MORPHOLOGY OF THE URINO-GENITAL SYSTEM IN SOME INDIAN TELEOSTEAN FISHES*

By

S. KAMALAVENI

Department of Zoology, Banaras Hindu University, Banaras (India)

(with 21 Text-figures)

CONTENTS

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I—Introduction

(a) *General*

The urino-genital organs of fishes in general and of certain species in particular have received the attention of zoologists from early times. Yet a comprehensive study of this system has seldom been attempted with the result that we have still to fall back upon the descriptions of this system as given for *Acipenser*, *Lepidosteus*, *Protopterus*, *Lepidosiren*, *Salmon* and *Clupea* for basic information and guidance. Standard treatises written by Balfour (1882), Parker and Haswell (1935), Sedgwick (1905), Goodrich (1930), and Kingsley (1926) do not give exhaustive information on the urino-gential system of the common fishes. The position has been well summed up by Pfeiffer (1933) who says that "All modern text-books follow either Balfour, Parker or Goodrich. The work of Goodrich shows that our knowledge of the urino-genital systems in these forms is very vague and incomplete".

The above mentioned works deal more with some of the rarer forms like *Lepidosteus, Acipenser* or *Polypterus* than with the common species of fishes. A knowledge of the structure and disposition of the urino-genital system in the above mentioned genera of fishes is undoubtedly helpful, but being restricted in their zoo-geographical distribution and obtainable with difficulty remain only of theoretical importance. Being confined in distribution to South America, South Africa, and Australia, these fishes are not ordinarily available to the students of zoology for dissection or detailed study. Much of the work on the urino-genital system of fishes is based on *Salmo*, an European form, not available in tropical Asia. These sources of information are, therefore, of little help in the study of the urino-genital system of the common Indian species. The need of an accurate description of the urino-genital system of the common Indian fishes has been felt in the Indian zoological laboratories for more than a quarter of a century.

Bridge (1932) states "Quot homines tot sententiae" regarding the morphology of the teleostean gonads. This statement holds good even to-day. Therefore, an attempt has been made by the present author to study the urino-genital organs of some of the common Indian teleostean fishes so as to further the bounds of knowledge in this field and to make reliable information available to teachers and students alike.

(b) *Historical Résumé*

As already mentioned, the literature bearing on this subject is scanty. The early workers had mostly concerned themselves with the development of the urino-genital organs. The earliest work in this field can be attributed to Rathake (1805) and Scott (1805) who traced the development of the renal organs in the *Ammocoetes* larva. Müller (1884) and Hyrtl (1855) described, perhaps for the first time, the anatomy of the excretory organs and the gono-ducts of the female of *Lepidosteus*. Hyrtl declared that the products from the testes passed through a duct (vas deferens) homologous to the oviduct of the female and entered the wolffian duct. Later, Balfour and Parker (1882) re-investigated this and proved that these ducts within the mesorchium were vasa efferentia and that the seminal fluid passed through the kidneys and the urinary

ducts to the exterior. Since then no substantial advance has been made in this direction.

It may be pointed out that the above work dealt with *Lepidosteus* only, and, as such, the description cannot hold good for the common teleostean fishes without some modification. The premier attempt to study the morphology of the teleostean urino-genital system was probably made by Sedgwick (1905) whose general account of the urino-genital organs of the Teleostei, however, was based on the work of Balfour and Parker (1882). Goodrich (1931) attempted to bring together, under one jacket, the existing knowledge of the urino-genital systems of the Dipnoi and the Teleostomi, and by schematising the diagrams attempted to bring out the points of resemblance and of difference between the various genera. Subsequent treatises or text-books on fishes have freely drawn upon the works of Balfour and Parker (1882) or Goodrich (1931). Bridge (1932) attempted to give a comparative account of the development and disposition of the urino-genital system in Cyclostomes, Elasmobranchs and other Teleostei in a generalised manner, so as to emphasize the basic points of difference and of resemblance between them in the well-known Cambridge Natural History volume on fishes.

Later workers, like Pfeiffer (1933) and Owen (1938), have worked only on *Lepidosteus* and *Cyclothone* respectively. Subsequent workers, during the last ten years or more, have been paying increasing attention to the development, breeding habits, stomach contents, sexual dimorphism and environmental ecology than to the anatomy of the common species of fishes.

(c) *Acknowledgment*

The author is grateful to Dr. A. B. Misra, Professor of Zoology, under whose guidance this work was done, for constant help, valuable guidance and constructive criticisms throughout the course of this work, without which it would not have been successfully completed.

II—MATERIAL AND METHODS

Great difficulty was experienced in obtaining fresh material for purposes of dissection and study throughout the year. Large-sized fishes like *Catla catla* (Hamilton), *Mastacembelus armatus* (Lacep.). *Labeo rohita* (Hamilton), *Ophiocephalus marulius* (Hamilton) could be had only at the fishing centres far away from the University campus. Except *Hilsa ilisha* (Hamilton) which could be had from the river Ganges, the remaining fishes were obtained from ponds or tanks situated several miles away from the University. The fishes available in the local market were found to be unsuitable for the purpose of this study as they were often in a semi-decomposed condition having been trapped at night or in the small hours of the morning and then dumped into the market. Freshly caught fishes were quickly brought to the laboratory or dissected

on the spot, sketched and preserved in 5 per cent formalin. Data bearing on the size of the gonads and the gonoducts were collected and recorded throughout the year.

Name	Famil
1. *Hilsa ilisha* (Hamilton)	Clupeidae.
2. *Catla catla* (Hamilton)	Cyprinidae.
3. *Rasbora rasbora* (Hamilton)	Cyprinidae.
4. *Cirrhina mrigala* (Hamilton)	Cyprinidae.
5. *Labeo rohita* (Hamilton)	Cyprinidae.
6. *Wallago attu* (Bloch and Schneider)	Siluridae.
7. *Mystus aor* (Hamilton)	Bagridae.
8. *Eutropiichthys vacha* (Hamilton)	Schilbeidae.
9. *Heteropneustes fossilis* (Bloch)	Saccobranchidae.
10. *Clarias batrachus* (Linn.)	Clariidae.
11. *Ophiocephalus gachua* (Hamilton)	Ophiocephalidae.
12. *Ophiocephalus marulius* (Hamilton)	Ophiocephalidae.
13. *Ophiocephalus punctatus* (Bloch)	Ophiocephalidae.
14. *Notopterus notopterus* (Pallas)	Notopteridae.
15. *Notopterus chitala* (Hamilton)	Notopteridae.
16. *Mastacembelus armatus* (Lacepede)	Mastacembelidae.

III—Description of the Urino-genital System

1. **Hilsa ilisha** (Hamilton)

(Text-fig. 1 *a*, *b*)

The kidneys, which are, in fact, double, look single on account of fusion along their inner margins. They are deep red in colour and extend from the cardiac region to the posterior end of the body cavity. Their outer margins are uneven, the anterior end being turned up. The upturned portion of the kidney lies anterior to the pericardium and corresponds to the head-kidney of other species.

The ureters arise from the last quarter of the length of the kidneys. In some cases, one of them is absent. When both are present, they unite posteriorly into a single wide ureter not assuming the form of a urinary bladder as in many other Teleosts. It narrows down posteriorly as it approaches the cloaca to open behind the genital pore (Text-fig. 1*a*,*b*, and 18*a*)

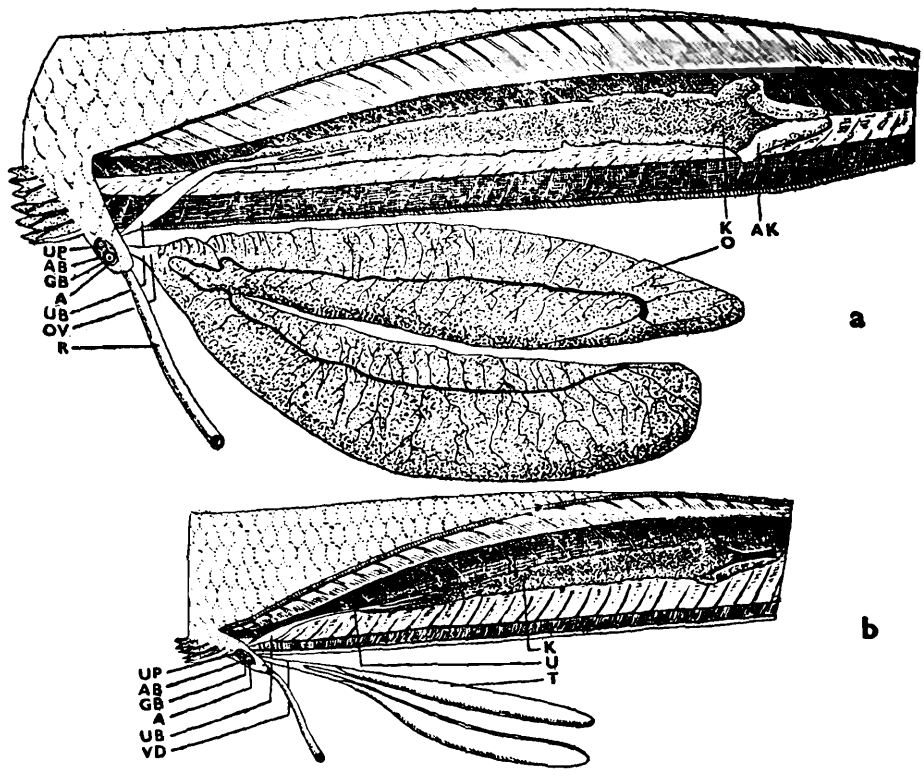
The gonads, which are paired, lie on the sides of the air bladder and do not become so much reduced in size in the "off-season" as in other species. The mesovariun and the mesorchium are highly pigmented during the "off-season", being black in immature specimens, red on approaching maturity and light pink in the ripe males or females. When the greater part of the colouration disappears from the mesovarium or mesorchium, it still persists in the oviduct or the vas deferens.

The ovaries are saccular and smooth-walled structures in immature pecimens which are found from September to January. Mature specimens are available from March to August when the ovaries are bright yellow in colour with an abundance of blood vessels distributed over the surface (Text-fig. 1*a*).

Before the end of August, the eggs are discharged and the ovaries become very much depleted of their contents and lose their yellow colour.

The testes are elongated, tubular, opaque structures creamy white in colour in the mature specimens. Mature males are available from March to August. (Text-fig. 1*b*).

The two vasa deferentia emerge from the anterior tip of the testes, run along their inner borders, and, on leaving them, career for a short distance to unite into a thick duct which opens into the cloaca behind the anus.



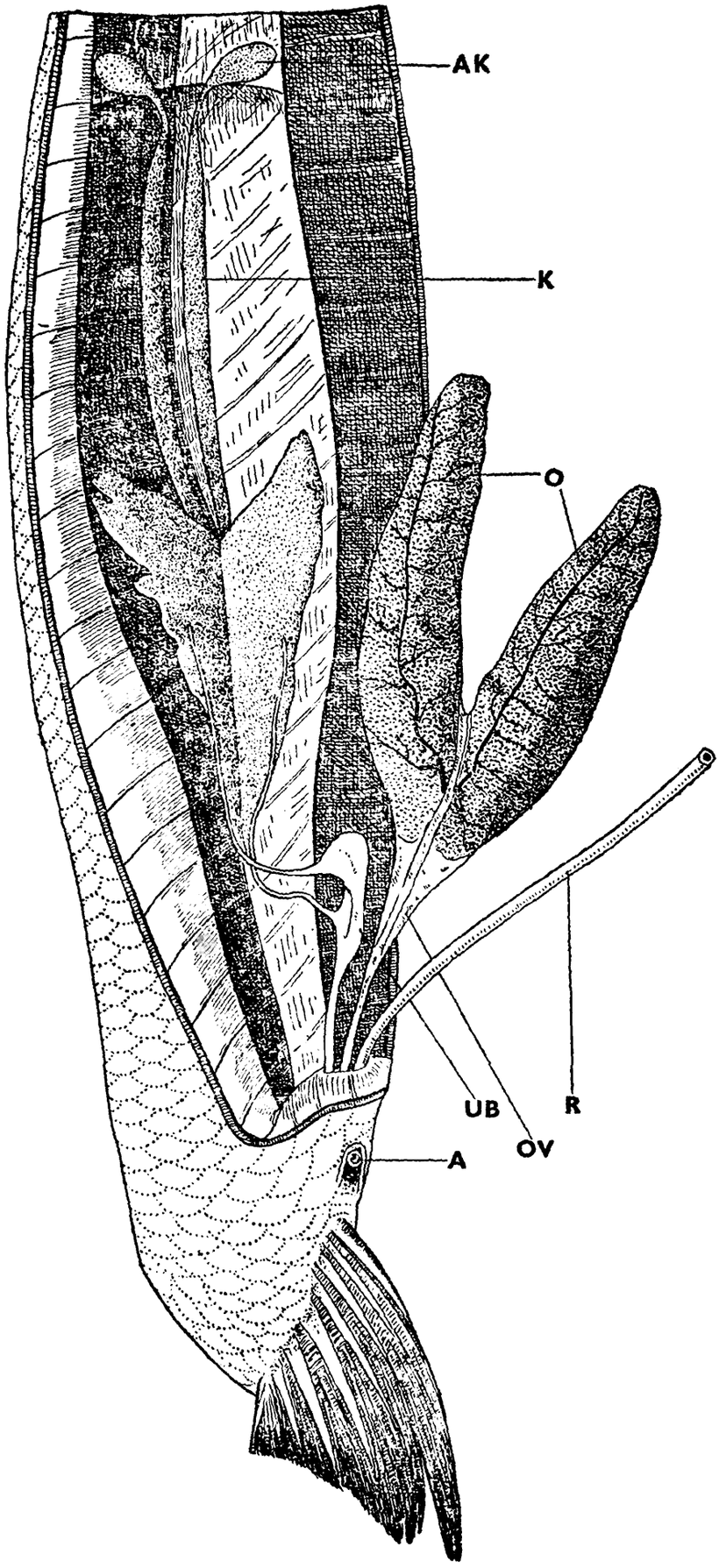
TEXT-FIG. 1.—*Hilsa ilisha* (Hamilton). (*a*). Female. (*b*). Male×½ Natural size).

The cloaca is similar in structure in the two sexes of *Hilsa ilisha* (Text-fig. 18*a*). It is not very deep but oval in outline and placed far behind the pectoral fins. The anus opens into its anterior sector, while the single median genital pore and the urinary orifice are placed one behind the other in succession and occupy the other sector of the cloaca. At the inner sides of the cloaca lie the abdominal pores (Text-fig. 1*a*,*b*).

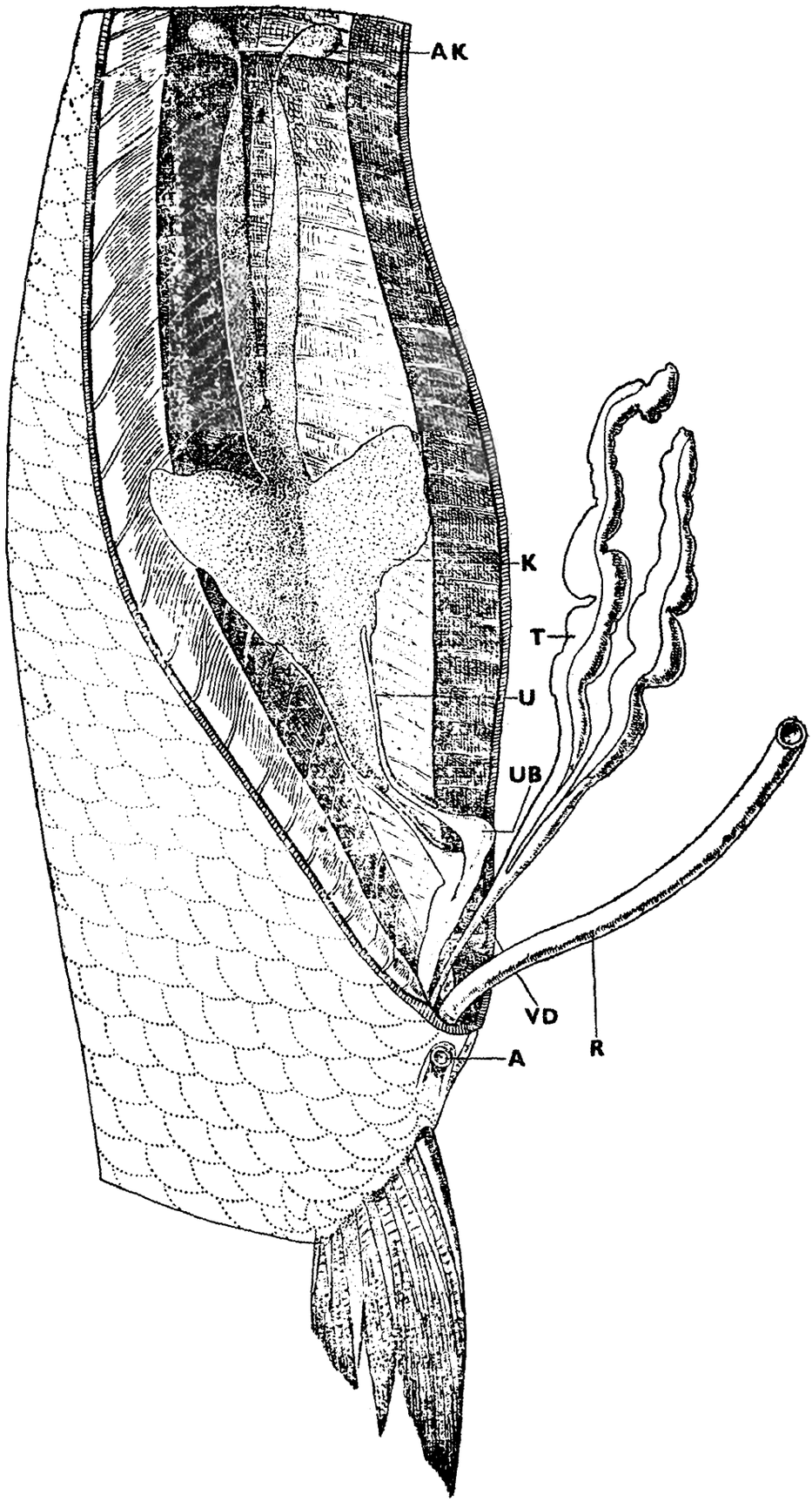
2. **Catla catla** (Hamilton)

(Text-figs 2 and 3)

The abdominal kidneys are tubular in outline in the anterior half of their length and are free from fusion or adhesion. The head-kidneys are attached to the anteriar ends of the kidneys by means of a narrow



TEXT-FIG. 2.—*Catla catla* (Hamilton). Female. (×5/6 Natural size).



TEXT-FIG. 3.—*Catla catla* (Hamilton). Male. (× 3/4 Natural size).

'neck and lie in front of the pericardium. At the middle of their length, they fan out into two lobes. From the point where the fanning occurs, the two kidneys are fused along their inner border. At the posterior extremity, the kidneys taper off. The fused portion of the kidneys is thick and massive thereby producing a difference in the level of the two halves (Text-figs. 2 and 3).

The point of origin of the ureters varies greatly in different individuals, but they are distinctly paired. Each of them dilates into a thin walled urinary bladder. The two urinary bladders unite and narrow off posteriorly to form a common duct which opens into the cloaca (Text-fig. 18*b*).

The sexes are separate but indistinguishable in the immature condition even on dissection, because the male and the female gonads are almost thread-like and thin. During the breeding season, it is easy to distinguish them because the ovaries become sac-like but the testes are like thick cords (Text-figs. 2 and 3).

During the non-breeding season, which extends from October to March, the ovaries are filamentary in form measuring about 5.8 cms. in length with a negligible width, even in specimens measuring $1\frac{1}{2}$ to 2 ft. in length. By the end of February or the beginning of March, enlargement of the gonads commences attaining full size by the end of March. At this time, the ovaries become massive organs in the body-cavity and measure about 40.2 cms. in length and 15.6 cms. in width. Fully mature ovaries are greyish in colour, and thin-walled smooth sacs abundantly covered with blood vessels. From their posterior ends, the oviducts arise as thin-walled tubes opening into the cloaca (Text-fig. 2).

The testes are also inconspicuous and thread-like, in form (measuring about 1.3 cms. in length with a negligible width) in the "off-season". By about the middle of March, they become enlarged and grow in thickness as well as in length. Further elongation occurs in the third week of April as a result of which it attains a length of 15.2 cms. and a width of 4.9 cms.

The cloaca, which is very deep and oval in outline is placed far behind the pelvic fins. The anus which is on a level with the ectal surface of the body occupies a great deal of it somewhat obscuring the genital and the urinary orifices placed behind it. The single median genital pore is placed immediately below the anus. The urinary pore is placed just behind the genital orifice (Text-fig. 18*b*).

3. **Rasbora rasbora** (Hamilton)

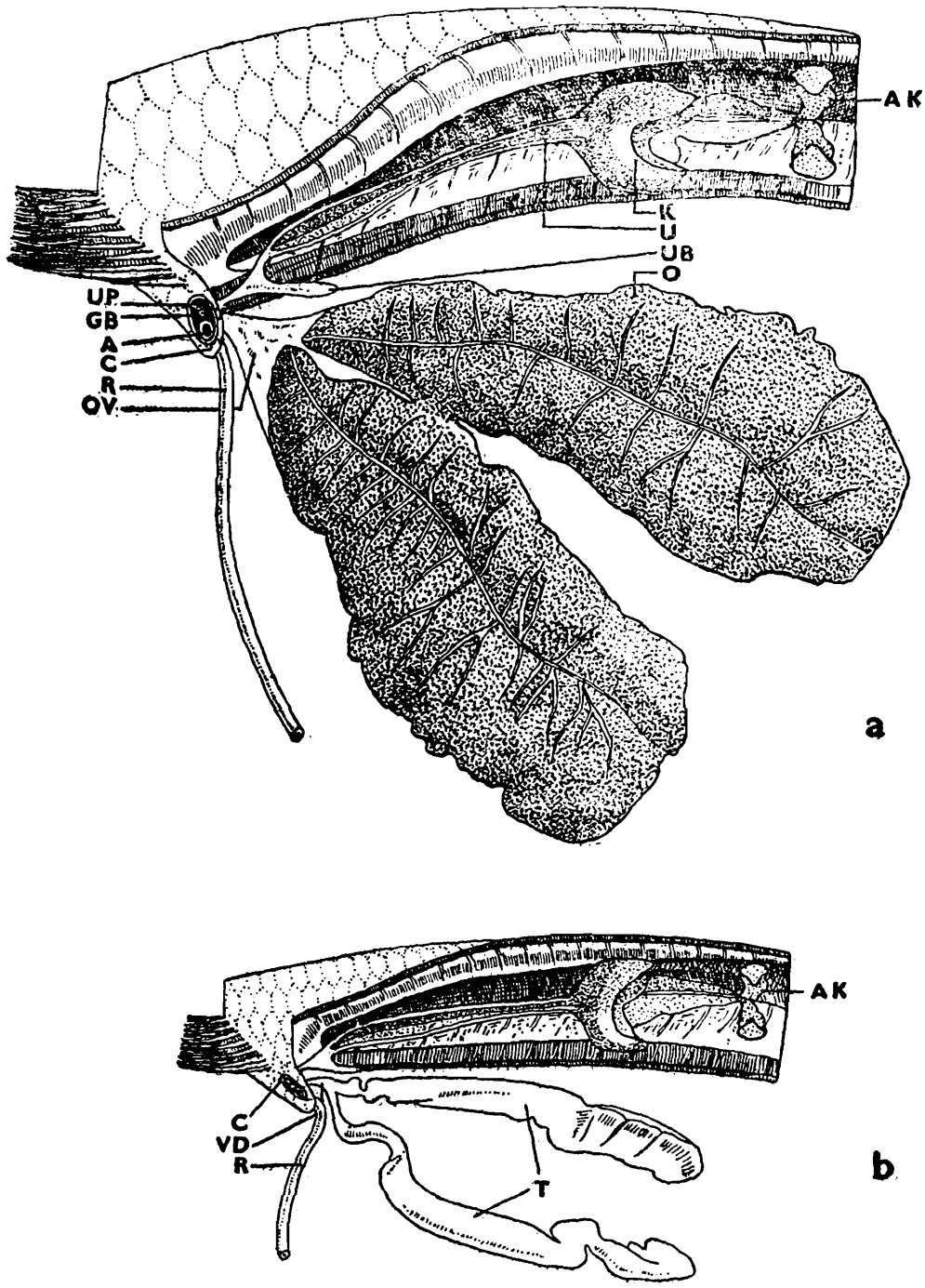
(Text-fig. 4*a*, *b*)

The kidneys resemble closely those of *Cirrhina mrigala* (Hamilton). Lateral expansions of part of the kidney, and difference between the levels of the anterior and the posterior halves of the kidney are the characters common to *Rasbora rasbora* and *Cirrhina mrigala*. The head-kidney is present and lies close to the pericardium. It is bilobed and the lobes are placed transversely.

The ureters, which are distinct and paired, arise from the hind end of the expanded portion of the kidney, run parallel for part of their course

and then unite into a common ureter which soon gives off the urinary bladder as a diverticulum (Text-fig. 4*a*,*b*).

Sexes are separate and the gonads paired in this species, but in the "off-season" the gonads are detectable with difficulty because they thin out considerably.



TEXT-FIG. 4.—*Rasbora rasbora* (Hamilton). (*a.*) Female. (*b.*) Male. (× 1/2 Natural size).

The "unripe" ovaries are hardly noticeable and remain so between November and February. The breeding season extends from March to August, or even up to October. The ovaries begin to enlarge in February and become marked off from their ducts. The enlargement proceeds rapidly thereafter, and by the end of April fully mature ovaries measuring

about 14.2 cms. in length and 6.6 cms. in breadth are present. When fully ripe, they are irregular in outline, dull yellow in colour and richly vascularised (Text-fig. 4*a*).

The mesovarium is continued behind as the oviducts which are confluent and transparent near the ovaries but narrow down posteriorly to open by means of a single median aperture into the cloaca (Text-fig. 4*a*).

The testes are also paired but not easily discernible during the non-breeding season which lasts from October to February. Towards the end of February, enlargement of them begins and they tend to become prominent. By March the testes and their ducts become distintcly defined and begin to enlarge rapidly thereafter, attaining 14.9 cms. in length and 1.9 cms. in width. The two testes are separate for the greater part of their length, giving off posteriorly the vasa deferentia which unite to form the common ejaculatory duct. The latter is a very short, thick-walled and straight tube running close to the ureter and opening into the cloaca (Text-fig. 4*b*).

The cloaca, which is a longitudinal slit, is not very deep as in the case of *Catla catla*, the anal opening being more prominent than tthe other openings. Below and behind the anus and at the middle of he cloaca lies the single median genital pore after which comes the single urinary pore.

4. **Cirrhina mrigala** (Hamilton)

(Text-fig. 5*a*, *b*)

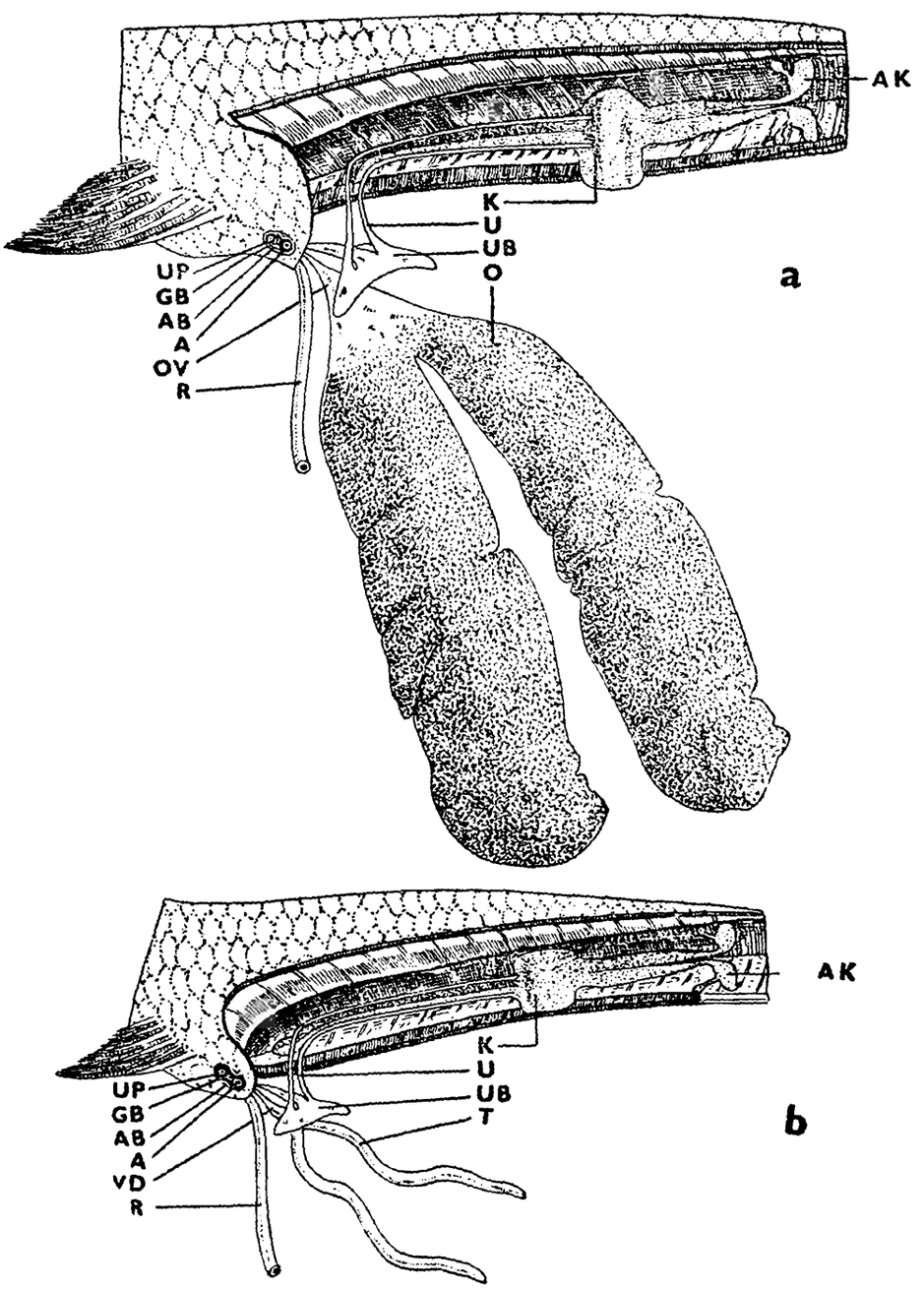
The kidneys, which are partly free and partly fused, have a somewhat peculiar shape on account of the thickening and enlargement of the middle portion in the transverse axis. The anterior end is double which shows that the two kidneys have become fused from the middle of their length. Behind this thickening, the kidneys narrow off and become defined again, being separated by a blood-vessel in the mid-line. To the free ends of the kidneys are attached the head-kidneys which, however, lie in front of the pericardium.

The ureters arise from behind the expanded portion and run somewhat parallel to where they expand into the urinary bladders. The latter are thin-walled sacs which unite posteriorly to form a duct that opens into the cloaca (Text-fig. 5*a*, *b*).

Between the months of September and March, which is the non-breeding season, the ovaries become filamentous, and, unless their position in the mature specimen is known, it is rather difficult to locate and identify them. They have a length of about 5.6 cms. and practically no width in the "off-season" By the third week of April, they begin to enlarge. Becuase of the limited space available in the body-cavity, the hypertrophied ovaries require considerable space for their lodgement, and, for want of it, become folded here and there. The ovaries are demarcated from the oviducts by their colour, opacity, uneven surface and the prominences due to the ova inside them. The thin, short and transparent oviduct opens into the cloaca by means of a single median pore (Text-fig. 5*a*).

A fully grown ovary measures 11.6 cms. in length and 4.2 cms. in breadth. Regression sets in after July, and, by the end of August, the ovaries become depleted of their contents and shrink in size.

The paired testes become reduced during the non-breeding season into short, thread-like structures measuring about 5.5 cms. in length.



TEXT-FIG. 5.—*Cirrhina mrigala* (Hamilton). (*a*). Female. (*b*). Male. × 1/2 Natural size).

Towards the end of April, they become convoluted by reason of having grown in length to 8.8 cms. and in width to 2.3 cms.

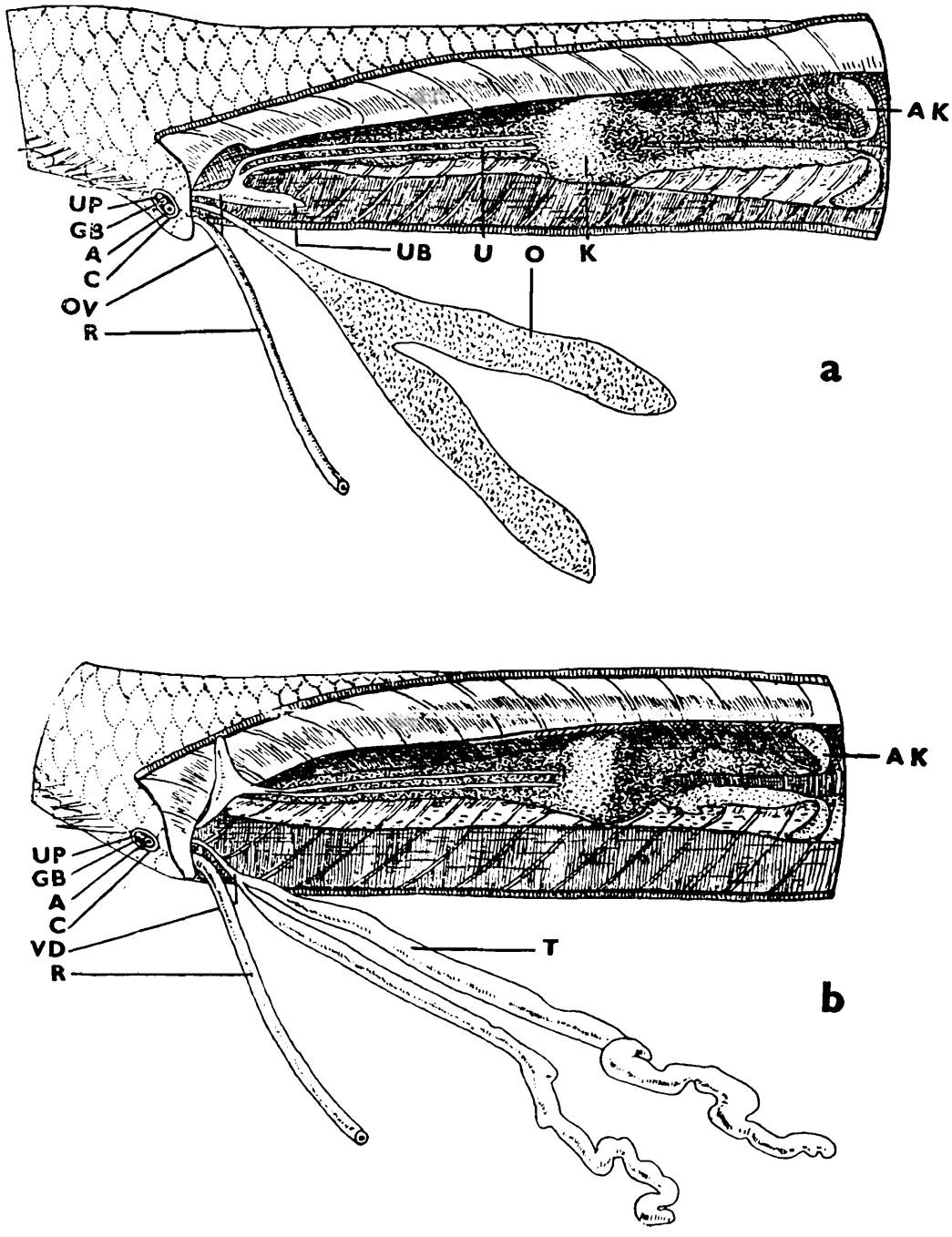
The testes lead into the vasa deferentia which unite to form the ejaculatory duct opening by a single median orifice into the cloaca (Text-fig. 5*b*).

The cloaca is oval in outline and not very deep. The anus, and the genital and the urinary pores open into it in the usual order. Abdominal pores are present on the lateral walls of the cloaca (Text-fig. 5*b*).

5. **Labeo rohita** (Hamilton)

(Text.Fig. 6*a*, *b*)

The head-kidneys of *L. rohita* resemble those of *R. rasbora* and *Cirrhina mrigala* in respect of disposition. The kidneys are separate and



TEXT-FIG. 6.—*Labeo Rohita* (Hamilton). (*a*). Female. (*b*). Male. × 1/2 Natural size).

free in the anterior one-third of their length, but fused in the latter two-thirds of their course. About the middle of their length, they are thickened and flattened out transversely (Text-fig. 6*a* ,*b*).

The ureters are distinct and arise just behind the thickening referred to above. They run almost parallel below the kidneys for a short dis-

tance, then converge behind them to form the urinary bladder which empties itself into the cloaca by means of a short duct.

In immature specimens, the testes and the ovaries are indistinguishable because both of them are filamentary in appearance, but, on attaining maturity, the gonads become properly differentiated in shape, size, and colour (Text-fig. 6*a*, *b*).

The ovaries commence to enlarge late in January and grow very rapidly becoming mature by the middle of February. In the ripe condition they measure about 16.3 cms. in length and 3.8 cms. in width, are yellow in colour and vascularised on the surface.

The two ovaries unite posteriorly and pass off into a thin walled duct which opens by a single median aperture into the cloaca.

Young testes are thread-like in form and begin to enlarge and thicken in February and fully ripe males are available in April. A fully grown testes measures 15.5 cms. in length and 1.2 cms. in breadth.

Posteriorly the two testes give off vasa deferentia, which unite to open by a single pore into the cloaca (Text-fig. 18*c*).

The cloaca is oval in outline and deep. The anus opens into its anterior section,while the posterior portions occupied by the genital and the urinary pores (Text-fig. 18*c*).

6. **Wallago attu** (Bloch & Schneider)

(Text-fig. 7*a*, *b*)

The abdominal kidney, which is broadly triangular and thick, is dark-red in colour. Its apex is bilobed, while the main body is compact and fused. Unlike other cases where the kidneys lie below the air-bladder, in this species they are placed behind it, the air-bladder being lodged in the fork of the kidney. The head-kidney lies in front of the pericardium and is practically severed off from the kidney proper, excepting for a blood vessel that links the two. The blood vessel of the left side is however separate, being very thin and embedded in lymphoidal tissue. In some cases, the lymphoidal tissue is so developed as to obliterate the blood vessel. The blood vessel of the right side, however, is prominent and extends between the head-kidney and the kidney. Remnants of the penal tissue are found adhering to this blood vessel.

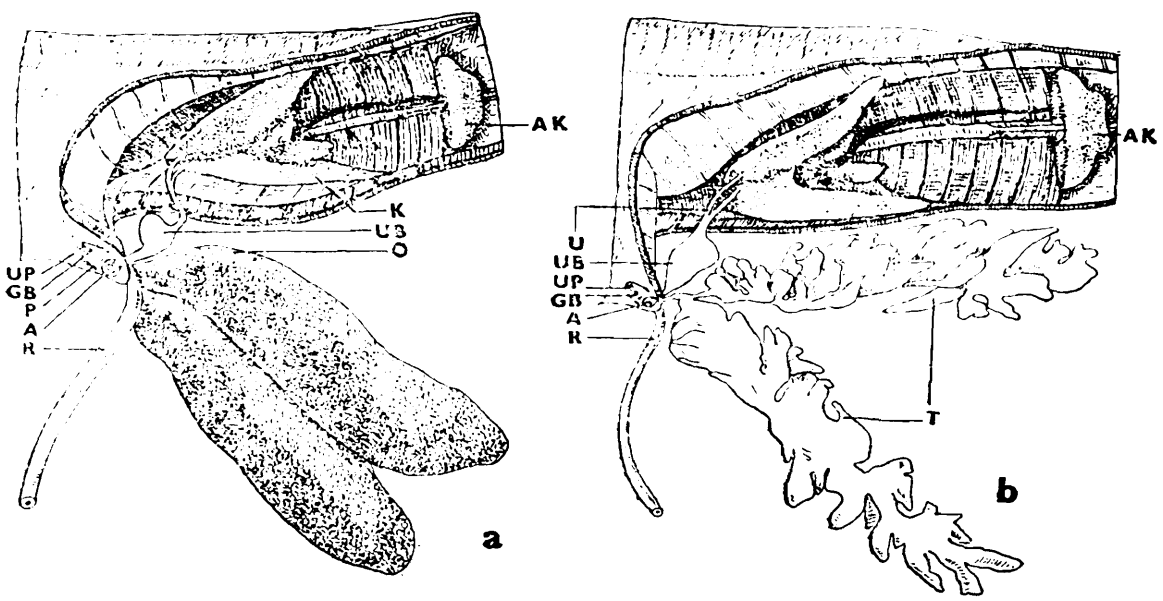
The head-kidney is massive in form and triangular in shape. Because of the thick short and compact nature of the kindeys the ureters are also shorter in length and arise from the fused posterior portion. After traversing a short distance, they unite and dilate to form the urinary bladder. The bladder tapers off posteriorly into a narrow duct (Text-figs. 7*a*, *b*; 19*a*) which opens on a very prominent urino-gential papilla.

The gonads are paired organs which adhere closely together and are separable with difficulty. The ovaries are sac-like structures having a pimpled surface, but the testes are lobulated and feathery in external form. Moreover, the immature ovaries are moss-green in colour, while

the testes look creamy white. When the gonads recress in the non-breeding season, they still retain their distinctive external appearance and can easily be made out.

The ovaries are paired, sac-like organs which are adherent for the greater part of their course, except for a short length anteriorly. In the early stages, they are dirty green in colour becoming light yellow in the regressive phase and vascularised in the breeding season. An immature ovary in January or February measures 3.6 cms. in length and 11.8 cms. in length and 3.5 cms. in width in July.

Posteriorly, the united ovaries form a single short oviduct which opens on the papilla by means of a separate opening in front of urinary orifice (Text-figs. 7*a*; 19*a*).



TEXT-FIG. 7.—*Wallago attu* (Bloch & Schneider). (*a*). Female. (*b*). Male. (*a* and *b* × 2/5 Natural size).

The testes do not suffer much change in length during the non-breeding season, but their finger-shaped out-growths decresae in size. A fully mature testes measures about 6.2 cms. in length and 2.3 cms. in width.

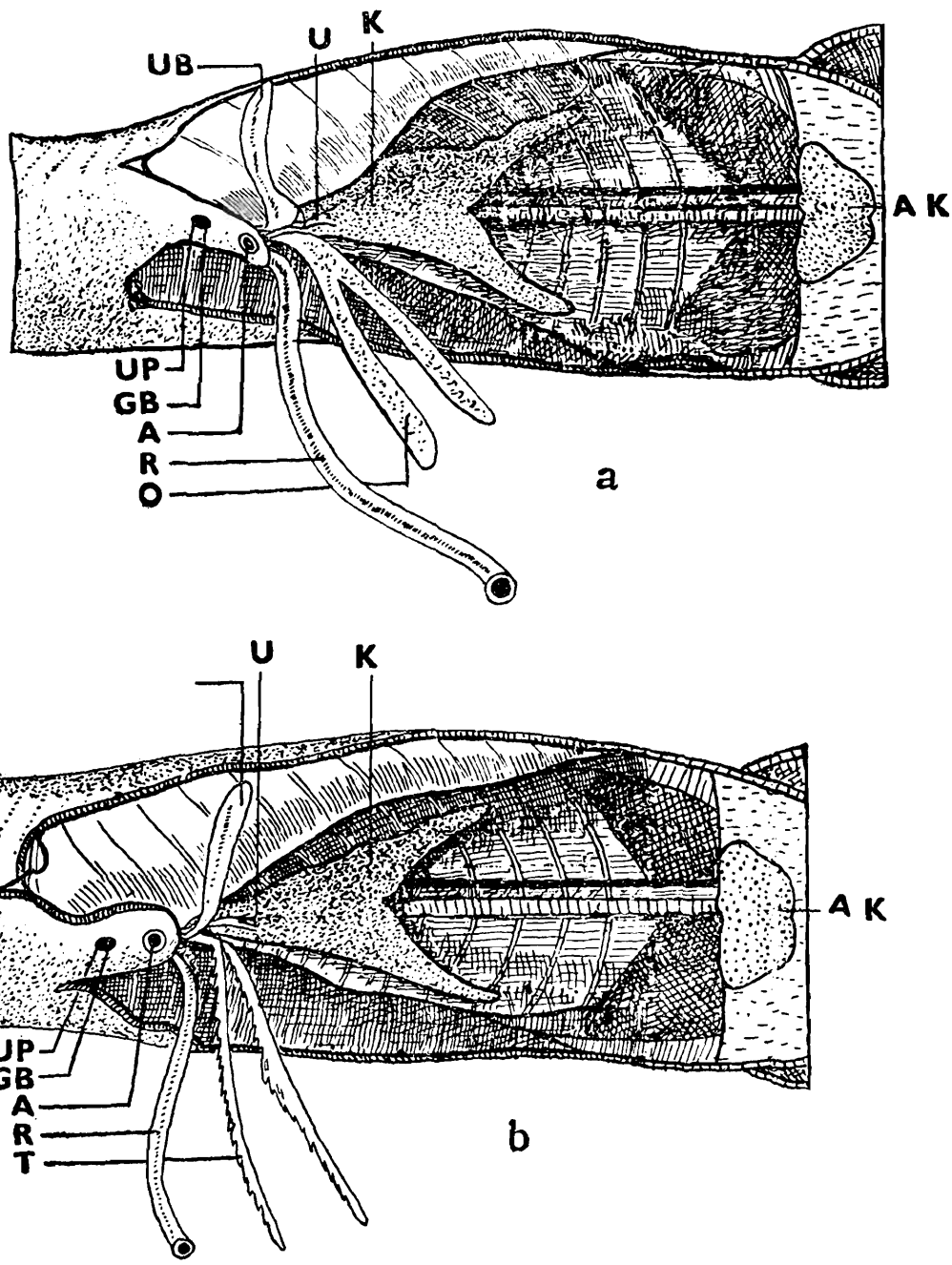
Posteriorly the two testes give off vasa deferentia which unite to open on the urino-genital papilla by means of a single pore placed in front of the urinary aperture (Text-figs. 7*b*; 19*a*).

There is no cloaca in this species and abdominal pores are wanting. The anus is aflush with the ectal surface. Behind the anus lies a very prominent urino-genital papilla which is similar in both sexes, being fleshy and blunt. On its summit are found the urinary and the genital apertures placed separately, the genital one being in front of the urinary. In mature specimens, it becomes reddish in colour, and in the males the urinary opening has a small protruberance on the papilla (Text-fig. 7*a*, *b*). The presence of such a big papilla in the male suggests that it acts as an intromittant organ, and in the female as an ovipositor.

7. **Mystus aor** (Hamilton)

(Text-fig. 8*a*, *b*)

The head-kidneys and the rest of the kidneys are connected in the same way as in *wallago attu*, that is, by means of a blood vessel. The kidney which is light red in colour looks single but its double nature is testified by the two anterior cornua-like prolongations of it. Between the cornual arms of the kidney lies the air-bladder. The ureters at their



TEXT-FIG. 8.—*Mystus aor* (Hamilton). (*a*). Female. (*b*). Male. × 2/3 Natural size).

origin are embedded in the mass of the kidney and the free portion is, therefore, short and single. Soon after emerging from the kidneys, it dilates into the urinary bladder, which is comparatively long, tubular and less muscular than that in *Wallago attu*. Posteriorly, the bladder opens in the immature specimens into a urino-genital sinus, and in the mature ones on a papilla (Text-figs 8*a*, *b*; and 21*a*).

The gonads are tubular sac-like structures which are united posteriorly for a short distance. Although they regress considerably and become thread-like during the non-breeding season, the gonads are still distinguishable from each other, the testes by their frilled ventral edge and the ovaries by their smooth outline.

The ovaries lie under the kidneys, but during the breeding season, they extend even below the air-bladder. During the non-breeding season, they look like elongated sacs measuring about 4.1 cms. in length and 0.2 cms. in breadth. The ovaries begin to enlarge from March onwards and grow somewhat slowly till July when they are full of eggs. The ovary does not become bright yellow in colour as in the case of *Wallago attu*, but remains creamy white and opaque. A fully enlarged right ovary in the breeding season measures about 12.8 cms. in length and 2.3 cms. in breadth. Towards the end of September, the ovaries become depleted of their contents and by December they are highly reduced.

A very peculiar change occurs during the breeding season. The urino-genital sinus which was aflush with the ectal surface now forms a protruberance in the form of a highly muscular papilla (Text-fig. 21*a*) on which the urinary and the genital pores are separately placed.

The testes are filamentous with one of their edges frilled. In the non-breeding season they become thin like a piece of sewing cord. This gives us an important means of distinguishing the males from the females during the non-breeding season. The enlargement of the testes begins by the end of April or at the beginning of May and proceeds rapidly thereafter. By July they become fully enlarged. The testes in the "off-season"measute about 5.2 cm. in length (and the right one about 3.6 cms.) but have a negligible breadth, whereas the fully hypertrophied ones measure 11.6 cms. in length and 2.1 cms. in breadth.

The vas deferens is short and thin, and opens by means of a single poe in front of the urinary aperture (Text-fig. 8*b*).

There is no cloaca and the abdominal pores are also wanting. The anus, which is aflush with the general surface, is placed in front of the urino-genital openings In the non-breeding season, there is a urino-genital sinus lying aflush with the general surface of the body, but, during the breeding season, the sinus becomes transformed into a finger-shaped vascularised papilla (Text-figs. 8*a*, *b* ; and 21 *a*).

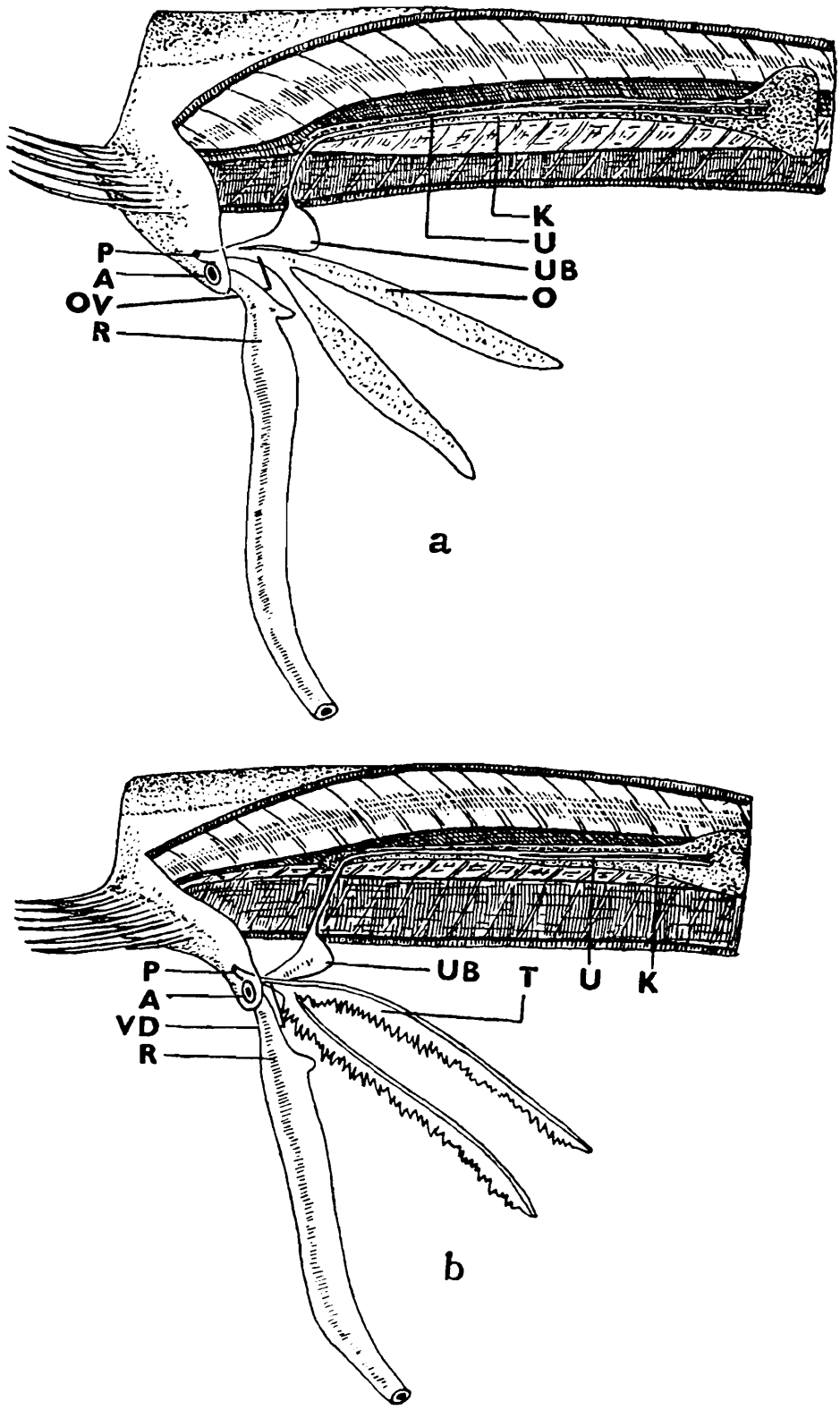
8. **Eutropiichthys vacha** (Ham.-Buch.)

(Text-fig. 9 *a*, *b*)

The head kidney is absent in this species and the abdominal kidney is saddle-shaped in front, but posteriorly a sudden narrowing takes place finishing off to a point at the posterior end.

The ureters, which are paired, emerge from the mid-posterior part of the broad saddle-shaped area and run caudal parallel to each other. Half the way down their course, they unite into a single duct, which

after leaving the kidney dilates into a single urinary bladder. The latter narrows off posteriorly to open on a papilla in confluence with the genital duct (Text-figs. 9*a*, *b* ; and 19 *b*).



TEXT-FIG. 9.—*Eutropiichthys vacha* (Hamilton). (*a*). Female. (*b*). Male. (× 1/3 Natural size).

The sexes are separate and are easily distinguishable because the testes have frilled edges and are cordlike, while the ovaries are saccular and smooth in outline (Text-fig. 9*a*, *b*).

The young ovaries are white in colour, smooth in outline and placed below the air-bladder. A fully grown ovary is 20·2 cms. long and 6·8 cms. broad. In August, when the ova are shed, the ovaries become flabby. The two ovaries remain free for the greater part of their length fusing behind only to form the single oviduct which unites with the ureter to open on the summit of a papilla (Text-figs. 9 *a* ; and 19 *b*).

The testes are filamentous in form and have a frilled edge. The two testes are flattened laterally and are white in colour in the " off-season. " When they begin to grow in May they first acquire pink dots and then turn completely pink in colour. The testes mature rapidly and though they start doing so only in May, they become ripe in July measuring 15·8 cms. in length and 3·8 cms. in width.

The two lobes unite posteriorly to form the single vas deferens which opens on the summit of a papilla (Text-figs. 9*b* ; and 19 *b*).

There is no cloaca and abdominal pores are absent. The anus, which lies separately in front of the papilla, is at the level of the surface. The single urino-genital papilla is placed immediately behind the anus. It is short, and on its summit lies the single urino-genital pore (Text-fig. 19 *b*).

9. **Heteropneustes fossilis** (Bloch)

(Text- fig. 10 *a*, *b*)

The head-kidneys are placed laterally and, being in the form of triangular lobes, are attached to the antero-lateral sides of the kidney proper. The abdominal kidneys are separate for the greater part of their length anteriorly and are united for a short distance, only posteriorly. The two kidneys are in close apposition to each other, being separated by a dorsal aorta running between them.

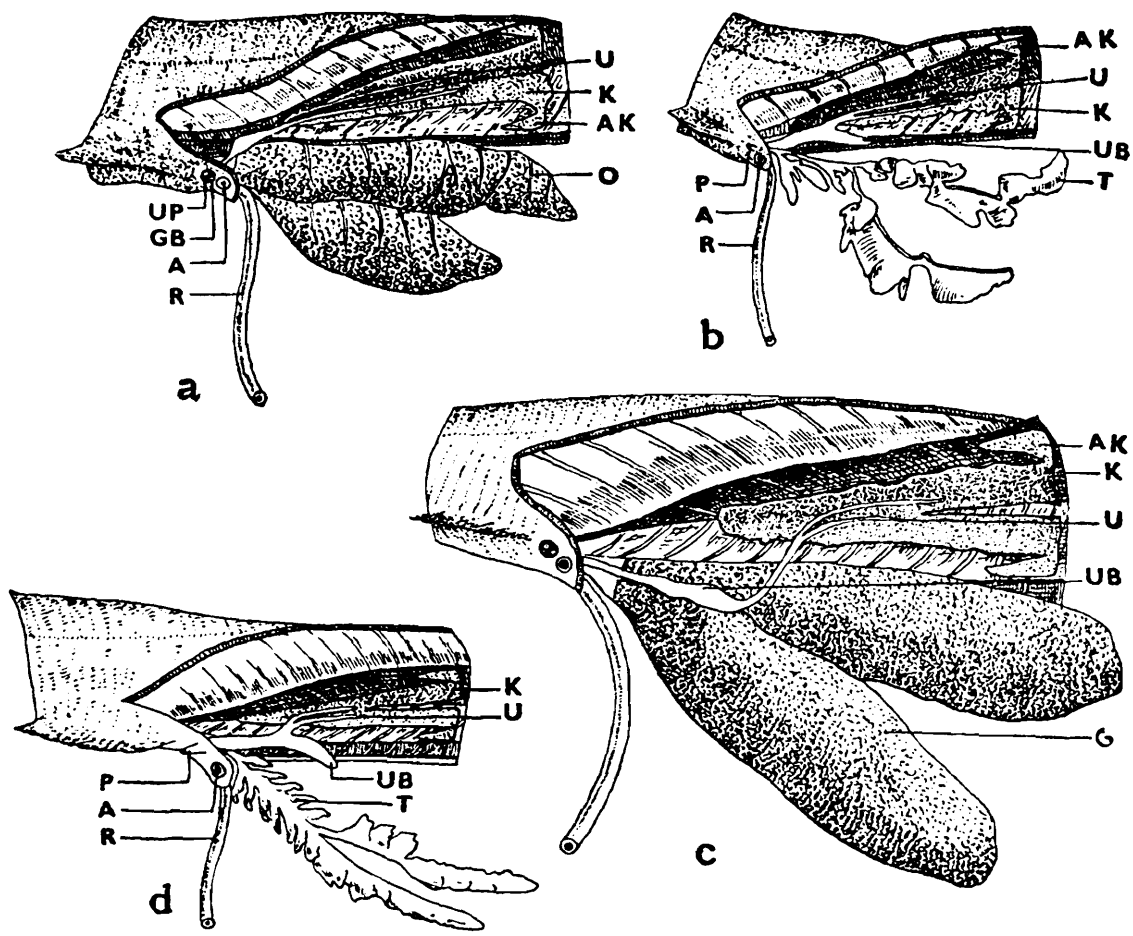
The paired ureters arise at about the same level, a little in front of the middle of the length of the kidneys and converge posteriorly to unite to form a short ureter which dilates into a thin walled urinary bladder The latter narrows down to a duct opening in the case of the male on the summit of a papilla along with the genital duct (Text-figs. 10 *b* and 19 *c*). The two ducts open very close to each other. In the case of the female, the ureter opens separately from the genital opening (Text-fig. 21 *b*). A comparison of Text-figs. 19 *c* and 21 *b* will make the point clear.

The sexes are separate and externally distinguishable by the presence of a urino-genital papilla in the male, and its absence in the female.

Immature and young ovaries are dull red in colour and saccular in shape. Between November and February (" the off-season ") the walls are wrinkled and the ovaries become flattened like a ribbon. In February, their enlargement commences and as they grow in size the red colour first changes into a greenish tint and finally into the dirty green colour persists during the breeding season from March to August. At this time, the ovaries measure about 5·5 cms. in length and 2·4 cms. in breadth. Towards the end of August, the eggs are discharged when the ovaries become flabby and begin to shrink in size.

The testes, which are paired, thin, white and thread-like structures, have a frilled edge during the non-breeding season, and lie close to the kidneys. The non-breeding season lasts from September to January. Towards the end of February, enlargement of the testes begins, frilling becomes more marked and the testes turn bright yellow in colour (Text-fig. 10 *b*).

The testes give off, posteriorly the vasa deferentia which open on the summit of a papilla along with the ureter in the male (Text-fig. 19 *c*).



TEXT-FIG. 10.—(*a* and *b*). *Heteropneustes fossilis* (Bloch). (*a*). Female. (*b*). Male. (× 1/2 Natural size).
(*c* and *d*). *Clarias batrachus* (Linn.). (*c*). Female. (*d*). Male. (× 1/2 Natura size).

In the immature condition, the vas deferens presents the normal appearance. But, in the middle of March two pairs of papillae-like outgrowths appear on them. As the testes grow in size, these diverticula also enlarge and become prominent. These are quite distinct from the testes and represent glandular appendages (Text-fig. 10 *b*).

There is no cloaca and the abdominal pores are also absent. The anus, which is placed a little behind the pelvic fins, lies in front of the urino-genital papilla. In the female, the papilla is wanting and the urinary and the genital pores separate and not confluent (Text-fig. 21 *b*).

10. **Clarias batrachus** (Linn.)

(Text-fig. 10 *c*, *d*).

In this species the head-kidneys are antero-laterally placed with respect to the kidneys proper and are small triangular structures. The

kidneys are dark red in colour, separate anteriorly, but fused posteriorly. The two kidneys are somewhat flattened at the anterior end.

The two ureters arise at about the level where the fusion of the two kidneys occurs, then proceed caudad converging to unite and, lastly, dilate into the urinary bladder. The bladder ends in a thin-walled urinary duct which proceeds posteriorwards to open on the summit of a papilla in the case of the male, and into a sinus in the case of the female (Text-figs. 10 *c*, *d* ; 20 *a* and 21 *c*).

The ovaries are paired, flattened, sac-like structures lying close to the kidneys and dull red in colour during the non-breeding season which extends from November to January. A few cases of hermaphroditism have also been noticed. Breeding season extends from February to October. Normally the two lobes of the ovaries are of equal size and are held together by a thin mesovarium. When fully ripe, they are dirty green in colour and measure about 7·9 cms. in length and 4·2 cms. in width.

The oviducts are clearly marked off from the ovaries and converge to open into an urino-genital sinus (Text-figs. 10 *c* and 21 *c*).

The testes resemble those of *Heteropneustes fossilis*, but the indentations are not so deep (Text-fig. 10 *d*). In the regressive condition, they are almost thread-like with serrated edges. By the end of March, the enlargement of the testes begins when their vascularisation becomes intensified. They measure 7·7 cms. in length and 2·5 cms. in breadth in April.

Posteriorly, the two lobes of the testes give rise to a vas deferens which courses along with the urinary duct to open on the urino-genital papilla (Text-fig. 20 *a*).

The anus is aflush with the surface of the body and opens in front of the papilla or the urino-genital sinus in the case of the female. Abdominal pores are absent.

11. **Ophiocephalus gachua** (Hamilton)

(Text-fig. 11 *a*, *b*, *c*).

The forked anterior end of the kidneys tapers off anteriorly and is connected with the head-kidneys. The kidneys, which are separate anteriorly, join each other at about the middle of their length to the posterior. The abdominal kidneys extend into the body cavity behind the cloaca (Text-figs. 11 *a*, *c* ; and 18 *d*).

The ureters, which are paired, arise from the posterior-middle region of the kidneys and proceed caudad. The two ureters take a turn to the left, become applied to the latero-ventral face of the air-bladder and finally dilate into the thin-walled urinary bladder which ordinarily lies between the two gonads in both the sexes (Text-fig. 11 *b*, *c*).

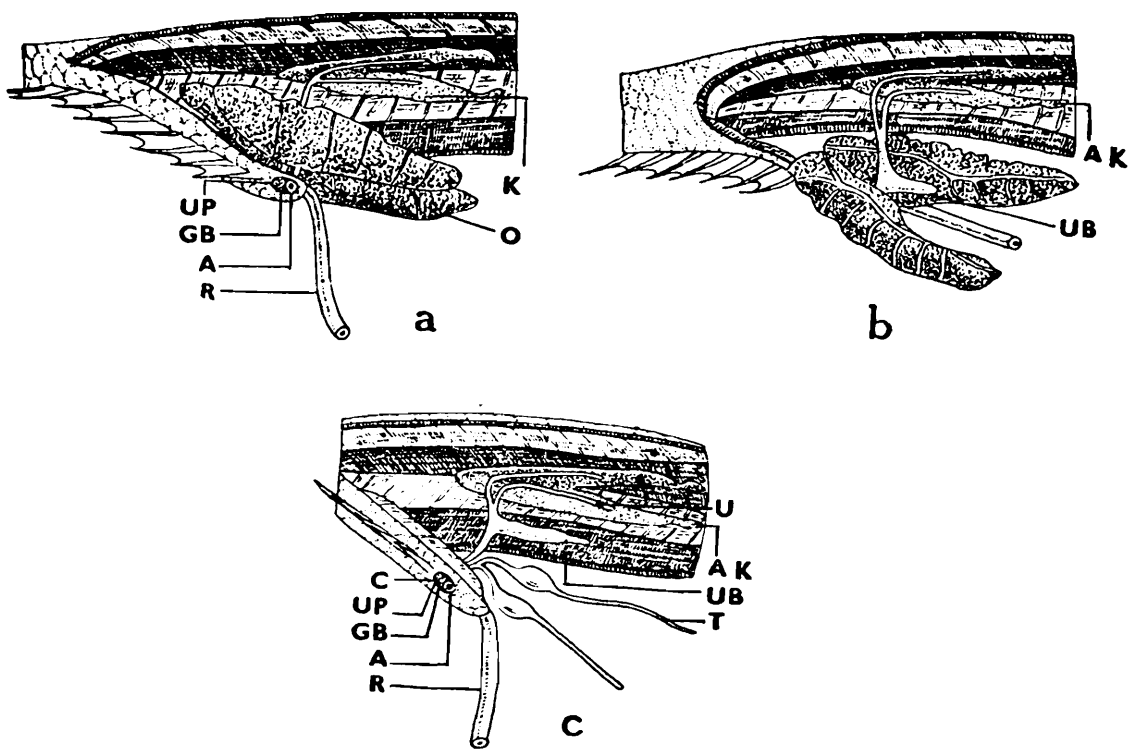
The bladder narrows off posteriorly into a thin duct which opens by a single pore at the posterior end of the cloaca (Text-figs. 11 *a*, *b* ; and 18 *d*).

In the female, the ovaries begin to enlarge about the middle of March, the growth manifesting itself in the posterior half first. The superficial

blood vessels show themselves more prominently at this time (Text-fig. 11*a*). Mature ovaries are bright yellow in colour, highly vascularised on the surface and measure about 5·9 cms. in length and 1·4 cms. in breadth. In this condition they are available from March to October. In fact, ripe females can be had throughout the year but are more abundant during the breeding season.

The testes are smaller in size than the ovaries and grow to 3·1 cms. in length and 1·2 cms. in breadth. During the non-breeding season, the testes are inconspicuous on account of reduction in size. Mature testes are of a pinkish hue and mature males are available from April to July but are not common during the remaining part of the year (Text-fig. 11 *c*).

Abdominal pores are absent, but a shallow cloaca is present into which the anus opens anteriorly. In the middle of it lies the single genital



TEXT-FIG. 11.—*Ophiocephalus gachua* (Hamilton). (*a* and *b*). Female. (*c*). Male. (× 1/2 Natural size).

pore which is small like a pin-hole during the non-breeding season but becomes prominent during the breeding season. The urinary orifice lies behind it (Text-fig. 18 *d*).

12. **Ophiocephalus marulius** (Hamilton)

(Text-fig. 13 *a, b*)

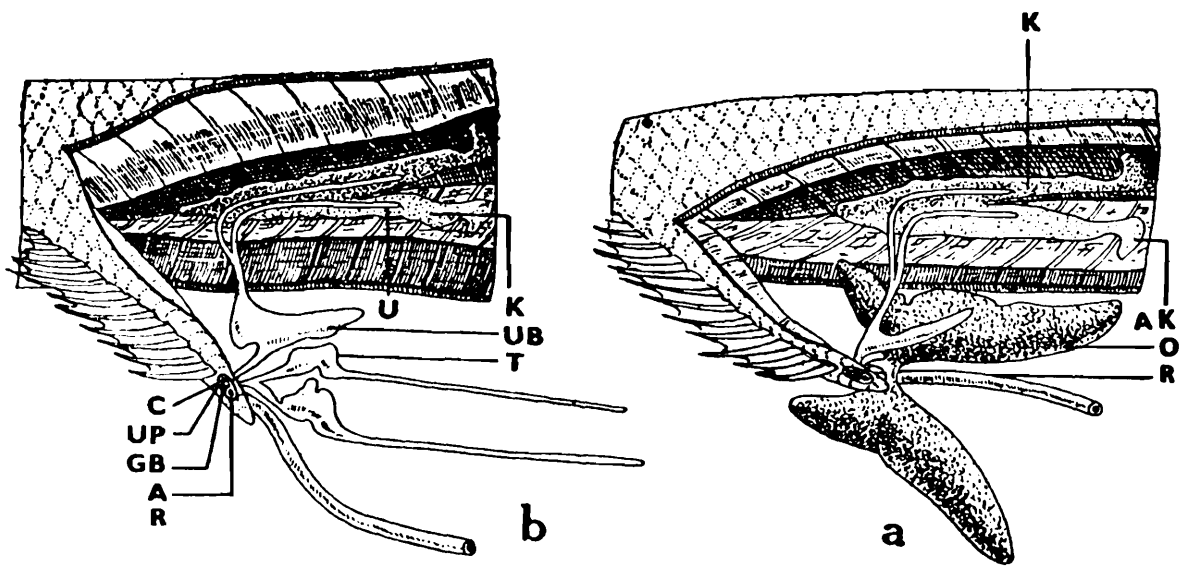
The head-kidneys are triangular or pyramidal in shape and are attached to the anterior ends of the kidneys by means of a short 'neck' Although the urino-genital organs of *O. marulius* resemble those of *O. gachua* and *O. punctatus* still there obtains difference in details.

The kidneys are separate anteriorly and somewhat elongated. Their outer edges are irregularly indented or wavy. The inner edges are, however, smooth. Posteriorly, the kidneys extend beyond the cloacal

region. The ureters arise somewhat suddenly from the hind portion as a thick-walled tube, which, piercing through the air-bladder, emerges on the ventral side to expand into a large-sized bladder. This narrows off posteriorly to open into the cloaca behind the genital duct (Text-fig. 13 *a, b*).

Sexes are distinct, but during the non-bereeding season the ovaries and the testes are scarcely distinguishable with the naked eye. During the breeding season, a ripe ovary measures about 5·9 cms. in length and 1·3 cms. in breadth. The right ovary is slightly longer than the left (Text-fig. 13 *a*).

The testes are very small when compared to the size of the fish. They never grow to more than 3·1 cms. in length and 2 cms. in width. During the non-breeding season they are not discernible because of their reduction in size, but assume a reddish hue during the breeding season.



TEXT-FIG. 12.—*Ophiocephalus punctatus* Bloch. (*a*). Female. (*b*). Male. (× 1/2 Natural size).

The anterior half of the cloaca is occupied by the anus which is partitioned off from the posterior half by a muscular sheet or partition. In the posterior half of it lies the single, median genital pore bordered by a thick rim which becomes vascularised during the breeding season. Behind it lies the single urinary pore. On the sides of the cloaca lie a pair of abdominal pores (Text-fig. 13 *a, b*).

13. **Ophiocephalus punctatus** Bloch

(Text-fig. 12 *a, b*)

The urino-genital organs of this fish differ little from that of *O. gachua.* Ripe ovary measures about 8·5 cms. in length and 2·1 cms. in breadth.

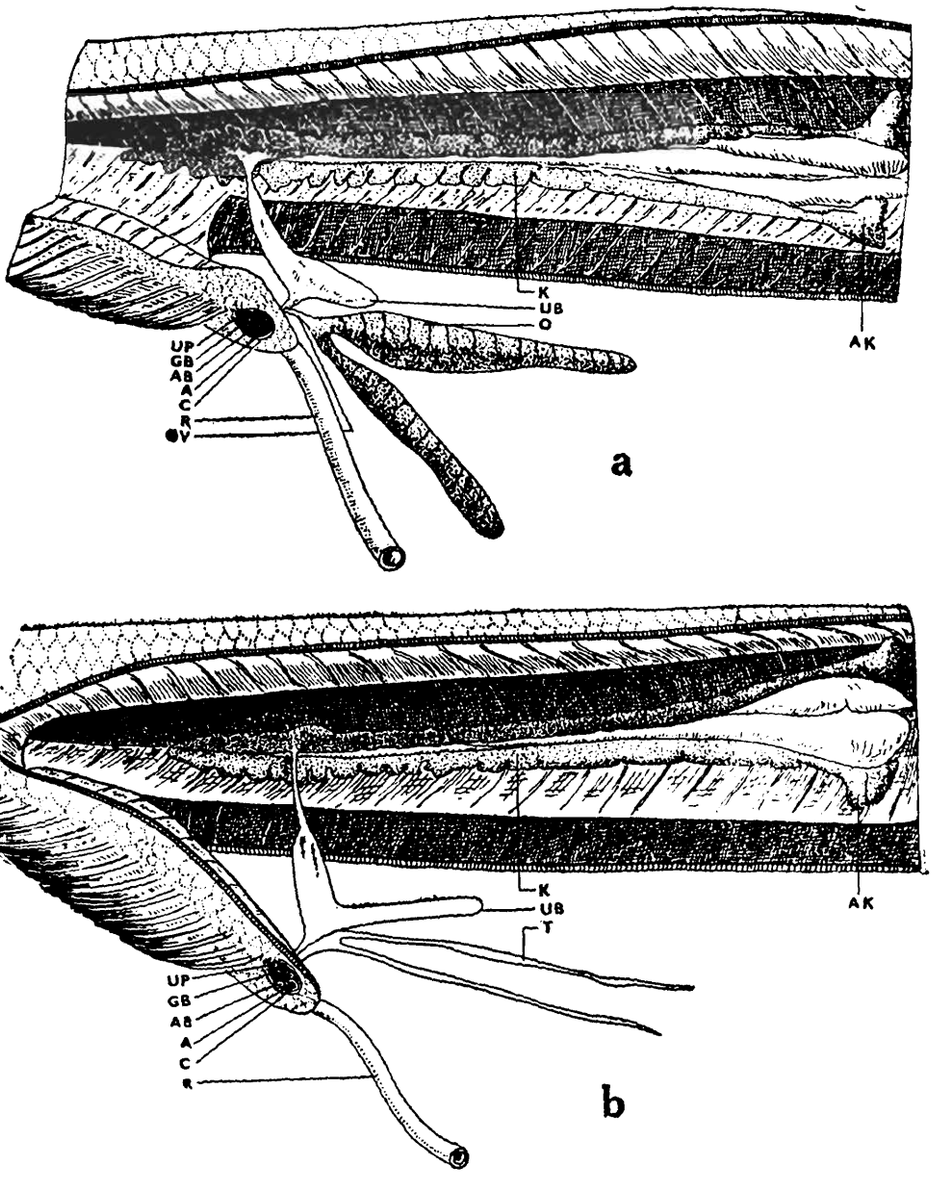
Testes measures 3·2 cms. in length and 1·4 cms. in breadth during the breeding season which extends from May to August. They become so reduced in size during the rest of the year as to be hardly distinguishable.

The structure of the cloaca is the same as that in *O. gachua.*

14. **Notopterus notopterus** (Pallas)

(Text-fig. 14 *a*, *b*)

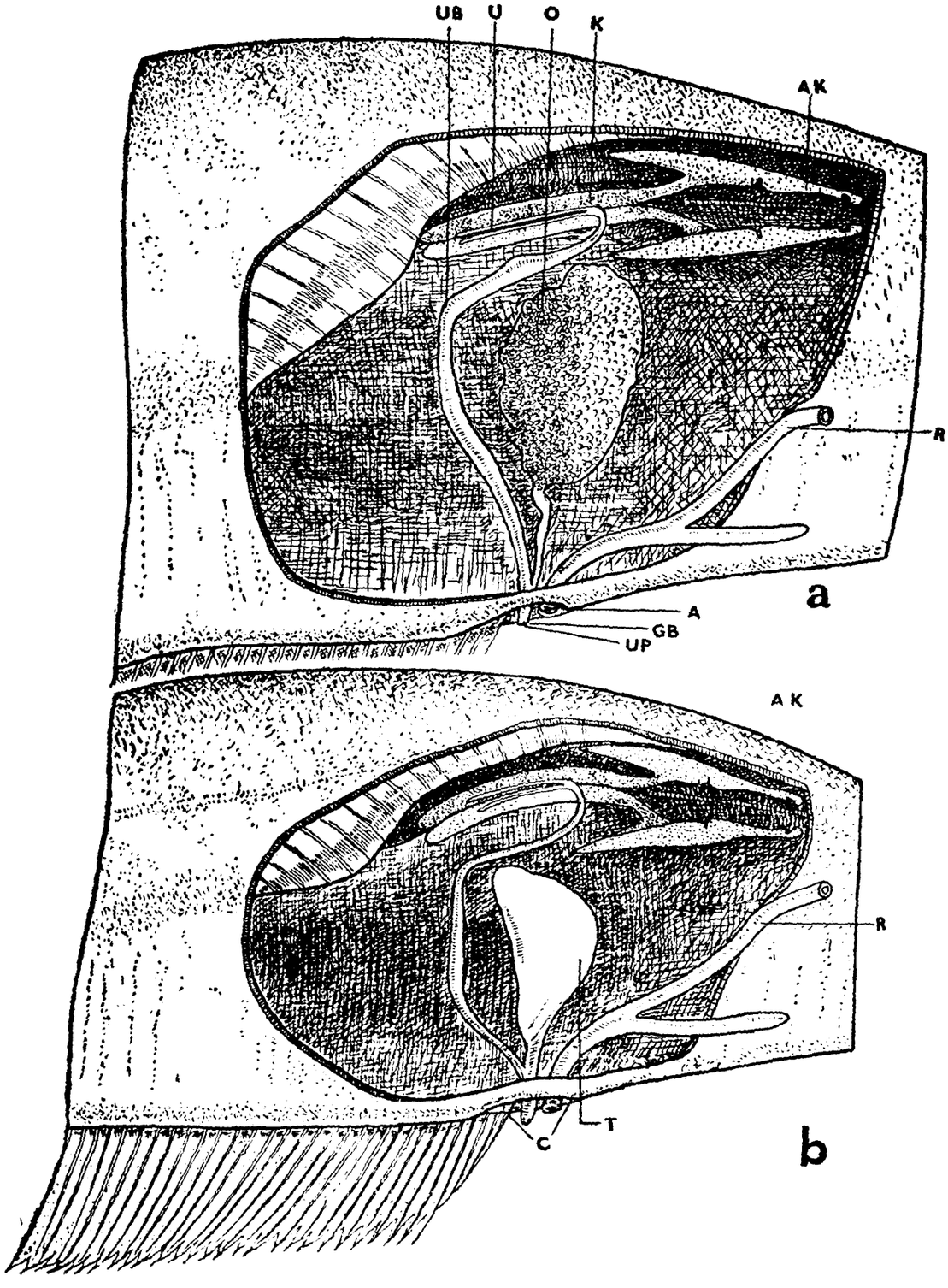
Due to the pronounced lateral compression of the body and the great reduction of the body-cavity, several peculiarities are noticeable in this fish. In both the sexes the *gonad is unpaired and usually present on the right side only*. The gonads are of the " open " type facing the body-wall (on the right side) and are covered by a loose mesovarium or mesorchium on the left side only which may be slightly projecting on the right side also (Text-fig. 14 *a*, *b*).



TEXT-FIG. 13.—*Ophiocephalus marulius* Hamilton. (*a*). Female. (*b*). Male. (× 5/6 Natural size).

The head-kidneys are prominent and very nearly equal to the kidney proper in size. The head-kidneys are more or less spindle-shaped and smooth-contoured, except for two small notches on their inner sides. They are connected with the main kidneys behind the middle of their length. The kidneys and the head-kidneys are separated by the

pericarddium. The kidneys are very small in size as compared to the body-size of the fish. Roughly they are bean-shaped, smooth-edged, pointed at both ends, and dark-red in colour, their inner faces being closely apposed.

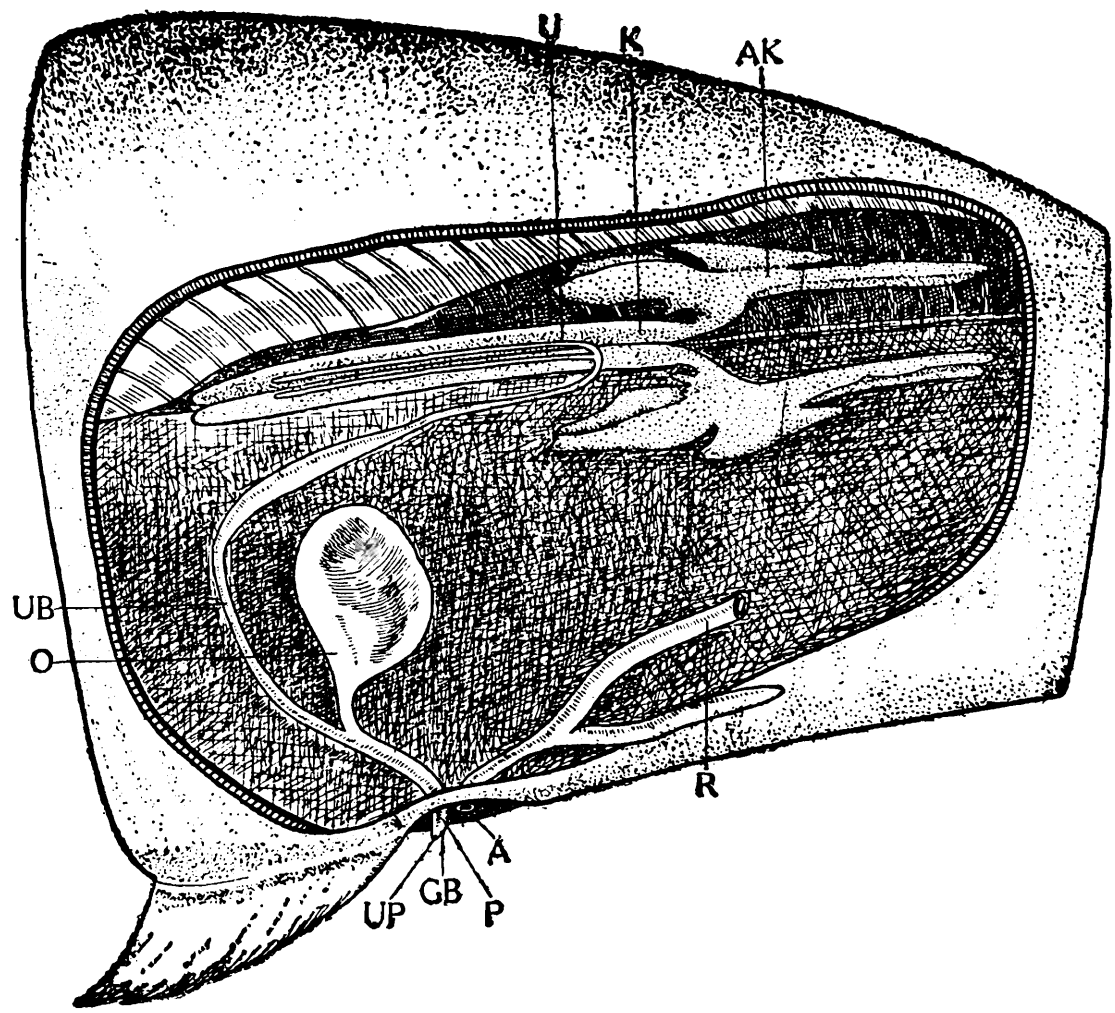


TEXT-FIG. 14.—*Notopterus notopterus* (Pallas). (*a*). Female. (*b*). Male. (× 1/4 Natural size).

The two ureters arise from the inner edges of the kidneys and run cephalad. This is quite the reverse of what occurs in other teleosts, a feature that has seldom been reported by previous workers. On leaving the kidneys, the single ureter formed by their union pierces

through the air-bladder to reach the ventral side of the body-cavity. Such a course of the ureter is uncommon in fishes and baffled the author for a long time as on emerging from the kidneys it was soon lost to view. By cutting through the air-bladder and following the course of the ureter it was found that it passed through the air-bladder. Soon after emerging from the air-bladder, it dilates into a glistening tubular structure which bends and then turns caudad to reach the cloaca and to open on a prominent papilla placed in it (Text-fig. 14 *a*, *b*).

A fully mature ovary is almost globular in outline (Text-fig. 14 *a*), measuring 2·4 cms. in length and 3·4 cms. in breadth. As has been already mentioned, the right ovary alone is present on the right side of the stomach adhering to the body-wall. The left face of the ovary is covered



TEXT-FIG. 15.—*Notopterus chitala* (Hamilton). Female. (×5/6 Natural size).

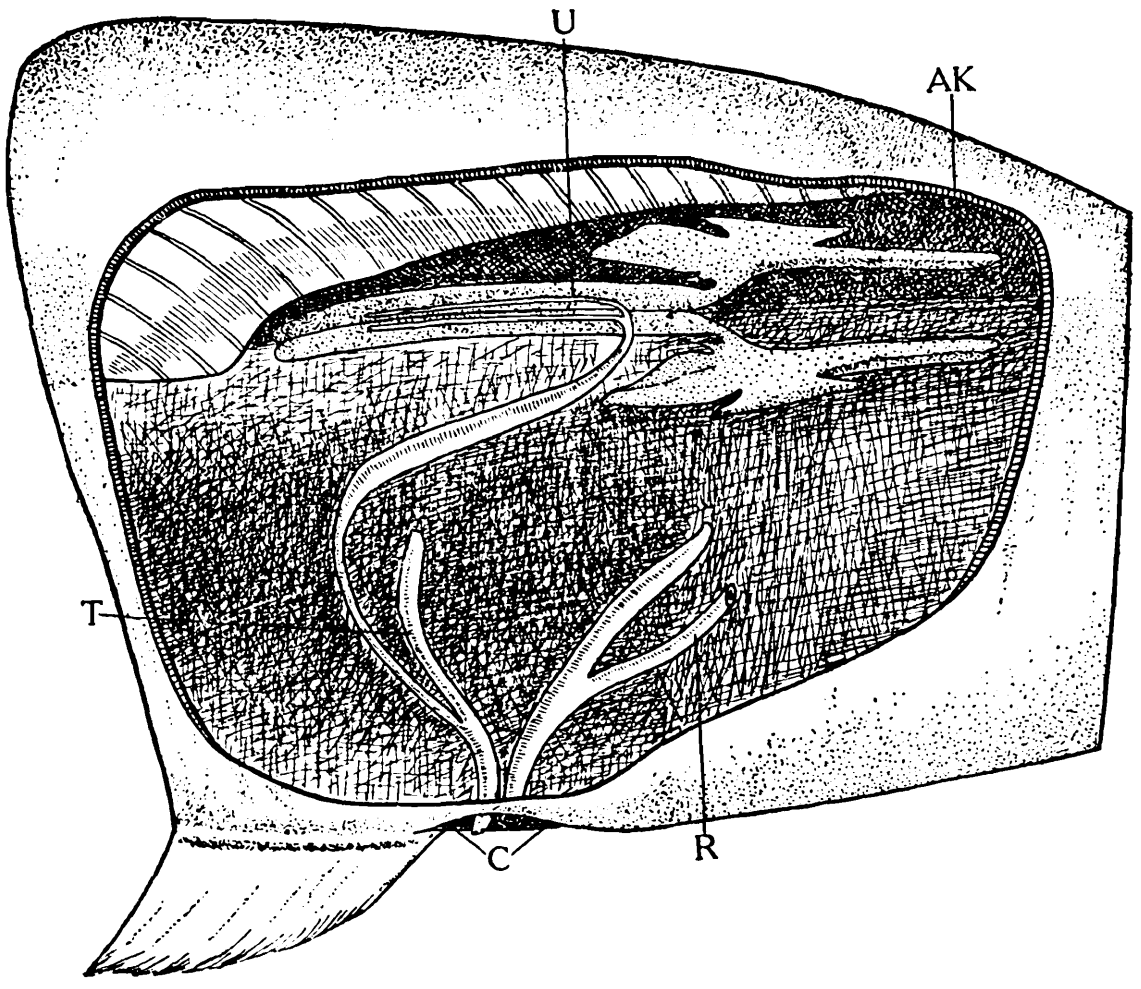
by the mesovarium which is a transparently loose and thin covering. On the ' open ' side (right side) the young ovary bears, in the breeding season, ridges or folds like those of the human cerebral hemispheres (Text-fig. 14 *a*). The ovary, at this time, is bright yellow in colour. The breeding season extends from April to August.

A duct in the form of an open groove proceeds for part of its course from the ovary, becomes tubular and muscular, and opens on the urino-genital papilla in the cloaca (Text-fig. 14 *a*). This duct measures about 2·2 cms. in length. In August, the mature specimens become scarce and by December the ovary and the duct become reduced in size

and shrivelled up. They begin to enlarge again in March for the next reproductive cycle.

The testis of the male, which is also single, occurs like the ovary on the right side and resembles it in external form and disposition except that the ridges are small and not very much convoluted (Text-fig. 14 *b*). It never grows bigger than 2·3 cms. in length. Fully mature males are available from July to August. The immature testis is white in colour, while the mature and ripe one is pinkish in hue.

The cloaca is a deep cavity placed betwen the reduced pectoral and ventral fins. It is an oval concavity in which the anus lies anteriorly and the genital and the urinary pores open on a papilla. The abdominal pores are absent (Text-figs. 14 *a, b* ; and 18 *e*).



TEXT-FIG. 16.—*Notopterus chitala* (Hamilton). Male. (× 5/6 Natural size).

15. **Notopterus chitala** (Hamilton)

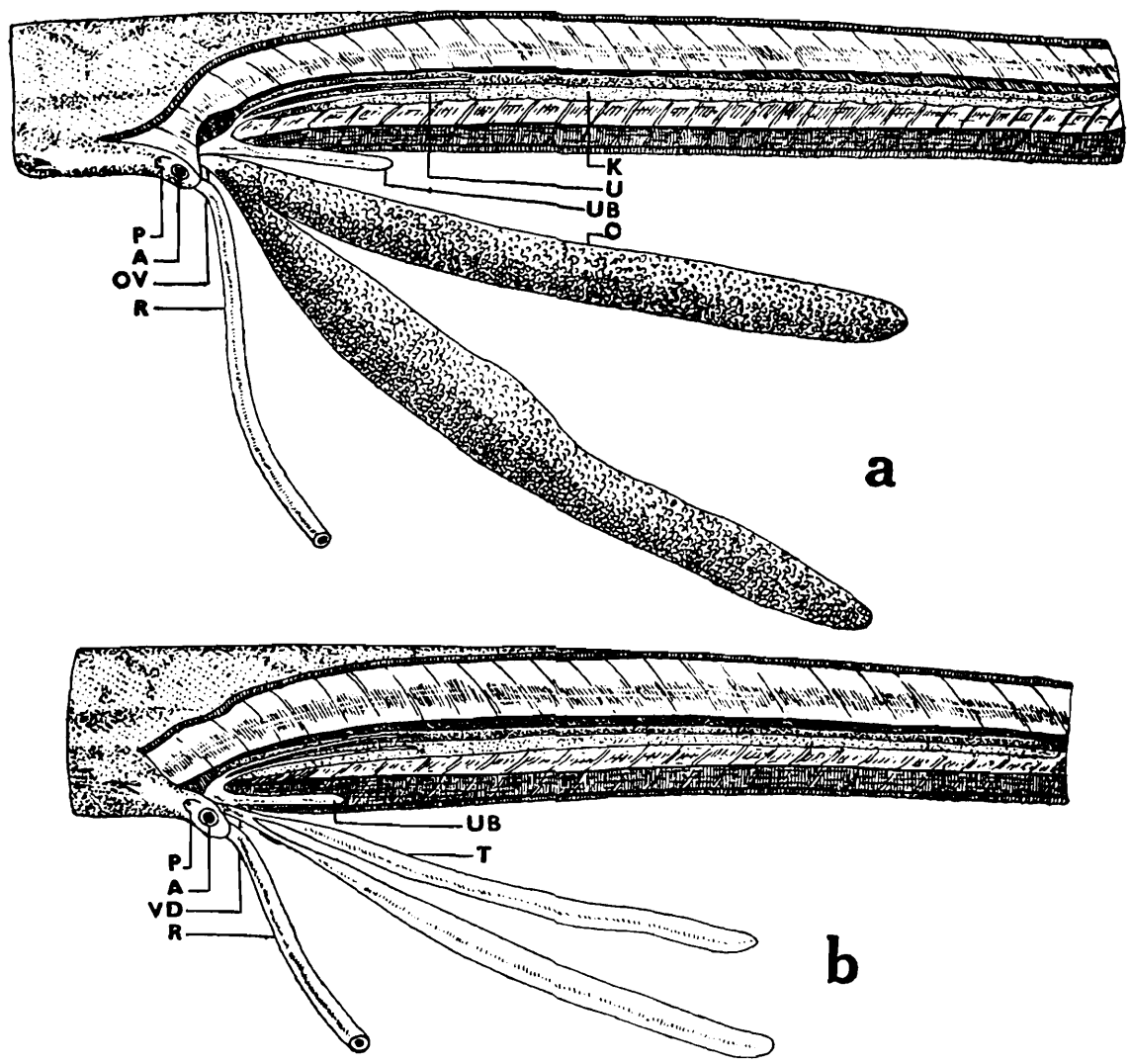
(Text-figs. 15 and 16)

N. chitala resembles *N. notopterus* in all essential respects so far as the urino-genital system is concerned. But the head-kidneys are proportionately larger than those of the *N. notopterus*. Further, the head-kidneys are not smooth in contour but are lobed.

The ovaries begin to enlarge in May and continue to do so till July when they become fully ripe. The ovarian ridges and convolutions are not so much pronounced in this species as in the case of *N. notopterus*.

A fully ripe ovary is pinkish in colour and measures 3·8 cms. in length and 3·2 cms. in breadth (Text-fig. 15).

In immature specimens the testis is ribbon-like in form and smooth on the surface (Text-fig. 16). The enlargement begins in May, and the species becomes fully ripe by July. At this time it measures 2·5 cms. in length and 1·6 cms. in breadth. The interior of the cloaca resembles that of *Notopterus notopterus.*



TEXT-FIG. 17.—*Mastacembelus armatus* (Lacépède). (*a*). Female. (*b*). Male. (x 1/2) Natural size).

16. **Mastacembelus armatus** (Lacépède)

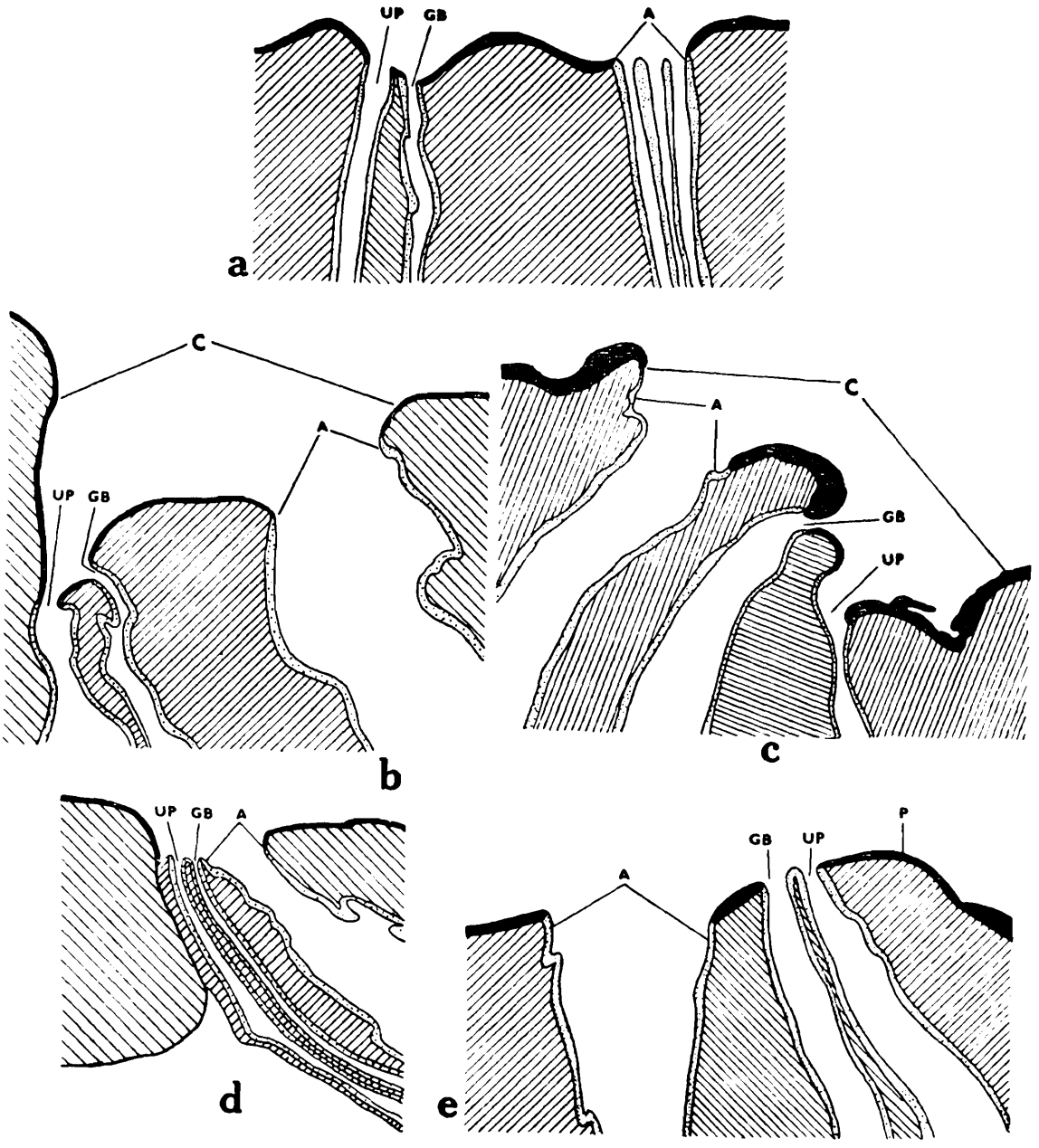
(Text-fig. 17 *a*, and *b*)

In this species, there is no head-kidney. The two kidneys remain separate throughout their length except in the hindmost part where they unite (Text-fig. 17 *a*, *b*.)

The paired ureters arise separately from the two lobes in the last quarter of their length, run caudad for a short distance and then join to form the ureter. The ureter gives off a long finger-shaped bladder which lies in between the gonads. The ureter joins the gonoduct just before opening at the summit of the papilla (Text-fig. 20 *b*).

The gonads are elongated and tubular structures. Immature male and female gonads resemble each other in external appearance.

In a mature female, the ovaries, which are bright yellow in colour and granulated on the surface, occupy a large part of the body-cavity, displacing other organs. At this time, they measure 18 to 20 cms. in length and 3 to 4·5 cms. in breadth. Ripe females are available from March to September. By the middle of September, the ovaries shrink in size, maximum reduction being reached in December. The mesovarium covering the immature ovries is somewhat thick.



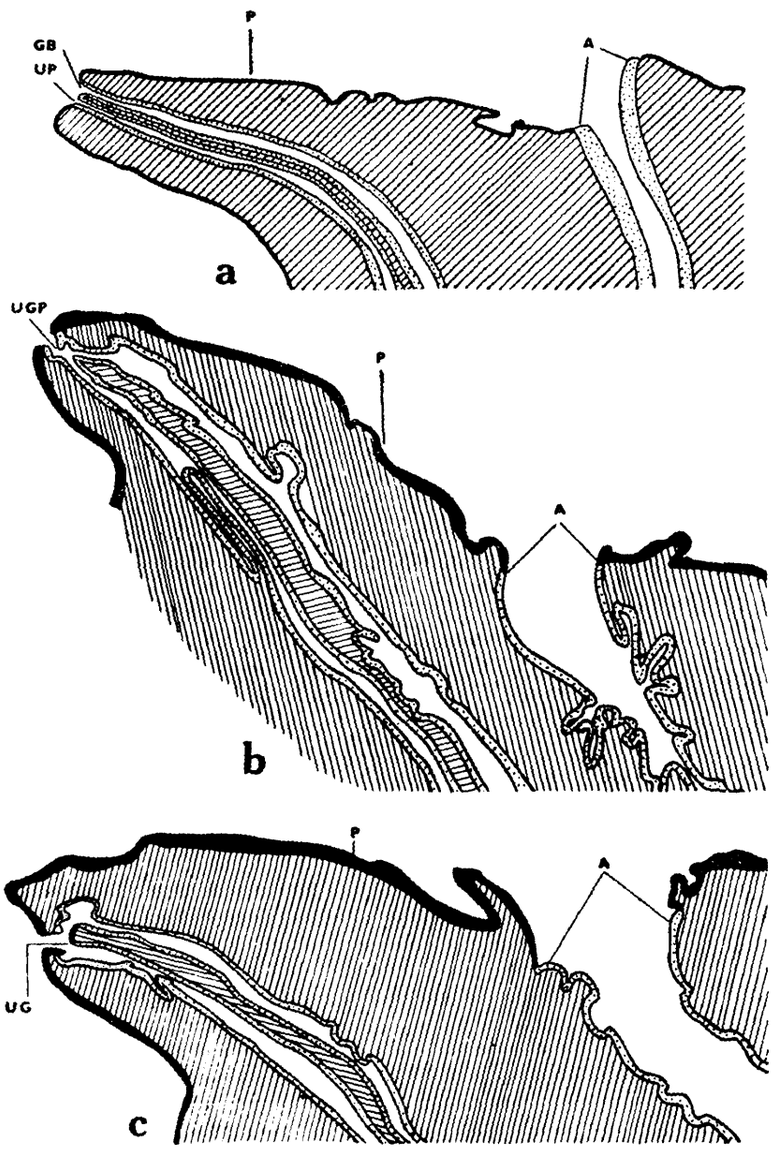
TEXT-FIG. 18.—Longitudinal sections through the cloaca of : (*a*). *Hilsa ilisha* (Hamilton). (*b*). *Catla catla* (Hamilton). (*c*). *Labeo rohita* (Hamilton). (*d*). *Ophiocephalus gachua* (Hamilton). (*e*). *Notopterus notopterus* (Pallas). (× 26·6).

The two ovaries narrow down caudally, and pass into the oviducts which unite and join with the urinary duct to open on the summit of a papilla (Text-figs.17 *a* and 20 *b*).

The paired testes are elongated, tubular, smooth-walled structures, pale white in colour in the immature stage, becoming pink as they grow.

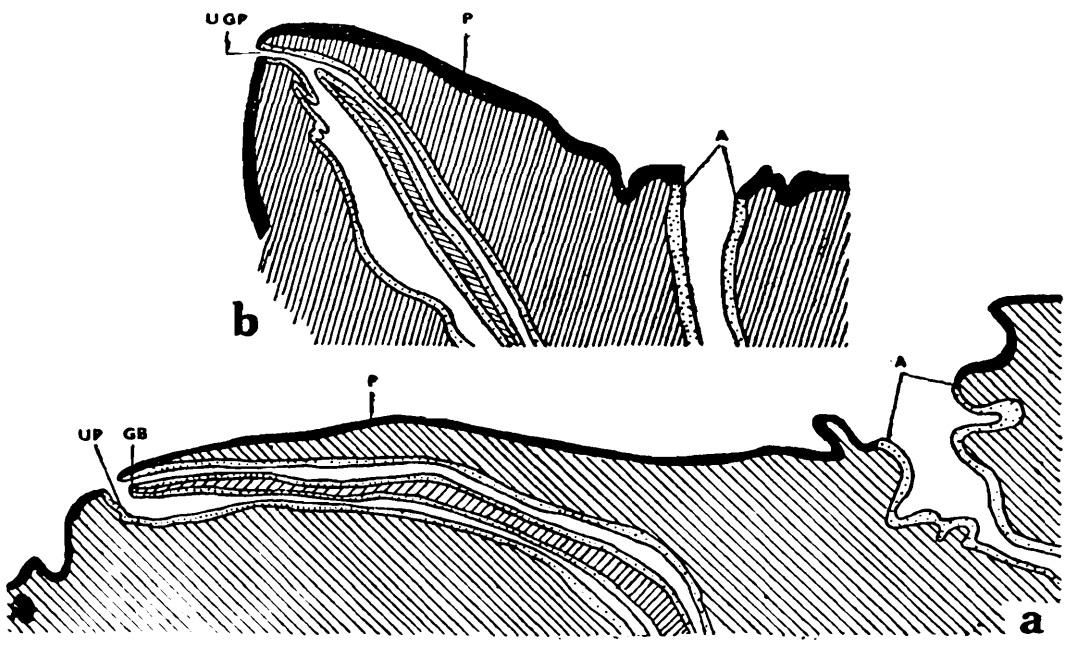
A fully mature testis measures from 18 to 20 cms. in length and 1 to 1·5 cms. in breadth.

At the posterior end, the testes give off the vasa deferentia which are distinguishable by their lighter colour. The two vasa deferentia join and then unite with the urinary duct to open on a papilla (Text-fig. 20 *b*).

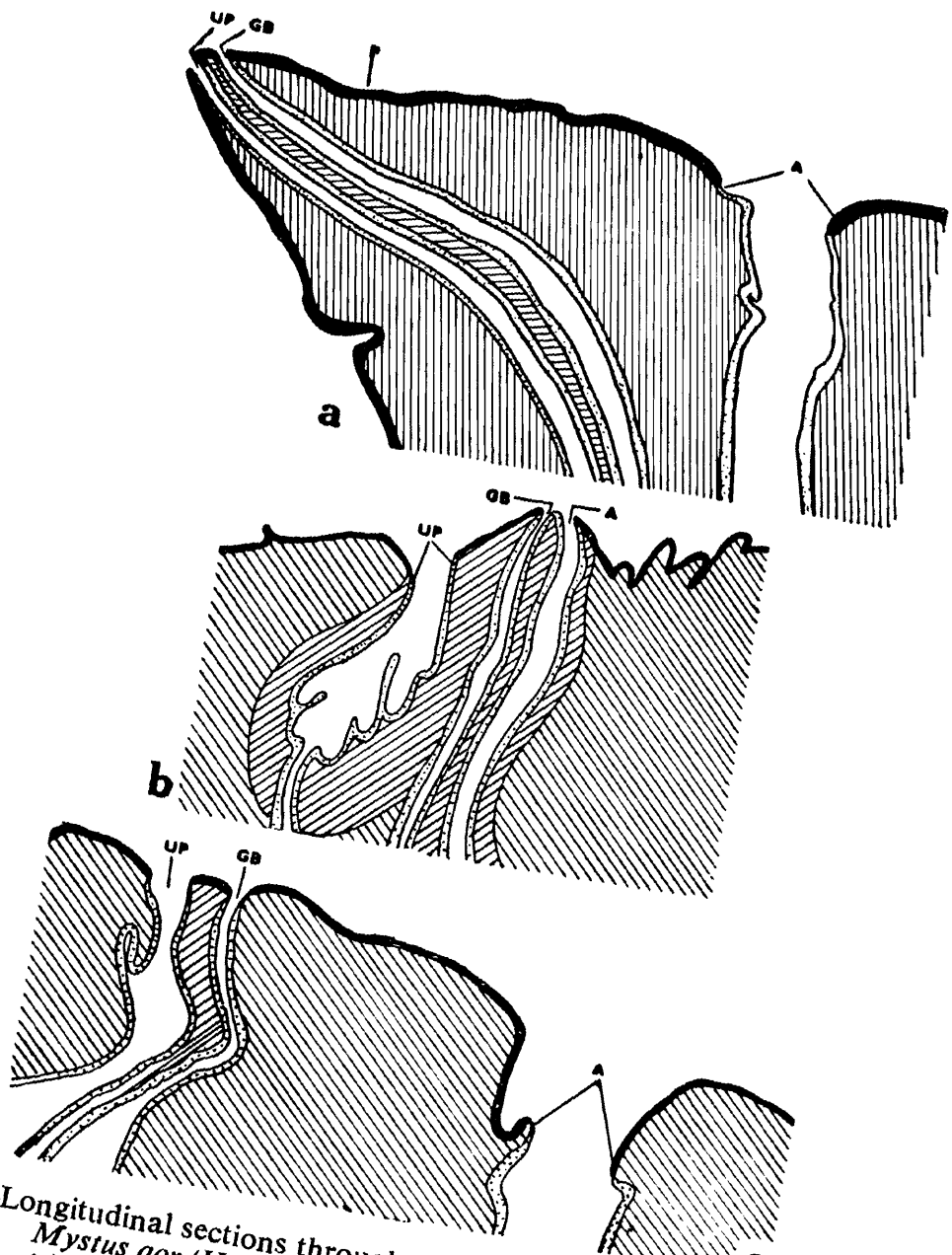


TEXT-FIG. 19.—Longitudinal sections through the anus and papilla of : (*a*). *Wallago attu* (Bloch and Schneider). (*b*). *Eutropiichthys vacha* (Hamilton). (*c*). *Heteropneustes fossilis* (Bloch). (× 26·6).

Immediately behind the anus lies the single urino-genital papilla, inconspicuous in the non-breeding season, but very prominent in the breeding season. The papilla is short and bears a wide and round pore at its tip (Text-fig. 17 *a*, *b*).



TEXT-FIG. 20—Longitudinal sections through the anus and papilla of : (*a*). *Clarias batrachus* (Linn.). Male. (*b*). *Mastacembelus armatus* Lacépède. (× 26·6).



TEXT-FIG. 21.—Longitudinal sections through the anus and urino-genital sinus of : (*a*). *Mystus aor* (Hamilton). (*b*). *Heteropneustes fossilis* (Bloch). Female. (*c*). *Clarias batrachus* (Linn.). Female. (× 26·6).

IV—General Remarks

Dissections and observations on several species of common fresh-water fishes have revealed many interesting facts and have cleared up ambiguities and misconceptions concrening the urino-genital oragns in teleostean fishes as the following remarks will show.

Kidney.—Balfour and Parker (1882), Goodrich (1930) and Bridge (1932) recorded that the kidneys in fishes are *separate* and double, but Kingsley (1926) mentioned that *fusion* also occurred in them. Embryologically the kidneys have a paired origin in the teleosts but they need not necessarily remain so in the adult stage. In all the fishes examined by the present author, the kidneys are not separate and double throughout their entire length, except in the Notopteridae and the Mastacembelidae. In *Hilsa ilisha* (Hamilton) the kidney is topographically single but for a short bifurcation at its anteriormost end. In the Cyprinoids like *Labeo rohita* (Hamilton), *Catla catla* (Hamilton), *Cirrhina mrigala* (Hamilton) and *Rasbora rasbora* (Hamilton), the kidneys have peculiar shape. They are bifid anteriorly, becoming fused for a short length, separate again and then become reunited posteriorly ; while in the Siluridae (composite family of Day) *Clarias batrachus* (Linn.) (Clariidae), *Eutropichthys va ha* (Hamilton) (Schilbeidae), *Mystus aor* (Hamilton) (Bagridae), *Wallago attu* (Bloch & Schneider) (Siluridae), and *Heteropneustes fossilis* (Bloch) (Saccobranchidae) the composite kidney is bilobed anteriorly but fused into one posteriorly. Similar condition occurs in the Ophiocephalidae, but in the Notopteridae and Mastacembelidae the kidneys are bilobed and separated for the greater part of their length.

Sedgwick (1905) referred to the occurrence of head-kidneys in all the Teleosts and my findings concur with his generalisation. The *Cyclothone* kidney according to Owen (1938) consists only of a pair of tubules, but in all the forms examined by the present author the kidneys are massive structures. The shape and contour, however, vary considerably in different species of fishes.

Ureters.—Sedgwick, Goodrich and Bridge report ureters as being invariably paired, united posteriorly and arising from the hind end of the kidneys, dilating to form a single " urinary bladder " Sedgwick mentions that " There are two longitudinal urinary ducts which unite posteriorly to form the single ureter. This structure, which frequently has a bladder-like dilatation, passes ventral-wards on one side of the air-bladder to open externally behind the anus, or into the rectum " Pfeiffer (1933) described the bladder as opening into the rectum and thought that " the above (this) condition would seem to resemble that found in most Teleosts " Variations in the number and position of the ureters and of the urinary bladder were found by the present author in the species of fishes dealt with here. Variations were sometimes found even among individuals belonging to the same species. For instance, in *Hilsa ilisha*, the ureters may be paired or single. When paired, the two may arise at the same level in some cases, while in others the left one may arise in advance of the right, or *vice versa*. Similarly, in *Labeo rohita, Cirrhina mrigala* and *Catla catla* the point of the origin of the ureters varies considerably from individual to individual. In *Wallago*

attu and *Mystus aor*, the paired ureters arise and leave the kidney abruptly, while in *Ophiocephalus marulius* a single ureter arises and leaves the kidney suddenly.

The condition in which the ureters run latero-ventrad on one side of the air-bladder, as indicated by Sedgwick, was found only in the case of *Ophiocephalus gachua* and *O. punctatus* by the present author. In the Notopteridae, the ureters pierce through the air-bladder and emerge on its ventral side to pursue their usual course to the cloaca. The first part of the course of the ureters is directed anteriorward, then they pierce through the air-bladder and emerge out of it ventrally. This is a novel course for the ureters to follow. Such a condition has not yet been reported in any other case. In *Ophiocephalus marulius* also the disposition of the ureters is through the air-bladder.

Urinary bladder.—The presence of a posterior dilatation of the ureters (or the 'urinary bladder') has been mentioned by Sedgwick, Goodrich, Bridge, Parker and Haswell, Pfeiffer and Owen. Goodrich, however, prefers to call it cloacal bladder. But the occurrence of two bladders has not been mentioned by any previous author. In *Cirrhinn mrigala, Labeo rohita* and *Catla catla*, the two ureters dilate separately into two bladders. This is very conspicuous in *Cirrhina mrigala* than in the other two species, The bladder in all the cases mentioned above narrows down caudally and opens independently or in confluence with the genital duct to the exterior *but does not open into the rectum* as stipulated by Sedgwick. The genital ducts also do not open into the bladder as mentioned by Pfeiffer in the case of *Lepidosteus.*

Ovary.—The author's observations on the ovaries agree mostly with the descriptions given by the previous investigators. In the majority of cases, the ovaries are paired, tubular or saccular and smooth-contoured. In the Cyprinidae, the ovaries are flat and slightly constricted in the middle. Mention of the unpaired condtion of the ovary in the Notopteridae was made by Francis Day (1889) and Goodrich (1930).

Oviducts.—According to Bridge in the Notopteridae and Salmonidae, the oviducts lose their continuity with the ovaries and degenerate to a great extent. He further holds the view that in some Salmonidae, the oviducts end anteriorly in wide funnel-like coelomic apertures, but do not embrace the ovaries. Such gymnovarian condition has not been found in the sepcies of fishes reported here. The oviducts are continuous with the ovaries being confluent with them posteriorly and opening externally by a single orifice. But in the Notopteridae it was found that a rut-like passage is formed by the partial folding of the mesovarium which serves as a conduit for the escape of ova to the exterior. On account of the degeneration of the oviduct reported by Bridge, this improvisation by nature is noteworthy.

Testes.—The description given by Sedgwick and Goodrich of the disposition of the male genital organs and their ducts has been found to be substantially correct.

Vasa deferentia.—There are two vasa deferentia in each case, excepting in the Notopteridae, which unite posteriorly and :

(*a*) open separately into the cloaca, e.g., *Hilsa ilisha* (Text-fig. 1 *a*, *b*) *Catla catla* (Text-figs. 2, 3) ; *Rasbora rasbora* (Text-fig. 4 *a*, *b*) ; *Cirrhina mrigala* (Text-fig. 5 *a*, *b*) ; *Ophiocephalus gachua* (Text-fig. 11 *a*, *b*, *c*) ; *O. punctatus* (Text-fig. 12 *a*, *b*) and *O. marulius* (Text-fig. 13 *a*, *b*) ;

(*b*) join the common ureter and open by means of a pore on the papilla, e.g., *Eutropiichthys vacha* (Text-fig. 9 *a*, *b*) ; *Heteropneustes fossilis* (Text-fig. 10 *a*, *b*) ; *Clarias batrachus* (Text-fig. 10 *c*, *d*) and *Mastacembelus armatus* (Text-fig. 17 *a*, *b*) ;

(*c*) do not join the common ureter but open separately on the papilla, e.g., *Wallago attu* (Text-fig. 7 *a*, *b*) ; *Notopterus notopterus* (Text-fig. 14 *a*, *b*) and *Notopterus chitala* (Text-figs. 15 and 16).

Cloaca.—In the Clupeidae, Cyprinidae and Notopteridae, the cloaca is very deep, but it is very shallow in the Ophiocephalidae. In the Siluridae (Day) and Mastacembelidae the cloaca is absent.

Abdominal pores.—Abdominal pores occur in *Hilsa ilisha*, some of the Cyprinidae like *Labeo rohita* and *Catla catla*, and in *Ophiocephalus marulius*. They are not found in gymnovarian forms like *Notopterus notopterus* and *N. Chitala*.

Sexual dimorphism.—Though a few cases of sexual dimorphism have been reported occasionally, this character is not so well-established in the fishes as in the case of the higher verterbrates. Davidson (1935) describes a very peculiar secondary sexual character in the male of pink Salmon, *Oncorhynchus gorbuscha*. As the breeding season approaches. the snout elongates, and a hump is developed on the dorsal side which starts from behind the head and tapers off caudally, the deepest portion being behind the dorsal fin. In the same year, Parker and Brower (1935) discovered the appearance of a melanophoric mark on the dorsal fin of the male of *Fundulus heteroclitus* which the authors label as the " nuptial secondary sex-character " because of its appearance in the breeding season.

Vladykov (1935) finds certain differences in the number and disposition of the fin-rays between the males and the females of some Chinese Cobitid fishes, which, according to him, are of some taxonomic importance.

According to Fraser-Brunner (1940), in the family Ostraciontidae sexual dimorphism is of common occurrence, but not of a very striking nature. It consists in colour differences, depth of the body and the form of the snout in the two sexes.

Among the sixteen species of fishes examined throughout the year by the present author, secondary sexual dimorphism was noticed only in *Heteropneustes fossilis* and *Clarias batrachus*. A urino-genital papilla occurs in the males of *Heteropneustes fossilis* and *Clarias batrachus* and the cloaca is absent, the anal opening being distinct and separate. In the case of the corresponding females, a urino-genital sinus exists. Day (1889) in his monumental work on Indian fishes does not record this important sexual difference.

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VI—Key to the Lettering used in the Diagrams

A., anus.
AK., head-kidney.
AB., abdominal pore.
ABL., air-bladder.
C., cloaca.
GB., genital pore.
GL., gland.
K., kidney.
O. ovary
OV., oviduct.
P., papilla.
R., rectum.
T., testis.
U., ureters.
UB., urinary bladder.
UGP., urino-genital pore.
UP., urinary pore.
VD., vas deferens.