*Reprinted from "The Proceedings of the Indian Academy of Sciences",*
*Vol. L, No. 2, Sec. B, 1959*

# ON THE RENAL UNIT IN SOME COMMON TELEOSTS*

BY P. R. S. TAMPI

(*Central Marine Fisheries Research Station, Mandapam Camp*)

Received November 24, 1958

(Communicated by Dr. S. Jones, F.A.SC.)

CONTENTS



## INTRODUCTION

THE numerous teleostean fishes inhabiting our coastal waters and estuaries, although normally restricted within definite ranges in salinity, show wide differences in their ability to endure changes in salt content of the environment. A few species among these are relatively more euryhaline and, on account of their remarkable powers of adaptation, are highly useful for culture in saline lagoons and coastal fish farms where seasonal fluctuation in salinity is a usual phenomenon. In view of the important role played by the excretory organs in the maintenance of water and salt balance in the body and the possible changes in their structure, the significance of a careful study of the renal units in these fishes, among other things, need hardly be overemphasised. Thus, this work was started as a basic means of approach to the wider problem on adaptation in some of the fishes as applicable to salt-water fish culture. However, in this preliminary report the scope has been circumscribed to cover only a brief description of the histologic characteristics of the renal units of a few selected species which might serve as a helpful background for experimental studies on adaptational physiology.

* Published with the permission of the Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp.

Considering the vast amount of literature from other countries dealing with the structure of the kidney in fishes it may be said that such basic information with regard to several of our teleosts is lacking. Extensive discussions on the subject are available in a series of earlier papers beginning with the classical anatomical study by Audigé (1910) and others too numerous to be included here. Periodic reviews by workers like Smith (1932) and Marshall (1934) have covered various aspects, particularly dealing with the functional morphology of the kidney. The recent book by Smith (1953) entitled *From Fish to Philosopher* is a valuable contribution as it contains a bibliography with summaries of subsequent work on the subject besides a fascinating account of the whole question of evolution of the kidney in relation to environment. In view of these comprehensive reviews and a brief summing up by the same author later in 1954, a detailed historical resume at present seems superfluous.

The author is grateful to Dr. N. K. Panikkar for suggesting this line of investigation and to Dr. S. Jones for his constructive criticism.

## Material and Methods

The material includes a few of the more common species of teleosts occurring along the coast and estuaries, obtained from the fishing nets either alive or immediately after death. The kidney from adult fish was dissected out in the field itself and a uniform procedure of fixing the material soon after dissection was adopted. Some care was exercised in the selection of the fixative as comparative measurements were to be made and corrosive-formol was used in all cases as this was found to give the best result compared to many other fixatives. Sections were taken from the posterior half of the kidney at a thickness of 5–7 micra and usually stained with Heidenhain's iron hæmatoxylin counterstained with eosin. Mallory's aniline blue stain was also helpful in differentiating the parenchymatous lymphoid tissue and blood capillaries clearly. In giving the diameter of the glomeruli in sections the procedure by Marshall and Smith (1930) was followed and hence the same limitations are applicable. No other strictly quantitative data are given in comparisons except in a general manner, as for example, the obvious differences in the relative amount of lymphoid tissue in some kidneys. Similarly, a rough idea of the distribution of the glomeruli in kidneys is given after taking their average number in 20 widely separated random sections in the series. Graphic method of reconstruction of the renal tubules was not very successful. Fresh pieces of the kidney was macerated in a 1 : 1 solution of hydrochloric acid and distilled water for 7–14 hours and a fairly satisfactory preparation of the major portion of the tubules was obtained in some cases which helped in the study of the general structure of the tubules.

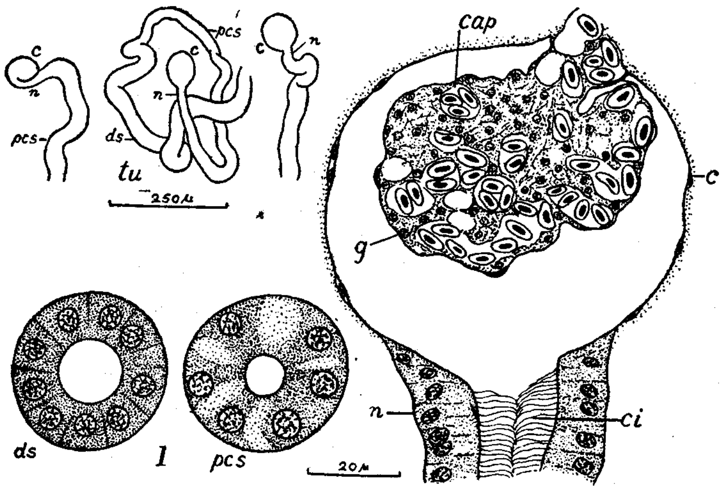
## OBSERVATIONS

The fish kidney is made up of numerous renal units as in other vertebrate kidney and whose anatomical structure is basically the same in all the species. Each unit is composed of a glomerulus enclosed in a capsule and connected to a coiled uriniferous tubule. The major part of the tubule may be sometimes divisible into a proximal convoluted segment nearer to the glomerulus and a distal segment opening into the collecting duct. But in many of the marine species this distinction may not be present. The space among these highly coiled tubules is filled by parenchymatous lymphoid tissue with rich ramifications of blood capillaries. The more important anatomical features and histology of the renal units in a few species of fish are given below:—

1. *Megalops cyprinoides* (Fig. 1).—The glomerulus has an average diameter of 64 micra together with the capsule which is composed of extremely flat or squamous epithelial cells and a glomerular tuft consisting of finely divided capillaries. A wide space is often observed within the capsule as the capillary tuft does not completely fill the capsule. At the junction of the glomerulus with the uriniferous tubule a neck region can be distinguished and which varies in length in the different tubules as shown in three typical cases (*tu*) obtained in maceration preparations. The neck is characterised by a narrow ciliated lumen of about 8 micra and the cells show an average height of 10 micra with uniformly staining cytoplasm and nucleus having rich, deeply staining chromatin granules. The rest of the uriniferous tubule is divisible into two regions of nearly equal lengths. In the initial regions the lumen is relatively narrow with a diameter of only 6 micra and the cells have large round nuclei situated nearer to the base of the cells. Distally the lumen becomes wider with an average diameter of 12 micra where the cells are more cuboidal with an average height of 7 micra and having almost centrally placed nuclei. Cilia are absent throughout the length of the uriniferous tubule except in the neck and the histology of the tubule reveals that the distal region is distinct from the proximal segment and that the former corresponds to the distal convoluted segment in the renal tubules of the freshwater species.

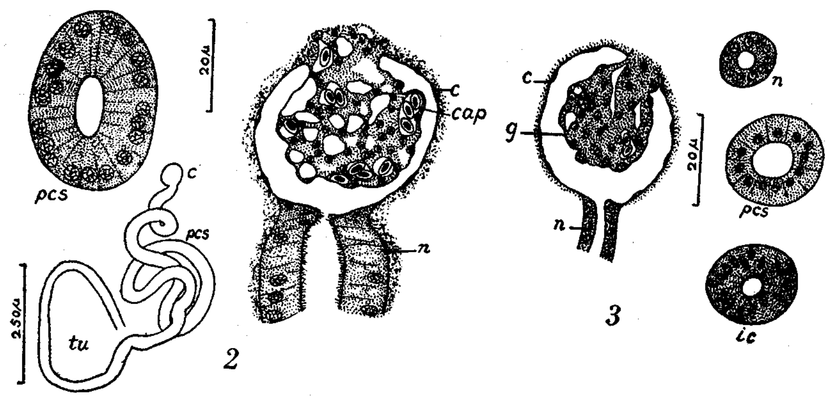
2. *Chanos chanos* (Fig. 2).—The glomerulus measures on an average 47 micra in diameter possessing a highly branching capillary tuft almost filling the capsule. A slight constriction at the junction between the glomerulus and the tubule represents the short neck composed of ciliated cells. These cilia are not very long and do not occlude the lumen as they do in the case

of *Megalops*. Beyond the neck the whole tubule is non-ciliated. Following the neck is the proximal convoluted segment, the wall of which is made up of cells of 12 micra in height with slightly ovoid and almost basally situated nuclei. But towards the distal regions of the tubule the lumen is narrowed




TEXT-FIG. 1. Sections showing the different regions of the renal tubule in *Megalops cyprinoides*. *c*, capsule; *cap*, capillary; *ci*, distal segment; *g*, glomerulus; *n*, neck segment; *pcs*, proximal convoluted segment,; *tu*, tubules obtained by maceration.

down to about 5 micra and the cells also become low cuboidal with centrally placed round nuclei. The staining property of the cells from the two different regions do not show any striking difference. The total length of each tubule is invariably far greater than those in the kidney of *Megalops*, often exceeding 1·5 mm. in length while those in *Megalops* are usually around 1·0 mm. in

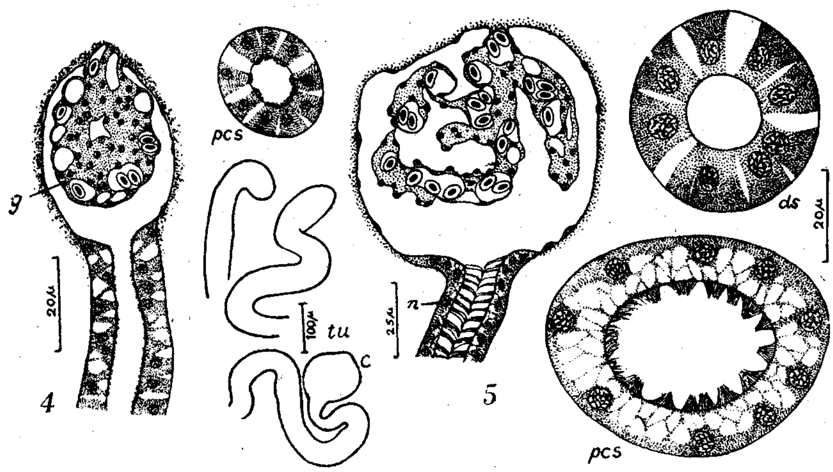



TEXT-FIGS. 2 and 3. Renal tubules of *Chanos chanos* and *Chirocentrus dorab*, respectively *ic*, initial collecting duct (other lettering the same as in the previous figure).

length. However, there is similarity in the structure of the tubules in the two species and both possess a distal region in the tubule distinguishable from the proximal segment.

3. *Chirocentrus dorab* (Fig. 3).—This is one of the species in the collection which shows a fairly small glomerulus, measuring only 30 micra in diameter. The glomerular tuft also indicates a correspondingly poor degree of branching. There is a short neck region of nearly 50 micra in length and of 6 micra in the width of the lumen where the cells are cuboidal but devoid of cilia. The cytoplasm of the cells stain only light with iron hæmatoxylin while the nuclei stain dark and have plenty of chromatin granules. At the end of this convoluted region is a much shorter segment with a very narrow lumen while the cells become tall and rather irregularly placed nuclei. The structure of this terminal portion of the tubule differs very much from that of the distal segment seen in either *Megalops* or *Chanos*, and resembles the initial portions of the collecting duct rather than a part of the uriniferous tubule itself.

4. *Sardinella longiceps* (Fig. 4).—The kidney itself is very narrow and slender and is composed of fewer tubules and little of lymphoid tissue than the kidney of many other species of teleosts given in this account. But these uriniferous tubules are comparatively much longer and the kidney itself is well vascularised. The glomerulus, although with only a diameter of 39 micra, has a branched capillary tuft filling the capsule. In the initial portions immediately following the glomerulus for about 20 micra the cells have scanty cytoplasm and indistinct cell boundaries. The rest of the tubule has




TEXT-FIGS. 4 and 5. Renal tubules of *Sardinella longiceps* and *Muræna favigenea*, respectively. Letterings are the same as in previous figures.

more or less the same internal diameter of 12 micra and the cells have uniformly staining cytoplasm, round nuclei and definite cell walls. There is a fine ciliated border throughout the whole tubule until it joins the collecting duct.

5. *Muræna favigenea* (Fig. 5).—This species shows the largest glomerulus in the present series and measures on an average 138 micra in diameter with a well-developed capillary tuft within the capsule. A short neck of about 130 micra long is seen characterised by the presence of long cilia projecting into the lumen which has a diameter of 14 micra. The cells of this region have almost clear cytoplasm staining light with iron hæmatoxylin and ovoid nuclei. The next region or the proximal segment is the longest in the tubule. Here too the cells are ciliated but apart from the very wide lumen of about 25 micra this segment can also be distinguished owing to the nature of the cells in which are found rather large round nuclei and the cytoplasm is granular and accumulated mostly around the nuclei leaving vacuoles within the cells. Whether these are artefacts or not cannot be certain from this study, and no cell inclusions have been observed in any of these vacuoles. Following the proximal segment there is reduction in the lumen to about 18 micra in the distal segment where the cells are without cilia, the cell walls more distinct and no vacuoles are present. Their nuclei is nearly ovoidal and centrally situated while the cytoplasm tends to stain more deeply along the outer ends of the cells. Another histologically different segment follows the distal segment, the cells of which seem to suggest a structure more like the initial regions of the collecting duct where more than one tubule open before forming the common collecting duct.

Maceration preparations of the kidney have revealed the presence of a number of aglomerular tubules besides the normal glomerular tubules. These aglomerular tubules shown in the figure have a blind ending and their initial regions correspond to the proximal convoluted segment of the glomerular tubules. Thus, excepting for the absence of the golmerulus and the neck these aglomerular tubules do not show any difference in structure from the normal type of tubules and both types open into the same common collecting duct. According to Edwards (1930) the kidney in *Muræna helena* also consists of both glomerular and aglomerular tubules but he has distinguished two ciliated segments following the neck region which have not been made out in the present species.

6. *Plotosus arab.*—The highly branching nature of the capillary tuft is clearly seen in the glomerulus which itself is large and measures 67 micra on an average. The neck is very short and is only about 50 micra long with a lumen of 14 micra and the cells are cuboidal possessing long cilia. The

rest of the tubule is non-ciliated. The proximal segment shows a much wider lumen of nearly 22 micra, the cells in this segment do not have distinct cell walls and the cytoplasm is slightly granular with vacuolations containing darkly staining granules. Their nuclei are round and have single nucleolus. A narrower segment with a lumen of 14 micra, also non-ciliated, follows the proximal region. Here the cells have a more uniform staining cytoplasm, without vacuoles and with distinct cell walls, and the nuclei tend to be nearer the lumen end of the cells. This last region of the tubule seems comparable to the distal convoluted segment.

7. *Saurida tumbil*.—The kidney is rich in lymphoid tissue and only a few tubules are seen in a section. The glomerulus measures 56 micra and the tubules appear to be less convoluted than in many other species. No marked change in the histology of the tubule could be made out along the length of the tubules so as to differentiate them into distinct regions except that the lumen immediately following the glomerulus is ciliated while in the remaining portions there are no cilia. The cells take a uniform stain with iron hæmatoxylin and possess round deeply staining nuclei. Thus, the whole tubule seems to be composed of only a proximal segment and there does not seem to be any indication of having a distal segment.

8. *Cypselurus oligolepis*.—There is relatively little of lymphoid tissue in the kidney which in sections appear to be composed almost entirely of tubules. The glomerulus measures an on average 45 micra and the capillary branching is not very conspicuous. The neck portion has usually an internal diameter of 17 micra and tall distinct cells of 18 micra high. Their cytoplasm stains well and is non-vacuolated, the nuclei are ovoid and situated slightly near the lumen end of the cells. Throughout this proximal segment the lumen is lined by fine cilia whereas in the succeeding region which is short cilia are absent, the cells are without clear cell walls, the cytoplasmic contents seem meagre and the nuclei are centrally located. The structure of this region recalls that of the initial collecting duct leading to the common urinary duct.

9. *Mugil troscheli*.—The glomeruli are of medium size measuring 45 micra on an average with a branching capillary tuft almost filling the capsule. The resemblance between the glomerulus of this species and that of *Chanos* is striking in many respects. The junction of the glomerulus and the tubule is constricted but excepting for this a separate neck region can hardly be distinguished from the tubule proper which has a more or less uniform diameter and structure throughout its entire length. It has a lumen of 8 micra and the proximal region has a ciliated border with cuboidal cells which stain well

with iron hæmatoxylin and have round nuclei with plenty of chromatin. But towards the distal end there is a long segment with almost the same kind of cells excepting for the absence of the ciliated border. This long non-ciliated region of the tubule is the distal segment.

10. *Sphyræna jello*.—The diameter of the glomerulus is about 40 micra on an average and the capillary tuft shows very poor brânching. Starting with a narrow lumen of only 6 micra at the neck the tubule widens in the proximal segment to about 17 micra. But the structure of the cells throughout the tubule seems the same. They are finely ciliated and have a basal round nucleus. Darkly staining granules of varying sizes are seen in many of the cells while some of the cells show vacuoles in them. Towards the succeeding regions the cytoplasm of the cells are only faintly granular and the nuclei are round and deeply staining with plenty of chromatin granules. The lumen in these regions has a narrower diameter of only 12 micra when it opens into the collecting tubule and this region may be distinguished as a distal segment, although it remains somewhat doubtful.

11. *Polynemus tetradactylus*.—The kidney is rich in lymphoid tissue and in sections somewhat resembles the kidney of *Saurida*. The glomerus is large having an average diameter of 65 micra with a well branching capillary tûft. The tubules on leaving the glomerulus has a diameter of 5–7 micra for a very short length of about 20 micra which region represents the neck where the cells are cuboidal, ciliated and have round deeply staining nuclei. This is followed by a long and coiled proximal segment distinguished by a wider lumen nearly four times that of the neck. The cells measure 8 micra in height with finely granular cytoplasm towards their base while at their end near the lumen the cytoplasm is scarce. The major portion is of this type and a separate distal segment seems to be wanting in these tubules.

12. *Cybium guttatum*.—The lymphoid tissue among the tubules is prominent though in much less quantity than in the kidney of *Polynemus* and the glomeruli are also much smaller measuring only 38 micra on an average. Although the size of the glomerulus and its capillary tuft is small the extent of branching of these capillaries is far more when compared to similar sized glomeruli in certain other species. At the junction of the glomerulus and the tubule the diameter of the lumen is only about 5 micra. However, this region is very short extending to only about 30 micra in length and the lumen widens to 9–12 micra in the proximal convoluted segment. The entire tubule is made up of the same type of cuboidal cells of 8 micra in height with uniformly light staining cytoplasm and round nuclei and cilia are absent. The tubule straight opens into a common urinary duct which, unlike the

uriniferous tubules, is composed of tall ciliated cells. Often, lightly staining accumulations have been observed within the lumen of the collecting duct which is unique and whose significance is not known.

13. *Trichiurus haumela.*—The glomeruli are small as in the case of *Cybium*, with an average diameter of 39 micra. But in a single section of the kidney several glomeruli can be seen suggesting the presence of a relatively large number in the whole kidney as compared with many other species described so far. The capillary tuft within the capsule shows a very poor extent of branching leaving a large vacant space within the capsule. A short neck of 7 micra in lumen and composed of ciliated cells having uniformly staining cytoplasm and round nuclei is followed by the proximal convoluted segment. This section has a diameter varying between 10–14 micra and is more or less uniform in its structure throughout its length. The cells are taller than those on the neck region, their cytoplasm is slightly granular and the nuclei are comparatively larger. The whole lumen of the proximal segment is ciliated and communicated directly with the initial regions of the collecting duct without showing a separate distal segment.

14. *Caranx affinis.*—Considering the small size of the corpuscles, the capillary branching may be regarded as moderate as compared to corpuscles of similar size of other species. The neck region of the tubule is extremely narrow with a lumen of only 3–4 micra and extends for about 15 micra in length. The cytoplasm of the cells as well as their nuclei stain well. There is a fine ciliated border in the lumen of the entire tubule. The proximal convoluted region has a comparatively wider lumen of 4 micra where the cells have a faintly granular cytoplasm and the nuclei are round with well staining chromatin granules. This region eventually joins the collecting duct and no segment corresponding to a distal region is noticed.

15. *Therapon puta.*—The kidney has very little lymphoid tissue. Glomeruli are frequently seen in sections of the kidney and are small measuring on an average only 30 micra. The glomerular tuft itself consists of moderate branching capillaries. The whole proximal convoluted segment has a uniform diameter of 10 micra composed of cells having nuclei with a darkly staining nucleolus and chromatin granules. No separate distal segment in the tubule could be made out in this sepcies.

16. *Teuthis marmoratus.*—The kidney is a thin, flat organ composed largely of uriniferous tubules and little of lymphoid tissue. The glomerulus has an average diameter of 49 micra and their number per section is considerably less than in *Therapon*. However, a well branching capillary tuft may be observed within the capsule. There is a ciliated neck region with

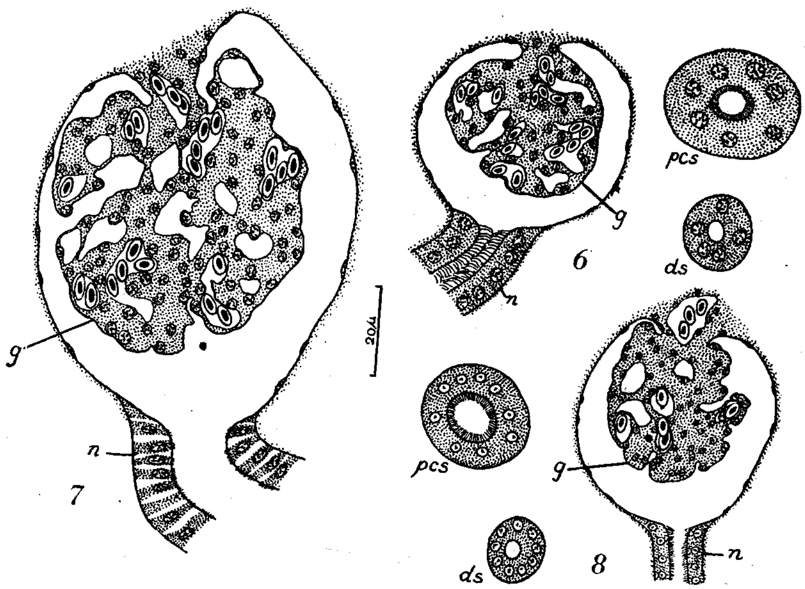
a narrow lumen of 4 micra extending for about 100 micra in length where the cells are nearly cuboidal with indistinct cell walls. The remaining major portion of the tubule is the proximal segment with a lumen diameter of 13 micra and the cells are also low cuboidal. Following this is the short distal segment with about the same internal diameter but whose cells are relatively taller of about 15 micra with round nuclei situated in the middle or sometimes towards the base of the cells. The cytoplasm is granular and in many cells large empty vacuoles may be seen. Throughout the proximal and distal regions of the tubule a fine ciliated border is present.

17. *Platycephalus scaber.*—The lymphoid tissue is comparatively richer than in the previous two species, the glomeruli are much larger having a diameter of 82 micra and have highly branching capillary tuft. The tubules do not show any constriction at the junction of the glomerulus but have nearly a uniform lumen of 12–15 micra for most of their length. The cytoplasm of the cells appear denser around the nuclei and cilia are also absent. Thus, only the proximal convoluted segment exists in these tubules and no distal segment could be distinguished.

18. *Etroplus maculatus* (Fig. 6).—The glomeruli are of medium size measuring on an average 47 micra. The capillary branching is very distinct in the glomerular tuft which occupies most of the available space within the capsule. Thus, although the glomeruli do not attain a size often given for many of the freshwater species these show a good development and offer a fair amount of glomerular surface. The tubule starts with a ciliated neck of 6–7 micra while in the proximal convoluted segment the lumen is slightly wider and the cilia are shorter. Here the cells have an average height of 8 micra with well staining round nuclei and uniformly staining cytoplasm. Following the proximal segment is a short narrow region whose cells are much shorter and also characterised by the absence of the ciliated border. This distal segment compares with that in the kidney of *Chanos.*

19. *Boleophthalmus boddærti* (Fig. 7).—The glomeruli measure on an average of 97 micra. The capsule is made up of thin epithelium and the well branching capillaries of the glomerular tuft is evident in sections. The tubule does not show any distinct neck and its internal diameter is more or less uniform throughout with a diameter of 20 micra and a fine ciliated border. The cells have a deeply staining nuclei while the cells themselves take only a light stain with iron hæmatoxylin. But towards the distal portions of the tubule the cells tend to become slightly taller and stain deeper than those of the proximal region.

20. *Tetradon lunaris* (Fig. 8).—The kidney is soft and composed o a large amount of lymphoid tissue. The glomeruli are not very numerous and do not show any high degree of capillary branching, measuring on an average 44 micra. Both the neck and the proximal segment is ciliated but in the latter the lumen is nearly three times wider than that of the neck, and again in the distal segment the lumen is reduced to less than 5 micra and where cilia are absent. The cells of the proximal region are slightly taller but their nuclei have very little chromatin and stain less intensely.




TEXT-FIGS. 6, 7 and 8. Renal tubules of *Etroplus maculatus, Boleophthalmus boddærti* and *Tetradon lunaris,* respectively. Letterings as in previous figures.

## DISCUSSION

The renal units in all the species of teleosts described in this account conform to the basic pattern of a functional glomerulus connected to a tubule, the length of which may vary even within the same kidney as pointed out by Marshall (1934). Measurements of the glomerular size of 43 species of fish were made and when arbitrarily classified according to the criteria developed by Marshall and Smith (1930) it is seen that all the species resolve themselves into three groups as given in table. None of these could be assigned to what they regard as Group IV, with very few or no functional glomeruli. The situation becomes somewhat apparent if we take into consideration the habitat of the species and their distribution within the coastal waters. Some of the species are pelagic forms such as *Chirocentrus, Sardi-*

*nella* or *Cybium* inhabiting the relatively more saline zones while many others are confined to areas nearer the coast. Our coastal waters where the fishing activity is largely concentrated are well known for their periodic fluctuations in salinity depending on seasons and especially during the monsoons when, owing to heavy drainage from the land and the river systems, a considerable reduction in salinity occurs along the coastal belt. Therefore, several of the species inhabiting this coastal strip seem to have necessarily developed varying degrees of adaptational powers to lower salinities. It may be seen in the table that a greater number of the more euryhaline forms with better developed glomeruli fall under Group I, and II while those under Group III comprise largely of the more stenohaline species. Although the range in the size of the glomeruli does not compare with that given in the extensive data furnished by Marshall and Smith (*loc. cit.*), the general tendency for the more euryhaline species to classify themselves under the same group is obvious from the table.

It may be pointed out here that the differentiation into the various regions of the renal tubules as given in this account is based only on histologic characteristics. In order to understand their true significance or their functional differentiation corresponding to these histologic changes, we need critical experimental evidence which is wanting in the case of our teleostean fishes. However, we can find a general agreement with some of the well-known facts that the more euryhaline species possess a well developed glomerulus indicative of an efficient filteration mechanism, together with the presence of a distal segment in their tubule. This is a common feature with many of the freshwater species where the function of the distal segment is believed to be reabsorption of salts from the glomerular filtrate leaving a relatively dilute urine for excretion. On the other hand, in true marine fishes which never invade waters of lower salinities and consequently have no excess water to get rid of their body the distal segment in the renal tubule is said to be completely absent (Smith, 1953). This general pattern of structure is by no means rigid and exceptions occur within the three groups as given in the table, and the reasons for the variations in individual instances cannot be adequately explained in this state of our knowledge of the excretory and adaptational physiology of the species. From field observations and experience in practical fish culture we do know that many species can withstand surprisingly low or high levels of salt concentrations in their environment although reliable data on the limits of tolerance levels for many of our species of fish are lacking at present. Among those marine species which can tolerate very low salt concentrations *Chanos chanos* and *Mugil* spp. are of special importance owing to their utility for fish culture. Several

TABLE

| Sl. No. | Species[1] | | Diameter of glomerulus | Habitat[2] | Distal segment[3] |
|---|---|---|---|---|---|
| | GROUP I | | | | |
| 1 | *Megalops cyprinoides* (1) | | 64 | M & E | + |
| 2 | *Muræna favigenea* (5) | .. | 138 | M | + |
| 3 | *Murenesox cinereus* | .. | 60 | M | |
| 4 | *Arius jella* | .. | 58 | E | |
| 5 | *A. maculatus* | .. | 65 | E | |
| 6 | *A. dussumieri* | .. | 72 | E | |
| 7 | *Plotosus arab* | .. | 67 | M & E | + |
| 8 | *Macrones vittatus* | .. | 42 | M & E | |
| 9 | *Polynemus tetradactylus* | .. | 65 | M | – |
| 10 | *Platycephalus scaber* | .. | 82 | M & E | – |
| 11 | *Etroplus maculatus* (6) | .. | 47 | F & E | + |
| 12 | *E. suratensis* | .. | 47 | F & E | |
| 13 | *Boleophthalmus boddærti* (7) | .. | 97 | E | + |
| | GROUP II | | | | |
| 14 | *Chanos chanos* (2) | .. | 47 | M & E | + |
| 15 | *Engraulis malabaricus* | .. | 42 | M | |
| 16 | *E. mystax* | .. | 37 | M | |
| 17 | *Dorosoma chacunda* | .. | 44 | M & E | |
| 18 | *Saurida tumbil* | .. | 54 | M | – |
| 19 | *Tylosurus strongylurus* | .. | 42 | M | |
| 20 | *Hemirhamphus georgii* | .. | 37 | M | |
| 21 | *Cypselurus oligolepis* | .. | 45 | M | – |
| 22 | *Cynoglossus* sp. | .. | 57 | M | |
| 23 | *Mugil troscheli* | .. | 45 | M & E | + |
| 24 | *Sphyræna jello* | .. | 40 | M | (?) |
| 25 | *Mene maculata* | .. | 43 | M | |
| 26 | *Gerres abbreviatus* | .. | 40 | M | |
| 27 | *Teuthis marmoratus* | .. | 49 | M | + (?) |
| 28 | *Psammoperca waigiensis* | .. | 56 | M | |
| 29 | *Therapon puta* | .. | 52 | M & E | – |
| 30 | *Tetradon lunaris* (8) | .. | 44 | M & E | + |

TABLE I—*Contd.*

| Sl. No. | Species[1] | | Diameter of glomerulus | Habitat[2] | Distal segment[3] |
|---|---|---|---|---|---|
| | GROUP III | | | | |
| 31 | *Chirocentrus dorab* (3) | .. | 30 | M | — |
| 32 | *Pellona brachysoma* | .. | 40 | M | |
| 33 | *Sardinella longiceps* (4) | .. | 39 | M | — |
| 34 | *Opisthopterus tartoor* | .. | 38 | M | |
| 35 | *Cybium guttatum* | .. | 38 | M | — |
| 36 | *Trichiurus haumela* | .. | 39 | M | — |
| 37 | *Caranx affinis* | .. | 38 | M | — |
| 38 | *Chorinemus lysan* | .. | 37 | M | |
| 39 | *Lactarius lactarius* | .. | 38 | M | |
| 40 | *Leiognathus splendens* | .. | 39 | M | |
| 41 | *Sciæna* sp. | .. | 37 | M | |
| 42 | *Otolithus ruber* | .. | 30 | M | |
| 43 | *Ephippus orbis* | .. | 43 | M | |

[1] The numbers in brackets against species refer to the corresponding figure and description in text.

[2] Gives the usual habitat of the species as M = marine, E = estuarine and F = freshwater.

[3] A *plus* sign (+) indicates presence of the distal segment, a *minus* sign (—) shows its absence while a (?) mark denotes doubtful cases.

other species also show the same behaviour. Many species of fish are capable of gradual acclimatisation to either lower or higher salinities than their normal environment and there are several records in literature of successful acclimatiisation. Recently the freshwater species *Etroplus maculatus* has been shown to be able to withstand a salt content up to 32·6 parts per thousand (Rao, 1958). Similarly the freshwater fish *Tilapia mossambica* is another example which, on account of its ability to withstand even hypersalinities and successful establishment in such media, are being experimented upon for rearing in marine fish farm ponds (unpublished work of the author). A study of the renal structure of these species would seem particularly interesting in view of such adaptational powers.

While discussing the structure of the renal tubules and the problem of adaptation in teleosts to fresh and salt water, Grafflin (1937 *b*) has rightly pointed out that the kidney is not the limiting factor for survival of the individual in media of different salt concentrations. Ample evidence exists in literature to show the presence of extrarenal powers of salt regulation in teleosts. Besides as Smith (1932) has remarked, " Like many other evolutionary specialisations the reduction of glomeruli probably proceeds slowly and more detailed palæntological history than is now available may be required to interpret the status of any one family, genus or species". It thus seems that the microscopical structure of the renal unit alone throws little light on the remarkable physiological operations carried out by the kidney but can greatly supplement experimental observations.

The object of this preliminary account, as mentioned earlier in the introduction, is mainly to provide some essential background information on the renal elements in some of the more common teleosts of our coast. However, based on these observations it seems possible to discuss briefly some of the essential lines on which further work seems fruitful. As the marine fishes show a wide range in glomerular development, the need for a more precise quantitative estimation of the glomerular number in relation to body size is felt as this gives a more reliable indication of the efficiency of their osmoregulatory mechanism. Nash (1931) had taken " *the volume* of glomeruli (assumed to be a measure of the filtration surface) per unit of *body surface area* " as the basis for comparison by which he found a sharp distinction between the freshwater and the marine teleosts. However, he had pointed out that the average size of a few glomeruli in the kidney of one individual of a species cannot be considered as an accurate average size for all the glomeruli of that one kidney, much less for the species as a whole. Rytand (1935) working on the mammalian kidney observed a close relationship between the total glomerular volume both to the kidney weight and to the body weight in mammals of different size. Gunter (1945) in his studies on the distribution of fishes along the coast of Texas observed seasonal movements of many of the relatively smaller members of the species penetrating brackish waters more persistently than the larger ones. This is also true of many of our fishes which generally show better adaptational powers in their younger stages and consequently enter tidal creeks and estuaries. This among other things, might suggest some kind of change in their excretory mechanism during the different phases in their growth which has to be carefully assessed on a quantitative basis. The assigning of definite physiological functions to the different parts of the renal tubule in the normal fish without interference by operational procedures is mainly due to the anatomical and experimental studies of Grafflin (1937 *b*) and Marshall and Grafflin (1942) and more recently of Forster (1953) and similar detailed work on some of the important species of culturable fish would be of great interest. In this connection we are also unable to overlook the fact that the question of osmotic regulation is intimately tied up with the physiological functions of certain other organs of the body, especially some of the endocrine glands which play an important role in initiating changes which are necessary for the successful penetration of the fish into new environment as has been pointed out by Black (1951). Similarly, the significance of certain essential salts such as calcium in the survival of fish is also a vital factor as indicated by Breder (1933) and Panikkar *et al.* (1953). Thus, there are many important gaps in our knowledge which have to be understood before the significance of structural and functional morphology of the renal units in different species of fish can be properly interpreted.

## Summary

The general histology of the renal units of 20 selected species of teleosts has been given. Besides, an analysis of the glomerular size in a total of 43 species of fish shows good agreement with some of the well-known theories of glomerular development in relation to habitat. This preliminary study has helped to bring out some of the essential lines on which reliable data on the renal physiology of some of the euryhaline fishes have to be obtained and these are briefly discussed.

## References

Audigé, J. .. "Contribution a l'etude des reins des poissons teleostens," *Arch. de Zool. exper. et gen.*, 1910, 5 me. ser. **4**, 275–524.

Black, V. S. .. "Osmotic regulation in teleost fishes," *Univ. Toronto Biol. Ser.* 59, *Publ. Ontario Fish. Res. Lab.*, 1951, **72**, 53–894.

Breder, C. M. (Jr.) .. "The significance of calcium to marine fishes invading fresh-water," *Anat. Rec.*, 1930, **57**, (Supplement).

Edwards, J. G. .. "The renal tubule and glomerulus," *Amer. J. Physiol.*, 1930. **95**.

Forster, R. P. .. "The comparative study of renal function in marine teleosts," *J. Cell. Comp. Physiol.*, 1953, **42** (3), 487–509.

Grafflin, A. L. .. "Observations on the structure of the kidney of the common eel," *Amer. J. Anat.*, 1937 *a*, **61**, 21–62.

——— .. "The problem of adaptation to fresh- and salt-water in teleosts viewed from the standpoint of the structure of the renal tubules," *J. Cell. Comp. Physiol.*, 1937 *b*, **9**, 469–75.

Gunter, G. .. "Studies on marine fishes of Texas," *Publ. Inst. Mar. Sci.*, 1945, **1** (1), 1–190.

Marshall, E. K. (Jr.) .. "The comparative physiology of the kidney in relation to theories of renal excretion," *Physiol. Rev.*, 1934, **14** (1), 133–47.

Marshall, E. K. (Jr.) and Smith, H. W. .. "The glomerular development of the vertebrate kidney in relation to habitat," *Biol. Bull.*, 1930, **59**, 135–53.

Nash, J. .. "The number and size of the glomeruli in the kidney of the fish with observations on the morphology of renal tubules of fishes," *Amer. J. Anat.*, 1931, **47**, 425–46.

Panikkar, N. K., Tampi, P. R. S. and Viswanathan, R. "Some aspects of adaptation in *Chanos chanos* (Forsakal)," *Proc. Ind. Acad. Sci.*, 1953, **37 B**, (6) 203–13.

Rao, K. P. .. "Salinity tolerance of *Etroplus maculatus* (Bloch)," *Curr. Sci.*, 1958, **27** (3), 99.

Rytand, P. .. "Number and size of mammalian glomeruli as related to kidney and body weight," *Amer. J. Anat.*, 1938, **62**, 507–20.

Smith, H. W. .. "Water regulation and its evolution in fishes," *Quart. Rev. Biol.*, 1932, **7**, 1–126.

——— .. *From Fish to Philosopher*, Little, Brown & Co., Boston, 1953, p. 264.

——— .. "Comparative physiology of the kidney," *J. American Med. Assn.*, 1954, **153** (17), 1512–14.