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A histomorphological comparison of the urinary systems in the Serranid fishes, Roccus sexatilis (Walbaum) and Roccus americanus (Gmelin)

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A Histomorphological Comparison of the Urinary Systems in the Serranid Fishes, *Roccus saxatilis* (Walbaum) and *Roccus americanus* (Gmelin)

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ABSTRACT

The urinary systems of Roccus saxatilis (Walbaum) and Roccus americanus (Gmelin) were studied to check the validity of the monogeneric classification and to examine the osmoregulatory mechanism that allows the species to survive in environments of various salinities.

The gross anatomy of the urinary systems of 13 R. saxatilis and 12 R. americanus showed a number of similarities to exist, e.g. the general mesonephric form and size, uretal position and length, and the renal venous system. The head kidney, a hemopoietic organ, was larger in R. saxatilis than in R. americanus. Histological comparisons were made of H and E serial sections of the posterior part of the kidneys, and of the ureter, from three R. saxatilis and four R. americanus; included were the entire kidneys of two 2-year-old males of each species. The kidney of a young specimen of each species was also studied. The glomeruli in R. americanus were found to be larger than those in R. saxatilis; however, in a previous study, freshwater R. saxatilis were shown to have glomeruli of intermediate size. The number of goblet cells in the anterior part of the ureter was greater in R. saxatilis and may be correlated with glomerular size. A distal tubular segment, usually present in freshwater fishes, was absent in both species; probably a reflection of their marine origin.

As the differences in the urinary system were explained on the basis of selective adaptation, they, and the number of similarities, were considered to support a monogeneric classification.

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INTRODUCTION

The genus Roccus (Mitchell) includes three subgenera; Roccus (Mitchell), Morone (Mitchell) and Dicentrarchus (Gill), each represented by two species. The latter inhabits North African and European coastal waters, and Roccus and Morone occur in North America. The first revision of the genus was by Jordan and Gilbert (1883:528-31) who classified the American species in the genus Roccus, and tentatively included the two species of Dicentrarchus. Berg (1949:1012-3) assigned the three subgenera to the genus Morone, using as diagnostic generic characteristics separate dorsal fins, teeth present on the base of the tongue, and absence of a supramaxillary bone. In a comparative skeletal study of the genus, Woolcott (1957:1-10) agreed with the monogeneric classification, but instead of Morone, used Roccus, following the first revisers, Jordan and Gilbert.

Roccus saxatilis (Walbaum), the type species of the genus and subgenus Roccus, is an anadromous fish occurring naturally on the Atlantic Coast from the St. Lawrence River, Canada, to the St. Johns River in northern Florida, and the Gulf of Mexico tributaries from western Florida to Louisiana. In the latter part of the 19th century it was introduced in Pacific waters, where it now occurs from southern California to the Columbia River, Oregon-Washington (Raney, 1952:16-9). A freshwater population of the Santee-Cooper Reservoirs, South Carolina was reported by Scruggs and Fuller (1955). Another such population occurs in Kerr Reservoir, Virginia-North Carolina.

Roccus americanus (Gmelin), the type species of the subgenus Morone, inhabits the Atlantic Coast from Nova Scotia to South Carolina, and inland

as far west as Lake Erie. The species occurs in anadromous populations, as well as brackish and freshwater populations of bays, estuaries and lakes (Woolcott, 1962:96).

The serranid family is typically marine; the ancestral stock of the genus Roccus probably inhabited the saline waters of the North Atlantic Ocean (Woolcott, 1957:2). A general trend toward a freshwater existence has occurred in the genus. Roccus chrysops and R. interruptus are completely freshwater species. Assuming that teleosts originated in freshwater (Smith, 1932:23; Black, 1957:164) the North American species of Roccus may be considered secondary invaders of freshwater. The osmotic problems that were resolved in the genus indicate considerable preadaptation to habitats of various salinities, and warrants an examination of the osmoregulatory mechanism. As time did not permit a study of the entire genus, the type species of the North American subgenera were used. The two species were compared to check the validity of a monogeneric classification.

The extensive literature on the histology and morphology of teleost kidneys reflects the great diversity and complexity of this organ. In the most complete of the earlier works, Audigé (1910:275-624) critically reviewed, in the light of his own findings, those of the major workers of the time. He also included a classification of fish kidneys based on the presence or absence of a pronephros, mesonephros and metanephros; distinguishable by location, and glomerular occurrence, frequency, and extent of capillary branching. Marshall and Smith (1930:140-7) proposed a more reliable system that divided the higher fishes into four groups on the basis of glomerular development. In group I, the glomeruli are medium or large in size and invariably well vascularized; in group II, either frequent and

small glomeruli, or few glomeruli which are small to fair sized; in group III, infrequent and small glomeruli; and group IV, functionally or actually aglomerular. Moore (1933:7), also using glomerular development as a criterion, suggested an improved system of six groups, each with a type species.

Other major contributors to the study of renal histomorphology of teleosts since 1900 are Edwards (1928:75-107, 1935:263-79), Nash (1931:425-45), Grafflin (1937a:287-304, 1937b:469-76) and Tampi (1959:88-104). Edwards (1929:15-28) and Defrise (1932:185-95) investigated the cytology of the teleost nephron and Pak Poy (1958:191-209) studied the fine structure of the glomerular cells. The problem of osmoregulation in fishes is reviewed by Black (1957:163-205), and its role in the evolution of fishes by Smith (1932:1-26, 1953:101-14).

The urinary system is not the only osmoregulatory mechanism in teleosts. Body surface permeability (Black, 1957:196) and chloride excreting cells of the gills (Keys and Willmer, 1932:368-78) and inner opercular epithelium (Burns and Copeland, 1950:381-5) are also influential in osmoregulation. However, as formalin fixed specimens do not lend themselves to the study of these problems, and time was not available, this study was limited to the urinary system.

MATERIALS AND METHODS

Standard morphological and histological technics were followed when possible. However, as the specimens were fixed in formalin, which sometimes gives variable fixation results, modifications were often necessary. The samples used in the study are given below with the age range, in years, in parentheses. The abbreviation UR represents the University of Richmond

Fish Collection and is followed by the catalog number.

Twenty specimens of Roccus saxatilis (2-5) UR 1008, captured by commercial fishermen in the lower York River, were obtained through the Virginia Fisheries Laboratory, Gloucester Point, in October, 1960. The fish were fixed by making a two-inch incision into the body cavity to the right of the mid-ventral line and immersing them in 10% formalin. After three days, they were washed in running tap water and preserved in 37% isopropyl alcohol. A young specimen of R. saxatilis (standard length 24 mm) UR 47, collected from the Pamunkey River in July, 1956 was examined. After fixing in 10% formalin, it was preserved in 37% isopropyl alcohol.

A sample of 21 specimens of Roccus americanus (2-3) UR 1006, from Back Bay, Virginia, was collected by the rotenone poisoning method in August, 1961. They were fixed by injecting 10% formalin into the body cavity and immersing them in 10% formalin for three days. After washing, they were preserved in 37% isopropyl alcohol. In addition, a young R. americanus (standard length 26 mm) UR 52, collected from the Pamunkey River in July, 1956 was examined. It was also fixed in 10% formalin and later stored in 37% isopropyl alcohol.

Morphological technic -- Morphological examinations of the kidneys were made after cutting the intestine and genital ducts close to the vent and reflecting them anteriorly. To examine the anterior limits of the mesonephros, it was often necessary to incise the esophagus at the transverse septum and completely remove the organs of the body cavity. The swimbladder and peritoneum were carefully separated from the kidney and then removed, thus exposing the ventral surface of the kidney and the ureter. The dorsal surface of the kidney and ureter were examined when these parts were excised for histological study. The head kidney was

exposed by ventral and lateral incisions through the musculature of the opercular region. General form, extent and position of the kidney and ureter was noted (Figs. 1a and 1b, 2a and 2b). Measurements in mm were made with dial calipers of the mesonephros length, and the length of the ureter (from the urinary bladder to the mesonephros) in 13 R. saxatilis and 12 R. americanus. These data were then converted to percentage of the standard length of the individual specimens and the two species compared.

Basic histological technic -- The kidneys from three R. saxatilis and four R. americanus were excised for histological study. The posterior part of the kidneys, including the ureter, was serially sectioned and examined; the entire kidney was sectioned in two 2-year-old males of each species.

The kidneys and ureters were removed by incising the ureter close to the vent and separating the kidney from the connective tissue that adhered to the dorsal surface. An elaboration of the technic described by Guyer (1930:17) was used for dehydration and paraffin (Fisher tissuemat) infiltration (See dehydration and infiltration schedule). Deviations from this procedure were sometimes necessary and are explained under the section on special technics.

Dehydration and infiltration schedule.

1. 35% ethyl alcohol	30 min
2. 50% " "	2 hrs
3. 70% " "	2 hrs (or more)
4. 85% " "	2 hrs
5. 95% " "	2 hrs
6. 100% " "	2 hrs
7. Xylene	5 hrs

8. Xyloparaffin (40 C)	8 hrs
9. First paraffin (mp 61 at 62 to 65 C)	2 hrs
10. Second " (" " " " " " ")	2 hrs
11. Embedded in 61 C paraffin	

Sectioning and mounting — The paraffin blocks were sectioned at 10μ on a rotary microtome. The sections were mounted in series on glass slides that had been coated with a thin film of albumen-glycerin adhesive following Carleton and Drury (1957:62), and flooded with boiled distilled water that had been cooled. They were then warmed over a micro-bunsen burner to a temperature just below the melting point of the paraffin to facilitate proper expansion. The slides were then drained, the sections positioned, and left to dry at room temperature for a minimum of seven hours. They were then placed on a hooded Cenco slide warmer with an open petri dish of anhydrous cupric sulfate for one hour at 40 C.

The staining schedule used in this study follows the general technic of Guyer (1930:49-59). The stained sections were covered with Canada balsam and a #1 coverslip. Deviations from this procedure are explained in the section on special technics.

Staining schedule.

1. Xylene	15 min
2. 100% ethyl alcohol	5 min
3. 95% " "	2 min
4. 85% " "	2 min
5. 70% " "	2 min
6. 50% " "	2 min
7. 35% " "	2 min

8. Delafield's haematoxylin (stock)	30 min
9. Tap water	5 min
10. Acid alcohol (0.2% concd HCl in 35% ethyl alcohol)	30 sec (or until pink)
11. Tap water	5-15 min (until blue)
12. 35% ethyl alcohol	1 min
13. 50% " "	1 min
14. 70% " "	1 min
15. 85% " "	1 min
16. 95% " "	5 min
17. 0.5% eosin Y	10 sec
18. 95% ethyl alcohol	5 min
19. 100% " "	10 min
20. Xylene	15 min

Special technics -- The vertebral column and the posterior part of the skull were excised with the anterior part of the kidney in R. americanus. Decalcification of the bone was accomplished by suspending the tissue in an aqueous solution of 5% nitric acid in 12.5% formalin for 24 hours. Following this, the tissue was washed in three changes of 80% ethyl alcohol for a total of 10.5 hours. The basic dehydration and infiltration schedule was then used starting with step 4. The tissue was sectioned at 15μ. The two young specimens of R. saxatilis and R. americanus were decalcified for 18 hours and treatment was similar to that of the anterior part of the kidney of the adult R. americanus. The kidneys of the young fishes were not excised; the fishes were sectioned whole at 10μ.

When sections of the anterior part of the adult fish kidney were prepared, steps 3 and 4 of the staining schedule were replaced with the technic of celloidin adhesive described by Gray (1958:162). They were then passed

to 70% ethyl alcohol for 15 minutes instead of the usual 2 minutes, and the basic staining schedule continued. Carboxylene was substituted for 100% ethyl alcohol in step 19.

Histological examinations -- A calibrated ocular micrometer was used in the following histological linear measurements. The diameter of the lumen of the left ureter, the uretal wall (epithelium and connective tissue tunic) and the lumen of the dorsal aorta were measured at the point where the right ureter gave off its first branch. Where these organs were irregular, the greatest dimension was measured. The diameters of the ureter and dorsal aorta were converted to percentage of kidney width at the point of measurement; the thickness of the uretal wall was converted to percentage of the luminal diameter of the ureter. The goblet cells in the cross section of the uretal epithelium of the two fishes were counted and compared.

The diameter of 50 glomeruli in two fish of each species was measured at regular intervals along the mesonephros. The relative area of the glomeruli from each species was compared by making camera-lucida drawings, on preweighed paper, of the glomeruli (1455 magnifications) and of the kidney cross sections (25 magnifications). The paper was trimmed so that only the drawing of the renal tissue remained. The weight of the cutouts of the glomeruli were divided by the weight of those of the respective kidney cross sections. The drawings were made of the section of kidney ventral to the last vertebra in contact with the kidney and the section of the preceding intervertebral area. The actual weight of the cutouts of the glomeruli were also compared.

In addition to the quantitative studies, which were analyzed using standard statistical methods, the general histological nature of the kidney and the ureter of the two fishes was compared.

RESULTS

A gross anatomical examination of the kidneys in R. saxatilis and R. americanus revealed a number of similarities between the two (Figs. 2a and 2b). In both species, the left and right kidneys were fused at the posterior four intervertebral segments; separation occurred at the fifth segment and increased anteriorly. The posterior segments were oblong in R. saxatilis and almost round in R. americanus.

The mean length of the mesonephros was about 30% of the standard length in both species. In one 2-year-old male R. saxatilis the kidney extended over the posterior half of the body cavity only, and as this condition was obviously aberrant, the specimen was not included in the mesonephros measurements of the sample.

The mean length of the ureter was about 6.4% of the standard length in both species. The point of uretal entry on the posterior mesonephros was found to be variable in both species. Entry most frequently occurred on the right side in both species. Left and medial entries were also found. No significant correlation was found between position of uretal entry and age, sex or species.

The number and position of segmental veins that entered the mesonephros varied with the individual specimen. The renal portal veins entered the posterior mesonephros laterally at a point anterior to that of the ureter. The same condition was found in all specimens. Intervertebral veins of the dorsal surface of the mesonephros were not compared as they were destroyed when the kidney was excised. The posterior cardinal vein and the dorsal aorta will be discussed below.

A lateral view of the head kidney (Figs. 1a and 1b) shows it to be

more extensive in R. saxatilis than in R. americanus. In R. saxatilis, the head kidney covered the entire pharynx and in R. americanus, only the posterior portion of the pharynx. In all specimens the tubules of the head kidney were infiltrated or replaced with lymphoid tissue.

The diameter of the lumen of the left ureter was found to be about 8% of the kidney width at the point of measurement in R. saxatilis and R. americanus. The thickness of the uretal wall was about 29% of the luminal diameter in both species. The diameter of the lumen of the dorsal aorta was about 29% of the kidney width in both species.

The glomeruli are shown in Figs. 3a and 3b. The mean glomerular diameter of R. saxatilis was 47.7μ (SD 6.8); that of R. americanus was 59.7μ (SD 12.6). The difference between the means was highly significant ($t = 5.96$).

The area of the glomerular cross sections, relative to that of the cross sections of the entire kidney, of R. americanus was approximately seven times greater than that of R. saxatilis; the absolute area was about twice as large in R. americanus than in R. saxatilis.

The nephrons of the fishes studied were of the proximal segment type (Figs. 3a and 3b). The lining epithelium of the ureter differed in the two species in the number of goblet cells and the location of the nuclei within the columnar cells. A cross section of the anterior part of the ureter of R. saxatilis had about twenty times more goblet cells than did that of R. americanus. However, in the posterior part of the ureter, the number of goblet cells was about the same. The nuclei of the columnar epithelial cells in R. saxatilis were basally located and in R. americanus, centrally.

Adrenal tissue was associated with the dorsal surface of the kidney.

In both species, an elongated mass of cortical and medullary tissue extended the entire length of the kidney. Adrenal and lymphoid tissue was more abundant anteriorly. Blood sinusoids, throughout the mesonephros of the two species, were separated from the nephrons by the prominent basement membrane of the nephrons. The sinusoids developed from the breakdown of the left branch of the caudal vein, several medial branches of the right posterior cardinal, and the segmental veins. The venous channels, formed by the union of the blood sinusoids anteriorly, entered the right posterior cardinal vein, which continued cephalad to the heart. In R. saxatilis and R. americanus this vein was so wide in the anterior mesonephros that the renal tissue was confined to narrow lateral bands.

The kidneys of the young fishes of both species were similar to that of the adults. However, blood sinusoids were lacking in the posterior portion of the mesonephros, and lymphoid replacement tissue of the head kidney was less than in the adults.

DISCUSSION AND CONCLUSION

A comparison of the gross anatomy of the urinary systems of R. saxatilis and R. americanus revealed few differences; the relatively larger size of the head kidney in R. saxatilis was the most diagnostic. However, in the head kidney of the young and adults of both species, infiltration and replacement of renal tissue by lymphoid tissue indicated a loss of excretory function. Jordan (1933:63-4) reported that in the adult teleost, the lymphoid replacement tissue of the kidney is functionally hemopoietic, especially active in granulocytopoiesis. The loss of excretory function is apparently a common condition in adult teleosts (Audigé, 1910:449-50),

although Guitel (in: Edwards, 1928:91) listed six families that include species with functional pronephroi in the adult stage. Alteration of the head kidney of young fishes, as found in this study, also occurs in the young of several other species (Padovani, 1932:1078-80).

The right posterior cardinal vein is the major vessel that returns renal blood to the heart in R. saxatilis and R. americanus. This agrees with the condition found in a number of other teleosts (Audige, 1910:323; Edwards, 1928:75-107; Moore, 1933:1-34). Moore, in addition, described the sinusoidal blood source as the left segmental veins. However, in the species of the present study, branches of the right posterior cardinal and the left branch of the caudal vein, as well as the segmental veins, supplied sinusoidal blood. This pattern is not wholly unique to these species, as Edwards (1928:81-83) reported the caudal vein as the major sinusoidal blood source in Hippocampus guttulatus and Lophius piscatorius. However, he did not mention medial branches of the right posterior cardinal vein. The kidneys of H. guttulatus and L. piscatorius are distinctly separate organs; those of R. saxatilis and R. americanus are fused posteriorly.

The major histological difference between the two species are in the number of goblet cells in the anterior part of the ureter, and the size of the glomeruli. In both species, with the exception of increasingly taller cells distally, the epithelium of the nephrons was like that of the collecting ducts and ureters. This differs from the condition in the serranid fishes Epinephelus guttatus and Mycteroperca bonaci, that have, according to Nash (1931:438), a translucent epithelium near the glomerulus that changes abruptly to an opaque type.

The similarity of the renal goblet cells with those of the digestive tract suggests a mucous secretory function (Audigé, 1910:576), but, until

a histochemical analysis is made, the exact nature of their secretions remains uncertain. However, where glomerular development is great, tubular secretion is poor, and vice versa (Marshall and Smith, 1930:151). Thus, it is possible that a greater number of goblet cells may be correlated with the smaller size of the glomeruli (R. saxatilis), and fewer goblet cells with larger glomeruli (R. americanus).

Generally, the nephrons of euryhaline teleosts have well developed glomeruli and distal segments (Tampi, 1959); species that never invade water of lower salinities either have no or poorly developed glomeruli, and no distal tubular segments (Smith, 1953:107). Roccus saxatilis and R. americanus have well developed glomeruli, but are exceptions to the general pattern, as both have proximal tubular segments only. The latter is probably a reflection of their marine origin (Black, 1957:196). Grafflin (1937b:472) reported a similar condition in the euryhaline cyprinodont, Fundulus heteroclitus.

The glomerular measurements of R. americanus agree with the measurements of the renal corpuscle of the same species made by Marshall and Smith (1930:142). This places R. americanus near the lower limits of group I, as defined by them. Roccus saxatilis, which was not included in their studies, probably should be in group I also, because of the abundance of well vascularized glomeruli; even though the glomerular size corresponded to those of group II. The weakness in Marshall and Smith's classification appears to be in the subjectivity of the criteria and in the assumption of categories which combine natural characteristics. More quantitative criteria, as well as the separation of these criteria would permit subgroups that would more accurately describe their members.

In previous unpublished work, using the same technics as in this study,

I demonstrated that R. saxatilis from a completely freshwater environment (Kerr Reservoir, Virginia-North Carolina) had significantly larger glomeruli (55.7μ) than those from the Chesapeake Bay population (47.7μ), a difference greater than between the freshwater R. saxatilis and R. americanus (59.7μ). The Kerr Reservoir population was presumably established with the completion of the impoundment in 1951, limiting the survivors to a permanent freshwater environment. Studies of meristic characters, e.g. lateral-line scales (70% divergence) and pectoral fin rays (68% divergence), using Ginsburg's (1938:253-86) method, also showed significant differences between the two populations of R. saxatilis. Therefore, on the evidence of these studies, and the present study, it is concluded that selective adaptation is probably the basis for the difference in glomerular size. This agrees with the statement of Smith (1932:18) that the kidney is a true phylogenetic character and not merely an individual's response to the environment. He used as an example the aglomerular freshwater pipe fish, Microphis boaja, a descendant of a typically aglomerular marine syngnathid. In the marine sculpin genus, Myxocephalus, the species M. octodecimspinosus has glomerular kidneys (Nash, 1931:432), but M. scorpius has renal tubules that are predominantly aglomerular (Forster, 1953:488). Thus, only if the species has the genetic potential, the environment will be a selecting force for a type of kidney best adapted to the fishes' habitat. Providing the above requirement is met, selection could be expected to occur at a rapid rate in a small isolated population, e.g. the Kerr Reservoir population of R. saxatilis. In large populations composed of freely moving individuals, selection would be expected to occur at the same rate, but the results on the whole population would not be as obvious and, therefore, would appear to occur at a lesser rate.

Mayr, Linsley and Usinger (1953:123) say that while characters that are adaptations to a specific mode of living, and are subject to rapid changes, may be of limited value in establishing higher taxonomic categories, they are useful in separating species and genera. The strong histomorphological similarity between the urinary systems of R. saxatilis and R. americanus, and the tendency for R. saxatilis to have larger glomeruli (approaching the size of those in R. americanus) when introduced into freshwater, supports the views of Jordan and Gilbert (1883: 528-31), Berg (1949:1012-3) and Woolcott (1957:1-10) that the species belong in the same genus.

SUMMARY

The specimens studied were: Roccus saxatilis (morphology 13; histology 3) and R. americanus (morphology 12; histology 4). Findings from this study were compared with the results of an unpublished study on a freshwater population of R. saxatilis from Kerr Reservoir, Virginia-North Carolina. Formalin fixed specimens were used to compare the histomorphology of the two species.

The gross anatomy of the urinary system in the two species was similar. Histological differences were observed, however, as these could be explained on the basis of environmental selection, they were considered to support the monogeneric classification of Jordan and Gilbert (1883:528-31), Berg (1949:1012-3) and Woolcott (1957:1-10). The major findings were:

1. Roccus americanus had larger glomeruli than R. saxatilis. However, the glomeruli in freshwater R. saxatilis were intermediate in size, suggesting considerable preadaptation for fresh water and a high rate of selection.

2. Roccus saxatilis had a greater number of goblet cells in the anterior part of the ureter than did R. americanus. This may be correlated with the smaller glomeruli of the former and the larger of the latter.

3. No significant differences between the two species were found in: mesonephric length, uretal length, luminal diameters of the ureter and dorsal aorta, or thickness of the uretal wall.

4. Neither species had a distal tubular segment; probably a reflection of their marine origin.

5. The tubular epithelium of R. saxatilis and R. americanus was of a

single type, as opposed to the translucent and opaque epithelia found in the serranids studied by Nash (1931:438).

6. In addition to the segmental veins and branches of the caudal veins, medial branches of the right posterior cardinal vein supplied sinusoidal blood in the two species.

7. The mesonephroi in both species were fused posteriorly forming oblong intervertebral segments in R. saxatilis and almost round ones in R. americanus.

8. The head kidney, a hemopoietic organ in the young and adults of both species, was larger in R. saxatilis than in R. americanus.

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Figure 1a. Roccus saxatilis. Lateral view of dissected opercular region showing head kidney in relation to other structures of the area. hk, head kidney; ht, heart; ph, pharynx; sv, sinus venosus.

Figure 1b. Roccus americanus. Lateral view of dissected opercular region showing head kidney in relation to other structures of the area. Abbreviations as in Figure 1a.

Figure 2a. Roccus saxatilis. Ventral view of mesonephros. lcv, left branch of caudal vein; lpcv, left posterior cardinal vein; lu, left ureter; r, rib; rcv, right branch of caudal vein; rpcv, right posterior cardinal vein; ru, right ureter; ts, transverse septum.

Figure 2b. Roccus americanus. Ventral view of mesonephros. Abbreviations as in Figure 2a.

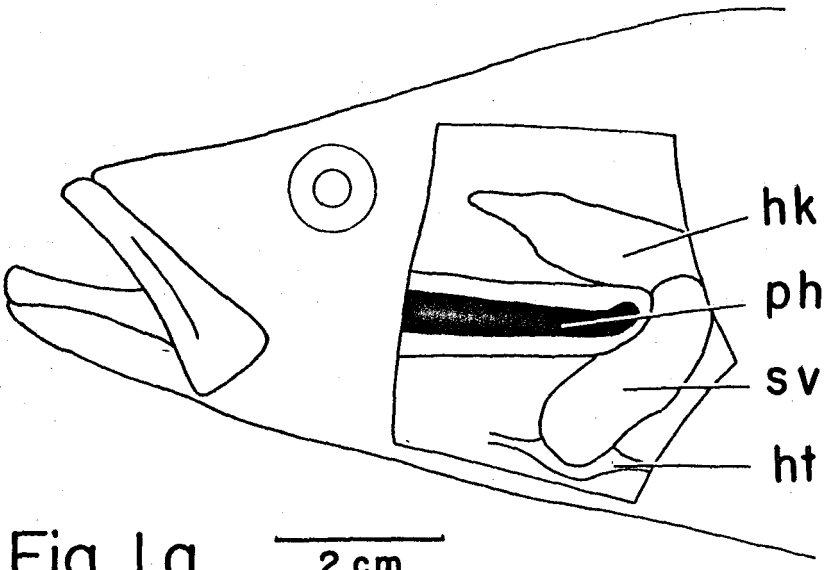

Fig. 1 a 2 cm

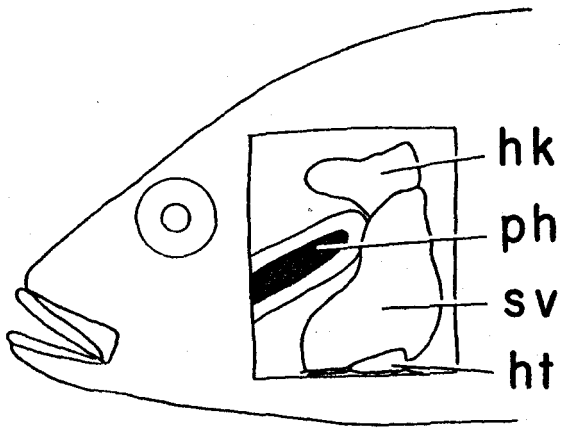

Fig. 1 b 1 cm

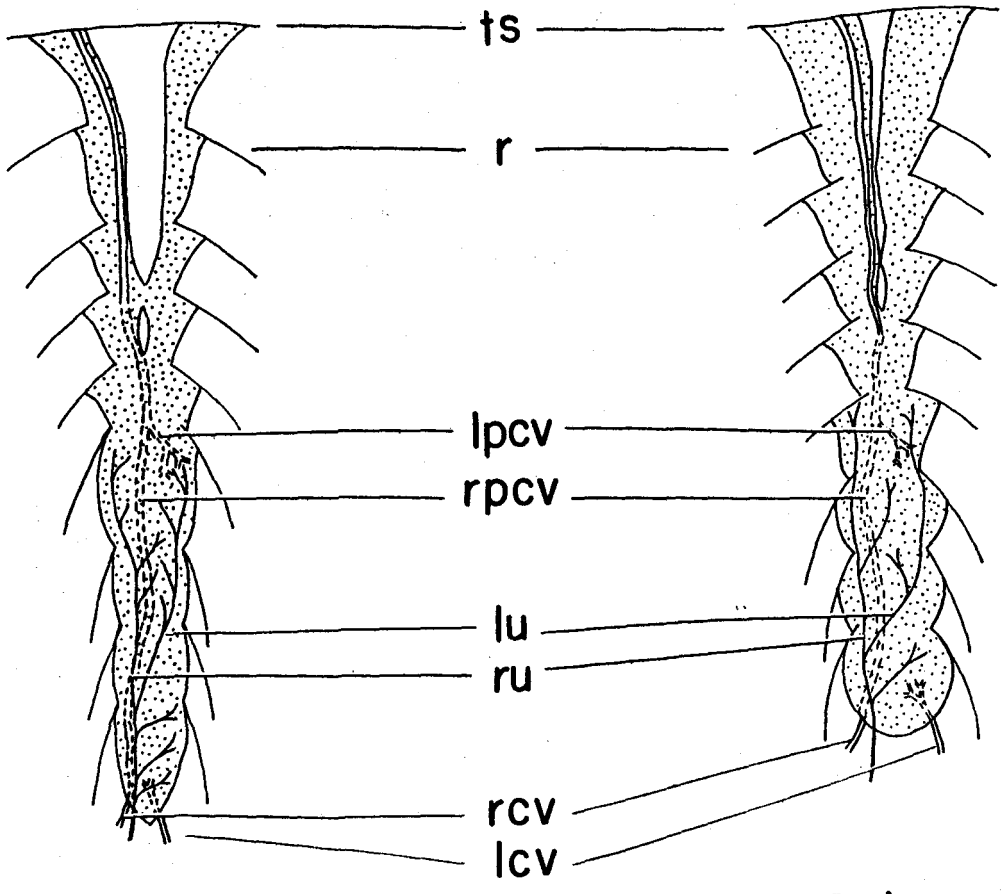

Fig. 2 a 2 cm

Fig. 2 b 1 cm

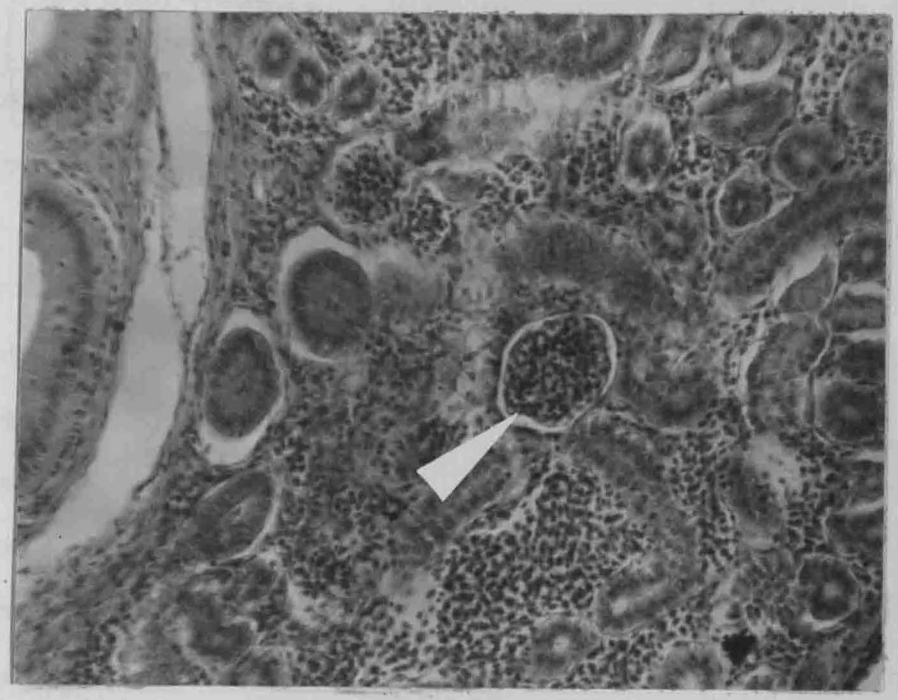

Figure 3a. Roccus saxatilis. Photomicrograph of H and E cross section of mesonephric tissue. Magnification 370X; maximum diameter of indicated glomerulus 46μ.

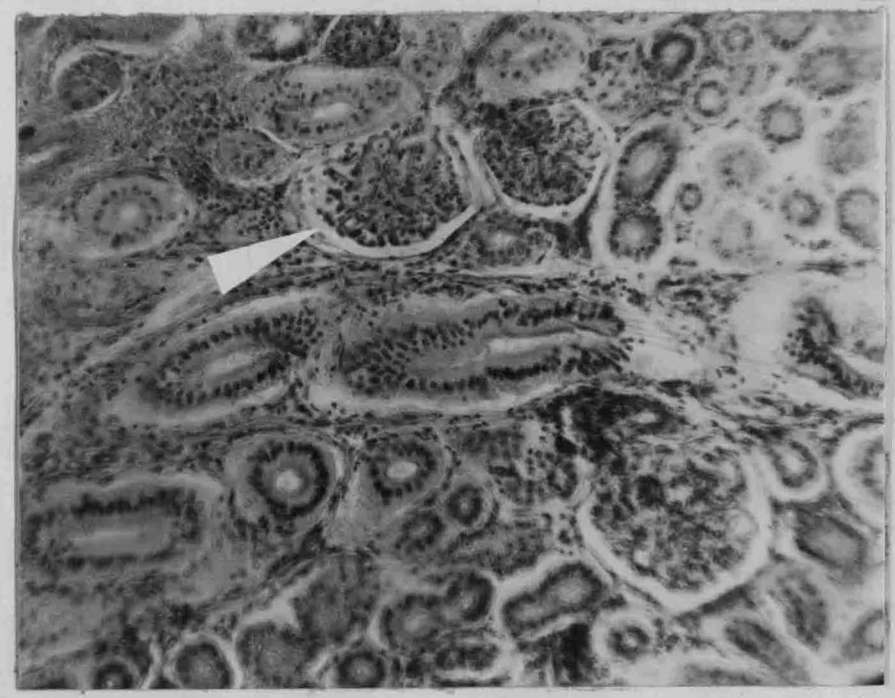

Figure 3b. Roccus americanus. Photomicrograph of H and E cross section of mesonephric tissue. Magnification 370X; maximum diameter of indicated glomerulus 62μ.

VITA

Irwin Beitch was born November 28, 1937 in Brooklyn, New York where he attended public school. He was graduated from New Utrecht High School in 1955. From September, 1955 to June, 1956 he attended West Virginia Wesleyan College in Buckhannon, West Virginia. In the fall of 1956, he transferred to the University of Richmond, Virginia, where, in June, 1960, he received a Bachelor of Science degree, and in August, 1962, a Master of Science degree in biology. While at the University of Richmond, he assisted in general biology and comparative anatomy classes. From 1960 to 1962, he worked for the Virginia Commission of Game and Inland Fisheries as an assistant field biologist and researcher. In his final year at the University of Richmond he was awarded a Williams Fellowship. He plans to continue graduate work toward the Ph.D. degree in zoology.