the pancreas. It branches posteriorly and ends somewhat in front of the caudal end of the liver. A typical gall-bladder is not present but the most cranial part of the bile-duct is slightly enlarged. At the same time the wall of the enlarged bile-duct becomes considerably thicker and consists, as does also the wall of the *ductus choledochus*, of proportionally large cubical cells.

THE REPRODUCTIVE ORGANS

The male reproductive organs reach a rather considerable size and occupy, together with their appendage organs, a large part of the body cavity. Besides the well-developed testis, which consists of a large undivided middle part with pairs of cranial and caudal lobes and the *vasa deferentia*, there appears also in the caudal part a paired appendage organ, of apparently glandular character, which extends jointly with the *vas deferens* right into the urogenital papilla. (See pl. 4, *B*.)

The two cranial testicle lobes reach forward beyond the middle of the ninth vertebra. They soon join caudad to a united part which extends in the body cavity between the ureter on one side and the organs of the digestive system on the other side. On the sides it lies close to the trunk musculature. (See pl. 8, *A, t*.) The testicle is divided into single vesicles by walls of connective tissue. During its course caudad it grows in dorso-ventral direction and reaches its greatest dimension immediately in front

of the cranial end of the swim-bladder. (See pl. 2, *B, t.*) Here in the dorsal part of the testicle the two *vasa deferentia* split off (pl. 2, *C*). At the same time the testicle again divides into two lobes which extend caudad on both sides of the swim-bladder, accompanied on the dorsal side by the *vasa deferentia.* Behind the caudal end of the swim-bladder the two testicle lobes draw again somewhat nearer together, at the same time somewhat increasing in dimension. The left testicle lobe increases in size just before its caudal end for a short section and is in this region divided by strong intervening walls of connective tissue into several (3 to 5) small lobes which lie over one another in a dorso-ventral direction. Of these the most ventral reaches farther caudad than the dorsal ones. The right lobe is somewhat longer than the left. It ends approximately three vertebra-lengths before the anus. Naturally, however, its length varies in the single individuals so that a definite assertion does not appear possible. The *vasa deferentia* extend caudad, in the beginning dorsal of both testicle lobes. (See pls. 7, *D*; 2, *D.*) They trend, however, ventrally, until they finally lie between the latter, and immediately dorsal of the digestive tract. (See pl. 3, *A.*) Just before the caudal end of the left testicle lobe they unite into one duct, which empties outward into the urogenital papilla. (See pl. 4, *B.*)

Between the right and left *vas deferens* there is shown in the specimens studied a distinct difference in the composition of the wall and the width of the lumen. While, namely, the wall of the right *vas deferens* consists of uniform, not very tall, apparently cubical cells, the cell boundaries of which are not to be distinguished, the cells of the left *vas deferens* are considerably taller, cylindrical and of irregular height. Taller cells alternate here with shorter, so that the inner wall of this *vas deferens* appears folded and not even as the right one. The usually elongate ellipsoid, seldom rounded nuclei lie in the two *vasa deferentia* on the base of the cells, which is the side away from the lumen. While the circumference of the left *vas deferens* is smaller than that of the right, yet its wall cells are considerably taller, so that this duct possesses only a quite narrow lumen. Further, in the left *vas deferens* no spermatozoa are to be distinguished, while the right is densely filled with them. All this allows the conjecture to arise that, possibly, the left *vas deferens* is yet in process of development, its lumen being developed later than that of the right. As already said, this difference does not exist throughout the entire length of the left *vas deferens.* In its most anterior and posterior regions, close to its origin in the testicle and before its union with the right *vas deferens* into one duct, it equals the latter almost perfectly in construction. In these sections its lumen is also filled with spermatozoa. The *vasa deferentia* are surrounded with a rich vascular plexus.

The testes contain sperm cells in the most varied stages of spermato-

genesis, and in the section of the testis from which the *vasa deferentia* originate, where the testis reaches its greatest enlargement, are the ripest sperm cells. Besides in the *vasa deferentia,* there are found in the testis section which lies craniad from the outlet of the *vasa deferentia* and ventrad from its point of origin ripe spermatozoa. (See pl. 2, *B.*) Likewise in the proximal part of the caudal lobes of the testes ripe spermatozoa are present. Outside of the just mentioned parts of the testis ripe spermatozoa are never found. The farther distal the part of the testis one examines, sperm cells are to be distinguished decreasing in ripeness. Moreover, there are on the two sides of the testis always less ripe sperm cells than in the middle.

In the caudal section on both sides of the *vas deferens* the previously mentioned paired appendage organ of the male reproductive apparatus appears. It apparently is a glandular structure which begins at the end section of the right caudal lobe of the testis, yet varies somewhat in length in the several individuals. From the section series it is certain that it consists craniad of one lobe on each side, constantly increases in size caudad, and in its caudal section is composed of two parts on each side which are united without by a membrane. The lobes on both sides unite in front of the anus and so form a united mass consisting of four parts dorsal of the *vas deferens,* which with its ramifications reaches into the genital papilla. (See pls. 3, *B, C*; 8, *C, D*; 9.) This organ is composed of an outer layer of palisade-like epithelium, which is not equally tall on all sides, but in the different sections as well as on the different sides changes in size. Usually the palisade-epithelium is tallest on the ventral side while on other sides, particularly on the surface of two parts united together, it is scarcely to be distinguished in the specimens studied. (See pls. 8, *C, D*; 9; 3, *B.*) The palisade-like epithelium surrounds a homogeneous, strongly colorable substance. It is a case here, possibly, of a viscous secretion which becomes mixed with the sperm, to which also its extension into the genital papilla appears to point. I could not identify outlets into the *vas deferens,* but possibly this is due only to the disadvantageous preservation, since it is probably a question of extremely small ducts.

The urogenital papilla lies immediately behind the anus. (See pl. 1.) It consists of a spongy tissue in which great cavities occur which are filled with a clotted mass. It was impossible to determine whether or not this was clotted blood. The whole makes an impression of an erectile tissue the exact function of which could not be determined. (See pl. 3, *D, E.*) Dorsal of the articulation of the urogenital papilla, on both sides of the urinary bladder, lies a conical shaped muscle which one sees in the most caudal urogenital sections. (See pls. 10, *C-E*; 3, *D.*) This may be a muscle which plays a role specially in the function of the bladder.

THE OVARY

The ovary of *Hemiramphus praematurus*, which reaches forward to below the third or fourth post-cranial vertibra and ends in the urogenital opening behind the anus, occupies the largest part of the body cavity. Although the condition of preservation is very unfavorable, the membranes being very much shriveled and torn, yet I think myself justified, from the figures which the cross and longitudinal sections furnish, in concluding that it is a cranially two-lobed, but in the caudal part united, ovary of elongated, sac-like shape. The ovary lies dorsal of the digestive tract. Due to its size the body cavity appears much more inflated than that of males. The union of the two cranial lobes takes place approximately midway between the caudal end of the swim-bladder and the urogenital opening.

The ovary is surrounded in both its cranial bi-lobed and its caudal parts by an extremely thin membrane and contains eggs of different degrees of ripeness. Fundamentally two clearly distinguishable egg stages can be recognized. First, extraordinarily large eggs, which possess so considerable a size that constantly two only find place beside each other in the body cavity (pl. 2, *A*); and second, much smaller ones, which lie lateral and ventral of the large ones. The smaller eggs are naturally, as follows from their lesser size, less mature than the others. The egg yolk is, just as the egg membrane, very much shriveled and, in the objects preserved in alcohol, opaque and of a yellowish color. The yolk of the large eggs, which alone will be discussed, is usually so greatly shrunken that these eggs possess an irregular shape. A somewhat less shrunken egg indicates that in fresh condition they are of ellipsoid form. The egg contents consist of the yolk mass and the germinal vesicle. The yolk mass is separated again into an inner, fairly homogeneous yolk and an outer part interspersed with numerous vacuoles and nuclei, which in the literature is usually designated as protoplasma. (See pls. 6, *D*; 2, *A*.) In the inner homogeneous yolk are shown many times round or somewhat lobed concretions which are made noticeable by darker coloring. The yolk is very solid and consequently breaks easily under the microtome into regular lumps contrary to cut direction, as is evident in plate 2, *A*. Further, peculiar stellate, dendritic, branched figures appear in it, which are shown by lesser coloring and were not deranged by the fracture. (See pl. 2, *A*.) Probably it is a question here only of products of technique. The egg protoplasm is interspersed by numerous egg nuclei and vacuoles. The vacuoles exhibit, probably because of the preservation, faint oil drops and fat-like substances. The large ellipsoid germinal vesicle always lies on the caudo-ventral pole of the egg. It possesses several, usually three, granules of which the middle one is almost always the largest. Spindle-rays are not present. The protoplasm is most strongly developed in the vicinity of the germinal

vesicle. It is surrounded by the *zona radiata,* which again is enclosed outside by the follicle epithelium. Especially from the structure, but also from the size, it follows that it is a question of eggs which are far advanced in development, although an exact statement of their degree of maturity is not possible. The position of the eggs with regard to each other is quite regular and those of one side alternate with the ones on the other side. The middle of eggs of one side always lies against the planes of cleavage of two eggs of the other side, which from a purely physical standpoint appears clearly to result in the best utilization of space. Instead of as before, two eggs next to each other, immediately in front of the urogenital opening, only one egg is found in the ovary which here fills its entire opening.

On both sides of the urogenital opening are found two little papillae which show the same structure as the urogenital papilla of males.

THE KIDNEY

In the kidneys of males and females are shown only quite unimportant differences which are solely in their most caudal sections. They begin craniad with a glomus which lies in the level of the first vertebra just behind the head. It is found under the aorta immediately in front of the branching of the *arteria mesenterica* ventral from the aorta (pl. 4, *E*), that is, the locality where the aorta is formed from the four branchial arches. This glomus owes its origin to a little ventral branch of the aorta. Rosenberg (16) gives the same position of kidney glomeruli (kidneys of Teleostei) for the young pike studied by him (Pike 13.4 mm. long shortly after the loss of the egg sac.) He says here, "Die vasa afferentia der beiden Glomeruli entspringen jetzt in der Medianebene des Körpers aus der ventralen Aortenwand, dessen Lage sehr genau angegeben werden kann; es ist die Stelle unmittelbar vor dem Abgange der Arteria coeliaco-mesenterica."

The greatest dimension of the glomus in transverse direction measured 60 to 70 μ. The longitudinal dimension is only slightly greater, many times no more than equal, or even less. The glomus is surrounded by a thin membrane which partially lies close to it, partially possesses a clear interspace between it and the glomus, and so forms a cavity resembling a pre-renal chamber. In the vicinity of this glomus, which is indented on the ventral side so that thus somewhat clearly a right and left side can be distinguished, a canal takes its origin on either side, that is right and left of the aorta, in the form of a small funnel which is provided within with fine cilia. The openings of these funnels in the glomus lie on its cranial side and are directed longitudinally in the same level. The right funnel however leads laterally from the glomus while the left discharges on the dorsal side. (See pl. 5.) This dorsal discharge of the left canal is explained by the fact that

left of the aorta the already mentioned muscle band runs which connects the alimentary canal with the connective tissue of the spinal column and the left canal runs dorsad of this muscle band. Whether besides the muscle band has to serve as support for the canal, which so to speak appears to be hung upon it, or the canal must take this way since the muscle band by its position obstructs the direct lateral access to the glomus, cannot be determined. The obstruction is occasioned by the fact that the muscle band reaches down to the middle of the glomus and over its dorsal end and the aorta is extended. Because of the shrinkage of the objects an indisputable statement in this regard is impossible. It appears however fairly obvious that both causes are to be accepted for it.

Describing a simple curve after their origin in the glomus, both canals proceed caudad without making turns, as is otherwise usually described for the cranial part of the urinary canals in the literature, and extend in longitudinal direction close under the spinal column. (See pl. 4, *A*.) In the region shortly behind the glomus these canals possess a diameter of approximately 30 μ and a lumen of 10 μ. At the point where the canals bend in cranio-caudal direction in order to run posteriorly parallel to the body axis, the cardinal veins rest against them on their body axis side. Both of these possess an almost equally wide lumen. At their origin they lie ventral of the two small canals. (See pl. 5.) In their course caudad they trend dorsally and finally lie close to the canals on their inner side. The longitudinal canals, as the small canals running in the longitudinal direction of the body will be called, approach each other caudad very quickly and with them naturally bring the *venae cardinales* also more closely together, until, in the level of the second vertebra, they unite into one single large vein, which fills the somewhat limited space between the two longitudinal canals. (See pls. 4, *A*; 8, *A*; 7, *C*.) Right at this point I might add that, from the whole structure of the kidneys, I consider these longitudinal canals to be ducts of the pronephros, to which I shall return later.

The walls of the longitudinal canals are formed of a single layer of cubical cells. The nuclei, especially in the just described cranial part but also in the caudal part of the kidney, are very close to the lumen of the canal. This is not so clearly seen in the caudal, as in the cranial part. The proximal-lying cells of the longitudinal canal, which are the cells which adjoin the *vena cardinalis*, appear, especially in the cranial part of the kidney, significantly taller and larger than the distal ones, that is, the cells withdrawn from the *vena cardinalis*. In the cranial kidney section the former are even more than twice as tall as the latter, from which fact naturally the lumen does not lie central, but is displaced toward the distal side. (See pls. 5; 6; 7, *A*.) This enlargement of the cells on the side lying next to the *vena cardinalis*

means that here the most active part of the kidney, which specially performs the excretory function, should be sought. From the fact that a difference of size of cells already exists in the cranial part of the kidney and that here are found the tallest cells, is to be inferred that in this part the excretory activity is greatest. Caudad the difference of size of cells of the longitudinal canal diminishes more and more and vanishes entirely in the level of the swim-bladder, so that between those lying on the *vena cardinalis* and the other wall cells of the longitudinal canal almost no difference is to be observed.

Just behind the region at which the *venae cardinales* adjoin the longitudinal canal, about in the level of the glomus, a tissue begins in the space between the cardinal veins and the aorta which appears to bring these veins in contact with the aorta. (See pl. 6, *A-C.*) Its outer wall is not distinguished from the outer wall of the *venae cardinales* and it is separated from these veins only by a quite thin membrane. This boundary membrane is in many cross-sections not at all or only very faintly visible. This membrane attracts attention specially because of the great number of strongly colorable nuclei. Cell boundaries are, however, never to be recognized. This could be lymphoid tissue bordering on the *venae cardinales*, which, however, cannot be indisputably identified. The lymphoid begins, as previously mentioned, in the level of the glomus on the body axis side of the cardinal veins and is at first of small size. Slightly farther caudad, where the *arteria mesenterica* branches from the aorta, it is to be noticed also on the ventro-lateral side of the artery, and fills for a very short distance the entire space between the *venae cardinales* and the *arteria mesenterica.* (See pl. 6, *C.*) Caudad of the branching off of the *arteria mesenterica* from the aorta it becomes again somewhat reduced and just before the junction of the two cardinal veins is no more than a small remnant between these until at their junction it completely vanishes. (See pl. 4, *A.*) This tissue corresponds most closely with that designated in the literature as "pseudolymphoid", over the origin of which among the authors very differing opinions prevail. B. Haller (8) interprets it as rudiments of kidney canals, which however does not come in question here, since it is separated wholly from the longitudinal canals by the cardinal veins and accordingly has entirely no connection with the former. Felix (4) says of it, "Das pseudolymphoide Gewebe entsteht durch Wucherung der Wandung des Venenplexus der Stammvene, welcher die Vorniere und den primären Harnleiter umgibt." He assumes that the "pseudolymphoide" tissue results through hyperdevelopment of vein walls. Indeed, in the case under consideration the tissue which I have designated as lymphoid apparently owes its origin to the cardinal veins.

Upon returning to the further course of the longitudinal canals it is to be

noticed that they continue in the same form and course only separated by the *vena cardinalis,* up to the level of the fourteenth to fifteenth vertebra, that is, one or two segments in front of the swim-bladder, so that their position in a dorso-ventral direction up to this region does not change. First, here their distance from each other begins to increase, and in this connection the *vena cardinalis* separates from the right longitudinal canal and lies only along the left on its body axis side. At this point a ventral branch is given off from the left side of the cardinal vein, just as a short distance farther craniad a ventral branch was also given off on its right side, both of which run ventrally in the body cavity. It is not necessary to specify the further course of these vessels since they are without significance for the kidneys. The divergence of the longitudinal canals is explained by the fact that the swim-bladder, lying somewhat farther caudad in the level of the sixteenth to seventeenth, or the fifteenth to sixteenth vertebrae, extends so far dorsally that only a very small space remains between it and the spinal column, which does not offer room for the two longitudinal canals with the *vena cardinalis.* Accordingly the longitudinal canals are forced to diverge, and lie, in the region in which the swim-bladder extends farthest dorsad, that is, in its cranial part, in the space between it and the lateral body musculature. (See pls. 7, *D*; 4, *A*.) It is to be noticed that in this region the right longitudinal canal lies somewhat farther ventrad than the left.

The longitudinal canals, which were forced by the swim-bladder to turn dorsad, now, in the anal part of the swim-bladder where it is reduced in dimension, draw farther ventrad, while they at the same time approach each other. In this connection the right longitudinal canal again rests against the *vena cardinalis.* The two longitudinal canals, now again united, so to speak, by the *vena cardinalis,* occupy in their further course caudad their more ventral position, in males somewhat dorsal of the middle between spinal column and ventral body boundary. In females the relation in this section is the same, with the slight difference that the longitudinal canals, after they have approached each other caudad of the swim-bladder, and after the right longitudinal canal has rested itself again on the *vena cardinalis,* do not draw ventrad but, owing to the very great size of the ovaries, keep to their dorsal position close under the spinal column. The two longitudinal canals do not change up to the locality where they unite to the same ureter. Since in this last section the relationship in females and males does not completely correspond, they will be described separately.

In females the two longitudinal canals unite in the level of the twenty-fourth vertebra, that is, one or two segments before the anus, into a single longitudinal canal. (See pl. 4, *A*.) The exact position is not to be given since here slight deviations between the different individuals appear. After

a short course this longitudinal canal enlarges its lumen especially through the fact that its wall becomes thinner. Finally the longitudinal canal in both, females and males, widens to the bladder, the wall of which consists of such thin epithelium, that one cannot assume its origin from the canals just described, since it cannot be clearly followed. (See pls. 10, *B-D*, 3, *D*.) In the first place the ventral cell wall of the longitudinal canal flattens to the thin cell wall epithelium of the bladder, while it, at the same time, widens out ventrad. In the dorsal wall of the bladder there can yet be distinguished, for a very short distance, cells just as tall as in the longitudinal canals. These cells flatten rapidly so that the bladder, the circumference of which has meantime significantly increased, is surrounded on all sides by equally extremely thin walled epithelium. The bladder is in this case of mesodermal origin, since it consists of a widening of the united longitudinal canal. It empties out through the urogenital opening.

When we follow farther the course of the cardinal vein in females, which, in the locality where as yet paired longitudinal canals are found, is located between these, we see that shortly before the union of the two longitudinal canals it bends dorsad. After their union it is found on the dorsal side of the canal, but separates soon from it, travels dorsad, and in the space between the longitudinal canal and the spinal column, divides into several branches. Before the *vena cardinalis* separates from the longitudinal canal, it gives off ventrally two little branches which now accompany the longitudinal canal on the right and left sides. Of the two branches of the cardinal vein which accompany the longitudinal canal laterally, the one lying on the left side is considerably larger. While the smaller right vein branch soon splits into a capillary net which distributes itself in the connective tissue around the longitudinal canal, and is no farther to be followed, one can determine the course of the left vein branch up to the bladder. For approximately two-thirds of its course on the left side of the longitudinal canal, from the point where it branches from the cardinal vein to the beginning of the bladder, this venous branch retains its original position almost unchanged. In the last third it divides into two branches, of which the much smaller one remains on the left side of the longitudinal canal and constantly diminishes in size until it finally disappears in the connective tissue. The larger one rests on the ventral side of the longitudinal canal but soon separates from it and pushes somewhat farther ventrad, while it forks once more into two nearly equally large branches of which one wanders right from the longitudinal canal. Both vein branches draw off from this point ventrad and branch out in the connective tissue.

The last kidney section of males differs only in slight details from that of females. Just as in the latter, the two canals unite one or two segments

before the anus to one single longitudinal canal the wall of which, however, is much thinner than is the case in the longitudinal canal of females. Correspondingly, naturally, the lumen of this longitudinal canal is much wider than in females. The nuclei appear to be very close to the lumen, much more so than in the longitudinal canals of females, and, especially in the caudal part where the canal assumes a circular form and the cardinal vein has already separated from it, the nuclei lie altogether on its inner wall. (See pl. 9, *C, D.*) Shortly before the formation of the bladder, the lumen of the longitudinal canal contracts again somewhat strongly by the fact that its wall becomes thicker. On cross section the longitudinal canal appears in males to be quite circular, in females more nearly rectangular. The bladder of males, which naturally has the same origin as that of females, is not so much widened ventrally as that of the latter.

The *vena cardinalis* is found at the point of union of the two longitudinal canals on the dorsal side in both males and females. Shortly behind this point however it is found on the left side of the longitudinal canal and on a horizontal level with it. (See pls. 8, *D*; 9, *A.*) A short distance farther caudad the cardinal vein moves again to the dorsal side of the longitudinal canal and bends, detaching from it, as in females, dorsad, after it likewise has left two branches on the sides of the longitudinal canal, of which again the left is considerably larger. The farther course of these two branches is now essentially the same as that described for females.

A short summary of what has just been said of the kidney of *Hemiramphus praematurus* gives the following. The kidneys consist solely of two canals which arise cranially in a glomus, proceed caudad accompanied only by the *venae cardinales,* in order to unite in the last section into a duct which widens to the bladder. This empties out through the urogenital opening. In the most cranial section a lymphoid tissue is also found between the *venae cardinales.* The excretory function is carried on by the cells of the longitudinal canals themselves, the greatest excretory activity apparently taking place in the cranial part. This is to be assumed from the fact that in this part, before the union of the *venae cardinales,* the cells of the longitudinal canals adjoining these veins are tallest, while caudad they are gradually reduced in height. This is probably a pronephros, as is indicated specially by the extremely simplified condition of the whole kidney system by which the longitudinal canals, that is, the anterior renal ducts, have taken over the excretory function. It might also be supposed that in this kidney system which appears to present an ultimate development, a mesonephros is represented, in which case in the cranial part earlier more glomi were present, which however are already reduced. Yet from the entire appearance of the kidney this does not seem to me to be probable.

This pronephros exhibits a simplified condition such as I find described at length nowhere in the literature. It should not be inferred however that this is an isolated case but only that this kidney form shows a maximum of simplification. The kidney of *Hemiramphus praematurus* is most readily compared with that of myxinoids. There appear in the posterior kidney of the myxinoids, upon which the excretory function devolves, numerous segmentally arranged glomi, but in this case it is only the primary urinary duct which has taken over the real excretory function. The kidneys of *Hemiramphus praematurus* seem to show a still more simplified structure than the myxinoids, granted that the functional importance in both is referred to the same parts, namely, the longitudinal canals (that is, in *Myxine,* the primary urinary ducts) which coincidentally have taken over the task of drainage of the urea. In the most simplified forms of kidneys of fishes described by Guitel (6), and Audigé (1), I find nowhere statements of so primitive a condition. When cranially the kidney arises in a glomus, there are found always, in the cranial, middle or caudal sections, folds, indentations, aggregations or glomerular structures. Also in contrast to the kidney forms described for fish embryos, differences are shown. In quite young stages, which show resemblances in the formation of the anterior portion of the kidney, usually the caudal part is not entirely formed. Almost always, also, intertwining of the cranial kidney ducts appears. For example, in the smallest embryos of *Salmo* (6 mm. long) studied by B. Haller (8), there were found in the cranial section, besides the two large kidney bodies, three to four smaller ones on each side which already showed retrogression. Also the cranial kidney duct showed intertwining. Moreover in the middle and caudal parts the otherwise simple kidney ducts display transverse canals and in the twelfth and thirteenth post-pericardial myomeres a kidney body is formed symmetrically on both sides. A considerably more complicated relationship is shown here than in *Hemiramphus praematurus.*

The presence of a pronephros in the species described here would by no means indicate that they are larval forms. There are described many cases of Teleostei where the pronephros persists in the adult stage. For example, Guitel (7) says:

> En résumé nous avons trouvé le pronéphros persistant jusque chez l'adulte dans quatorze espèces de Téléostéens appartenant à huit genres différents . . . . [Here follows the enumeration of the species.]. Si l'on ajoute ces quatorze espèces aux deux étudiées par Emery et aux neuf Gobiésocidés dont il a été question plus haut, on voit, que le pronéphros se montre persistant dans un nombre de Téléostéens qui, actuellement n'est pas inférieur à vingt-six . . . Ces faits nous semblent d'autant plus dignes d'intérêt qu'on donne généralement le mésonéphros des Téléostéens comme constituant le seul rein fonctionnel de ces animaux à l'état adulte.

CONCLUSION

If we, in conclusion, once more survey the most striking and weighty characteristics which indicate that it is a case of fish larva and the characteristics which are otherwise only peculiar to adult fishes, then the following are to be emphasized. Larval characteristics are especially: the form of the heart by which auricle and ventricle are found behind one another in the long axis of the body; the lack of pigmentation of the body surface; and the spinal column yet in course of development. Against these stand the fact that in both males and females reproductive products are found already far developed, in males the *vasa deferentia* and parts of the testicle being already filled with ripe spermatozoa. The appearance of a pronephros, as said, is an argument for neither the one nor the other state. The extremely slight body size, likewise, is no indication that it is a larval form, since even smaller sexually mature fishes, especially gobies, are described.

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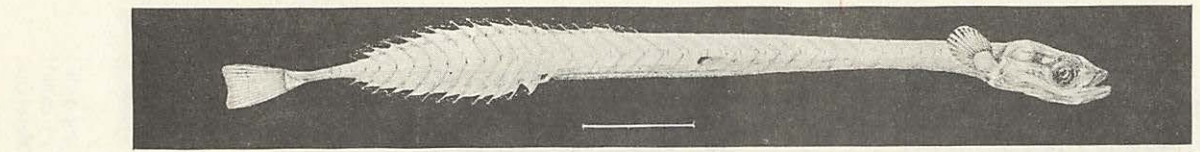
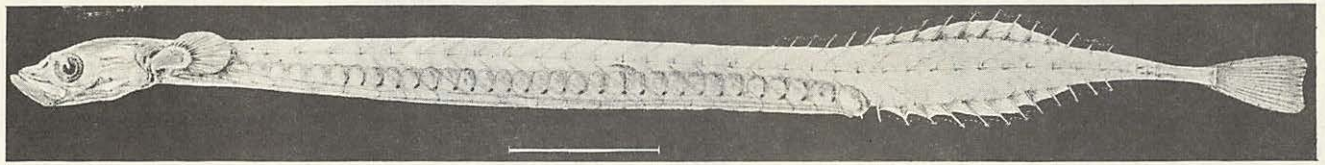


1



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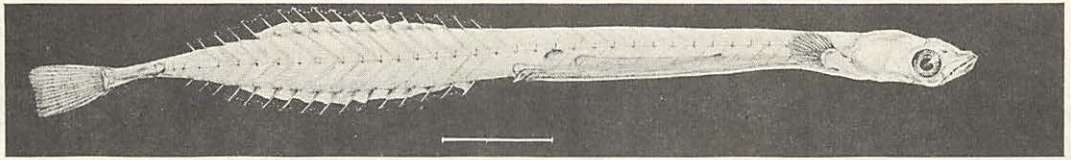
B



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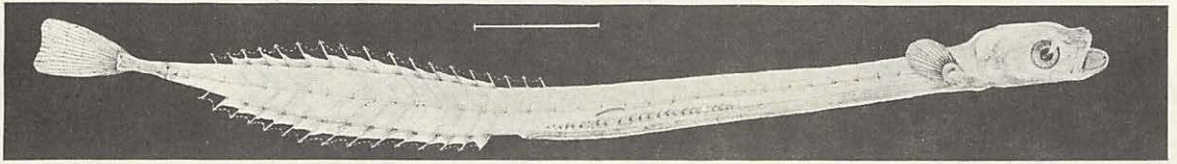
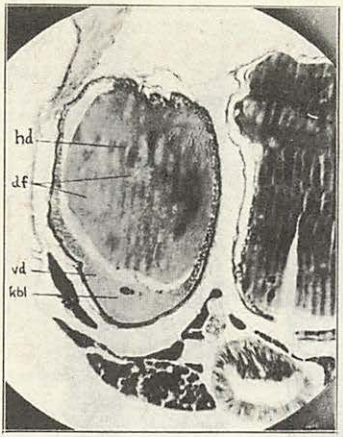


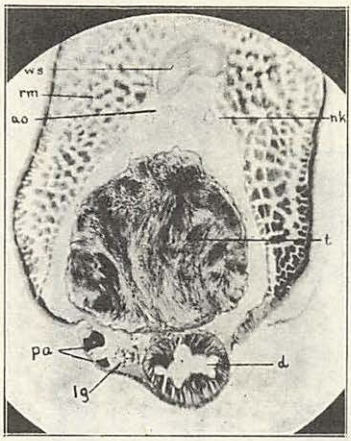
2

A

A, HEMIRAMPHUS PRAEMATURUS SCHINDLER: 1, MALE; 2, FEMALE. *B*, HEMIRAMPHUS PIETSCHMANNI SCHINDLER: 1, MALE; 2, FEMALE.



A



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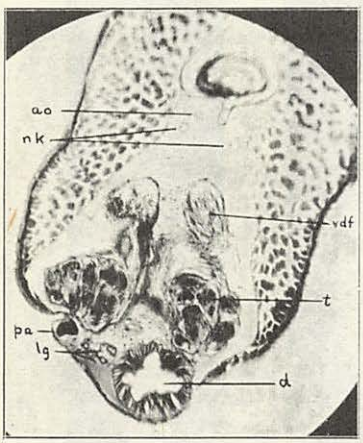
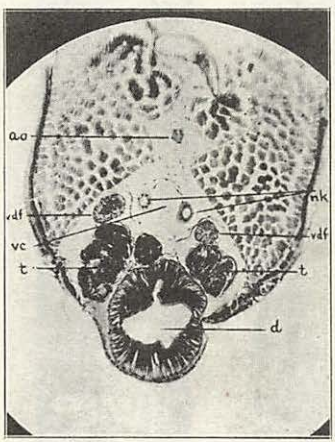


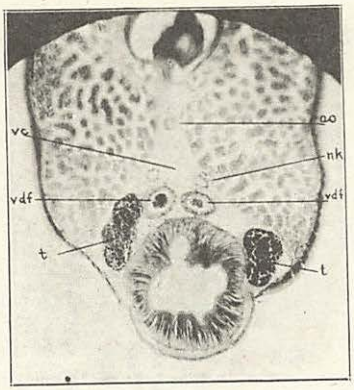
C



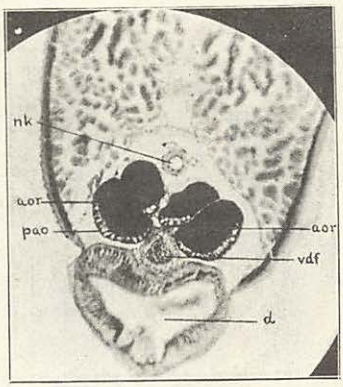
D

CROSS SECTIONS OF HEMIRAMPHIDAE: *A*, THROUGH AN EGG; *B*, THROUGH THE GREATEST DIAMETER OF THE TESTIS; *C*, AT THE POINT OF BRANCHING OF THE VASA DEFERENTIA FROM THE TESTIS; *D*, CLOSE BEHIND THE CAUDAL END OF THE SWIM-BLADDER (*B*, *C*, *D*, MALE).

ao, aorta; *d*, intestine; *df*, dendritic figures in the egg yolk; *hd*, homogeneous egg yolk; *kbl*, germinal vesicle; *lg*, air duct of the swim-bladder; *nk*, longitudinal (urinary) canal; *pa*, pancreas; *rm*, trunk musculature; *t*, testis; *vd*, vacuole of egg yolk; *vdf*, vas deferens; *ws*, spinal column.



A



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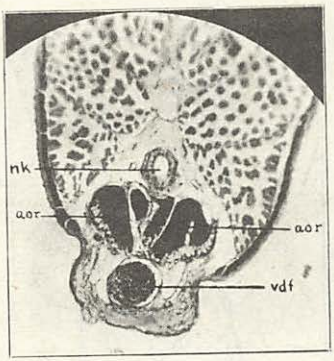

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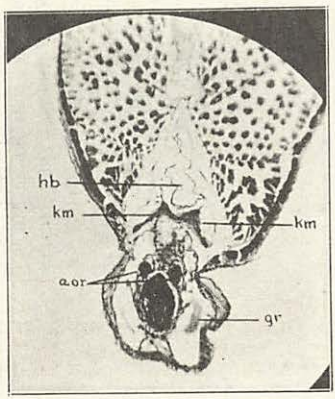
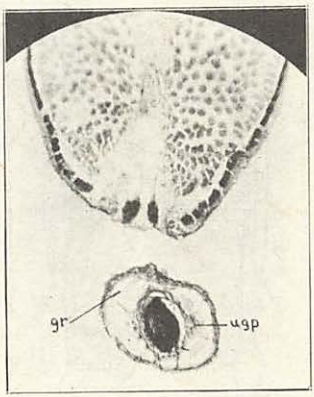


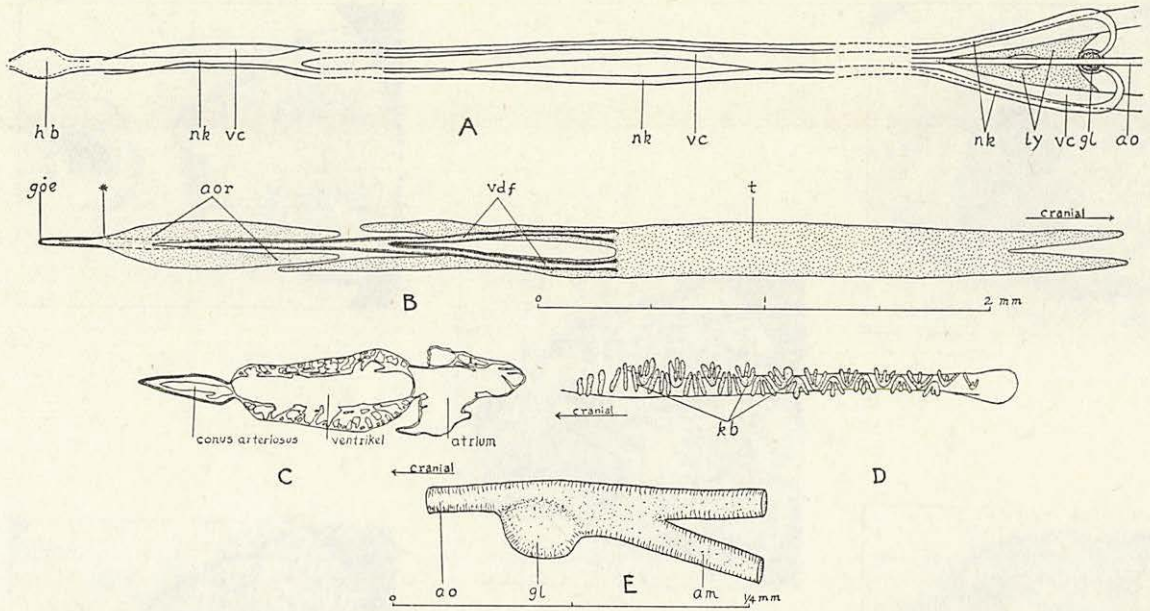
D



E

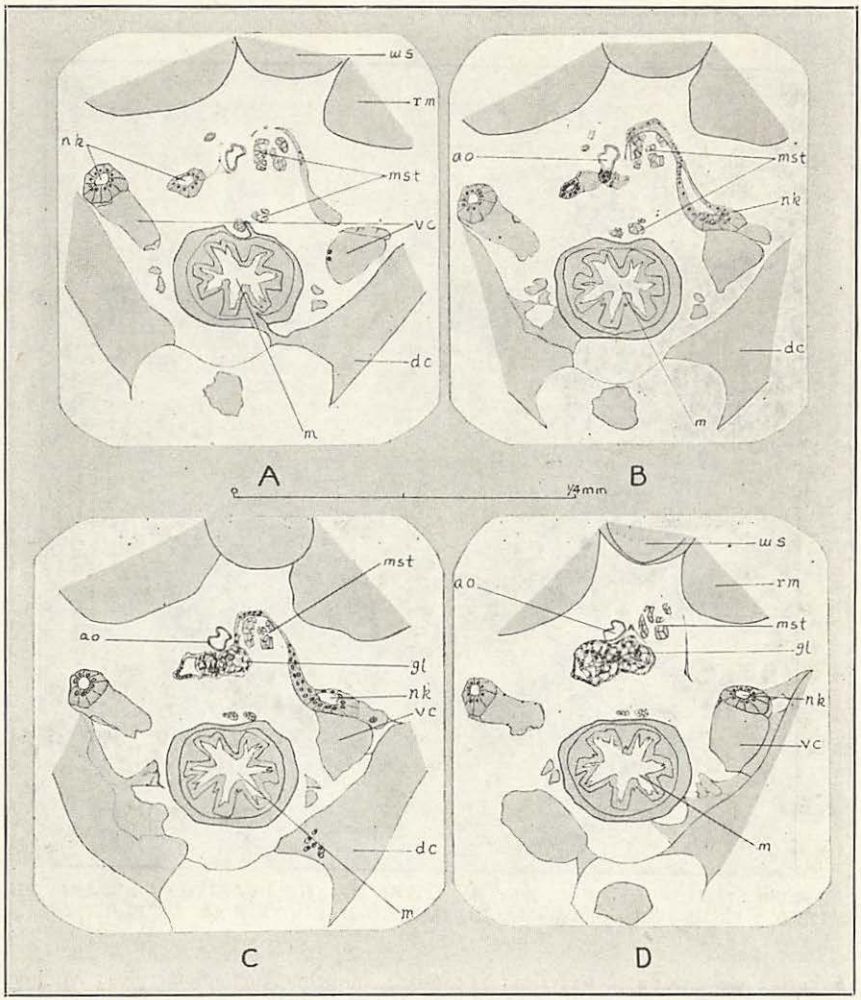
CROSS SECTIONS OF HEMIRAMPHIDAE: *A*, IMMEDIATELY BEFORE THE UNION OF THE VASA DEFERENTIA (MALE); *B*, IMMEDIATELY BEFORE THE ANUS (MALE); *C*, *D*, JUST IN FRONT OF THE UROGENITAL PAPILLA (MALE); *E*, THROUGH THE UROGENITAL PAPILLA AND THE VENTRAL POST-ANAL BODY SECTION (MALE).

ao, aorta; *d*, intestine; *gr*, clotted mass in the urogenital papilla; *hb*, urinary bladder; *km*, cone-shaped muscle; *nk*, longitudinal (urinary) canal; *pao*, palisade epithelium of the appendage organ of the male reproductive system; *ugp*, urogenital papilla; *vc*, vena cardinalis; *vdf*, vas deferens.



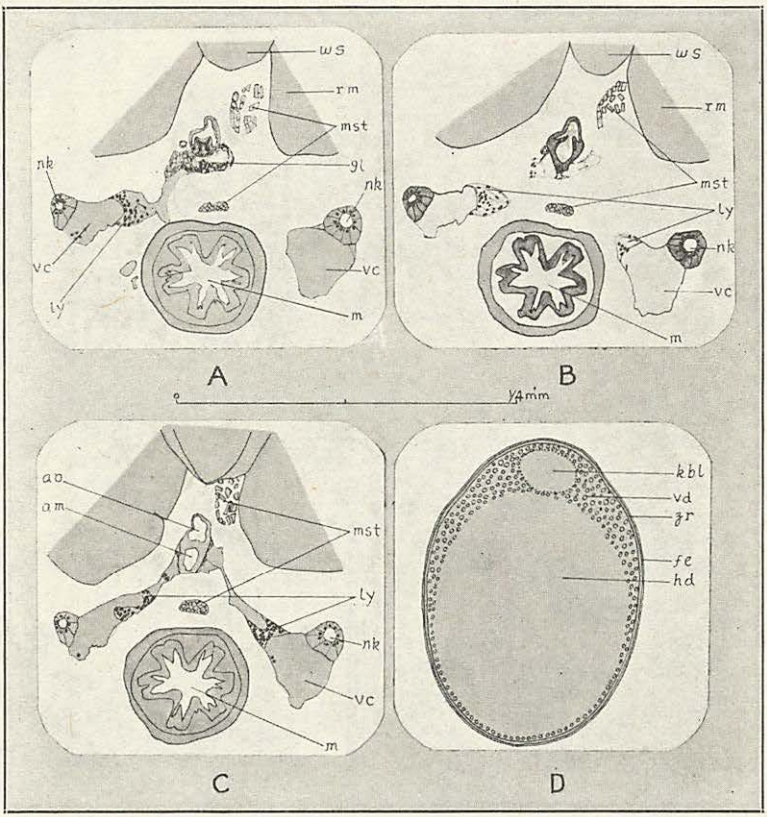
HEMIRAMPHIDAE: *A*, DORSAL VIEW OF KIDNEY RECONSTRUCTED FROM CROSS SECTIONS (THE DOTTED LINES ON LEFT REPRESENT 72 MM., AND THOSE ON RIGHT, 226 MM.); *B*, DORSAL VIEW OF MALE REPRODUCTIVE ORGANS RECONSTRUCTED FROM CROSS SECTIONS; *C*, LONGITUDINAL SECTION THROUGH THE HEART; *D*, VENTRAL VIEW OF ONE GILL ARCH; *E*, AORTA WITH KIDNEY GLOMUS.

ao, aorta; *aor*, appendage organ of the male reproductive system; *am*, arteria mesenterica; *gl*, glomerulus; *goe*, opening of the reproductive system; *hb*, urinary bladder; *kb*, gill-membranes; *ly*, lymphoid tissue; *nk*, longitudinal (urinary) canal; *t*, testis; *vc*, vena cardinalis,



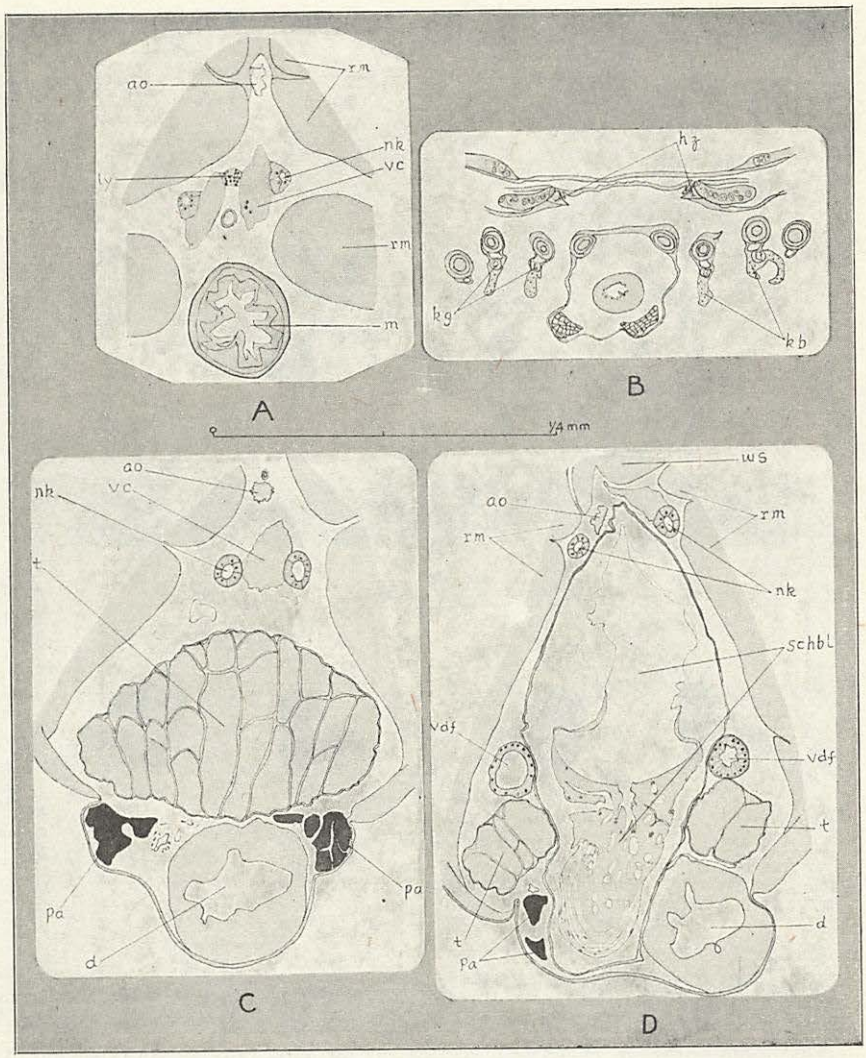
CROSS SECTIONS: *A*, *B*, THROUGH THE MOST ANTERIOR KIDNEY REGION (MALE); *C*, *D*, AT THE LEVEL OF THE KIDNEY GLOMUS (MALE), SHOWING THE OPENING OF THE FUNNEL.

ao, aorta; *dc*, ductus Cuvieri; *gl*, glomerulus; *m*, stomach; *mst*, muscle bands which bind the alimentary canal to the dorsal wall of the body cavity; *nk*, longitudinal (urinary) canal; *rm*, trunk musculature; *vc*, vena cardinalis; *ws*, spinal column.



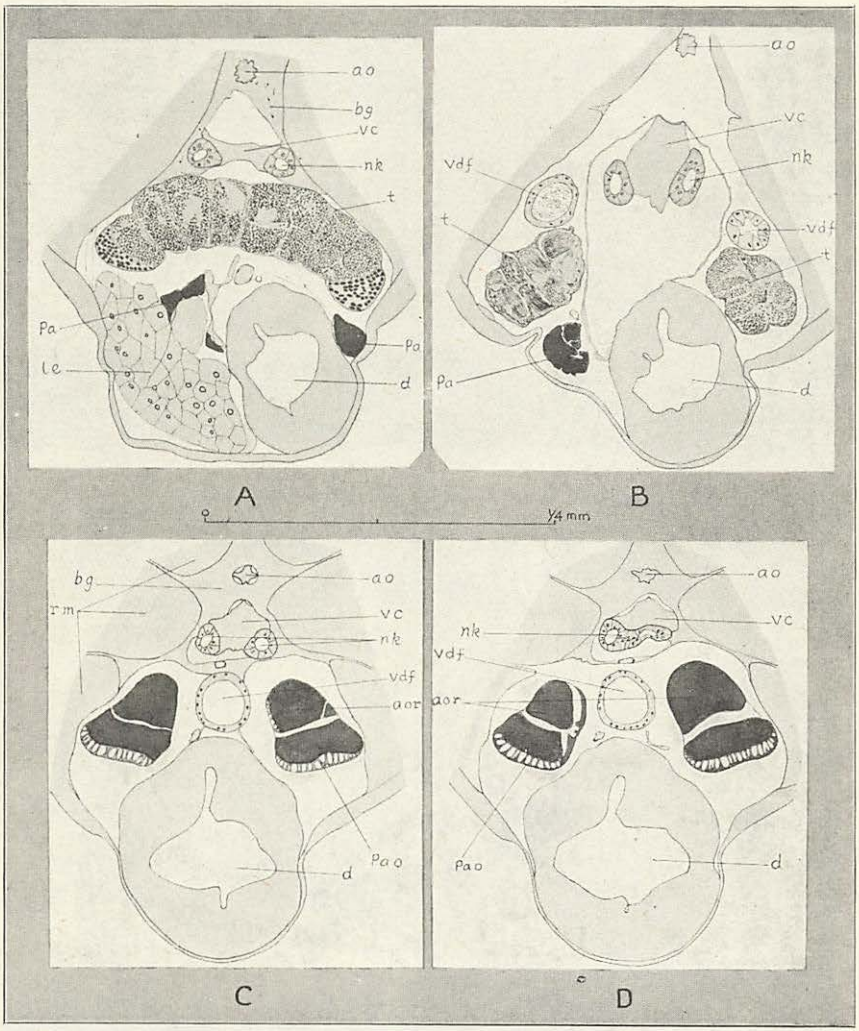
CROSS SECTIONS: *A, B, C,* AT THE LEVEL OF THE BRANCHING ARTERIA MESENTERICA FROM THE AORTA (MALE); *D,* RECONSTRUCTION OF AN EGG.

ao, aorta; *am,* arteria mesenterica; *fe,* follicle epithelium; *gl,* glomerulus; *hd,* homogeneous egg yolk; *kbl,* germinal vesicle; *ly,* lymphoid tissue; *m,* stomach; *mst,* muscle bands which bind the alimentary canal to the dorsal wall of the body cavity; *nk,* longitudinal (urinary) canal; *rm,* trunk musculature; *vc,* vena cardinalis; *vd,* vacuole of egg yolk; *ws,* spinal column; *zr,* zona radiata.



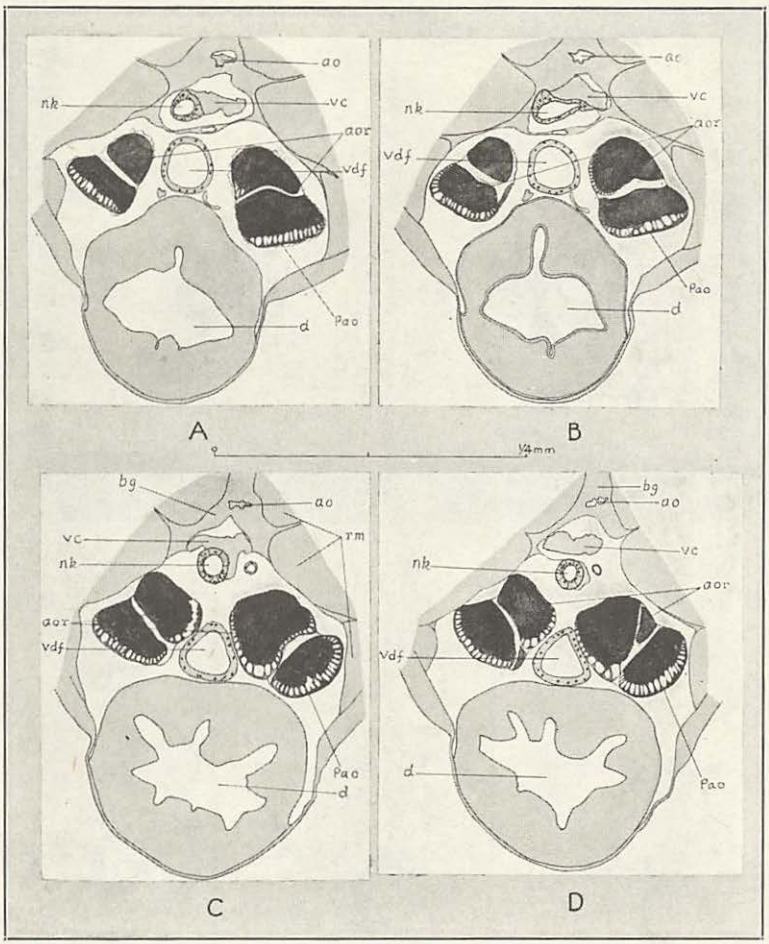
CROSS SECTIONS: *A*, JUST IN FRONT OF THE UNION OF THE VENAE CARDINALES (MALE); *B*, THROUGH THE GILL REGION; *C*, CLOSE BEHIND THE CAUDAL END OF THE LIVER (MALE); *D*, AT THE LEVEL OF THE SWIM-BLADDER (MALE).

ao, aorta; *d*, intestine; *hz*, denticles; *kb*, gill membranes; *kg*, gill-duct; *ly*, lymphoid tissue; *m*, *stomach*; *nk*, longitudinal (urinary) canal; *pa*, pancreas; *rm*, trunk musculature; *schbl*, swim-bladder; *t*, testis; *vc*, vena cardinalis; *vdf*, vas deferens; *ws*, spinal column.



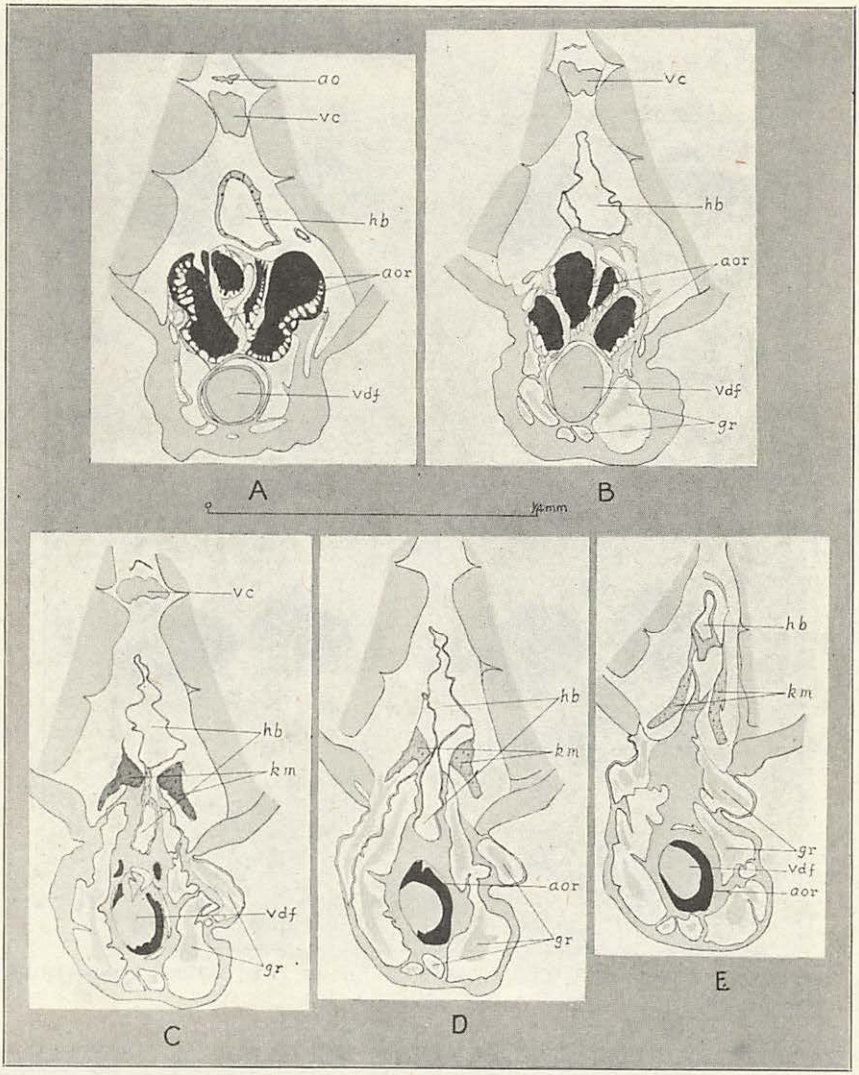
CROSS SECTIONS: *A*, IN THE CRANIAL PART OF THE TESTIS; *B*, CLOSE BEHIND THE SWIM-BLADDER (MALE); *C*, IMMEDIATELY BEFORE THE UNION OF THE TWO LONGITUDINAL CANALS (MALE); *D*, AT THE LEVEL OF THE UNION OF THE TWO LONGITUDINAL CANALS (MALE).

ao, aorta; *aor*, appendage organ of the male reproductive system; *bg*, connective tissue; *d*, intestine; *le*, liver; *nk*, longitudinal (urinary) canal; *pa*, pancreas; *pao*, palisade epithelium of the appendage organ of the male reproductive system; *rm*, trunk musculature; *t*, testis; *vc*, vena cardinalis; *vd*, vas deferens.



A, B, C, D, CROSS SECTIONS AT THE LEVEL OF THE UNITED LONGITUDINAL CANALS (MALE).

ao, aorta; *aor,* appendage organ of the male reproductive system; *bg,* connective tissue; *d,* intestine; *nk,* longitudinal (urinary) canal; *pao,* palisade epithelium of the appendage organ of the male reproductive system; *rm,* trunk musculature; *vc,* vena cardinalis; *vdf,* vas deferens.



A, B, C, D, E, CROSS SECTIONS AT THE LEVEL OF THE URINARY BLADDER (MALE).

ao, aorta; *aor,* appendage organ of the male reproductive system; *gr,* clotted mass in the urogenital papilla; *hb,* urinary bladder; *km,* cone-shaped muscle; *vc,* vena cardinalis; *vdf,* vas deferens.