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GILL-NET SELECTION OF LATES MARIAE STDR. (NILE PERCH) IN LAKE TANGANYIKA

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Received July 15, 1969

Abstract: *Lates mariae* (nile perch) in Lake Tanganyika were caught with gill-nets using nine mesh sizes ranging from 5.1 cm to 15.2 cm in approximately 1.3 cm increments (stretch measure). Nets were laid on the bottom between the littoral and 160 m depth. *L. mariae* was found to occupy deeper water with increase in size, the large majority of mature fish occuring between 100 m and 160 m depth.

Catch curve distributions of the mesh sizes between 5.1 cm and 8.9 cm were approximately normal, but in mesh sizes 10.2 cm to 15.2 cm the distributions were not normal. Reasons for this asymmetry are apparent when the curves are divided into components which represent the selection properties of five capture positions on the head and body. Girth-length relationships at these positions can be expressed, with one exception, in linear regressions. In most cases, the size of fish caught in any mesh size depends upon its girth near the position of capture. Some bias in selection is thought to be caused by the marked size variations in the population at different depths of bottom.

INTRODUCTION

Rates of exploitation of fish on most lakes and rivers in Africa are increasing rapidly, and nylon gill-nets are the commonest gear used. Unfortunately, mesh sizes are mostly chosen to catch the maximum quantity of fish without regard to selective effects. So far, gill-net selectivity for African fishes has been studied only for Lake Victoria *Tilapia esculenta* (Garrod, 1961) and for *Clarias mossambicus* in Lake Bangweulu (Gulland and Harding, 1961). The length frequency distributions of catches from a series of mesh sizes were found to be normal in the case of *T. esculenta* over most of the length range caught, but those of *C. mossambicus* were very asymmetrical.

The genus *Lates* (nile perch) is widely distributed in Africa, and its few species are among the most commercially valuable fishes. They possess spiny cephalic processes by which they are usually enmeshed. Three endemic *Lates* species occur in Lake Tanganyika, and experimental netting indicates that there is a potentially valuable gill-net fishery for one of these, namely *Lates mariae* (Coulter, 1967b).

In this paper, catch curves of *Lates mariae* caught by a series of gill-net mesh sizes are analysed. The paper may have some general value because it illustrates a case where asymmetry in catch curves results from capture in several positions on the body at which retention characteristics are different. The curves seem also to be influenced by size frequency variations on the fishing ground.

METHODS

Gill-nets were used in gangs of nine nets with mesh sizes 5.1 cm to 15.2 cm stretched measure in approximately 1.3 cm increments (2in to 6in, in $^1/_2$in increments). Nylon twine sizes were 210/3/2 in the 5.1 cm to 7.6 cm meshes, and 210/3/3 in the 8.9 cm to 15.2 cm meshes. All nets were 2.4 m mounted depth, with a hanging coefficient of 50% on 46 m (50yd) head and foot ropes. High density floats were used. On each occasion of fishing, all nets in a gang were laid along the same isobath as determined by echosounding and remained overnight. About 11,000 *L. mariae* were caught from 1961 through 1963 in the southeast and southwest arms of the lake. Length was measured to the nearest centimetre from lower jaw tip to the end of the median caudal ray. The isobaths in Fig. 1 were drawn from echo-sounding data gathered in the course of this work.

DISTRIBUTION OF LATES MARIAE ON THE BOTTOM

Bottom slope in the southeast and southwest arms of the lake is mostly gradual resulting in extensive "shelf" areas, but on the coast between the bottom is generally too steep for gill-netting (Fig. 1).

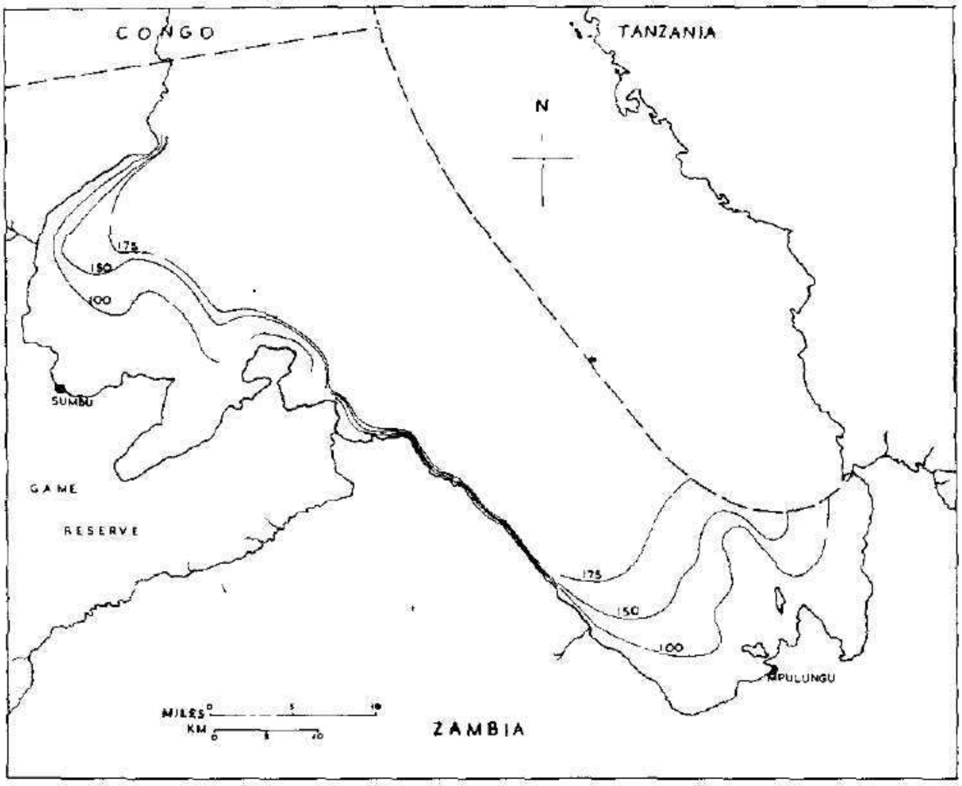

Fig. 1. Southern Lake Tanganyika, showing the extent of the fishing grounds for *L. mariae* between the 100 m and 175 m isobaths.

Catches indicated the presence of benthic fish populations rich both in species and numbers, and *L. mariae* formed the majority of the catch in meshes larger than 8.9 cm. Juveniles of this species between about 4 cm and 17 cm live in littoral weed patches and gradually occupy deeper water with increase in size. Maturity is attained at about 44 cm in males and 49 cm in females (Coulter, 1966). Fig. 2 illustrates the size distribution with depth by length frequency plots of catches per gang of gill-nets in certain depth ranges between the littoral and 160 m depth. It is apparent that the large majority of mature fish occur between 100 m and 160 m depth. Although *L. mariae* occur near the oxygen limit around 200 m depth (Coulter, 1967), catches were poor below 160 m.

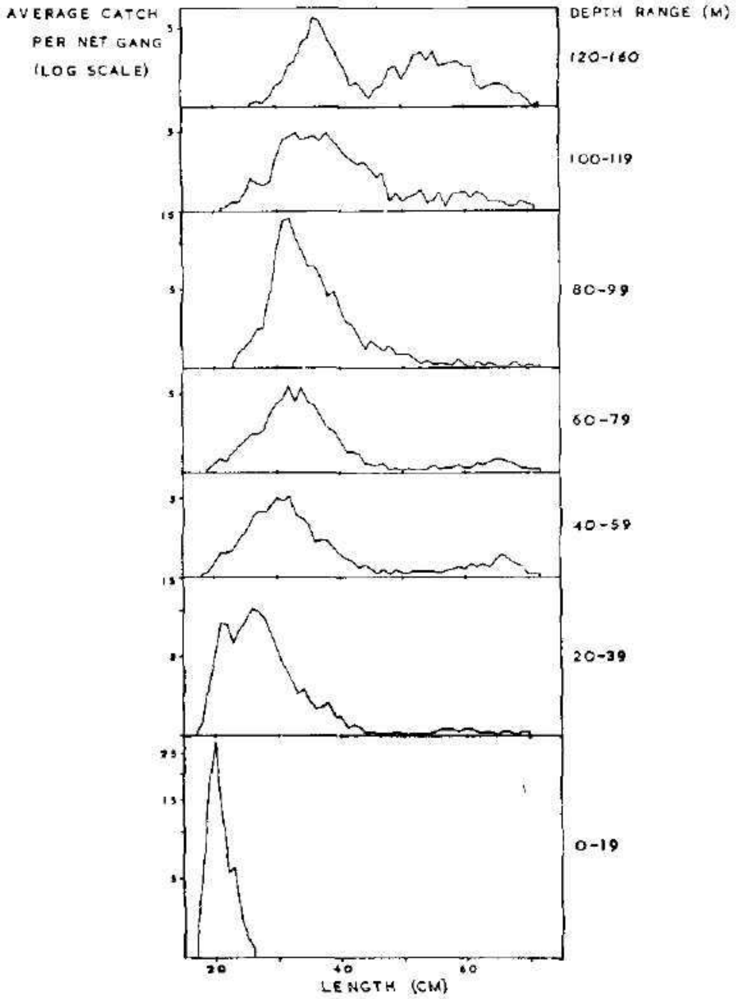

Fig. 2. Length frequency distributions of numbers of *L. mariae* caught **in different depth ranges** in the southwest arm. Lengths are plotted in 1 cm intervals, and numbers **are expressed on a logarithmic** scale.

SIZE SELECTION BY THE GILL-NETS

In gill-net catches there is generally a close relationship between mesh size and size of fish caught, and catch curves are usually similar to the normal distribution. The catch curves for *L. mariae* in each of the mesh sizes used are shown in Fig. 3. Curves for meshes between 5.1 cm and 8.9 cm are approximately normally distributed, but in each there is a tail representing relatively few larger fish. Catches in the 10.2 cm, 11.4 cm and 12.7 cm meshes

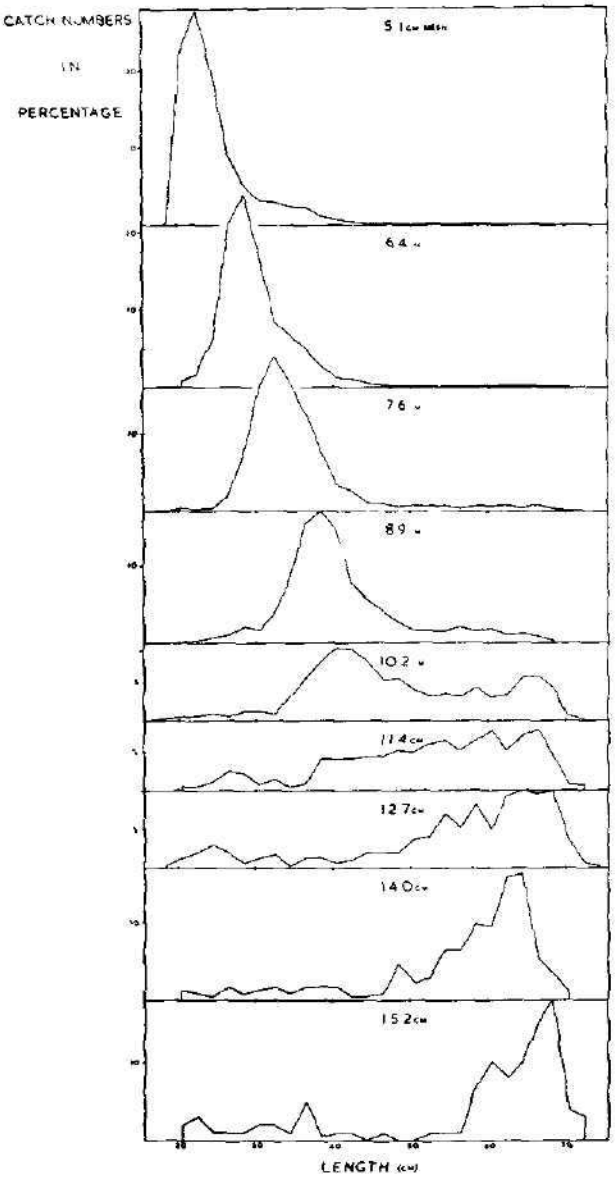

Fig. 3. Length frequency distributions of numbers of *L. mariae* caught by each mesh size (all catches in the southeast and southwest arms). Lengths are plotted in 2 cm intervals, and numbers are expressed as percentages of the total catch by each mesh size.

form asymmetrical curves extending over wide length ranges. In the 14 0 cm and 15 2 cm meshes, mostly large fish between 60 cm and 70 cm were caught but there were also significant numbers of smaller ones.

The extent to which these curves depart from the normal distribution is illustrated in Fig 4 by Holt's method. Holt (1963) showed that for normal selection curves of nets which differ little in mesh size and have the same standard deviation, the logarithms of the ratios of each length group when plotted should lie in a straight line. The catch ratios of the 6.4/5.1 cm, 7.6/6.4 cm and 8.9/7.6 cm meshes are expressed in nearly straight lines representing the fairly normal peaks in each, and non-linear portions representing the tails. The ratios of the larger meshes form non-linear plots.

The relationship between the size of fish and size of mesh in which it is caught should, provided that capture is due to being wedged into the mesh, be a simple one and depend upon girth at the position of capture. *L. mariae* were caught in the gill-nets in one or other of the following positions: (i) just anterior to the dorsal fin (ii) at the supra-opercular spine (iii) at the sub-opercular spine (iv) at the eye, and (v) at the posterior end of the maxillary bone. These positions of capture are indicated on the photograph of a specimen in Fig. 5 by the symbols PD, SpO, SuO, E and M, respectively. Girth measurements were made at each position in specimens between 30 cm and 72 cm length at 1 cm intervals of length. Mean girths of five specimens were taken as the girths for each 1 cm length group.

Girth-length relationship for the capture positions can be expressed as linear regressions except for the eye position where girth increase is slightly disproportionate (Fig. 6). The large eyes of this species are probably an adaptation concerned with visual ability in the dim light at the depths where the adults live, and their allometric growth may be related to the occupation of deep water by adults. In all meshes, about threequarters of the specimens for which capture position was noted were caught at E, SuO and SpO and, except for the 5.1 cm mesh, more were caught at the eye than elsewhere (Table 1).

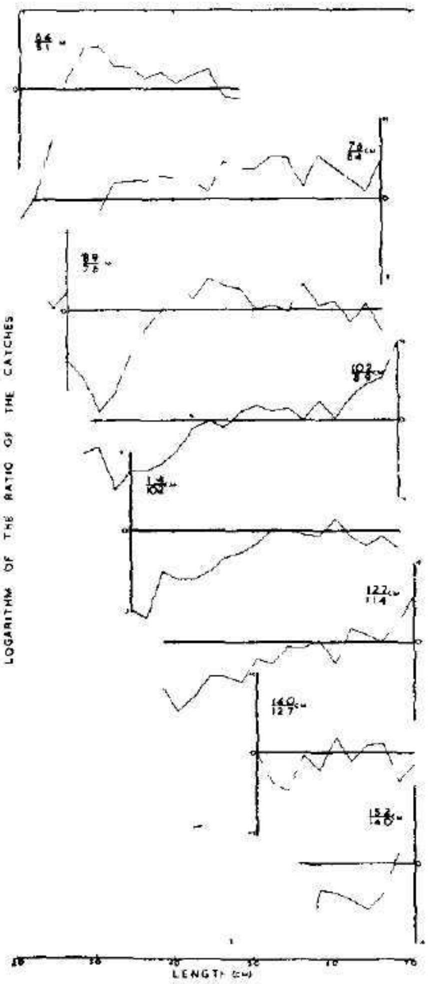

Fig. 4. Plots of the logarithms of catch ratios (ratio of the numbers of fish in each 2 cm lengt group) in successive mesh sizes between 5.1 cm and 15.2 cm.

The catch curves for each mesh size can be divided into components representing the selection properties of the five capture positions (except for the 15.2 cm mesh in which catches were insufficient). These component curves mostly overlap, and their mean values only, i.e. the mean retention lengths, have been plotted in Fig. 7. The plot shows that in each mesh there is generally an inverse relationship between the size of fish caught and girth at the position of capture; thus smaller fish are caught at positions of greater girth, and *vice versa*. The biggest specimens were caught in the 10.2 cm mesh at position M, but in larger meshes they were caught at the capture position of slightly greater girth, that is, at E. This is consonant with the usual assumption that fish will generally be caught where girth approximates to the size of the mesh encountered. However, only those caught near the dorsal fin were truly wedged in the mesh, and at each of the other positions a projection (either spines, eye or maxillary bone) retained fish with girths which varied between that at the position and that at the next position of greater girth. Since girths at the capture positions appear to increase linearly with general size increase (except at the eye, though variation from linearity

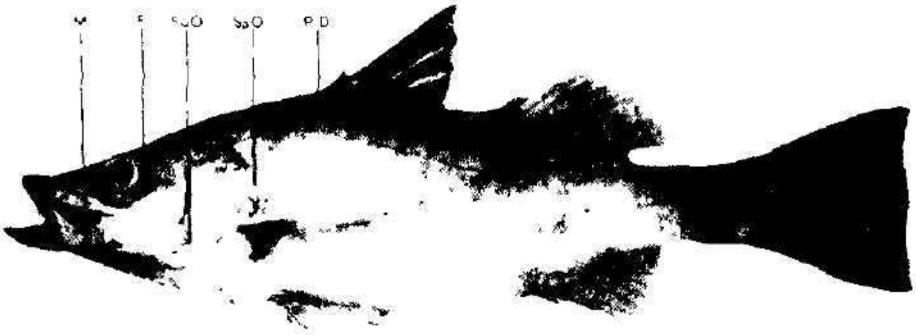

Fig. 5. *Lates mariae*. Photograph of specimen 50 cm in length. The five positions of capture are indicated by the symbols PD, SpO, SuO, E and M.

Table 1.

Percentage of the total catch caught in the different gilling positions						Total number of fish examined for position of capture
	%PD	%SpO	%SuO	%E	%M	
5.1 cm mesh	7.9	23.7	28.8	25.2	14.4	2547
6.4 cm mesh	9.3	24.1	21.7	31.3	13.2	1860
7.6 cm mesh	10.0	19.1	23.5	32.2	15.2	1291
8.9 cm mesh	10.5	23.4	20.1	29.0	17.0	683
10.2 cm mesh	14.1	21.0	21.7	29.6	13.6	618
11.4 cm mesh	11.0	19.3	20.1	33.5	16.1	254
12.7 cm mesh	11.7	19.9	22.0	38.8	7.7	196
14.0 cm mesh	9.5	16.3	21.8	42.2	10.2	147

is not great — Fig. 6), the mean retention lengths of each component in successively larger meshes should also increase linearly and show corresponding expansion in the length ranges of fish caught. In fact, increases both in mean lengths and ranges of lengths of captures at SpO, SuO and E in successively larger meshes are sufficiently regular to indicate a close relationship between girth increase and size at capture.

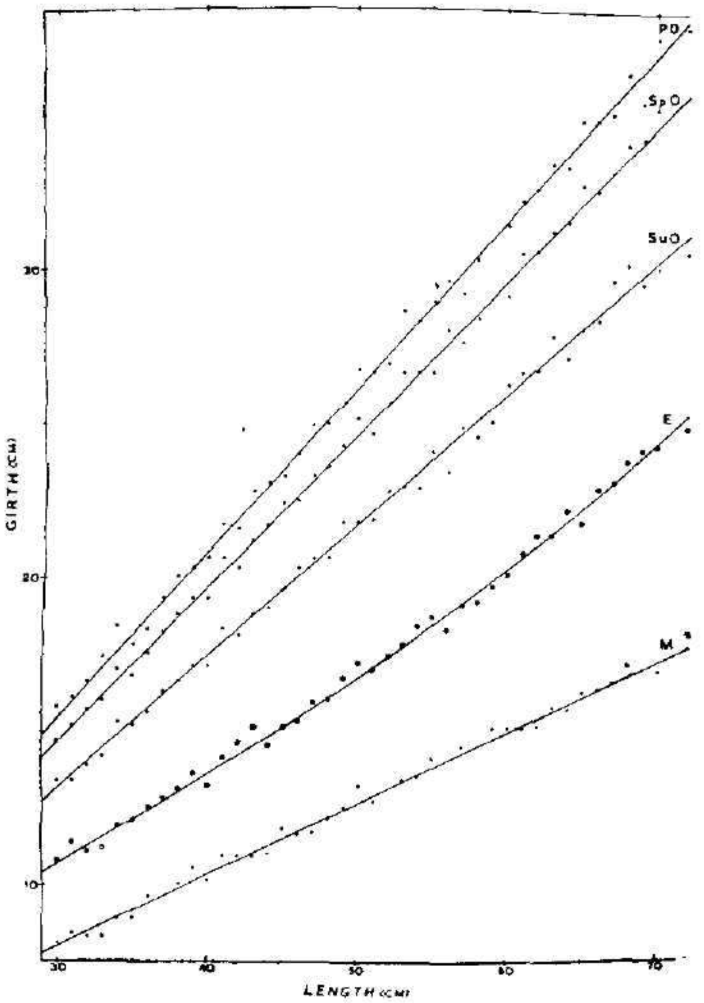

Fig. 6. Relations between length and girth at the five positions of capture, denoted by the symbols PD, SpO, SuO, E and M.

However, mean lengths of catches at PD and M *decrease* in the 11.4 cm, 12.7 cm and 14.0 cm meshes. It might be expected that these components will depart most from the general trend, since irregularities are most likely to occur at the extremes of each catch curve (i.e. for any mesh, fish much smaller than the mean retention length will tend to be caught at PD and fish much larger than the mean at M). Some deflection from linearity is also apparent at SpO, SuO and E, but it is much less marked. This bias in selection in the larger meshes towards the lower end of the length scale is not likely to be due to allometric growth (the regular girth increases and other evidence (Coulter, 1966) indicate that growth is close to isometric), but it may result from the high proportion of relatively small *L. mariae* present down to at least 160 m depth (Fig. 2). This is because the catch curve of any

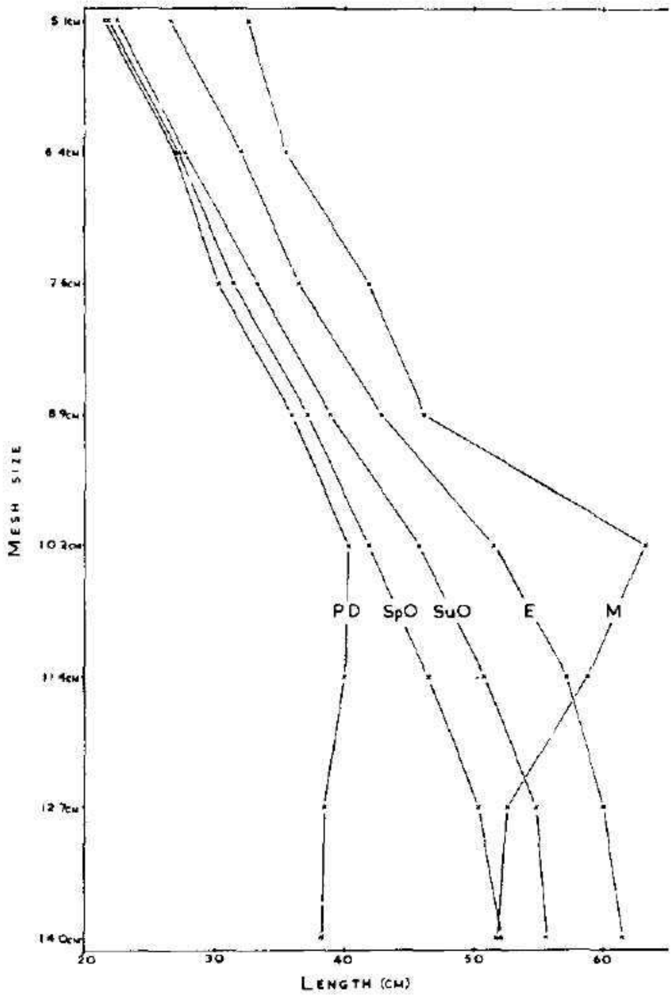

Fig. 7. Mean retention lengths at the five positions of capture (PD, SpO, SuO, E and M) for the mesh sizes between 5.1 cm and 14.0 cm.

mesh size will be determined not only by the relative efficiency with which it catches fish of different sizes, that is its selection curve, but also to some extent by the size distribution of the fish in the vicinity of the net. For example, the catch curve of a 15.2 cm mesh net in depths less than 40 m would have a peak between 20 cm and 40 cm length, whereas if the net were laid throughout the depth range of *L. mariae* most of the catch would be between 60 cm and 70 cm length. Where there is a preponderance of a particular size of *L. mariae*, meshes of the various dimensions will catch this size but the mesh in which the catch curve is closest to its selection curve will catch the most.

An overall selection curve for *L. mariae* would best be derived from selection curves for each capture position (as suggested by Holt (1963) in the case of herring enmeshed in several positions), and it should also take into account the effect introduced by the marked size variations in the population on different depths of bottom. No satisfactory synthesis was found and much more detailed catch data are probably required for this.

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STUDIES ON THE ENDOSKELETON OF OMPOK BIMACULATUS (BLOCH)
PART I — THE SKULL

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Received April 18, 1969

INTRODUCTION

The fish, *Ompok bimaculatus* (Fam Siluridae, Ord. Cypriniformes) is a fresh water catfish, commonly available in ponds and rivers of Muzaffarnagar town (Uttar Pradesh, India). It is a carnivorous fish of high edible value. Osteology has its own importance in fish systematics and as such the present study on the osteology of the catfish, *O. bimaculatus* has been undertaken The available literature on the osteology of fish deals with both the individual parts as well as complete endoskeleton The important contributions on the complete endoskeleton comprise, McMurrich (1884) on *Ameiurus catus*, Sarbahi (1933) on *Labeo rohita*; Awati and Bal (1933) on *Tetradon oblongus*, Joshi and Bal (1953) on *Coila dussumieri* and Nawar (1954) on *Clarias lazera*. The individual parts, particularly the skull of fishes attracted the attention of several workers The main contributions on the skulls of siluroids include those of Bhimachar (1933) on *Rita*, *Silonia*, *Plotossus*, *Wallago*, *Pangassius*, *Macrones*, *Arius* and *Osteogeniosus*, Eaton (1948) on *Ictularis lacustris punctatus*; Shrinivasachar (1957) on *Heteropneustes fossilis*, Sinha (1959) and Joseph (1960) on *Wallago attu* and Mahajan (1966) on *Sisor rabdophorus*, Gauba (1963) on *Bagarius bagarius*, and Rastogi (1963) on *Silonia silondia* and *Clupisoma garua*. Knanna (1961) contributed on the hyobranchial skeleton of certain siluroids.

MATERIAL AND METHODS

The fish of different sizes were procured from the local fish market. Skeletons were prepared by immersing the specimens in hot water and removing the flesh and muscles with extensive care. The skeletons thus cleaned were dried in the open sun and then transferred to the mixture of equal amounts of hydrogen per oxide and water for quick bleaching. Alizarin transparencies were also prepared by using Hollister's technique The observations were made under stereoscopic microscope

OBSERVATIONS

The skull of *Ompok bimaculatus* is wedge-shaped with a blunt snout. It is dorsoventrally flattened and loosely articulated with the vertebral column The skull includes two sharply contrasting divisions, the neurocranium and the branchiocranium (Gregory, 1933).

Neurocranium

It is compact wedge-shaped structure with olfactory and auditory capsules fused on the antero-lateral and postero-lateral aspects. Dorsally it bears two median fontanelle, the anterior one lies between the ethmoid and the frontals while the posterior one lies between the frontals and the supraoccipital. The posterior fontanelle is more prominent than the anterior The neurocranium is distinguishable from behind forward into five regions Occipital region, Auditory region, Sphenoidal region, Orbital region and Ethmoidal region.

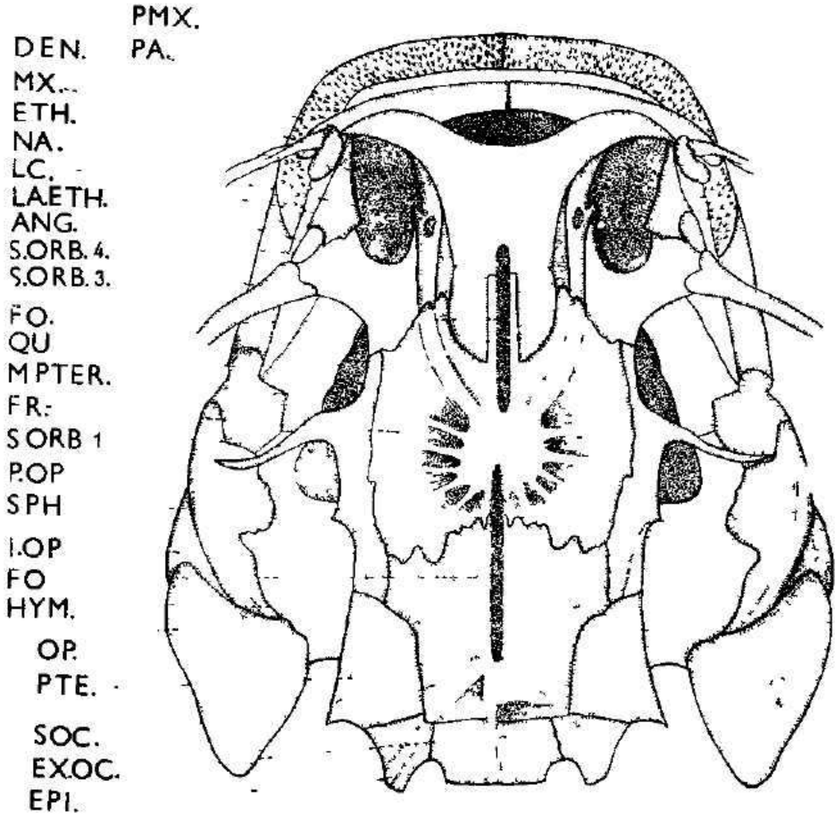


Plate 1 Dorsal view of the skull

1. Occipital region

It forms the posterior most part of the neurocranium and is made up of four replacing bones, the median supraoccipital on the roof, the median basioccipital on the floor, and the paired exoccipitals on the sides. The supraoccipital (Pls. 1,3 & 4; Fig. 1; S.OC.) is a median flat bone with convex dorsal surface and slopping margins. It lies on the dorsal surface of the occipital region. Anteriorly the bone bears a cleft (CL.) which divides it into two arms (AR.). The cleft forms the major portion of the posterior fontanelle and joins behind with a laterally compressed occipital crest (OC.C.); the latter touches behind the neural spine of the complex vertebra. Diverging from the sides of the occipital crest, on the dorsal surface of the bone, are two forwardly directed and two backwardly directed radiating ridges (RI.) which form a cross-like pattern. These ridges denote the positions of the underlying semicircular canals of the internal ear. The supraoccipital articulates anteriorly with the frontals, antero-laterally with the sphenotic, postero-laterally with the pterotic and posteriorly with the epiotic and the exooccipitals. The basi occipital (Pls. 2,3 & 4; Fig. 2; B.OC.) is a median elongated bone, lying midventrally in the occipital region. Posteriorly it has a rounded occipital condyle (OC.CO.) and two backwardly directed accessory articular processes (A.ART.P.). These processes articulate with the similar forwardly directed

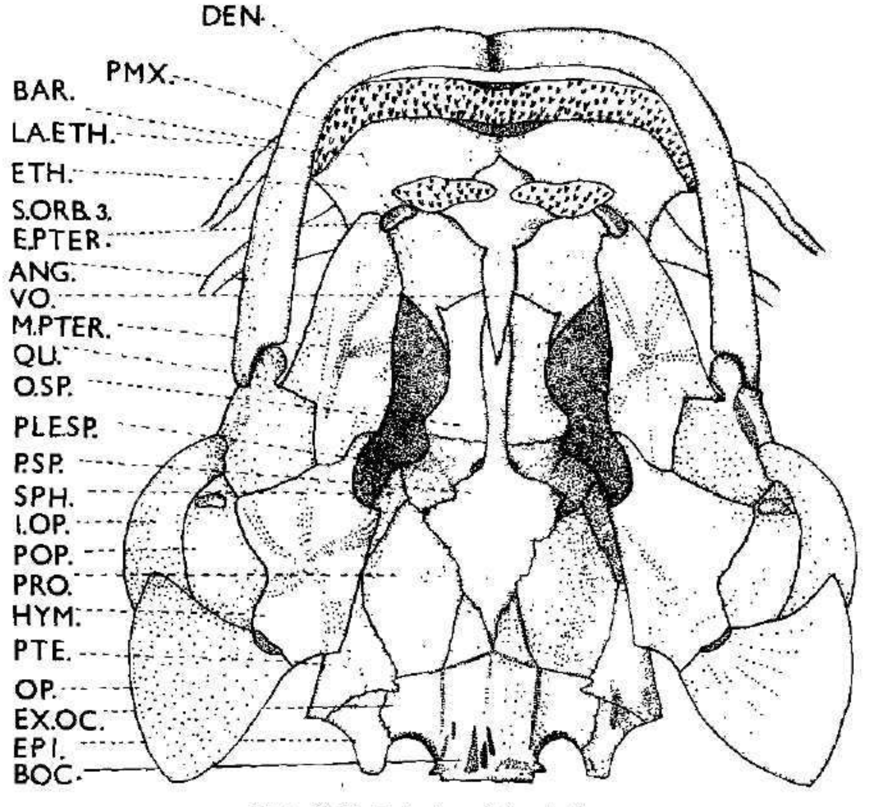


Plate 2 Ventral view of the skull.

processes of the first vertebra. Anterior to these processes, lie a pair of lateral processes (L.P.) which meet with the median ridge present on the ventral surface of the bone. Lateral processes touch the convexities present on the inferior limbs of the posttemporal bone of the pectoral girdle. The cranial surface of the bone is deeply excavated and bears two vertical ridges (RI.) infront of the occipital condyle. These ridges meet with the horizontal plates of the exoccipital and enclose a cavity, the "cavum sinus imparis" (CA.S.I.) of Weber. On either sides of the ridges lie two lateral grooves, the "foveae sacculi" (F.S.). The basioccipital articulates anteriorly with the parasphenoid, antero-laterally with the prootics and postero-laterally with the exoccipitals. The exoccipitals (Pls. 1,2 & 4; Fig. 3; EX.OC.) are paired irregular bones which contribute in the formation of foramen magnum. Dorsally each exoccipital bone bears a thin laterally compressed neural plate (PL.) which articulates dorsally with the supraoccipital. On the inner side of the neural plate there lies a small horizontal plate (HO.PL.) and on the outerside present an inclined plate (IN.PL.). The horizontal plates of the two exoccipitals meet in the middle line and form a platform for medulla oblongata. The inclined plate is bent backward and articulates with the epiotic posteriorly. Two foramens (FOR.) perforate the inclined plate ventrally which

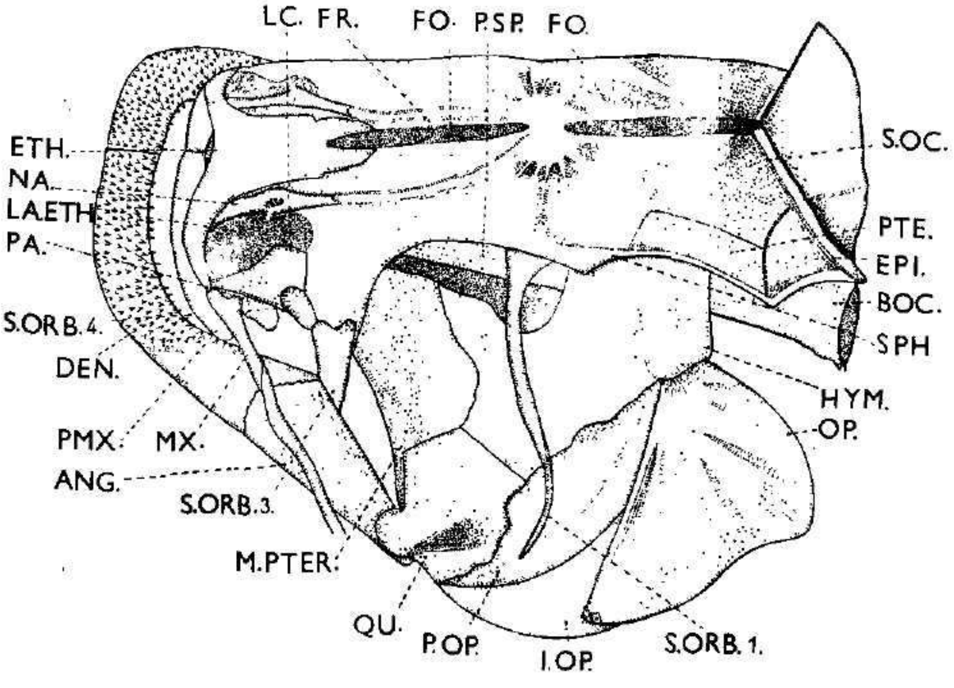


Plate 3 Lateral view of the skull.

act as exits for glossopharyngeal and vagus nerves. The exoccipital articulates dorsally with the supraoccipital, ventrally on the inner side with the basioccipital and on the outerside with the pterotic, antero-ventrally with the prootics and posteriorly with the epiotic.

2. Auditory region

This region lies on the postero-lateral sides of the neurocranium and is completely ossified. It is formed of four replacing bones, the prootics, the epiotics, the pterotics and the sphenotics. The prootics (Pl. 2 & 4; Fig. 4; PRO.) are paired flattened bones which lie on the ventral side of the auditory region. They are more or less pentagonal in shape. On the cranial surface, the bone bears a transverse plate bent backward. The cavity, formed posteriorly by the inclination of this plate forms the anterior recess of membranous labyrinth. The prootic articulates on the outerside with the sphenotic and pterotic, anteriorly with the pleurosphenoid, antero-medially and mediallly with the parasphenoid, postero-medially with the basioccipital and posteriorly with the exoccipital. The epiotics (Pl. 1, 2, 3, & 4; Fig. 5; EPI.) are irregular bones lying at the posterior end of the auditory regions At its posterior end the bone bears a vacuity (VA) which lodges a part of the posterior vertical canal of the membranous labyrinth The epiotic articulates dorsally with the supraoccipital and the pterotic, and ventrally with the pterotic and the exoccipital. The pterotics (Pl. 1, 2, 3, & 4; Fig. 6; PTE.) are paired bones which form the postero-lateral boundary of the auditory region. The bone is formed of a main part (M PT.) and a process (P) The main part of the bone lies posteriorly and bears a vacuity (VA) on the inner side. This vacuity lodges the horizontal canal of the membranous labyrinth On the ventral surface of the bone lies a shallow groove which meets with the similar groove of the sphenotic and forms an area, meant for the articulation of hyomandibular. The process after arising from the main part runs along the outer dorsal surface of the sphenotic and articulates with it. The main part articulates dorsally with the supraoccipital and the sphenotic, ventrally with the prootic and the exoccipital and posteriorly with the epiotic. The sphenotics (Pls. 1, 2, 3 & 4; Fig. 7; SPH.) are paired more or less axe-shaped bones, marking the posterior boundary of the eye orbit. Each bone consist of a main part (M.PT.) and a forwardly directed flat process (P). From the ventral surface of the main part arises a thickened flattened prominent outgrowth which bears on its outer surface a shallow groove and a vacuity on the inner surface. In the former fits the head of the hyomandibular where as the latter lodges the acoustic tubercle of the brain. On the dorsal surface of this bone are present transverse and longitudinal marks of post orbital canal and commissures of the frontal. The sphenotic articulates ventro-laterally with the prootic and the pleurosphenoid, postero-laterally with the supraoccipital and posteriorly with the pterotics. On its dorsal surface lies the process of the pterotic. The process of this bone runs along the side of the frontal and extends upto the lateral ethmoid.

3. Sphenoidal region

This region comprise the paired frontals, the paired pleurosphenoids, the median orbitosphenoid, the median basisphenoid, and the median parasphenoid. The parietals are absent and basisphenoid is much reduced The frontals and parasphenoid are investing bones while rest are replacing bones. The frontals (Pls. 1, 3 & 4; Fig. 8; FR.) are paired large bones, lying on the dorsal side of the frontal segment and extend behind to cover the dorsal side of the parietal segment completely and the posterior part of the supraoccipital to some extent. The two bones articulate medially leaving clefts at the anterior and posterior ends. The anterior cleft forms the posterior two third part of the anterior fontanelle and the posterior cleft forms the anterior one third of the posterior fontanelle. On the dorsal surface of the bone are present a number of radiating oblique ridges (RI). The supraorbital canal of the lateral line system lies along the inner side of the bone. The inner margin of the bone sharply drops down and articulates ventrally with the orbitosphenoid and the pleurosphenoid. The frontal articulates anteriorly with the ethmoid and antero-laterally with the lateral ethmoid, postero-laterally with the sphenotic and posteriorly with the sphenotic and the supraoccipital. The pleurosphenoids (Pls. 2 & 4; Fig. 9; PLE.SP.) are paired irregular bones, lying on either sides of the sphenoidal region. Each bone comprise a thickened broad body (BO.) and a small process (P.). A wide fenestra is formed at the place where the pleurosphenoid, the parasphenoid and the prootic meet for the common trunk of 5th and 7th cranial nerves. There is also an aperture in between the parasphenoid and the pleurosphenoid for the optic nerve. The body of the bone articulates dorsally with the sphenotic and frontal and posteriorly with the prootic. The process articulates with the orbitosphenoid. The orbitosphenoid (Pls. 2 & 4; Fig. 10;

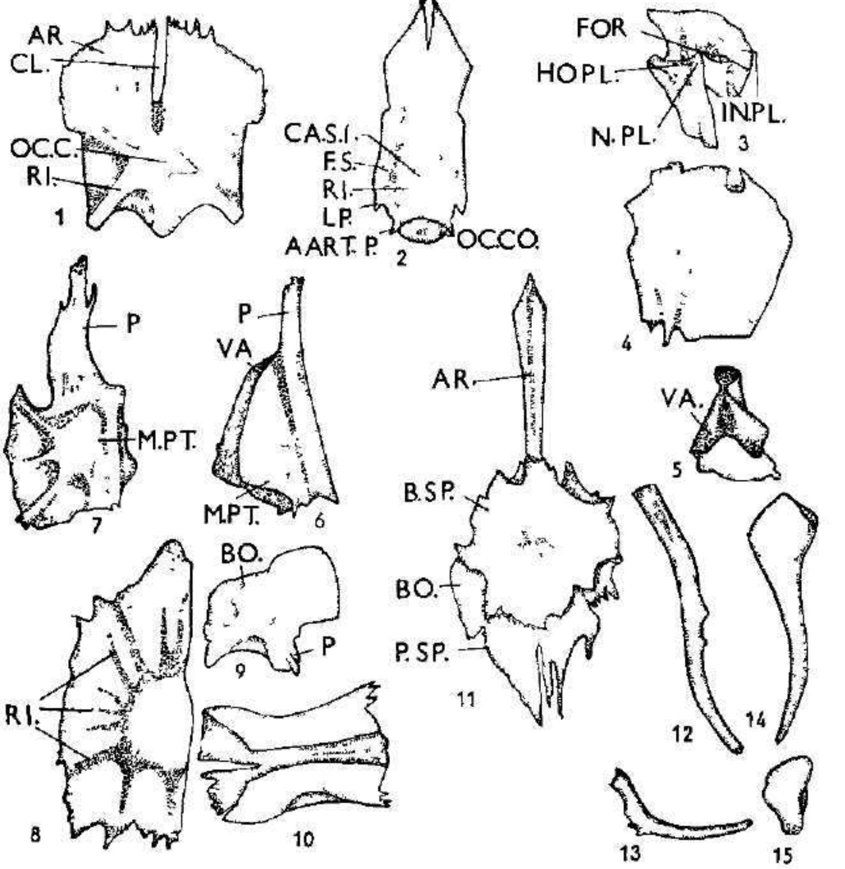


Plate 4

Fig. 1 Dorsal view of the supraoccipital. Fig. 2 Dorsal view of the basioccipital. Fig. 3 Dorsal view of the exoccipital. Fig. 4 Outer view of the prootic. Fig. 5 Ventral view of the epiotic. Fig. 6 Dorsal view of the pterotic. Fig. 7 Dorsal view of the sphenotic. Fig. 8 Dorsal view of the frontal. Fig. 9 Outer view of the pleurosphenoid. Fig. 10 Dorsal view of the orbitosphenoid. Fig. 11 Dorsal view of the parasphenoid and basisphenoid. Fig. 12 Lateral view of the first suborbital. Fig. 13 Lateral view of the second suborbital. Fig. 14 Lateral view of the third suborbital. Fig. 15 Dorsal view of the fourth suborbital.

O.SPH.) is a single median dumb bell-shaped bone, lying in the frontal segment of the cranium. It is formed of two paired ossifications and is like the drain pipe. The two lateral margins of the bone run upward, inward and articulate with the dropping margins of the frontals. The interior space of the bone lodges the olfactory tracts of the brain. Anteriorly the bone articulates with the lateral ethmoid, postero-laterally with the pleurosphenoids and ventrally with the arm and the body of the parasphenoid. The basisphenoid (Pl. 4; Fig. 11; B.SP.) is a small rhomboidal bone lying intimately fused with the parasphenoid on its cranial surface. It is concave dorsally. The parasphenoid (Pls. 2, 3 & 4; Fig. 11; P.SP) is a single median bonel lying mid-ventrally in the sphenoidal region and is made up of a rhomboida, body (BO.) and a forwardly directed arm (AR.). There is a median ridge running along the ventral surface of the bone. The cranial surface of the bone is concave. The bone forms the boundary of the apertures for the optic nerve and the common trunk of 5th and 7th nerves. The body articulates posteriorly with the basisphenoid and dorso-laterally with the pleurosphenoid. The arm runs forward on the ventral surface of the orbitosphenoid and is connected with the vomer.

4. Orbital region

It consist of eye orbits and the orbital bones. The orbits are two in number and lie on the antro-lateral aspect of the skull. These are bounded dorsally by the frontals, anteriorly by the lateral ethmoids, and posteriorly by the sphenotics and pleurosphenoids. The orbital bones comprise four sub-orbitals and one lacrymal bone. All these bones are investing bones and enclose the infraorbital canal of the lateral line system. The first sub-orbital (Pls. 1, 3 & 4; Fig. 12; S.ORB 1.) is a long narrow splent-like bone. It articulates dorsally with the sphenotic and ventrally with the second sub-orbital. The second sub-orbital (Pl. 4; Fig. 13; S.ORB 2) is a small curved bone with narrow posterior and comparatively broader anterior end. It articulates posteriorly with the first sub-orbital and anteriorly with the third sub-orbital. The third sub-orbital (Pls. 1, 2, 3 & 4; Fig. 14; S.ORB 3.) is the stoutest bone of the series with its ventral end narrow and dorsal end broader. It articulates dorsally with the posterior arm of the fork of the lateral ethmoid and ventrally with the anterior end of the second suborbital. The fourth sub-orbital (Pls. 1, 3 & 4 ; Fig. 15; S.ORB 4.) is a small roughly semilunar bone with one end broad and other end narrow. It lies dorsal to the posterior arm of the fork of the head of the lateral ethmoid. The broad end of the bone fits into the notch present in the lacrymal bone and the narrow end articulates with the third sub-orbital. The lacrymal (Pls. 1, 3 & 5; Fig. 16; LC.) is a small irregular bone with a notch at its outer narrow end. The inner broader end of the bone is expanded with two anterior and posterior projections. The anterior projection reaches upto the tip of the dorsal horn of the ethmoid. The infraorbital trunk of the lateral line system terminates into it.

5. Ethmoidal region

It consist of bones developed in relation to the snout and the nostrils. It is made up of the median ethmoid, the paired lateral ethmoids, the paired nasals and a median vomer. The lateral ethmoids are replacing bones while rest are investing bones. The ethmoid (Pls. 1, 3 & 5; Fig. 17; ETH.) is a median flat bone roughly triangular in out line, lying on the dorsal side of the ethmoidal region. Anteriorly it is deeply notched in the middle; the two arms of the notch are curved and called the dorsal horns (D.HR.). A vacuity differentiates the bone posteriorly into the dorsal and ventral plates (D.PL. and V.PL.). The ventral plate also bears on its antero-lateral ends two ventral horns (V.HR.) which lie just behind the dorsal horns. A median longitudinal septum divides the vacuity into two tubular passages for lodging the anterior ends of the olfactory lobes. Posteriorly the dorsal plate is divided by a median cleft (CL.) into two leaf-like processes. This cleft forms the anterior one third of the anterior fontanelle. The dorsal horns of

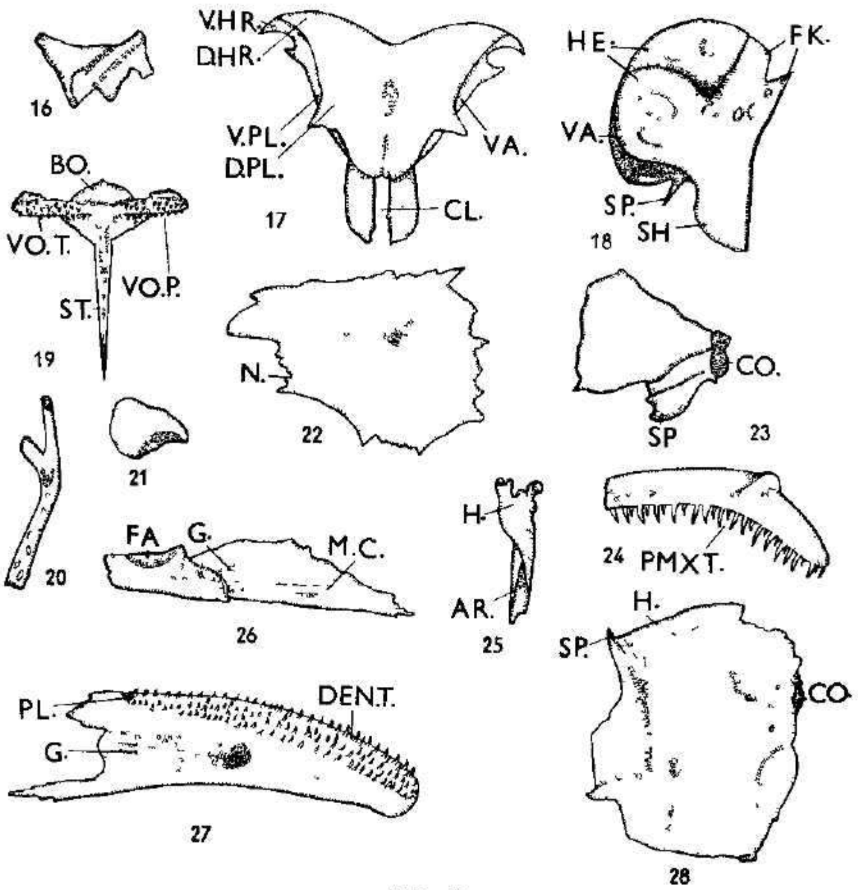


Plate 5

Fig. 16 Outer view of the lacrymal. Fig. 17 Dorsal view of the ethmoid. Fig. 18 Dorsal view of the lateral ethmoid. Fig. 19 Ventral view of the vomer. Fig. 20 Dorsal view of the nasal. Fig. 21 Dorsal view of the palatine. Fig. 22 Outer view of the metapterygoid. Fig. 23 Lateral view of the quadrate. Fig. 24 Dorsal view of the premaxilla. Fig. 25 Dorsal view of the maxilla. Fig. 26 Inner view of the angular. Fig 27 Inner view of the dentary. Fig. 28 Outer view of the hyomandibular.

the bone lie above the premaxillae at the two ends and their tips reach upto maxillae. Postero-laterally these horns articulate with the nasals. Laterally the bone articulates with the lateral ethmoid and postero-medially with the frontal. Ventrally the posterior end of the ventral plate is overlapped by the body and lateral processes of the vomer. The lateral ethmoids (Pls. 1, 2, 3 & 5; Fig. 18; LAT.ETH.) are paired hammer-shaped bones, lying on the flanks of the ethmoidal region. Each bone is made up of two parts, i.e. the head (HE.) and the shaft (SH.). The shaft is small and runs backwardly to articulate with the side of the frontal. Posteriorly the shaft articulates with the sphenotic. A vacuity (VA.) is present in the head which divides it into dorsal and ventral heads. The ventral head is broad, semicircular and bears a postero-medially directed spine. It articulates with the orbitosphenoid and parasphenoid. The spine articulates with the outer margin of the orbitosphenoid. The dorsal head is small and bears a fork (FK.). It articulates with the frontals medially. The anterior limb of fork articulates with the palatine while the posterior limb articulates with the third sub-orbital. Dorsally on it lies the fourth suborbital with which it articulates. The vomer (Pls. 2 & 5; Fig. 19; VO.) is T — shaped bone lying on the ventral side of the ethmoidal region. It is made up of a rhomboidal body (BO.) articulating dorsally with the ethmoid and a stem (ST.) lying under the arm of the parasphenoid. The lateral vomerine processes bearing vomerine teeth (VO.P. and VO.T.) arise from the junction of the body and stem. These processes articulate dorsally with the ethmoid. The nasals (Pls. 1, 3 & 5; Fig. 20; NA.) are paired capillary-like bone, lying on the outer margins of the ethmoid, embedded in the connective tissue. The supraorbital canal of the lateral line system traverse through them and terminates at their ends.

Branchiocranium

It consist of the oro-mandibular region, the hyoid region and the branchial region.

1. Oro-mandibular region

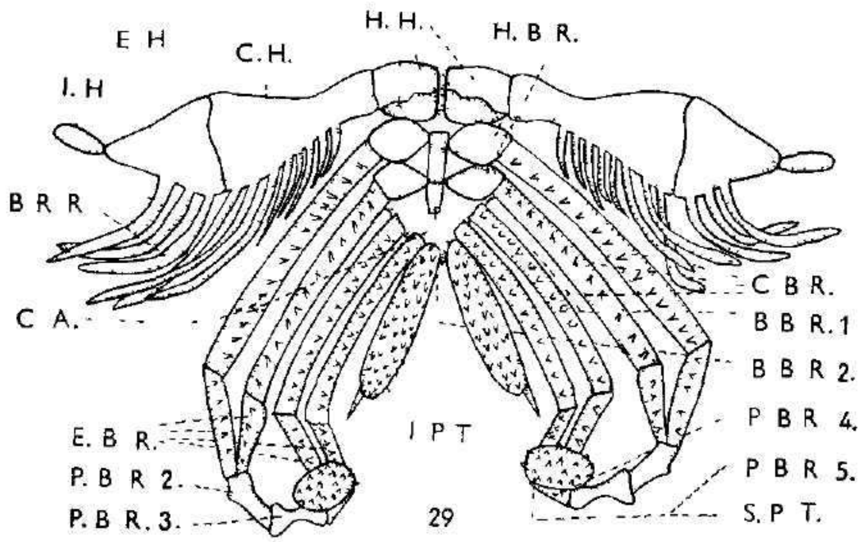
It forms the upper and lower jaws. The upper jaw is made up of two halves; each half is formed of three replacing bones, the palatine, the metapterygoid and the quadrate and three investing bones, the ectopterygoid, the premaxilla and the maxilla. The palatine (Pls. 1, 3 & 5; Fig. 21; PA.) is a very small nodule-like bone lying on the inner side of the maxilla. Anteriorly it is connected with the maxilla and posteriorly with the lateral ethmoid by means of ligaments. The ectopterygoid (Pl. 2; E.PTER.) is a very small bone which articulates anteriorly with the vomerine process and posteriorly it fits in the notch of metapterygoid. The metapterygoid (Pls. 1, 2, 3 & 5; Fig. 22; M.PTER.) is a large flattened plate-like bone with the anterior end narow and posterior end broad. The anterior end bears a notch (N.) for the ectopterygoid. The posterior end articulates with the hyomandibular and the quadrate. The quadrate (Pls. 1, 2, 3 & 5; Fig. 23; QU.) is roughly triangular bone with the broad end lying postero-dorsally and narrow end antro-ventrally. A condyle (CO.) is present at the anterior end of the bone, which articulates with the facet present in the angular bone. Arising from the postero-ventral border of the condyle is a prominent spine (SP.)

for the articulation with the lower ventral tip of the preopercular. The bone articulates antero-dorsally with the metapterygoid, postero-dorsally with the hyomandibular and posteriorly with the preopercular. The premaxilla (Pls. 1, 2, 3 & 5; Fig. 24; PMX.) is a curved rod-like bone bearing numerous rows of villiform teeth (PMS.T.) on the inner side. The teeth of the outer rows are small and of the inner rows are large and stout. The two premaxillae of two halves meet in the middle line in a symphysis and form the whole upper margin of the gape of the mouth. The outer end of the premaxilla reach upto the point where the angular and the dentary meet. Dorsally but at the outer end, the premaxilla articulates with the dorsal horn of the ethmoid. The maxilla (Pls. 1, 2, 3 & 5; Fig. 25; MX.) is a poorly developed narrow rod-like bone lying on the outer side of the premaxilla. It consist of a bifid head (H.) and a backwardly directed arm (AR.). The head articulates with the palatine and the arm supports the barbel.

The lower jaw is made up of two halves. Each half is made up of two investing bones, the angular and the dentary. The angular (Pls. 1, 2, 3 & 5; Fig. 26; ANG.) is a stout, slightly curved bone with broad anterior end and narrow posterior end. A facet (FA.) is present at the posterior end of the bone for lodging the condyle of the quadrate. On the inner side of the bone is present a groove (G.) for lodging the mandibular canal of the lateral line system. It forms posterior one third part of each half of the lower jaw. It articulates anteriorly with dentary and posteriorly with quadrate and preopercular. The dentary (Pls. 1, 2, 3 & 5; Fig. 27; DEN.) is a stout and curved bone, forming anterior two third of each half of the lower jaw. Anteriorly the two dentaries meet in the middle line at symphysis. A plate-like (PL.) structure is present on the dorsal side of the bone bearing numerous rows of villiform teeth (DEN.T.). The teeth of the outer rows are small while those of inner rows are large and stout. The posterior end of the bone is forked. In between the fork there is a narrow groove (G.) for lodging the mandibular canal of the lateral line system.

Hyoid region

It consist of hyoid arch and the bones of the opercular series. The hyoid arch is made up of two halves. Each half of the hyoid arch is formed of two segments: (1) dorsal hyomandibular and (2) ventral hyoid cornu. The hyomandibular (Pls. 1, 2, 3 & 5; Fig. 28; HYM.) is large thin plate-like bone of irregular shape. Dorsally it bears well marked head (H.) which fits into the groove present on the ventral surfface of the sphenotic and the pterotic bones. Just anterior to the head there is a spine (SP.) which articulates with the pleurosphenoid. Postero-laterally towards the dorsal surface the bone bears a condyle (CO.) for articulation with facet of the opercular bone. Anteriorly the bone articulates with the metapterygoid, posterorly with the opercular and preopercular, and ventrally with quadrate. The hyoid cornu (Pl. 6; Fig. 29) hangs from the hyomandibular and lies on the inner side of the preopercular and the opercular bones. It is made up of four segments, the hypohyal, the ceratohyal, the epihyal and the interhyal. The hypohyals (Pl. 6; Fig. 29; H.H.) are two well formed bones in each half, lying one behind the other at the tip of the branchial apparatus. The anterior one is more prominent than the posterior one. They articulate medially with the fellow of opposite side and laterally with the anterior end of ceratohyal. The cera-



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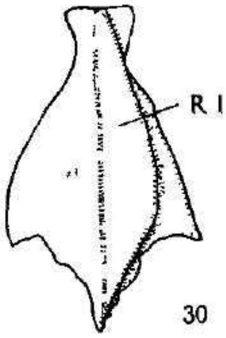

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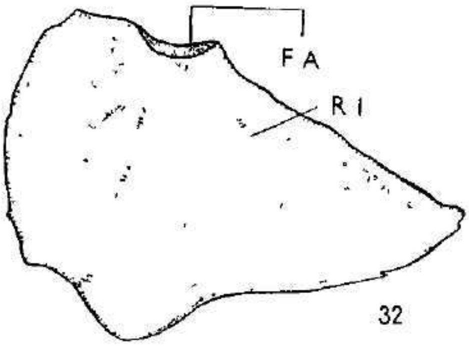

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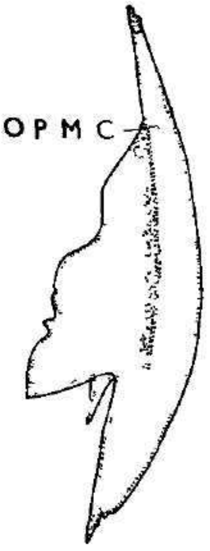

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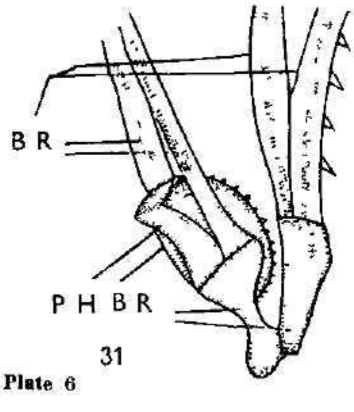

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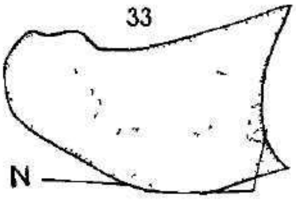

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Plate 6

Fig. 29 Dorsal view of the hyobranchial skeleton with the pharyngobranchial in ventral view. **Fig. 30** Dorsal view of the urohyal. **Fig. 31** Dorsal view of the pharyngobranchial with the epibranchials. **Fig. 32** Lateral view of the opercular. **Fig 33** Lateral view of the interopercular. **Fig. 34** Lateral view of the preopercular.

tohyal (Pl. 6; Fig. 29; C.H.) is a flattened stout bone lying at the side The anterior end of the bone is narrow and posterior end is broad and flattened. The bone is narrow in the middle. Anteriorly it articulates with the hypohyal and posteriorly with the epihyal On its postero-lateral margins it bears eight branchiostegal rays (BR.R.). The epihyal (Pl. 6; Fig. 29: E H.) is triangular in form with its broad base articulating anteriorly with the posterior end of the ceratohyal. The narrow apex of the bone articulates with the interhyal and inter opercular The postero-lateral margin of the bone bears three branchiostegal rays. The interhyal (Pl. 6; Fig. 29; I.H.) is very small rod-like bone connecting the hyomandibular with the epihyal and lies on the inner side of the interopercular The urohyal (Pl. 6; Fig. 30; U.H.) is a single median bone with forwardly directed stem, and posterior broad body bearing three backwardly directed processes It lies below the hypohyal and the basibranchials At its anterior end it is attached with the hypohyals. A median vertical ridge (RI) is present on the dorsal surface of the bone, *an either sides of which articulates the cleithral bones of pectoral girdle.*

The bones of the opercular series are the opercular, the interopercular and the preopercular. The opercular (Pls. 1, 2, 3 & 6; Fig 32; OP.) are paried somewhat triangular bones hanging from the sides of the hyomandibular. Each bone bears a facet (FA.) on their antero-dorsal side for articulation with the condyle of the hyomandibular There are numerous rediating ridges present on the outer surface of the bone, commencing from the dorsal end. Antero-laterally the bone articulates, with the hyomandibular and the preopercular, ventrally its lower tip fits into the notch of interopercular and over-laps the posterior part of the later. The interopercular (Pls 1, 2, 3 & 6; Fig. 33; I.OP) is scute-like bone with narrow curved blunt anterior end and broad notched posterior end. It is overlapped anteriorly by the preopercular and posteriorly by the opercular The preopercular (Pls 1, 2, 3 & 6; Fig 34; P OP.) are long curved bones with thick posterior canaliculized margins. Through it passes the operculo-mandibular canal (OP.M.C.). The bone articulates dorsally and antero-laterally with the hyomandibular, ventrally with the quadrate and posteriorly with the interopercular. The lower tip of the bone articulates with the angular

Branchial region

It is made up of five pairs of branchial arches, out of which the first four are of normal type and bear gill lamellae while the fifth is modified and is devoid of gill lamellae. Each normal branchial arch consist of a single mid-ventral basibranchial (Coupla), ventral hypobranchial, ventro-lateral ceratobranchial and dorsal pharyngobranchial. The basibranchials (Pl. 6; Fig. 29, B.BR.) are two in number lying midventrally one behind the other. Both the basibranchials are rod-shaped but the anterior one is more prominent. These bones connect the two halves of first and second branchial arches The third, fourth and fifth basibranchials are absent. The hypobranchials (Pl. 6; Fig. 29; H.BR.) are only two pairs belonging to first and second branchial arches. They are absent in the third, fourth and fifth branchial arches. The first hypobranchial is more prominent than the second one. The hypobranchials articulate medially with the first and second basibranchials and on the outer side with the first and second ceratobranchials A median cartilage (CA.) is present in between the third, fourth and fifth ceratobranchials and represent their basibranchials. The ceratobranchials (Pls. 6; Fig. 29; C.BR.) are five in number corresponding to its own branchial arches and lie on the ventral wall of the pharynx. The first four ceratobranchials are rod-shaped bearing a groove on their ventral surfaces for supporting the gill lamellae. Dorsally the ceratobranchials bear single row of gill rakers. The first ceratobranchial is largest and there is a gradual reduction in size in successive ceratobranchials. The first and second ceratobranchials articulate medially with the hypobranchials while the third, fourth and fifth ceratobranchials articulate with the median cartilage. The posterior ends of the first, second, third and fourth ceratobranchials articulate with the epibranchials. The fifth ceratobranchial, the only representative of the fifth branchial arch, is flattened into plate like structure. It is free at the posterior end and on its dorsal surface it bears numerous fine teeth called as inferior pharyngeal teeth (I.P.T.). The epibranchials (Pl. 6; Fig. 29, 31; E.BR.) are four pairs of rod-like bones, lying on either sides and supporting the dorso-lateral walls of the pharynx. On their inner surface they bear gill rakers. The first epibranchials belonging to the first branchial arch is the largest but there is a gradual reduction in size of successive epibranchials. These articulate anteriorly with the ceratobranchials while dorsally the first and second epibranchials articulate with the second pharyngobranchial and the third and fourth epibranchials articulate with the third and fourth pharyngobranchials. The pharyngobranchials (Pl. 6; Fig. 29, 31; P.BR.) are four pairs of bones, lying dorsally in the pharynx. The first pharyngobranchial belonging to the first branchial arch is absent. The second pharyngobranchial is a bony piece. The upper end of first and second epibranchials articulate with it. The third pharyngobranchial is a flat bony piece with one end narrow and other broad. The narrow end of the bone articulates with the third pharyngobranchial while its broad end articulates with the third epibranchial and fourth pharyngobranchial. The fourth pharyngobranchial is a bony plate articulating with the third and fourth epibranchials and third pharyngobranchial at the other end. It lies dorsal to the fifth pharyngobranchial. The fifth pharyngobranchial is an ovoidal plate lying ventral to third and fourth pharyngobranchials. On the ventral surface, it bears superior pharyngeal teeth (S.P.T.).

DISCUSSION

The skull of *Ompok bimaculatus* shows following characters of normal siluroid pattertn: —

1. Platytrabic nature of the skull.
2. The absence of parietals, opisthotics, suboperculars, symplectics and supratemporal bones.
3. The presence of well developed drain pipe-like orbitosphenoid bone for strengthening the attachment of the ethmodial region with the cranium.
4. The presence of two dorsal fontanelle.
5. The complete absence of myodome.
6. The presence of endentulus maxillae for support of barbels.
7. The presence of a palatine bone in connection with the lateral ethmoid and not with the pterygoquadrate.
8. The absence of basihyal.

Nawar (1954) in *Clarias lazera* and Shrinivasachar (1958) in *Heteropneustes fossilis* reported the presence of well defined cephalic shield, which is absent in *O. bimaculatus*. Rastogi (1963) reported the absence of cephalic shield in *Clupisoma garua*. Goodrich (1909) and Gregory (1933) have reported the presence of denticles over the surface of the bones as the common feature of a number of siluroid fishes. Bhimachar (1933) have also reported the presence of denticles in certain catfishes studied by him. But in *Ompok bimaculatus* we have not found any trace of such denticles. The supraorbital and dermosphenotic bones are not found in this fish. Regan (1911) stated that the epiotics are rarely prominent in siluroids. Nawar (1954) in *Clarias lazera* and Shrinivasachar (1958) in *Heteropneustes fossilis* had reported that the epiotics are missing. The small epiotics are met in *O. bimaculatus*.

Two dorsal fontanelle are met in this fish, a character which is most common in siluroids. Merriman (1940) considered the fontanelle as the passage for sensory nerves to the snout and barbel. These nerves were not traced by Nawar (1954) in *Clarias lazera*, by Shrinivasachar (1958) in *Heteropneustes fossilis* and by Rastogi (1963) in *Clupisoma garua*. We have not observed the nerves emerging out through these fontanelle in this fish.

Bridge and Haddon (1893) and Bhimachar (1933) stated the presence of rudimentary temporal fossae in *Mystus*. Rastogi (1963) has also reported the presence of these fossae in *Silonia silondia*. Bhimachar (1933) reported the presencee of supratemporal bone in *Silonia*, *Mystus* and *Rita*. The temporal fossae and the supratemporal bone are missing in *O. bimaculatus*.

The presence of hollow tube-like orbitosphenoid bone was reported by McMurrich (1884) in *Ameiurus catus* and by Nawar (1954) in *Clarias lazera*. In this fish it is drain pipe-like and open, formed of two paired ossifications. It serves to attach the ethomoidal region with the neurocranium and thus is an important bone.

Regan (1911) mentioned the absence of basisphenoid is Siluridae. Nawar (1954) in *Clarias lazera* and Shrinivasachar (1958) in *Heteropneustes fossilis* had confirmed Regan's statement. Bhimachar (1933) in certain siluroid fishes, Sinha (1959) in *Wallago attu*, Gauba (1962) in *Bagarius bagarius* have found it attached with the cranial surface of the parasphenoid bone. We have observed basisphenoid intimately attached on the cranial surface of the parasphenoid bone.

In correlation with the reduction of bones in siluroid skulls the parietal, opisthotic, symplectic, subopercular and subtemporal bones are wanting in this fish. The vomer is well developed and bears vomerine teeth on vomerine processes. These teeth probably help in checking the escape of prey and probably for crushing.

The myodome is present in primitive catfishes and its vestiges have been reported by McMurrich (1884) in *Amiurus catus* and by Bhimachar, (1933) and Rastogi (1963) in *Silonia*. Rastogi (1963) reported the absence of myodome in *Clupisoma garua*. The myodome is not found in this fish.

The metapterygoid and ectopterygoid are usually present in most siluroids. Regan (1911) in some Ariidae, Gregory (1933) in Bagaridae and Merriman (1940) in *Gaelichthys* and *Bagre marinus* have reported the presence of pterygoid. Bhimachar (1933) and Rastogi (1963) have reported the presence of small endopterygoid in *Silonia*. Rastogi (1963) had reported the presence of metapterygoid and ectopterygoid in *Clupisoma garua*. Sinha (1959) had reported the same case in *Wallago attu*. In *O. bimaculatus* prominent metapterygoid and a very small ectopterygoid is present.

The hyobranchial skeleton of the fish is highly modified. Khanna (1961) has reported the absence of basihyal in siluroid fishes studied by him. The basihyal is found missing in this fish. There is some confusion about the basibranchials and the pharyngobranchials. We find two basibranchials, lying mid-ventrally one behind the other and connecting the two halves of first and second branchial arches. Nawar (1954), Srinivasachar (1958) and Joseph (1960) called them as second and third basibranchials. Khanna (1961) and Joseph (1960) have claimed them in *Wallago attu* as basibranchials belonging to first and second branchials arches. According to Khanna (1961) third, fourth and fifth basibranchials are absent and are represented by a median cartilage, lying in between the two halves of third, fourth and fifth branchial arches. According to first three authors the first basibranchials is represented by a median cartilage. Here we agree with Khanna's view and named them as first and second basibranchial. We could not find any median cartilage for the first basibranchial. The fact is further supported by Gegenbaur's statement that each basibranchial belong to and derieved for the arch in front of it. There appears to be lot of confusion regarding the exact nature of pharyngobranchials. In the *Ompok bimaculatus* we find four pharyngobranchials. The first pharyngobranchials is absent, the second pharyngobranchial is for the first and second epibranchials of first and second branchial arches. The fifth pharyngobranchial is highly modified to form a pad-like structure. It bears suprapharyngeal teeth on its ventral surface. The fifth pharyngobranchial is a point of controversy. Joseph (1960) called fourth and fifth pharyngobranchial as fourth pharyngobranchial, Shrinivasachar (1958) called it as a separate dentigerous plate independent of pharyngobranchials. Khanna (1961) called it as fifth pharyngobranchial.

The dentition, jaw suspensorium and hyobranchial skeleton throw some light on the food and feeding habits of the fish. *Ompok bimaculatus* feeds on small crustaceans and small animals. The suspensorium is methyostylic. It helps in widening the gape of the mouth more and thus allowing a large amount of food to go into the mouth. The presence of teeth on premaxillae and dentary help in crushing the food and check in escaping the prey due to their incurved nature. The presence of gill rakers on the branchial arches probably checks the small prey from escaping through the gill slits.

SUMMARY

1. The skull is wedge-shaped with two fontanelle on the cranial roof. The anterior one lies in between the ethmoid and the frontals. The posterior fontanelle lies in between the frontals and the supraoccipital.

2. There are no parietals, opisthotics, symplectics and suboperculars. The orbitosphenoid is a drain pipe-like bone formed of two paired ossifications. Two perforations are present on either side of the cranium, one in between the pleurosphenoids, the parasphenoid and the prootics, and the second between the pleurosphenoid and the parasphenoid.

3. The basisphenoid lies on the cranial surface of the parasphenoid intimately fused with it.

4. The auditory capsule is formed of two recesses, the anterior is furnished by the prootics, the exoccipitals, epiotics and pterotic and is for the utriculus. The posterior is furnished by the basioccipital and the exoccipitals and is for sacculus, lagena and cavum sinus imparis.

5. The palatines and maxillae are reduced. The maxillae support the barbel.

6. The suborbitals run in a chain and bound the eye from behind, below and front. The third suborbital is the stoutest of the series. The infraorbital trunk of the lateral line system run through them and ends in the lacrymal bone.

7. The pterygoid is absent. The metapterygoid is well developed and the ectopterygoid is very small lying in between the metapterygoid and the vomerine processes.

8. The angular and dentaries are the only two bones developed to form the half of lower jaw.

9. The basihyal is absent and each ramus of the hyoid arch has two hypohyals.

10. The first four branchial arches are of normal type while the fifth one is reduced and represented by a plate like ceratobranchial bearing inferior pharyngeal teeth on its dorsal surface. The pharyngobranchials are four in number. The first pharyngobranchial is absent and the fifth pharyngobranchial is represented by a pad-like structure bearing superior pharyngeal teeth on its ventral surface. It lies below the fourth pharyngobranchial and third epibranchial. Gill rakers are present on the ceratobranchials and epibranchials.

11. There are two basibranchials for the first and second branchials arches. There is a median cartilage representing the basibranchials of third, fourth and fifth branchial arches.

Acknowledgement

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Key to abreviations

ANG.	Angular
AR.	Arm
A. ART. P.	Accessory articular process.
B. OC.	Basioccipital
BAR.	Barbel
BO.	Body
B. SP.	Basisphenoid
B. BR.	Basibranchials
BR. R.	Branchiostegeal rays
CA. S. I.	Cavum sinus imparis
CL.	Cleft
CO.	Condyle
C. H.	Ceratohyal
C. BR.	Ceratobranchial
CA.	Cartilage
DEN.	Dentary
D. PL.	Dorsal plate
D. HR.	Dorsal horns
D. L.	Dorsal lamella
EX. OC.	Exoccipital
EPI.	Epiotic
ETH.	Ethmoid
E. PTE.	Ectopterygoid
E. H.	Epihyal
E. BR.	Epibranchial
FK.	Fork
FOR.	Foraman
F. S.	Foveae sacculi
FO.	Fontanalle
FR.	Frontal
FA.	Facet
G.	Groove
HO. PL.	Horizontal plate
HYM.	Hyomandibular
H. H.	Hypohyal
HE.	Head
IN. PL.	Inclined plate
I. OP.	Interopercular
I. P. T.	Inferior pharyngeal teeth
LC.	Lacrymal
L. P.	Lateral processes
LA. ETH.	Lateral ethmoid
M. PT.	Main part
M. PTER.	Metapterygoid
MA. T.	Mandibular teeth
MX.	Maxilla
MA. C.	Mandibular canal
N. PL.	Neural plate
N.	Notch
NA.	Nasal
OC. C.	Occipital crest
OC. CO.	Occipital condyle
O. SP.	Orbitosphenoid
OP.	Opercular
OP. MA. C.	Operculomandibular canal
PRO.	Prootic
PTE.	Pterotic
P.	Process
PLE. SP.	Pleurosphenoid
P. SP.	Parasphenoid
PA.	Palatine
PMX.	Premaxilla
PMX. T.	Premaxillary teeth
P. OP.	Preopercular
QU.	Quadrate
RI.	Ridges
S. P. T.	Supra pharyngeal teeth
SP.	Spine
SH.	Shaft
ST.	Stem
S. ORB. C.	Sub orbital canal
SPH.	Sphenotic
S. OC.	Supraoccipital
VO.	Vomer
VO. T.	Vomerine teeth
VO. P.	Vomerine process
VA.	Vacuity

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FIRST RECORD OF THE SILVER CARP — HYPOPHTHALMICHTHYS MOLITRIX (VALENCIENNES, 1844) IN THE DANUBE RIVER

JURAJ HOLČÍK & OLDŘICH PÁR

Recived March 31, 1969

Abstract: The authors describe the occurrence of the silver carp — Hypophthalmichthys molitrix (Valenciennes, 1844) caught in Radvaň nad Dunajom, Czechoslovak part of the Danube river at the river kilometer 1749, in July 1968. The fish, the taxonomic characteristics of which do not differ from the data of literature, originates most probably from the Hungarian pond breed, from which it escaped into the Danube river.

In July 15th, 1968, the group of the State Fishery led by Mr. Béla Patkány, caught one specimen of the Silver carp — *Hypophthalmichthys molitrix* (Valenciennes, 1844). The catch was realised by means of a haul seine in the main stream of the Danube river near the village Radvaň nad Dunajom, river kilometer 1749. Besides the silver carp, also other fish species were present: *Barbus barbus*, *Chondrostoma nasus*, *Rutilus pigus virgo*, *Acerina schraetser*, *Vimba vimba carinata*, *Abramis sapa*, *Abramis ballerus*, *Leuciscus cephalus* and *Leuciscus idus*.

One of the present authors has published this finding in the popular press (Pár, 1969). In the present paper we introduce a more detailed information and description of the mentioned specimen now deposited in the Slowak National Museum in Bratislava.

Diagnosis: D III 6, A III 12, P I 17, V I 6, scales in lateral line $121 \frac{32}{18}$, pharyngeal teeth in one row, flattened, 4 — 4. The gill rakers, numbering about 110, are grown together thus forming a dense filtration basket. On the tip of the belly there is a characteristic sharp keel starting from the throat and ending before the anus. The first part of the keel is covered with scales, the posterior one is scaleless.

The standard length of specimen (measured from the tip of the upper lip to the base of C) is 395.8 mm, the length including the tip of the lower lip is 397.9 mm, body weight 1195 grams. The sex cannot be determined exactly which is due to an unsuitable fixation, probably the fish was a male. The age according to the scales (see Photo 3) 2 +. Between the first annulus and the scale centre there is another annulus — like mark, probably the so called juvenile — mark. The back calculated growth (evaluated by means of the Lea method and using the length 397.9 mm) is 98 mm in the first year of life 339 mm in the second. The length calculated up to the juvenile mark: 60 mm.

Measurements in % of standard length (395.8 mm): the head length 24.3 (or 26.0 if the membrane margining the opercular bone is included), internasal distance 6.8, snout length 8.5, diameter of eye 2.6, interorbital distance 12.7, the postorbital length 15.2, the head depth 21.9, the head width 14.1, the predorsal distance 50.1, the preventral distance 44.7, the preanal distance 66.4, the body depth 13.0, body width 17 1, caudal peduncle length 19.0, caudal peduncle depth 13.0, the caudal peduncle width 9.8, the minimal body depth 11.2, theP — V distance 21.5, V — A 24.0, the length of D 10.3, the length of A 17.0, the length of P 17.8, the length of V 14,0, the depth of D 15.4, the depth of A 9.7.

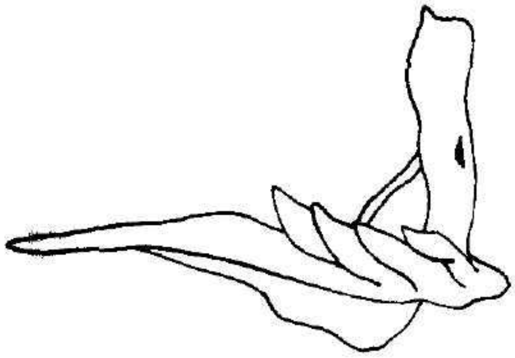

Fig. 1: Fifth branchial arch of the silver carp (removed from the right side) showing pharyngeal teeth

Comparing our data with those in the literature (Berg, 1949; Nikolskij, *1956: Nakamura, 1963;* Wu, *1964) we did not find any considerable* difference with exception of rays number in D which is only 6, while all other mentioned sources state 7 ramified rays in this fin.

The silver carp inhabits the rivers of Eastern Asia beginning with the Amur river on the North up to the rivers of the Kanton province southwards (Berg, 1949; Nikolskij, 1956). Owing to its rapid growth and ability to utilize the phytoplankton it was introduced elsewhere, i.e. in Taiwan, Thailand, Japan, Ceylon and in the middle of this century also in Europe (USSR, Czechoslovakia, Poland, Hungary, Roumania, Germany, Austria — Nikolskij et alii, 1966; Krupauer, 1968). First imports to Europe originated directly from China or from the Amur river, USSR, later they came only from the Amur river. Originally the pond breeding fully depended on the import of fry or young caught in the original localities the technique of the africial reproduction was known as late as in 1958 (Wu and Chung, 1964.)

As we known, our discovery has been the first in the Danube river basin up to this time. It is interest in to note that the silver carp was caught at the same place as another "planteater" from the Amur river — namely the grass carp *Ctenopharyngodon idella* (Balon, 1968). As to the origin of our silver carp it is doubtless if this fish originates from Hungary or Roumania. The first mass imports both of grass carp and silver carp were made to these countries already in 1960—1966 (Nicolau, 1962, 1964, 1966; Sedlár — Geczö, 1967; Berinkey, 1966). Our silver carp apparently came from the imported fish bred in ponds and not from the descendants of these fishes which were reproduced only in 1967 (Antalfi and Tölg, 1967). In the silver carp the attention should be paid to its reproduction in the Danube river, which has suitable environmental conditions for a successful spawning of this fish. Concerning the spawning the silver carp seems to be a considerably adaptable species for the temperature of water. Chen and Lin (1935) stated 26—30° C of watter temperature for silver carp spawning in Chinese rivers, Nikolsky (1956) writes on spawning in the Amur river at 15—26° C. The spawning occurs directly in the current over the rocky or gravel bottom. In the Danube river (Dub, Duba and Szolgay, 1966) the average temperature over 15° C occurs in the course of 4 months, from July to September. Moreover, the Slovak part of the Danube river is a transitional zone between the submountaneous and lowland zone (Balon, 1966) having a gravel substrate of the river bed.

The growth of our specimen is very good like that of the grass carp (Balon, 1968; Holčík, 1969) and surpasses the values stated by Sysojeva (1956) for the silver carp from the Amur river. According to Sysojeva in ist first year of life the fish reaches 94—123 mm of standard length, and 243—281 mm at the end of its second year. Our specimen, as stated above, reached 339 mm at the end of the second year. Obviously also the silver carp found suitable life conditions in the Danube river.

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The plates will found be at the end of this issue.

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Aus der Hydrobiologischen Abteilung der Naturwissenschaftlichen Fakultat der Karls-Universitat in Prag und aus der Hydrobiologischen Station bei Blatná

ZUR KENNTNIS DER BODENFAUNA ZWEIER TEICHE IM BLATNÁ-GEBIET

MILAN LAUPY

Eingegangen am 11. Juni 1969

Abstrakt: Es wurde eine quantitative Untersuchung der Bodenfauna zweier Teiche im Blatná-Gebiet durchgeführt. Den uberwiegenden Teil der Bodenfauna reprasentieren Oligochaeta und Chironomidae. Die grosste Abundanz und Biomasse wurde im Winter festgestellt (XI.—III.), das Minimum im Sommer (VI.—IX.). Die qualitative Vertretung und die Menge der Bodenfauna ändert sich auch zusammen mit der Tiefe, dem Bodencharakter und dem Ausmass der uberschwemmten Vegetation der einzelnen Teichsektoren.

EINLEITUNG

Auf die Bedeutung der Bodenfauna als einen wichtigen Teil der Fischnahrung hat schon im Jahre 1888 **Šusta** aufmerksam gemacht. Nach **Lellák** (1957a, 1961), deckt die Bodenfauna 1/3 bis 1/2 der Fischproduktion in Karpfenteichen. Die Kenntnis der Bodenfauna und ihrer Menge während des Jahres ist daher bei der Bewertung der sogenannten „Ernahrungsfahigkeit" des Teiches wichtig (**Grandilevskaja-Deksbach**, 1931; **Boruckij**, 1936; **Lellák**, 1961).

Die qualitative und quantitative Charakteristik der Teichbodenfauna, die Sukzession, Verlauf der Abundanz und Biomasseveranderungen der wichtigsten Vertreter und Gruppen im Laufe des Jahres bilden den Inhalt dieser Arbeit. Es wurden dazu die Teiche Hadí und Žoldánka gewahlt, die sich voneinander durch ihre Wasserflache, Tiefe, Bodencharakter, Ausmass der Bewüchse als auch durch ihr Alter und die Grosse des Fischbestandes unterscheiden (Tab. 1A,B). Ausserdem ist aus dem Teiche Žoldánka im Jahre 1960 bei der Ausbaggerung die Makrovegetation entfernt worden.

MATERIAL UND METHODIK

Um Proben der Bodenfauna zu erhalten wurde der von **Lellák** modifizierte Lenz-Zonationsgreifer verwendet. Er wurde von **Lellák** (1957b) einschliesslich weiterer methodischer Angaben beschrieben. Mit dem Greifer, der eine Arbeitshöhe von 30 cm hat, wurden Bodenstucke von 15 x 15 cm entnommen. Als Probe wird dann in der Arbeit solches Material bezeichnet, das durch die Entnahme zweier solcher Stucke erhalten wird, d.h. mit einer Flache von 450 cm^2. Im Ganzen wurden 96 Proben verarbeitet, die in 2 — 6-wochigen Intervallen in 1963—64 in beiden Teichen entnommon wurden und eine Gesamtfläche von 3,10 m^2 — für den Teich Hadí und 1,21 m^2 für den Teich Žoldánka vorstellen.

In den einzelnen Proben wurde die Abundanz und das Formalingewicht (**Boruckij**, 1934), das im weiteren als Biomasse der einzelnen Vertreten oder Gruppen der Benthonten bezeichnet wird, festgestellt. Die erhaltenen Werte wurden mit dem Koeffizienten 2,22 multipliziert, auf ganze Zahlen abgerundet und sind in den Tabellen und Abbildungen als Abundanz — Ind./0,1 m^2 und Biomasse — mg/0,1 m^2 angegeben.

Bei der quantitativen Bewertung ist in den Übersichten die Abundanz und Biomasse der nicht zu den Benthonten gehorenden Tiere nicht inbegriffen (z. B. *Hydracarina*, *Piscicola*, *Chaoborus* u. a.), ferner auch nicht die Tiere, die sich quantitativ mittels der angewandten Methodik nicht feststellen lassen (z. B. *Corynoneura, Cloeon)*. Auch vereinzelt gefundene Benthonte (z. B. *Limnaea, Radix*), die durch ihr grosses individuelles Gewicht und verhältnismässig zufälliges Vorkomen das ganze Bild der Biomasse verzerren würden (**Lellák**, 1957a, b), wurden nicht ausgewertet.

Tab. 1A — Teich **Hadí**

Wirtschaftsverhältnisse

Wasserflache ha	Jahr	Fischsatz Stück/ha	Futter q/ha	Superphosphat, Kalk q/ha	Gesamtzuwachs kg/ha
12,4	1963	274 K_{2-3} Schleie Hecht	1,0	1,2 2,5	268
	1964	282 K_{2-3}	2,0	1,2 2,2	136

Entnahmestellen

Standort	Tiefe m	Boden	Vegetation	Verfolgter Zeitabschnitt
A	3,3	20 cm schwarzer Schlamm (Gyttja), Unterlage grauer Lehm mit Sand	fehlt	V. 63—XI. 64
B	2,4	15—20 cm schwarzer Schlamm, Detritus, Unterlage grauer Lehm mit Sand	fehlt	V. 63—XI. 64
C	1,1	3—5 cm Detritus mit 10 cm Sand, Pflanzenreste, Unterlage brauner Lehm mit Sand	Batrachium (vereinzelt)	V. 63—IV. 64
D	0,5	2—3 cm Detritus, 8—10 cm Sand, Pflanzenreste, Wurzelsysteme, Grundlage brauner Lehm mit Sand	Batrachium (Bewuchs)	VI. 63—IV. 64

Gleichzeitig mit der Probenentnahme wurde auch die Temperatur der Bodenoberflache und die Temperatur, pH, Alkalinität und Sauerstoffgehalt im Wasser über dem Boden gemessen (Abb. 1).

BESCHREIBUNG DER TEICHE

Hadí — Maximaltiefe 3,3 m. Submersionsvegetation (es dominiert *Batrachium*) bildet nur einen engen Streifen das Ufer entlang. Der Boden in den tieferen Teilen des Teiches ist schlammig, mit abnehmender Tiefe überwiegt Gneissand. Während der Untersuchungen änderte sich einigemale der Wasserspiegel, wobei im Dezember und Jänner 1963/64 ein Teil des Litorals entblosst wurde. Nach der Füllung zum Normalstand wurde der Teich im April wieder etwa zur Hälfte entleert und wegen Wassermangel bis zum Herbstausfischen im Oktober 1964 so gelassen.

Žoldánka — Maximaltiefe 1,2 m. Der Boden der tieferen Teile ist schlammig, ansonsten überwiegt Grundlehm, der bei der durch Baggern ausgeführten Melioration im Jahre 1960 entblösst wurde. Die Submersionsvegetation (es dominiert *Potamogeton, Elodea*) überwuchs wahrend des Sommers beinahe den ganzen Teich. Wahrend der Untersuchungen war der Teich immer gefüllt.

Weitere Angaben über die Wirtschaftsverhältnisse und Probenentnahmestellen sind in Tab. 1A,B angeführt.

Tab. 1B — Teich **Žoldánka**

Wirtschaftsverhältnisse

Wasserfläche ha	Jahr	Fischsatz Stück/ha	Futter q/ha	Superphosphat, Kalk q/ha	Gesamtzuwachs kg/ha
0,75	1964	294 K_{1-2}	0	0 0	132

Entnahmestellen

Standort	Tiefe m	Boden	Vegetation	Verfolgter Zeitabschnitt
A	1,2	3—5 cm Detritus, 15 cm schwarzer Schlamm mit Sand, Pflanzenreste, Wurzelsysteme, Grundlage braun-grauer Lehm	Potamogeton, Elodea (vereinzelt)	X. 63—IX. 64
B	0,8	3—5 cm Detritus, 10 cm Lehm mit Sand, Pflanzenreste, Wurzelsysteme, Unterlage brauner Lehm	Potamogeton, Elodea, Batrachium (Bewuchs)	V.—IX. 64
C	0,3	brauner Lehm, stellenweise, dünne Sand- und Detritusschicht	Heleocharis	V.—IX. 64

BENTHOSPOPULATION

Der Teich Hadí (Tab. 2, Abb. 2, 4)

Der Jahresdurchschnitt der Abundanz und Biomasse der Boden-fauna aller untersuchten Sektoren beträgt 578—1504 Ind./0,1 m^2 und 2466—3743 mg/0,1 m^2.

Die Quantität der Bodenfauna der verfolgten Standorte zeigt klare Schwankungen mit Maximum-Abundanz und Biomasse im Winter und Minimum im Sommer (mit Ausnahme des während des Sommers festgestellten Maximums im Batrachium-Bewuchs am Standort D).

In der Winterperiode (XI.—III. 1963/64) beträgt die Gesamt-Biomasse in den tiefer gelegenen schlammigen Teilen des Bodens (Standort A und B) im Durchschnitt 3783—4205 mg/0,1 m^2. Auf beiden Standorten stellen während des Winters die Larven des *Procladius*, *Tanypus*, *Chironomus* und *Sphaeromias* 66—93% der gesamten Biomasse der Bodenfauna vor. Im Frühjahr, zufolge des sichtbaren Herabsinkens der Biomasse der *Procladius* und *Chironomus*-Larven, sinkt die gesamte Biomasse und erreicht die niedrigsten Werte auf A, B während VI.—IX. Die für diesen Zeitabschnitt festgestellten Durchschnittswerte im Jahre 1963 und 1964 betragen auf A — 1390 *und* 1373 *mg/0,1* m^2, *auf* B — 973 *und* 1328 *mg/0,1* m^2. Im Sommer herrschen in der Bodenfauna auf A und B *Sphaeromias*-Larven durch ihre

Abundanz (im Durchschnitt 50%) und Oligochaeta (im Durchschnitt 28% der ganzen Abundanz) vor. An der ganzen Biomasse der Bodenfauna nehmen neben den angeführten Vertretern auch die grossen *Chironomus*-Larven teil, die trotz des verhältnismässig kleinen numerischen Auftretens (im Durchschnitt 4% der ganzen Abundanz) in der Sommerperiode 25—30% der gesamten Biomasse bilden.

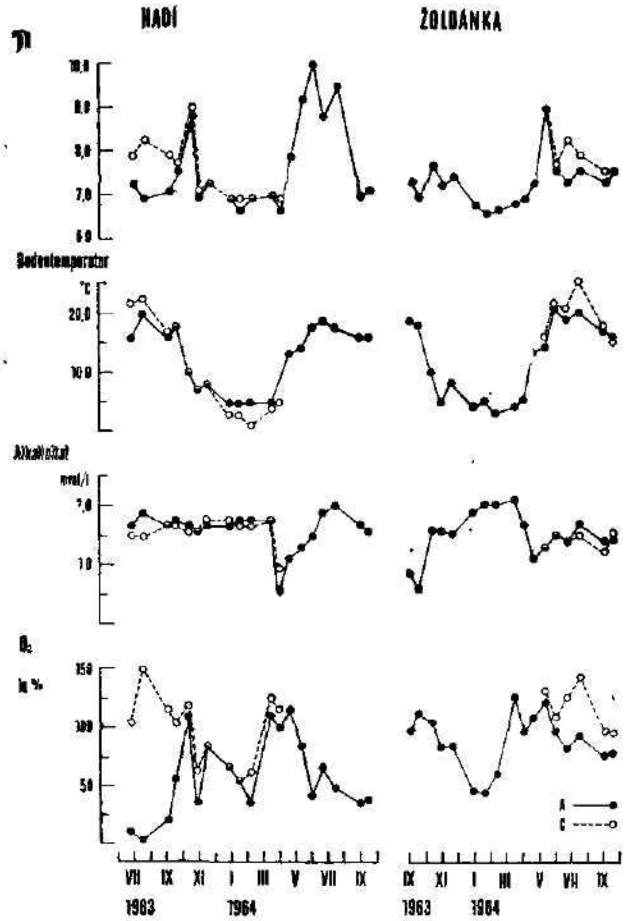


Abb. 1. **Verlauf der Temperaturwerte auf der Bodenoberfläche, pH, Alkalinität und Sauerstoffsättigung des Wassers über dem Boden.**
Erklärungen: Teich Hadí — Standort A: ——— Standort C: ; Teich Žoldánka — Standort A: ——— Standort C: ···········.

Die durchschnittliche Biomasse der Bodenfauna aus dem Litoralgebiet mit sandigem Boden (C, D) erreicht während der Winterperiode (XI.—III. 1963/64) auf C — 5239 mg/0,1 m². Im Durchschnitt bilden 53% der gesamten Biomasse auf diesem Standort *Microtendipes*- und *Glyptotendipes*-Larven. Oligochaeta und Hirudinea nehmen an der ganzen Biomasse im Winter durchschnittlich mit 39% teil. Der Rückgang der ganzen Biomasse um 51%

anfangs April 1964 wurde zufolge des Ausfliegens der *Microtendipes*-Imagin festgestellt. Im Sommer (VI—IX. 1963) beträgt die ganze Biomasse a C durchschnittlich 1470 mg/0,1 m². Mit Ausnahme von Juli, wo sich d Vorkommen der *Endochironomus*- und *Polypedilum*-Larven erhöhte, übe wiegen in der Bodenfauna im Sommer Oligochaeta, die durchschnittlich 55 der ganzen Abundanz und 53% der ganzen Biomasse vorstellen.

Tab. 2. Durchschnittliche Jahres-Abundanz und -Biomasse

$\frac{\text{Ind.}}{\text{mg}}$ / 0,1 m²

Teich	Hadí				Žoldánka
Standort	A	B	C	D	A
Verfolgter Zeitabschnitt	V. 1963 bis IV. 1964	V. 1963 bis IV. 1964	V 1963 bis IV 1964	VI. 1963 bis IV. 1964	X. 1963 bis IX 196
Tanypinae	$\frac{233}{462}$	$\frac{211}{414}$	$\frac{18}{21}$	$\frac{43}{64}$	$\frac{23}{50}$
Chironomus	$\frac{33}{1475}$	$\frac{22}{924}$	$\frac{5}{31}$	$\frac{0}{0}$	$\frac{0}{0}$
Chironomidae übrige	$\frac{5}{15}$	$\frac{22}{72}$	$\frac{484}{1505}$	$\frac{467}{727}$	$\frac{4}{4}$
Ceratopogonidae	$\frac{188}{412}$	$\frac{142}{242}$	$\frac{11}{22}$	$\frac{15}{23}$	$\frac{18}{18}$
Ephemeroptera	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{2}{13}$	$\frac{29}{158}$	$\frac{6}{11}$
Hirudinea	$\frac{1}{19}$	$\frac{2}{8}$	$\frac{28}{282}$	$\frac{111}{548}$	$\frac{12}{411}$
Mollusca	$\frac{1}{1}$	$\frac{0}{0}$	$\frac{5}{22}$	$\frac{10}{28}$	$\frac{4}{19}$
Oligochaeta	$\frac{116}{526}$	$\frac{250}{803}$	$\frac{745}{1077}$	$\frac{829}{2195}$	$\frac{453}{2686}$
Temporarfauna	$\frac{460}{2366}$	$\frac{398}{1655}$	$\frac{520}{1592}$	$\frac{554}{972}$	$\frac{51}{83}$
Permanentfauna	$\frac{118}{546}$	$\frac{252}{811}$	$\frac{778}{1381}$	$\frac{950}{2771}$	$\frac{469}{3116}$
Summe	$\frac{578}{2912}$	$\frac{650}{2466}$	$\frac{1298}{2973}$	$\frac{1504}{3743}$	$\frac{520}{3199}$

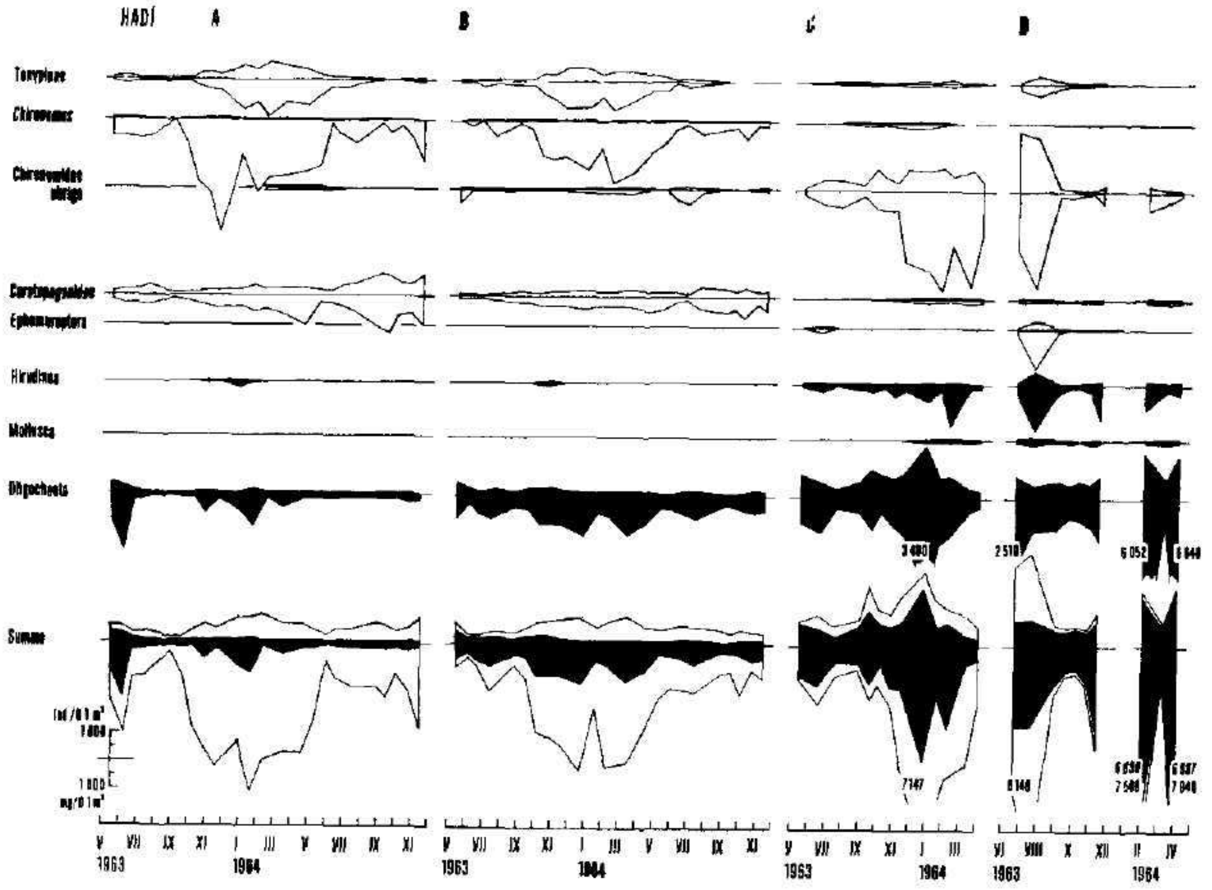
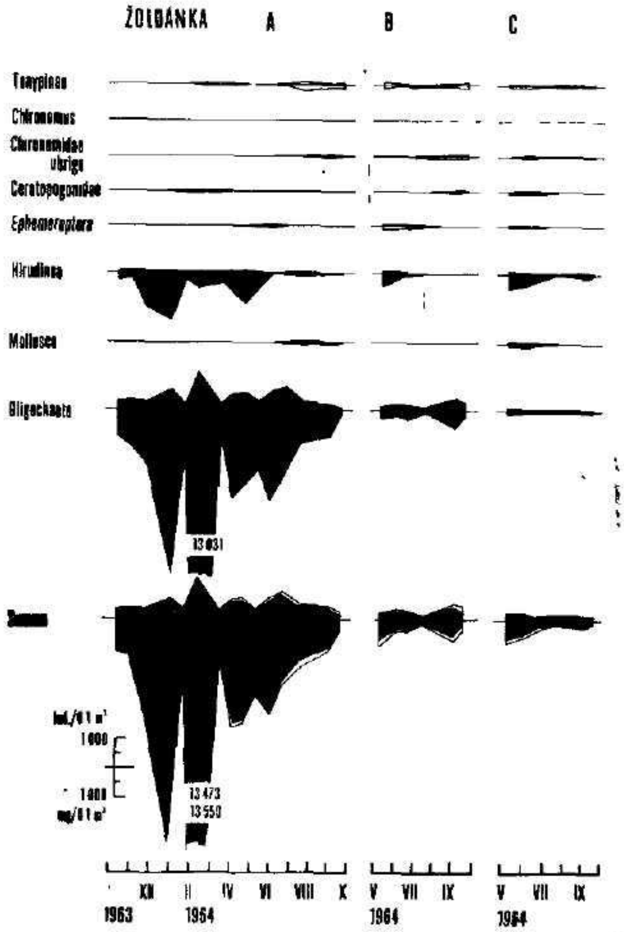


Abb. 2 Verlauf der Abundanz- und Biomassewerte der Bodenfauna im Teich Hadí

Erklarungen: Standorte A, B, C, D sieh Tab. 1A. *Permanentfauna: schwarz.* Temporarfauna: weiss. Abundanz (Ind./0,1 m²): oben; Biomasse (mg/0,1 m²): unten.

Auf Standort D beteiligen sich an dem Aufstieg der gesamten Biomasse er Bodenfauna im Winter hauptsächlich Oligochaeta und Hirudinea. Auf en Temporäranteil entfällt in dieser Periode nur 1,4—28% der ganzen iomasse. Durch die verhältnismässig kurzfristige Bodenentblössung im ezember und Jänner 1963/64 wurde die Entwicklung der Fauna nicht esonders gestört. Im Gegenteil, die Biomasse der Oligochaetengruppe wuchs edeutend an. Aus der gesamten im Feber und April 1964 festgestellten iomasse von 7569 und 7040 mg/0,1 m² fallen an die Oligochaeten 80% und 4% an. Eine bedeutende Entwicklung der Fauna auf Standort D wurde leichfalls in der Sommerperiode von VI.—VII. 1963 festgestellt, wo die



bb. 3. Verlauf der Abundanz- und Biomassewerte der Bodenfauna im Teich Žoldánka. Erklärungen: sieh Abb. 2, Standorte A, B, C sieh Tab. 1B.

Abundanz als auch Biomasse zwischen dem *Batrachium*-Bewuchs auf 3550 Ind., 8148 mg/0,1 m² anstieg. Den Hauptteil der Gesamtbiomasse, von der auf den Temporärbestandteil 65% anfällt, bilden die Larven der *Micro-endipes*, *Endochironomus*, *Trichocladius* und *Polypedilum* (Chironomidae), ferner *Caenis* (Ephemeroptera). Den Permanentanteil vertritt in diesem Zeitraum hauptsächlich *Helobdella* (Hirudinea) und Oligochaeten.

Der Teich Žoldánka (Tab. 2, Abb. 3,4)

Der auf Standort A festgestellte Jahresdurchschnitt der Abundanz und Biomasse beträgt 520 Ind./0,1 m² und 3199 mg/0,1 m². (Die übrigen Standorte wurden nur im Zeitabschnitt von V.—IX. 1964 verfolgt.)

Die Hauptvertreter der Bodenfauna sind Oligochaeten und Hirudinea (*Herpobdella*). Die Gesamtbiomasse in der Winterperiode (XI.—III. 1963/64) erreicht im Durchschnitt 5426 mg/0,1 m: (Standort A). Auf Oligochaeten deren Biomasse in diesem Zeitabschnitt bis auf 13 041 mg/0,1 m² steigt, fällt durchschnittlich 78 %, auf Hirudinea 15 % der Gesamtbiomasse der Benthosfauna an. Beide Gruppen bilden den Hauptanteil der ganzen Biomasse auch im Sommer (VI.—IX. 1964), wenn die durchschnittliche Biomasse auf A, B und C 1701, 462 und 296 mg/0,1 m² beträgt. Auf die einzelnen Sektoren entfallen auf Oligochaeten 28—80%, auf Hirudinea 3—37% der Gesamtbiomasse der Benthosfauna.

Die auf den Temporärbestandteil entfallenden 1,4—30% der gesamten Biomasse sind überwiegend *Procladius*-, *Clinotanypus*- und *Ablabesmyia*-Larven. Die Gesamtbiomasse der Temporärfauna überschritt während der Untersuchungen nicht den Wert von 319 mg/0,1 m² und die jahreszeitliche Dynamik ihrer Vertreter ist unbedeutend. Ein kleiner Aufstieg in der Abundanz und Biomasse der *Clinotanypus*-Larven wurde im Juli 1964 festgestellt (das Maximum beträgt 44 Ind., 132 mg/0,1 m².

SCHLUSSFOLGERUNG

Nach Belláks Ergebnissen (1961) erreicht der jährliche Durchschnitt der Biomasse in den einzelnen Bodenteilen einiger Karpfenteiche in der Blatná-Teichgegend 176—360 kg/ha (Velký Pálenec 1954), 203—363 kg/ha (Velký Pálenec 1955), 179—265 kg/ha (Smyslov 1955) und 217—350 kg/ha (Vitanovy 1055). Ähnliche Werte wurden auch im Teich Hadí festgestellt, wo der Jahresdurchschnitt der Benthosfaunabiomasse in den einzelnen Abschnitten 247—374 kg/ha beträgt. In dem am dichtesten bevölkerten Teil des Teiches Žoldánka (Standort A), beträgt der Jahresdurchschnitt 320 kg/ha. Mit Rücksicht darauf, dass in den weiteren Sektoren des Bodens die Bodenfaunabiomasse beträchtlich niedriger ist (durchschnittliche Bodenfaunabiomasse im Zeitabschnitt VI.—IX. 1964 ist auf B 3,7 mal und auf C 5,7 mal kleiner als die durchschnittliche Biomasse auf Standort A), kann man die jährlichen Durchschnittswerte der Biomasse in diesem Teich etwa auf 150—160 kg/ha abschätzen.

In beiden Teichen repräsentieren die Permanentfauna vor allem Oligochaeten und Hirudinea. Der Unterschied der Bodenfauna in den zwei Teichen zeigt sich in der qualitativen und quantitativen Vertretung der Temporärfauna. Im Teich Hadí bildet den Hauptteil dieser Fauna auf tiefer gelegenen schlammigen Flächen *Procladius*, *Tanypus*, *Chironomus* und *Sphaeromias*, in den Litoralsektoren *Microtendipes*, *Glyptotendipes* und im Sommer auch *Endochironomus*, *Polypedilum*, *Trichocladius*, *Critocopus*, *Limnochironomus* und *Caenis*-Larven (Emphemeroptera). Der Anteil der Temporärfauna beträgt in den einzelnen Sektoren 26,0—81,3% der jährlichen Durchschnittswerte der Biomasse. Das Maximum der Biomasse dieser Komponente beträgt 5325 mg/0,1 m². Im Teich Žoldánka bildet den überwiegenden Teil der Vertreter der Temporärfauna in allen Teilen *Procladius*, *Clinotanypus* und *Ablabesmyia*. Das Biomassenmaximum dieser Fauna, die 2,6% der durschchnittlichen jährlichen Biomasse vorstellt, beträgt 319 mg/0,1 m².

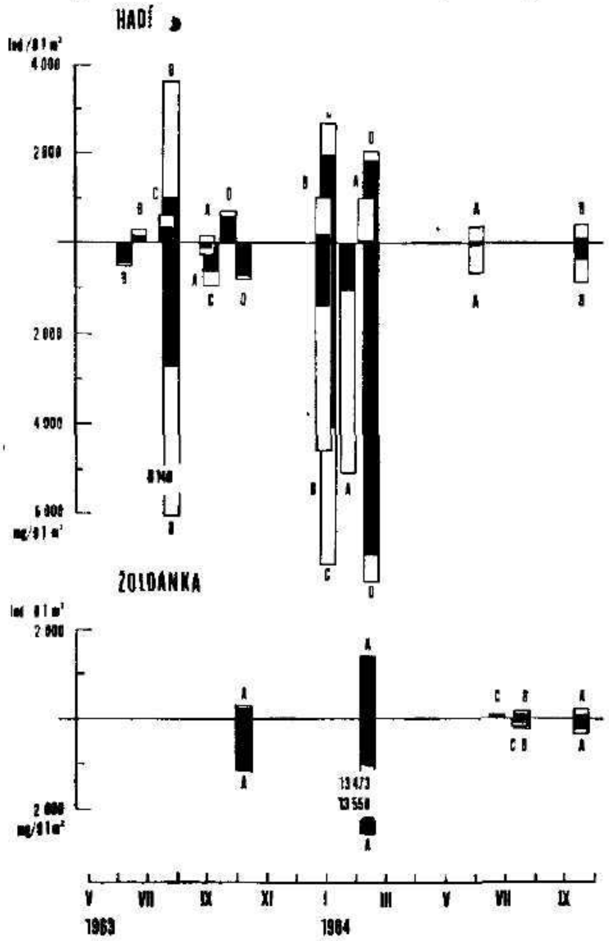


Abb. 4. Maximal- und Minimalwerte der Abundanz und Biomasse der Bodenfauna im Teich Hadí (Standorte A, B, C, D) und im Teich Žoldánka (Standorte A, B, C).
Erklarungen: sieh Abb. 2.

Die Saisondynamik der Bodenfauna ist in beiden Teichen beinahe die gleiche. Maximalwerte der Abundanz und Biomasse wurden in der Periode vom XI.—III., die Minimalwerte in der Periode vom VI.—IX. festgestellt. Der Aufstieg der Abundanz und Biomasse während des Sommers in Sektoren mit Submersionsvegetation (Teich Hadí — D, Žoldánka — B) wurde nur im Teich Hadí festgestellt. Diese Angaben stimmen mit den Ergebnissen von **Lellák** (1958, 1961) überein, der die Maximalabundanz in der Periode vom X.—XII., die Maximalbiomasse in der Periode vom III.—IV. und die Minimalabundanz und -biomasse in der Periode vom VII.—IX. feststellte.

ZUSAMMENFASSUNG

1. Während des Jahres 1963—1964 wurde die Bodenfauna zweier Teiche im Blatná-Gebiet untersucht. Der Teich Hadí — Wasserfläche 12,4 ha, Maximaltiefe 3,3 m, mit schlammigem und auch sandigem Boden, Submersionsvegetation auf einen kleinen Teil der Litoralsektoren begrenzt, Fischbestand 274—282 Stück/ha $K_{2\text{-}3}$. Der Teich Žoldánka — Wasserfläche 0,75 ha Maximaltiefe 1,2 m, ausser dem tieferen schlammigen Teil ist der Boden grösstenteils lehmig (infolge der Melioration im Jahre 1960), Submersionsvegetation fast über den ganzen Teich verbreitet, Fischbestand 294 Stück/ha $K_{1\text{-}2}$

2. In den tiefer gelegenen Sektoren mit schlammigem Boden überwiegt im Teiche Hadí die Temporärfauna, die 67—81% der jährlichen Durchschnittswerte der Biomasse vorstellt. Die Hauptvertreter der Bodenfauna sind in diesen Sektoren *Procladius*, *Tanypus*, *Chironomus* und *Sphaeromias*. In den Litoralsektoren mit Sandboden beträgt der Anteil der Temporärfauna 26—53% der jährlichen Durchschnittswerte der Biomasse. Die Hauptvertreter sind Oligochaeta, Hirudinea, *Microtendipes*, *Glyptotendipes* und während des Sommers auch *Endochironomus*, *Trichocladius*, *Polypedilum*, ferner *Caenis*-Larven (Ephemeroptera).

In dem Teich Žoldánka beträgt der Anteil der Temporärfauna 2,6% der jährlichen Durchschnittswerte der Biomasse. Die Hauptvertreter der Bodenfauna sind Oligochaeta und Hirudinea.

3. Die Maximal-Abundanz und -Biomasse wurde in beiden Teichen in der Periode vom XI.—III. festgestellt (960—2667 Ind., 4276—7569 mg/0,1 m² in den einzelnen Sektoren im Teich Hadí und 1374 Ind., 13 550 mg/0,1 m² im Teich Žoldánka).

Auf die niedrigsten Werte sinkt die Abundanz und Biomasse in dem Zeitabschnitt vom VI.—IX. (136—617 Ind., 302—946 mg/0,1 m² im Teich Hadí und 70—152 Ind., 117—388 mg/0,1 m² im Teich Žoldánka Ein markantes Sommermaximum von 3550 Ind., 8148 mg/0,1 m² wurde im VII. 1963 zwischen dem *Batrachium*-Bewuchs festgestellt.

4. Die jahrlichen Durchschnittswerte der Biomasse der Bodenfauna im Teich Hadí betragen 247—388 kg/ha. Im Teich Žoldánka schätze ich diesen Wert auf etwa 150—160 kg/ha ab.

Für die wertvollen Anregungen zur Arbeit und für das Durchlesen des Manuskripts möchte ich hier Herrn Doz. J. Lellák, C.Sc. herzlichst danken.

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A NEW LOACH, COBITIS GRANOEI OLIVAI, SSP. N., FROM MONGOLIA, WITH SOME REMARKS ON THE COBITIS ELONGATA-BILSELI-MACROSTIGMA GROUP (PISCES, OSTARIOPHYSI, COBITIDAE)

TEODOR T. NALBANT, 1) JURAJ HOLČÍK, 2) KAREL PIVNIČKA 3)

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Abstract: The authors describe the new subspecies of loach — *Cobitis granoei olivai* ssp.n. — from the basin of the Selenga river, Mongolia. It was found that the name *sibirica* Gladkov, 1935 proposed for the loach in the Amur river basin is only the synonym for *granoei* Rendahl, 1935. Phyletical relationships among the loaches inside the group *Cobitis elongata-bilseli-macrostigma* are discussed as well as phylogeny of the genus *Cobitis*.

Among the sample of fishes collected by Dr. Radim Ergens in Mongolia in 1966 (see Holčík and Pivnička 1969) we have found a relatively numerous material of loach belonging to the genus *Cobitis* Linnaeus, 1758. After a thorough investigation of this fish and comparison of it with other species of the genus *Cobitis* it appearad that this may be a new subspecies of *Cobitis granoei* Rendahl, 1935. The description of this subspecies is the main aim of this paper. At the same time we attach some considerations concerning the systematic status of the species *Cobitis taenia sibirica* Gladkov, 1935 and concerning the phylogenic relations inside the subgenus *Acanestrinia* Bacescu, 1961.

Cobitis granoei olivai ssp. n.

(Figs. 1, 2, 3, 4, 5, 6)

Holotype: SNM RY-2093, one male of 43.5 mm of standard length caught in the Ögijn-nuur (lake) Narijn-gol (River), the upper right tributary of the Orkhon River, basin of the Selenga River), Archangaj (Arkhangaj) ajmak (= county), Mongolia, May 23, 1966, leg. R. Ergens.

Paratypes: ZICU 34985, 10 specimens (1 male, 9 females) of 37.6 — 62.5 mm in standard length and bearing the same locality and data as the holotype; SNM RY-2094, 7 specimens (1 male, 6 females — the male and one female treated with alizarine Red S), 43.8 — 62.4 mm in standard length, same locality and date as the holotype, IBTS 2290, 9 specimens (1 male, 8 females) 38.5 — 64.7 mm of standard length, same locality and date as the holotype; LFR 96752, one female, 50.6 mm of standard length, Tuul-gol, (tributary of the Orkhon river) near the settlement Songino, Mongolia, May 4, 1966, leg. R. Ergens.

Comparative material:

Cobitis taenia paludicola De Buen, SMF 4923, one female 42.3 mm in standard length, Marismas Coto Rociana (Huelva), South-West Spain, June 14, 1959, leg. Kurt Klemmer.

Cobitis taenia haasi Klausewitz, SMF 3231, paratypes, two females, 65.0 and 66.0 mm in standard length, Silla at Valencia, Aqua Comunero, 1.5 km from Albufera, Spain, July 30, 1917, leg. F. Haas.

Cobitis taenia bilineata Canestrini, three fishes 54.0—65.0 mm in standard length, Lago Maggiore, North Italy, no other data.

Cobitis taenia zanandreai Caviccioli, one fish 63.0 mm in standard lenght, Lago di Fondi, Central Italy, no other data, leg. E. Tortonese.

Cobitis taenia taenia Linnaeus, twelve fishes 31.2—72.0 mm of standard length, Cefa, Bihor, Western Roumania, December 3, 1966, leg. T. T. Nalbant.

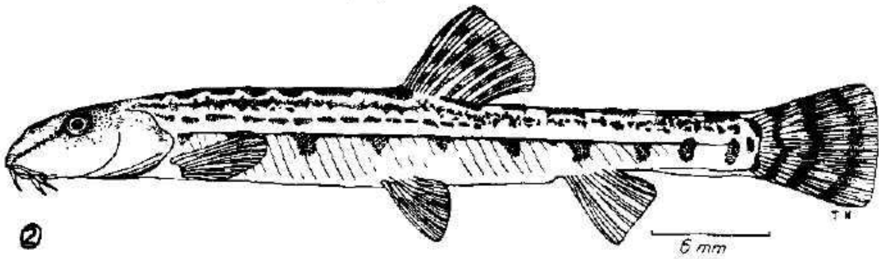

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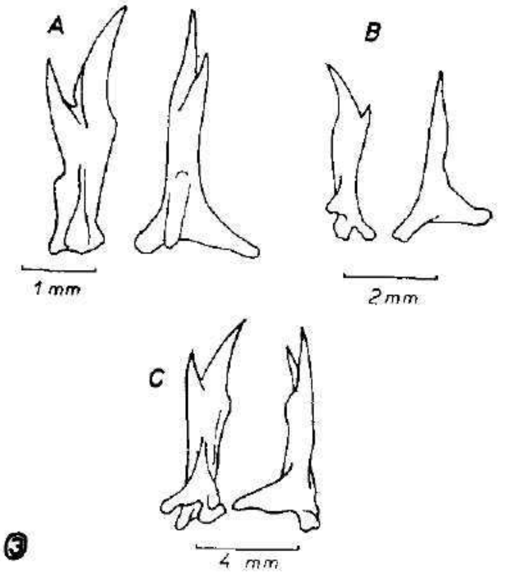
Fig. 2 *Cobitis granoei olivai* ssp. n. Paratype, female, IBTS 2290

Cobitis taenia strumicae Karaman, IBTS 1633, two fishes, 70.0 and 75.0 mm in standard length, Mariza River at Pazardjik, Bulgaria, September 2, 1965, leg. P. M. Banarescu.

Cobitis elongata elongata Heckel and Kner, 39 specimens, 63.0—149.0 mm in standard length, Nera River at Sasca Montana, South-West Roumania, August 22, 1956, leg. P. M. Banarescu and T. T. Nalbant.



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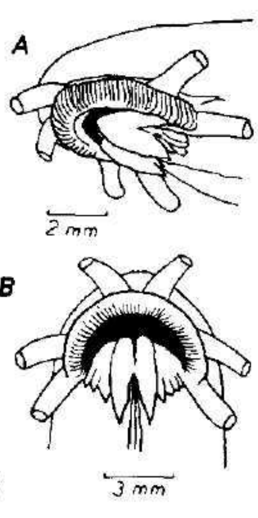

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Fig. 3 Suborbital spines: A — *Cobitis granoei olivai* ssp. n. B — *C. dolichorhynchus*, C — *C. bilseli* (according to Banarescu and Nalbant, 1964)

Fig. 4 Mouth: A — *Cobitis granoei olivai* ssp. n., B — *C. dolichorhynchus*

Cobitis bilseli Battalgil, HZM 1929, one female, 174.0 mm in standard length, Beishehir-golü (lake), Anatolia, Turkey, ZMT 3948, one female 195.0 mm in standard length, same locality, August 17, 1951, leg. E. Tortonese.

Cobitis simplicispina Hankó, two specimens 54.0—75.0 mm in standard length, Karahüyuk Aci-golü (lake), South-West Anatolia, Turkey, September 6-7, 1957, K. Kosswig; BMNH 1927. 5. 7. 7-8, two specimens 44.0—50.7 mm in standard length, Emir Gheul (Mohan Gheul), Ankara, Turkey, no date, leg. Gadeau de Kerville.

Cobitis macrostigma Dabry, two fishes 136.0 and 139.0 mm in standard length, Liang-tse-hu Lake, Hupeh Province, no date, leg. H. W. Wu.

Cobitis dolichorhynchus Nichols, SU 32613, four specimens 62.1—90.0 mm in standard length, Fung Hwa River, Ningpo, Chekiang Province, China, October 18, 1936, leg. A. W. Herre.

Cobitis biwae Jordan and Snyder, USNM 71196, one male 52.0 mm in standard length, Nanas, Hondo Island, Japan, no other data.

Cobitis biwae ssp., IBTS 1350, five specimens 52.0—85.0 mm in standard length, Taiwan, no other data, leg. Chen.

Cobitis striata Ikeda, SU 7780, seven specimens 54.2—72.0 mm in standard length, Chikugo River, Karume, Japan, no data, leg. D. S. Jordan and J. O. Snyder.

Cobitis matsubara Okada and Ikeda, BMNH 1905. 2. 4. 135—136, two specimens 62.5—64.5 mm in standard length, Matsuhima, Rikunen, Japan, no date, leg. D. S. Jordan and J. O. Snyder

Diagnose: A very slender *Cobitis*, with a long head and caudal peduncle, but the head is always longer than the caudal peduncle. Mouth inferior with three pairs of barbels: one pair rostral, one pair maxillar and one pair maxillo-mandibular. Mental lobes developed. Males with *lamina circularis* at the base of pectorals. Black oblique spot at the base of caudal.

Description: Body slender, the greatest height (depth) being 6.60—12.70 (x 10.62*)); length of head 17.80—22.50 (20.00), caudal peduncle long and compressed but shorter than the head, being 16.00—19.80 (17.80); minimal body depth 5.19—8.55 (6.82); interorbital space narrow, being 1.76—3.80 (2.59); praeorbital space (length of snout) shorter than postorbital space: 6.83—9.50 (8.12) and 8.70—12.5 (10.13) respectively. Insertion of the dorsal fin slightly behind from the middle of body, praedorsal space being 49.00—53.40 (50.75). Pectoral fins longer in males than in females: 12.70—15.90 (13.83) and 9.90—12.90 (11.00) respectively.

Body covered by minute rounded scales with large focal area. Generally they are slightly embeded. Lateral line short, not exceeding the length of pectorals but neuromast pits may be observed up to base of caudal fin.

Barbels short, especially the rostral pair. Mental lobes developed with pointed tips.

Suborbital spine slender with mediocaudal process longer and slightly curved, than the laterocaudal process.

Color and pigmentation: Coloration in alcohole is generally yellowish-white. A series of 11—19 (x̄ 15.96) dorsal median dusky gray spots arranged as follows: 4—9 (6.32) praedorsal, 2—3 (2.09) subdorsal and 5—10 (7.09) postdorsal. Subdorsal pigmentation based on three (sometimes on two) rows of minute dusky gray dots which in the second half of body are joined in a single marble-like row. A series of 11—18 (13.60) lateral dusky gray spots. They are elongated or rounded. The medio-lateral intermuscular septum visible, blackish. Pigmentation of head and its sides based on minute dots. A dusky gray line from the front of eye to the tip of snout, on each side of head. Superior part of the caudal base possesses a blackish oblique

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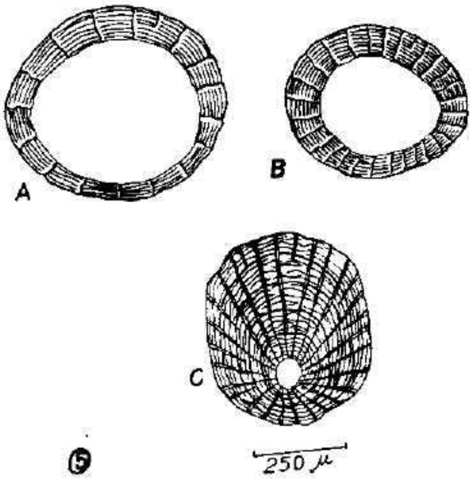
*) all measurements reported in percents of the standard length

streak. Sometimes under this streak appears a second but very minute and somewhat lighter one.

The dorsal fin with three, and caudal fin with three to six rows of grayish dots. Other fins pale.

Fin rays formula: The number of the fin rays was counted in twelve specimens. The number of ramified rays in all fins, except that of the caudal fin is very constant:



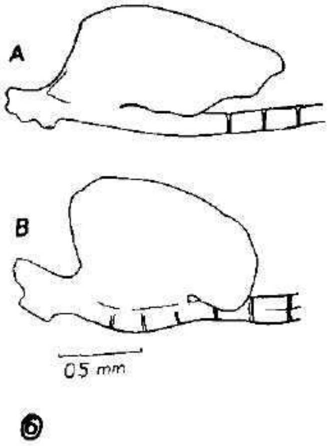


Fig. 5 Subdorsal scales: A — *Cobitis granoei olivai* ssp. n., B — *C. dolichorhynchus*, C — *C. bilseli* (according to Banarescu and Nalbant 1964)

Fig. 6 Lamina circularis: A — *Cobitis granoei olivai* ssp. n., B — *C. dolichorhynchus*

D II—III 7 (in a single male specimen were 5 ramified rays), A II—III 5, V I 5 I, P II 8, C 12—15 (14.02).

Sexual dimorphism: The four male specimens have at the base of their pectoral fins the Canestrini scale. This is a thin osseous process (*lamina circularis*) formed at the base of the second simple ray of pectoral fin. In *Cobitis granoei olivai* this *lamina circularis* is slightly elongated, somewhat similar to that of *Cobitis biwae*.

On the first two rays of pectorals and ventrals, three or four rows of small tubercles are visible in both sexes, but in males they are more expressed, larger and pointed.

Pectoral fins are longer in males than in females (13.83 in males versus 11.00 in females, in average).

Derivation of the name: This new subspecies is named in honour of Asst. Professor Dr. Ota Oliva from the Zoological Institute of the Charles University, Prague in appreciation of his work in ichthyology.

Discussion

Cobitis granoei olivai differs from the nominate form *C. granoei granoei* by longer head (20.0 versus 18.2%) and by a more slender body (10.6 versus 12.8 %). In these respect *olivai* appears to be somewhat similar to the population from the Nura River, Western Siberia (*C. taenia sibirica*, see

Gladkov 1935: 70—71) and to *C. elongata elongata*, *C. bilseli* and *C. macrostigma* in its slender body. From *sibirica* (population from the Nura River) subspecies *olivai* differs by its shorter head (20.0 versus 21.2 %) and by its elongated body (10.6 versus 11.4 %). About the caudal peduncle Gladkov's data appear somewhat contradictory. At page 71 Gladkov says (translated from Russian): "... in Siberian loaches the caudal peduncle is remarkably longer than the head". Comparing, however, the values given by him in his tables I and II, the population from the Nura River appears to have longer head and shorter caudal peduncle. According to his statement a large part of the Kurkaldjin lake population (Nura River basin) have the head longer than the caudal peduncle. Only the population from the Baikal Lake exhibits caudal peduncle remarkably longer than the head, like in *C. macrostigma*. Unfortunately, Gladkov does not give any value for other *sibirica* populations and no figure for his new subspecies. According to existing nomenclatoric rules, ssp. *sibirica* Gladkov represents a "collective notion", which includes many different populations. Since the Rendahl's contribution is dated "1933—1934, *Helsingfors*, 1935" and since he gives an excellent description and figures (male and female), we retain *granoei* Rendahl as the valid name for the central Siberian populations, and *sibirica* Gladkov from these regions became ipso facto a senior synonym of *granoei*. The name *sibirica*, however, must be retained for the type locality population, i.e. that from the Nura River and Kurgaldjin Lake which differs from *granoei* by a considerably longer head.

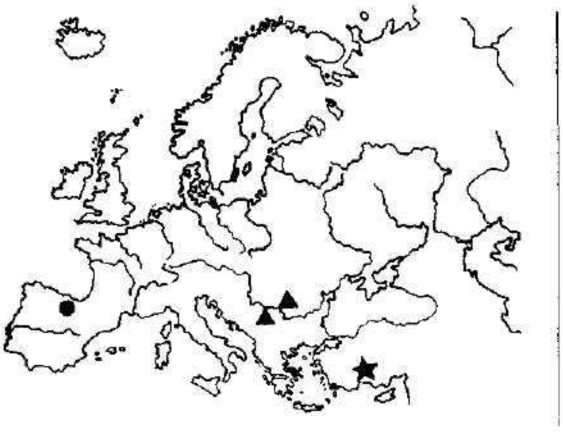


Fig. 7 Distribution of European and Anatolian species of the subgenus Acanestrinia. Solid dot — *Cobitis calderoni*, black triangle — *C. elongata elongata*, black star — *C. bilseli*

We fully agree with Bacescu and Mayer (1969 : 59) who consider *C. sibirica* (i.e. *granoei*) for an valid species.

According to our opinion, the polytypic species *Cobitis granoei* covers an extensive area from the Obi River basin and some isolated West Siberian basins up to the Baikal Lake, and, possibly also to the Amur River watershed (see the values of "*Cobitis taenia*" from the Elabuga given by Nikolsky 1956). Due to its features (slender body, scales with large focal area, reduced dorso-lateral pigmentary bands, oblique black spot or streak at the superior lobe of the caudal fin base), *Cobitis granoei* may be considered as a member of an old group of *Cobitis*, which, according to Bacescu (1961), represents the subgenus *Acanestrinia* .This subgenus covers an huge range, from Anatolia (*Cobitis bilseli*), throughout northern Balkan and western Roumania *(Cobitis elongata)*, Siberia and Mongolia *(Cobitis granoei)*, to the central and northern China *(Cobitis macrostigma* and, possibly, *C. dolichorhynchus)*.

The reduced size of body and the presence of *lamina circularis* at the base of pectorals in males in *granoei* may be interpreted as primitive character. On the other hand, extreme elongation of body, very reduced *lamina circularis* or its complete absence in three species — *bilseli*, *elongata* and *macrostigma* — seems to be more specialized character or an anagenetic feature Also the loss of *lamina circularis* in the males along with elongated body

Fig. 8 Distribution of the asiatic species of subgenus Acanestrinia. Open circle — *Cobitis granoei sibirica*, black circle with horizontal line — *C. ganoei granoei*, black circle with cross — *C. granoei olivai* ssp. n., black rectangle — *C. macrostigma*, black triangle — *C dolichorhynchus*

in the Siberian species *C. calderoni* Bacescu, favours the view that this species may be referred to *Acanestrinia* group It is very interesting that both *C. calderoni* and *C. bilseli* have their scales with a reduced and excentric focal area.

According to our opinion, four phyletic lines may be discerned in the genus *Cobitis*. Terminal parts of these lines represent four subgenera (Fig 9): *Acanestrinia* (A), *Cobitis s. str.* (B) and *Bicanestrinia* (C). The last phyletic line (D) represents an unnamed subgenus of a species to which Ki Chyung (1961, pl. 86, figs 406—409) has given the name "*Cobitis taenia*".

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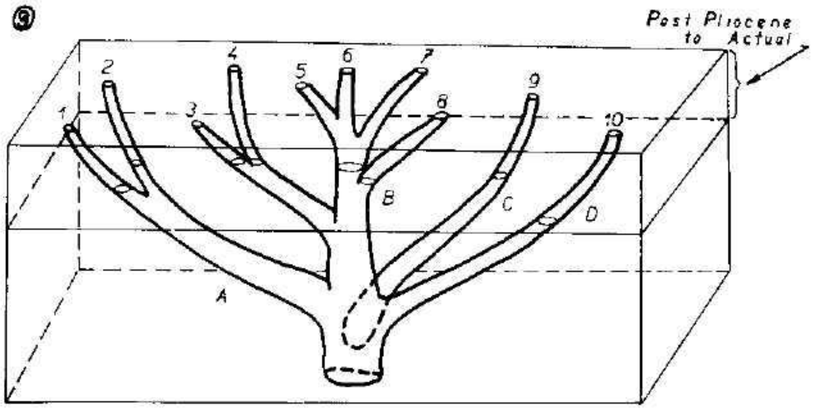

Fig. 9 Proposed outline of phyletic lines inside the subgenus *Acanestrinia*. 1 — *C. taenia* (European), 2 — *C. biwae-striata* (East Asian), 3 — *C. calderoni* (Iberian), 4 — *C. bilseli* (Anatolian), 5 — *C. elongata* (S E. European), 6 — *C. macrostigma* (Chinese), 7 — *C. dolichorhynchus* (Chinese), 8 — *C. granoei* (Central Asian), 9 — "*C. taenia*" (after Chyung, Korean), 10 — *Bicanestrinia* (Anatolian)

Following abbreviations of institutions or museums have been used in this paper:

BMNH — British Museum (Natural History), London
HZM — Hamburg Zoologisches Museum, Hamburg
IBTS — Institutul de Biologie „Traian Savulescu", Bucarest
LFR — Laboratórium rybárstva SPA, Bratislava
MSNG — Museo Civico di Storia Naturale „Giacomo Doria", Genova
SNM — Slovenské národné múzeum, Bratislava
SMF — Senckenberg Museum u. Forschungs-Institut, Frankfurt am Main
SU — Stanford University, Stanford, California
USNM — United States National Museum, Washington D. C.
ZICU — Zoologický ústav Karlovej Univerzity, Praha
ZTM — Zoological Museum, Torino

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The plate will be found at the end of this issue

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FUNCTIONAL ANATOMY OF DIGESTIVE ORGANS OF A FRESH-WATER FISH RHYNCHOBDELLA ACULEATA (HAM.)

PART I A MORPHOLOGY

V. M. S. SRIWASTWA

Received December 30, 1967

Abstract: The present work has been undertaken to make a study of the functional anatomy of digestive organs of a fresh-water burrowing eel *Rhynchobdella aculeata* (Ham.) of India in relation to its food and feeding habits. It is found that this fish shows marked differentiation in different parts of the alimentary tract according to type of food and way of feeding.

INTRODUCTION

The important works in record are by Ben Dewes (1928—29); Blake (1936); Suyehiro (1942); Al-Hussaini (1945, 1946, 1947 and 1949); and Weinreb and Bilstad (1955). In India important contributions are by Vanajakshi (1938) on *Saccobranchus fossilis* and *Macrones vittatus*; Sarbahi (1940) on *Labeo rohita*; Mohsin (1944—46) on *Anabas testudineus* and *Glossogobius giuris*; Mahadevan (1950) on *Caranx djedaba* and *Trichiurus haumalla*; Mahadevan (1954) on *Mugil crenolabis*; Kapoor (1954, 1957, 1958) on *Wallago attu*, *Gadusia chapara* and *Barbus stigma*; Das and Moitra (1956, 1963) on the food and feeding habits of some fresh water fishes of U.P. India; Nagar and Khan (1958) on *Mastacembalus armatus*; Sahagal (1960) on *Mystus seenghala*; Agrawal and Singh (1961) on *Colisa fasciatus* and Chitrey (1964) on *Eutropiichthys vacha*.

MATERIAL AND METHOD

A large number of dissections were made on fresh and preserved specimens for the study of anatomy of alimentary canal. A median longitudinal incision was given to entire alimentary canal to study the mucosal folds of different regions. The study of bucco-pharyngeal cavity was made in both fresh and preserved specimens.

ANATOMY OF ALIMENTARY CANAL

The alimentary canal of *R. aculeata* is a long tube of variable diameter having a pair of appendices epiloicae. It begins with a subterminal mouth and opens out through anus situated in near approximation with the beginning of anal fins. (Fig. 1).

Mouth and lips. The mouth is subterminal forming an inverted "Y" shaped slit which is bounded by long, truncate, muscular upper lip and a short, triangular less muscular lower lip. The upper lip has a ventral shallow groove, leading into the mouth, which helps in directing the food particles towards the mouth.

Bucco-pharyngeal cavity The mouth leads into a dorsoventrally compressed buccal cavity which is narrow anteriorly and wide posteriorly. The mucosal thickening at the anterior end of the floor is directed forward from the basihyal as a poorly developed fleshy lobe free from the floor, known as tongue.

Chitinous ridges are developed on the upper jaw and the lower jaw bears villiform backwardly directed teeth known as mandibular teeth. They help in checking the escape of prey.

The epithelial folds of the buccal cavity are poorly developed

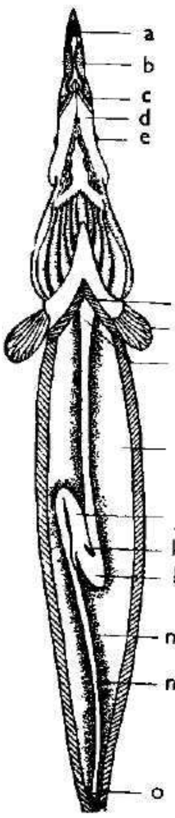


Fig. 1 Ventral view of the fish showing the alimentary canal· a — upper lip; b — upper jaw, c — mouth; d — lower jaw, e — eye; f — body wall; g — pectoral fin; h — oesophagus, i — visceral cavity; j — duodenum, k — appendix epiloica; l — stomach, m — ileum; n — rectum; o — anus.

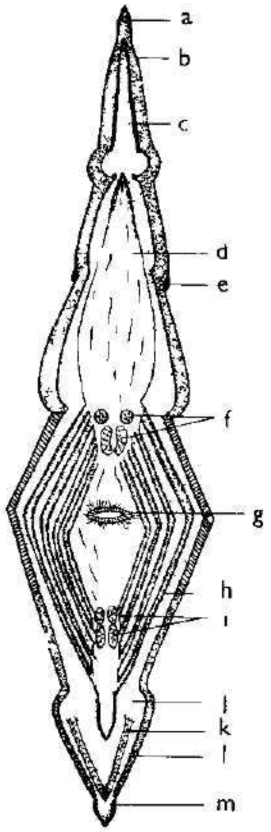


Fig 2 Diagramatic representation of the bucco — pharyngeal cavity: a — upper lip; b — upper jaw; c — groove; d — roof of the buccal cavity; e — eye, f — superior pharyngeal teeth; g — gullet; h — gill;— arch; i — inferior pharyngeal teeth; j — floor of the buccal cavity; k — mandibular teeth; l — lower jaw, m — lower lip

The buccal cavity opens into a dorsoventrally compressed pharyngeal cavity. On the roof of pharynx a little in front of gullet two pairs of oval patches of superior pharyngeal teeth are found. The first pair of pharyngeal teeth is small and lies on the second gill arch and the second pair is oval, well developed lying in relation to third and fourth branchial arches. On the floor of pharynx opposing the superior pharyngeal teeth are two pairs of inferior pharyngeal teeth The anterior pair of inferior pharyngeal teeth is borne on third branchial arch and the posterior pair on the fourth arch. The anterior pair is small and posterior is well developed

The teeth of both the superior and inferior pharyngeal teeth are directed towards gullet. They help in taking a firm grip of the prey and quieten them before they are gulped in the stomach. (Fig. 2)

The pharynx is perforated ventrolaterally by four pairs of gill clefts. On the inner face of the branchial arches separating the adjescent clefts are borne double row of gill reckers The number of gill reckers is not uniform and varies in size and development. They are developed on the anterior ones and reduced on the posterior. The organic particles and small preys are seived through gill rackers. (Fig. 3).

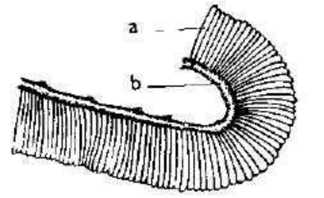
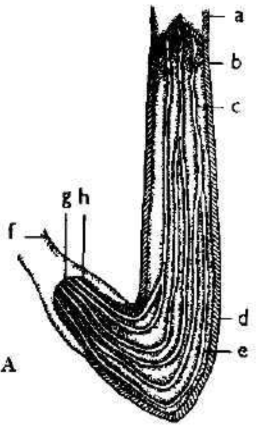


Fig 3 Gillarch: a — gill filament; b — gill arch.

The pharynx is lined with papilated mucosal linning produced behind the pharyngeal teeth into longitudinal folds which continues into oesophagus.

Oesophagus The pharynx leeds into a long, tubular structure the oesophagus which is broad anteriorly and narrow posteriorly. It passes dorsally to liver lobe. The mucosal folds of oesophagus are straight throughout thewhole length and continues with the mucosal folds of stomach (Fig. 4B).



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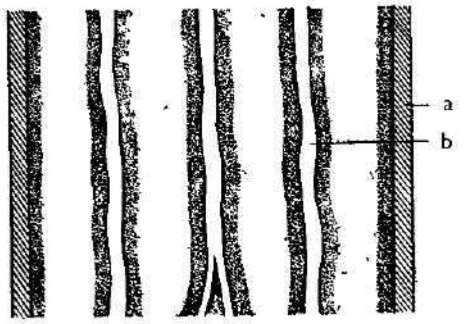

4B

Fig. 4 A. Mucosal folds of the oesophagus and stomach a — oesophagus; b — wall of the oesophagus; c — mucosal fold of the oesophagus; d — wall of the stomach; e — mucosal fold of the cardiac region of the stomach, f — duodenum, g — appendix epiloica; h — mucosal folds of the pyloric region of the stomach.

Fig. 4 B. Mucosal folds of the oesophagus: a — wall of the oesophagus; b — mucosal fold of the oesophagus.

The stomach can be distinguished into cardiac and pyloric parts in *R. aculeata*. The stomach is muscular with a pair of appendix epiloicae and varies in size due to contained food, which shows its elastic capacity The mucosal folds of stomach are similar to that of oesophagus and virtually they are in continuation of the same. (Fig. 4A). All the folds converge at the pyloric end of stomach.

The duodenum is V- shaped arising from the pyloric end of the stomach and has got a honey comb shaped well devepoled mucosal folds. (Fig. 5).

Ileum is a straight narrow tube without any external demarcation between the duodenum and ileum. The mucosal folds of ileum are differentiated in areas forming longer cavities of irregular shape and thus showing internal demarcation between the two. (Fig 6).

Rectum The tubular short, narrow rectum is not demarcated externally from ileum but internally the mucosal folds of rectum are straight and well marked (Fig. 7).

The liver is a reddish brown single lobed structure situated on the ventral side of the digestive tract. (Fig. 8.). The right side is longer than the left and extends upto ileum. The liver is narrow in the anterior region and broadens posteriorly. A gallbladder of light green colour is situated on the posterior side of the liver. The bile duct opens into duodenum near pylorus as a common bile duct after meeting with the pancreatic duct. (Fig. 9).

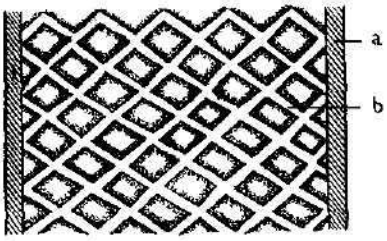

Fig. 5. Mucosal folds of the duodenum: a — wall of the duodenum; b — mucosal fold of duodenum.

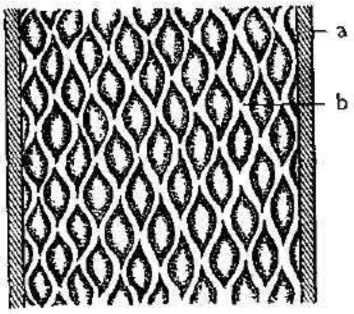

Fig. 6 Mucosal folds the ileum: a — wall of the ileum; b — mucosal fold of ileum.

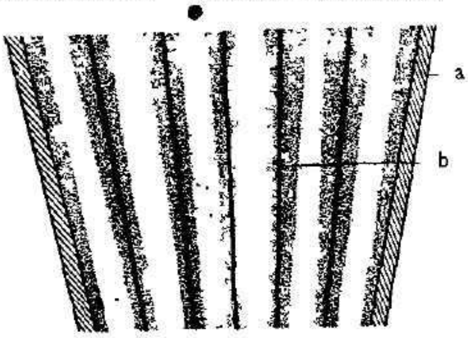

Fig. 7 Mucosal folds of the rectum: a — wall of the rectum; b — mucosal fold of the rectum.

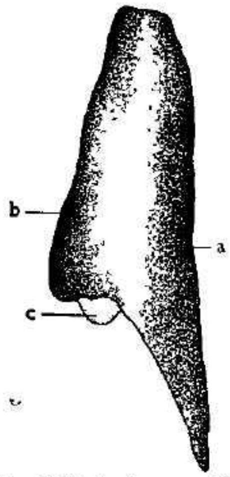

Fig. 8 Ventral view of the liver: a — left liver lobe; b — right liver lobe; c — gall bladder.

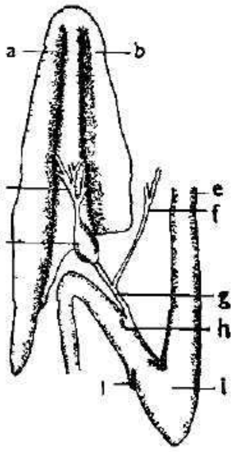

Fig. 9 Dorsal view of the liver: a — left liver lobe; b — right liver lobe; c — cystic duct; d — gall bladder; e — oesophagus; f — pancreatic duct; g — common duct; h — duodenum; i — stomach; j — appendix epiloica.

The pancreas is a diffused structure, scattered over the surface of the visceral cavity and embeded in the substance of liver. The pancreatic duct is formed by joining of the pancreatic ductules.

DISCUSSION

The adaptation of the digestive organs of fish to its normal food and feeding habits is demonstrated by the form of mouth, size, shape and structure of bucco-pharyngeal cavity, dentition, gill rackers, stomach and intestine.

The mouth of *R. aculeata* is subterminal forming an inverted Y-shaped slit. A long truncate upper lip with a shallow groove and a short lower lip help in directing the food towards mouth

The bucco-pharyngeal cavity has got the mandibular, superior pharyngeal, inferior pharyngeal teeth and chitinous ridges on the upper jaw which help in checking the escape of the prey and gripping them Al-Hussaini (1946) has given similar account in *Mulloides auriflemma* and *Scarus sordidus*. Das and Moitra (1956) have shown that the teeth of the bucco pharyngeal region make it a well aquiped zone for holding, biting and rasping the prey.

Al-Hussaini (1946) and Das and Moitra (1956) have shown that the gill rackers provide additional hold for gripping the prey. In *R. aculeata* the size and development of the gill rackers suggest that it might be helpful in sieving the prey.

Table 1.

Length of the fish (mm)	Length of gut (mm)	Length of Intestine (mm)
460	240	150
500	270	160
175	95	56
360	178	102
412	193	120

The epithelial linning of the bucco-pharyngeal cavity of *R. aculeata* is not much developed but papilated foldings are found in the posterior part which are produced behind the pharyngeal teeth into longitudinal folds

The alimentary canal of *R. aculeata* is thick walled muscular and elastic tube. The mucosal folds are highly developed throughout the alimentary tract. The mucosal folds are straight in oesophagus and stomach, honey comb shaped in duodenum, irregular elongated cavities in ileum and straight in rectum. They provide enough space for gastric glands in stomach and increased absorptive surface in duodenum ileum and rectum. Ben Dewes (1929) in *Pleuronectes platessa* and Al-Hussaini (1946) in *Scarus sordidus* and *Mulloides auriflemma* have given similar acount.

Das and Moitra (1956) observed that the relative length of the gut alone showed well marked deviation from herbivorous to carnivorous conditions of the alimentary canal and they further stated that a constant ratio existed between the gut length and the total length of the body for species of fishes in large number of freshwater food fishes of U.P. (India) from the same water sources. The relative gut length of *R. aculeata* is 0.60. (Table No. 1).

The gut contents of *R. aculeata* shows the presence of rotifers, insects, crustaceans, and their larvae, fish scales, fish vertebrae and insect larvae etc. Similar observation was made by Al-Hussaini (1949) and Das and Moitra (1956) for the species of carnivorous fishes.

The present observation of the bucco-pharyngeal cavity, mucosal folds, relative gut length and the gut contents in R. aculeata shows the carnivorous adaptation.

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SUMMARY

This paper deals with the functional anatomy of the digestive organs of *Rhynchobdella aculeata* (Ham.). The alimentary canal of *R. aculeata* is differentiated into subterminal mouth bucco-pharyngeal cavity, oesophagus, stomach with appendix epiloicae, duodenum, ileum and rectum.

The long truncate upper lip along with short lower one is important for directing the food particles towards mouth. The presence of teeth and chitinous ridges on jaws and in bucco-pharyngeal cavity help on sieving the prey.

The mucosal folds are well developed in all the parts of the alimentary canal and they provide enough space for gastric glands in stomach and increased absorptive surface in duodenum, ileum and rectum.

The liver is single lobed structure situated ventrally to the digestive tract. The pancreas is a diffused structure.

The study of the alimentary canal of *R. aculeata* shows the carnivorous adaptation of the fish.

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FUNCTIONAL ANATOMY OF DIGESTIVE ORGANS OF A FRESH-WATER FISH RHYNCHOBDELLA ACULEATA (HAM.)

PART I B HISTOLOGY

V.M.S. SRIWASTWA

Recived December 30, 1967

Abstract: In this a part of work a marked differenciation in different parts of alimentary tract of *Rhynchobdella aculeata* is found according to type of food and way of feeding. The types of cells and glands found in different parts in histological study show the differenciation.

MATERIAL AND METHOD

Fresh specimens were procured and after removing different parts of alimentary canal they were thoroughly washed to get rid of mucous. Then the pieces were fixed in Alcoholic Bouin's fluid. Sections of 8—10 um were cut and studied after staining in Heidenhain's Iron Haematoxylin, Mallory's triple stain and Azans technique

HISTOLOGY OF ALIMENTARY CANAL

The histological study of bucco-pharyngeal cavity, oesophagus, stomach, duodenum, appendix epiloicae, ileum, rectum, liver and pancreas of *R. aculeata* revealed the following details

Bucco-pharyngeal cavity The linning of bucco-pharyngeal cavity consist of mucosa and subepithelial connective tissue In between the cells

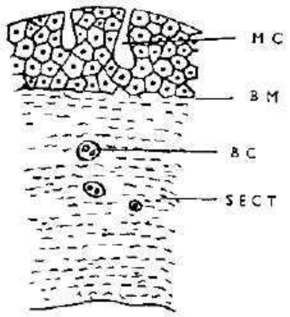

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Fig. 1 V.S. linning of buccal cavity

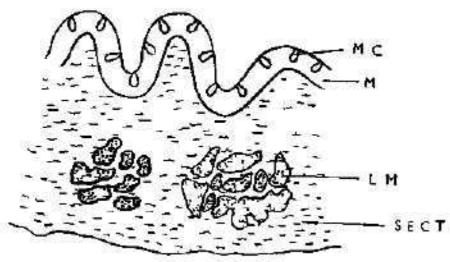

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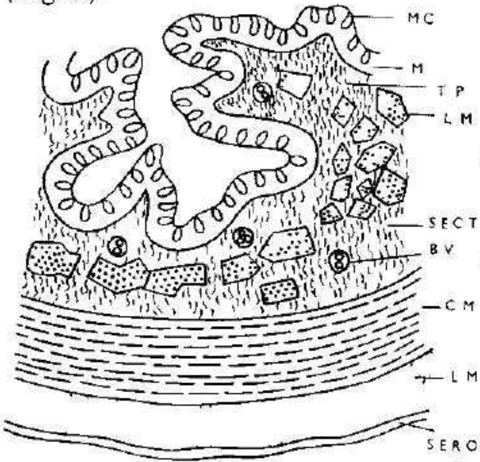
Fig. 2 V.S. linning of pharynx

of mucosa there are round mucous cells The subepithelial connective tissu is richly supplied with blood cappillaries and muscle patches found in pharynx (Figs. 1, 2).

Oesophagus. The wall of oesophagus consits of mucosa, submucosa muscularis and serosa. The mucosa contains mucous cells in abundanc which have oval shape They open into oesophagus The submucosa contain bundles of longitudinally disposed muscles. The submucosa has got a laye of tunica propria The muscularis consists of circularly arranged muscl fibres and is covered externally with serosa which contains blood capillaries (Fig. 3).



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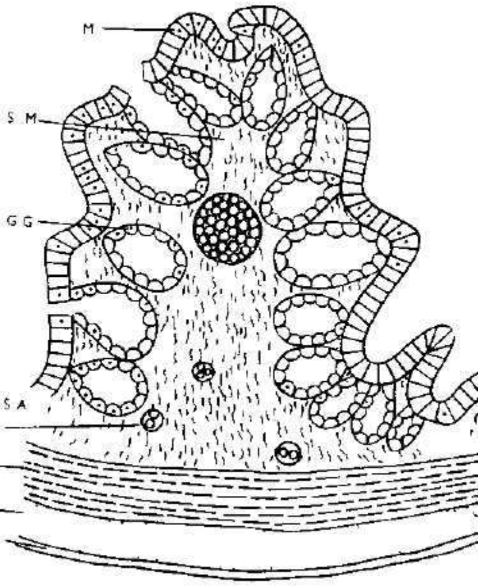

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Fig. 3 T.S. of oesophagus
Fig. 4 T.S. of cardiac stomach

Stomach The mucosa of cardiac stomach is composed of columnar cells and is incurved at intervals to form crypts. The cytoplasm is granular and nuclei basal in these cells. The submucosal connective tissue contains gastric glands which are separated at regular intervals by connective tissue. The gastric glands are branched and saccular Each is formed of polygonal cells with central nuclei and cytoplasm filled with grannules. The submucosa consists of connective tissue The tunica propria separates submucosa with mucosa The muscularis consists of a inner circularly disposed and outer longitudinally running fibres. The serosa is thin. (Fig. 4)

The pyloric stomach differs from cardiac stomach in the absence of gastric glands. Due to absence of gastric glands tunica propria of submucosa is absent The muscularis is highly developed and circular and longitudinal muscle layers are more thick than that of cardiac stomach. Serosa is thin (Fig 5).

Duodenum The muscosa of duodenum consists of single layer of columer cells with basal nuclei. The mucosal folds of duodenum are very well developed. The submucosa contains several wandering cells in the connective tissue. The submucosal connective tissue is mostly confined to mucosal folds and region below the folds is poorly developed. The muscular later is not well developed. The outer longitudinally disposed muscle layer forms thinner belt than the inner circularly disposed muscle fibres. Out side the muscularis there is a thin layer of serosa composed of a layer of connective tissue covered on the outside by a layer of flat cells. (Fig. 6)

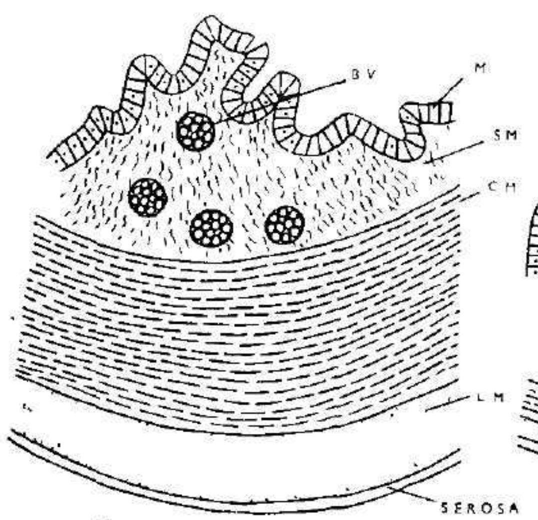

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Fig. 5 T.S. of pyloric stomach

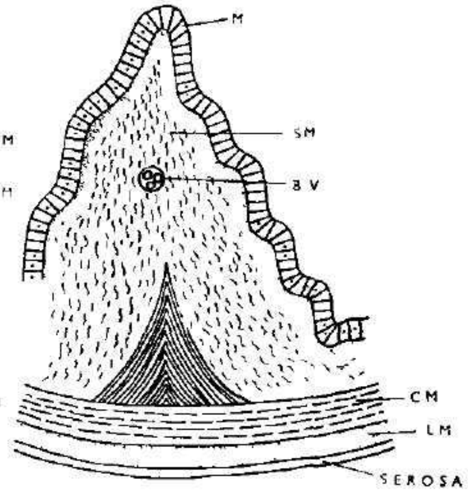

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Fig. 7 T.S. of appendix epiloicae

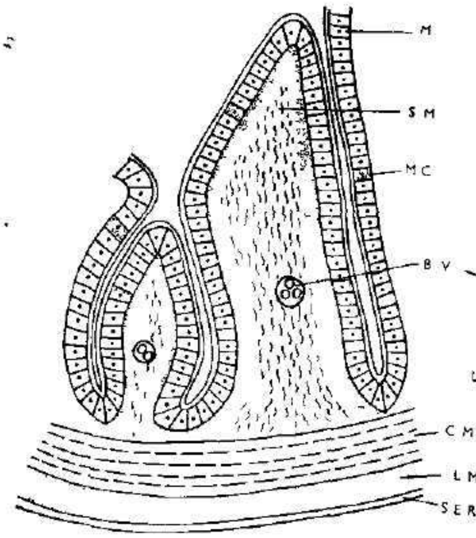

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Fig. 6 T.S. of duodenum

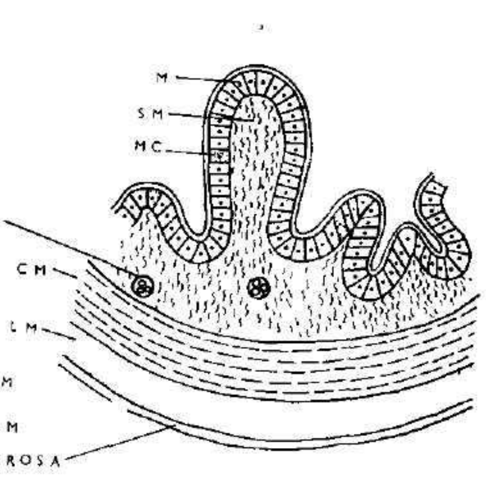

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Fig. 8 T.S. of ileum

Appendix epiloicae. The mucosal layer consists of columner cell with basal nucleus and grannular cytoplasm. The mucosal folds are not s well developed. The submucosa consists of connective tissue crowded wit wandering cells below mucosa and abundant in the middle. Like duodenum the submucosa is confined to parts in mucosal folds and its part below th mucosal folds is much reduced. The muscularis is similar to duodenum bu longitudinal muscle belt is thin. (Fig. 7).

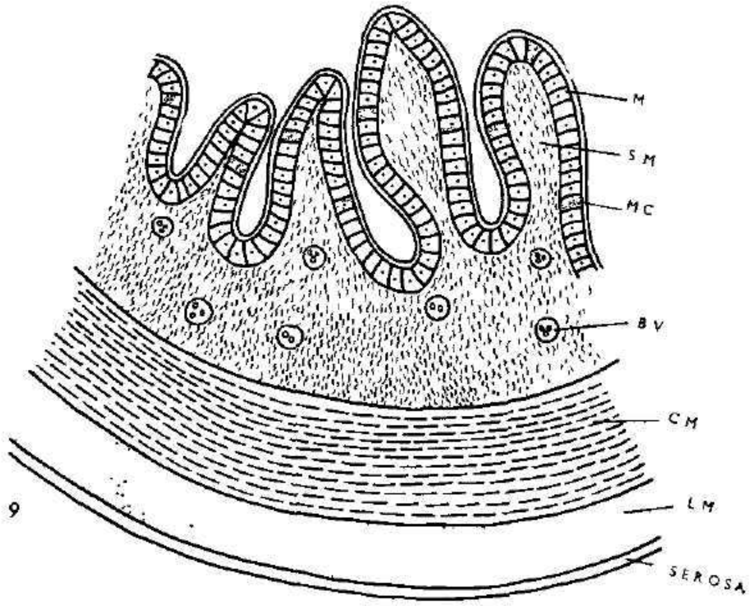

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Fig. 9 T.S. of rectum

Ileum. The histological details are similar to duodenum except in having the muscularis thicker than duodenum due to heavy development of circularly disposed muscle layer. (Fig. 8).

Rectum. In histological details it ressembles ileum but mucosal folds are not very well developed and they contain goblet cells. The muscular layer is very well developed in muscularis of rectum and is thicker than ileum. The greater thickness is due to the development of circular muscle fibres. Outer layer is of usual type. (Fig. 9).

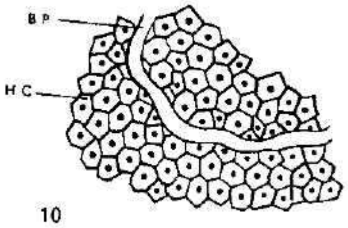

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Fig. 10 T.S. of liver

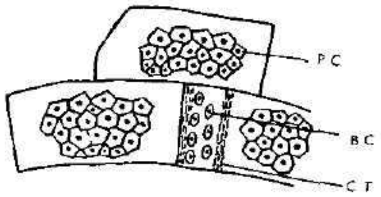

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Fig. 11 T.S. of pancreas

Liver. consist of irrergularly arranged polygonal cells. Each cell contains centrally placed nucleus and deeply staining cytoplasm. A number of passage cells are seen in between the irregular row of hepatic cells. Each ductule is linned with a single layer of cubical epithelium with basal nuclei. On the outer side of the epithelium is a sheath of connective tissue. (Fig. 10).

The **pancreas** is composed of compactly arranged glandular cells which aggregate to form acini. Each cell is polyhedral and contains a round nucleus and deeply stained cytoplasm. Islets of Langerhans are absent. Pancreatic ductules are *invested with thick layer of the connective tissue.* (Fig. 11).

DISCUSSION

The histology of gut of *R. aculeata* shows that food material caught by fish is not retained in bucco-pharyngeal cavity for a long time.

The mucosa of bucco-pharyngeal cavity is mentioned stratified by Ben Dawes (1929) in *Pleuronectes pletassa*; Al-Hussaini (1946) in *Mulloides auriflemma*, and Nagar & Khan (1957) in *Mastacembelus armatus* distinguished subepithelial layer as layer of loosely held fibres and connective tissue. In *R. aculeata* the bucco-pharyngeal cavity is divided into stratified mucosa and subepithelial connective tissue. The mucosa contains mucous cells but not clavate cells. The mucous cells secrete mucous to lubricate the food for easy swallowing.

The mucosa of oesophagus was found of a single layer by Al-Hussaini (1947) in *A. forskali* and was found stratified by Blake (1936) in *Pleuronectes carolinus*. In *R. aculeata* mucosa of oesophagus indicates to be stratified but without distinction into three strata. The mucous cells are abundant and clavate calls absent. The mucous provides additional lubrication and softenning for slipping the prey in stomach. The musculature of the wall of oesophagus is well developed due to developed muscle layer and additional longitudinally disposed bundles of muscles.

Ben Dewes (1929) in *P. platassa*, Vanajakshi (1938) in *H. fossilis* and *M. vittatus*, and Al-Haussini (1946) in *M. auriflemma* have shown that crypts of mucosa of stomach were found to open into gastric glands directly. Vanajakshi (1938) & Mohsin (1945) and Al-Hussaini (1946) described a distinct neck region between crypts and gland. In *R. aculeata* gastric glands open into crypts directly and no neck cell has been distinguished. The gastric glands are tubular and cells of these glands are polygonal. The stomach serves for mechanical mixing due to extensive musculature and provides digestive enzymes from the gastric glands. The musculature is highly developed in stomach. The major part of the stomach is cardiac which is glandular. The pyloric part of the stomach is reduced and non grandular. This is due to voraceous feeding of the fish which needs greater digestive activity.

The mucosa of intestine is composed of mucous and columner cells. Ben Dewes (1929) in *P. platessa*, Kapoor (1953) in *W. attu*, and Nagar & Khan (1957) in *M. armatus* reported wandering cells in rectal part of intestine.

In *R. aculeata* the intestinal region is differentiated into duodenum, ileum and rectum. The mucosal folds are well developed in duodenum and ileum *but is very much thick in rectum. The mucous cells are absent from the* intestine but the wandering cells are present. Theile um is mainly absorptive and numerous goblet cells in rectum help in defaection of the undigested food.

The liver is of usual fish type histologically. Sarabahi (1939) in *L. rohita*, Kapoor (1953) in *W. attu* found pancreatic tissue embeded in the substance of liver. Kapoor (1953) mentioned the pancreas consisting of one type of cell. In *R. aculeata* Islets of Langerhans were not observed.

In histological study we get the bucco-pharyngeal cavity abundantly supplied with mucous to lubricate the food. The oesophagus is profusely supplied with mucous cells to soften the food before passing to stomach. The major part of the stomach is cardiac and glandular and the nonglandular part is reduced. This is due to the vorace ous feeding habits of the fish which needs great digestive activity. Well developed intestinal folds provide greater absorptive surfaces. The abundance of goblet cells in short rectum helps in the defaection of the undigested food.

SUMMARY

(1) *R. aculeata* is a carnivorous fish and its digestive tract consists of bucco-pharyngeal cavity, oesophagus, stomach, duodenum, ileum and rectum.

(2) The buccal cavity and pharynx contain compactly held polygonal cells. The mucous cells are present but clavate cells are absent. The subepithelial connective tissue of pharynx contains muscularis in the form of longitudinally disposed muscle fibres. They are richly supplied with blood vessels.

(3) The mucosa of oesophagus is stratified mucous cells. The muscularis is represented only by circularly disposed straited muscle fibres. The serosa is well developed.

(4) In the cardiac part of the stomach the mucosa is formed of columner cells and it is produced as crypts into the subepithelial connective tissue. In them are present a belt of gastric glands. The glands are saccular. The cells of the glands are polygonal with centrally placed nuclei. They open into crypts without neck cells. The muscular layer is formed by circularly arranged fibres. The serosa is of usual type. The pyloric stomach differs from cardiac stomach in the absence of gastric glands and the muscular layer is very well developed in it.

(5) In the ileum, duodenum and appendix epiloicae the muscularis is equally developed while in rectum it is comparatively better developed. The folds of the duodenum are branched while in ileum they are longitudinally arranged. The mucous cells are altogether absent but the top plate is present in mucosa.

(6) The liver is formed of polygonal cells which are arranged in irregular rows separated by bile passages. It is provided with blood capillaries and hepatic ductules.

(7) The pancreas is formed of polyhedral cells arranged to form acini. The Islets of Langerhans are scarce but the blood capillaries and pancreatic ductules are present in the pancreatic tissue.

CORRELATION

The abundance of mucous cells in mucosa of buccal cavity, pharynx and oesophagus is associated with the lubricating and softenning of food for digestive activity in the stomach.

The stomach is with appendix epiloicae and major part is cardiac which provides enough space for the gastric glands which are neccessary for greater digestive activity.

The duodenum and ileum are very long to provide more absorptive surface and the rectum is short.

Acknowledgements

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LITERATURE

See the references in the previous paper of same author.

List of abbreviations used in the figures

BC — Blood corpuscle
BM — Basement membrane
BP — Bile passage
BV — Blood vessel
CM — Circular muscle
CT — Connective tissue
GG — Gastric gland
HC — Hepatic cell
LM — Longitudinal muscle
M — Mucosa
MC — Mucous cell
SEROSA — Serosa
SECT — Subepithelial connective tissue
SM — Submucosa
TP — Tunica propria

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EFFECTS OF ESTRADIOL BENZOATE AND TESTOSTERONE PROPIONATE ON SEXUAL DIFFERENTIATION IN TRITURUS VULGARIS AND TRITURUS ALPESTRIS

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Abstract: Studies were carried out on the effects of estradiol benzoate and testosterone propionate on sexual differentiation in *Triturus vulgaris* L. and *Triturus alpestris* Laurenti. The hormones were administered to embryos and larvae of newts in different concentrations and at different developmental stages (gastrula, neurula, tail bud, larva) till metamorphosis. Both hormones bring about a partial reversal of sex (feminization) and the occurrence of intersexual types and have other secondary, basically negative effects on the development of these species of newts. The application of hormones in its beginning did not show any marked differences in sexual differentiation among experimental series.

The effects of sexual steroid hormones on sexual differentiation of amphibians has been studied more systematically since about the thirties. The study of Padoa (1936), who masculinized the tadpole of *Rana esculenta* by action of folliculine, can be considered as one of the first outstanding works of this kind. A series of subsequent studies listed in Gallien's monograph (1967) have shown, that sexual hormones affect sexual differentiation in different species of amphibians differently and that their effects depend on the concentration, mode and time of their application. These hormones either do not affect sexual differentiation at all, or bring about partial changes in sexual development or, a total, i.e. permanent or temporary sex reversal.

The effects of estradiol benzoate and testosterone propionate on different species of amphibians were studied in detail by Collenot (1965). According to his results the estradiol benzoate partially feminizes the gonads of genetic males in *Pelodytes punctatus*, *Triturus alpestris* and *Salamandra salamandra*, completely feminizes the gonads in *Pelobates cultripes* and *Triturus helveticus* and does not affect sexual differentiation in *Bombina variegata*. This hormone stimulates the development of Müllerian ducts in *Pelobates* and in *Pelodytes* and has a pathologic effect on the general development of these animals. By contrast, in urodeles the hormone inhibits the differentiation of Müllerian ducts and may also prevent it altogether, but, on the other hand, it stimulates their development in case that its effect starts after their differentiation. The testosterone propionate does not affect the sexual differentiation of gonads in *Bombina variegata*, *Pelobates cultripes*, *Pelodytes punctatus* and *Salamandra salamandra*. In *Triturus alpestris* and *Triturus helveticus*, besides the feminizing effect, it inhibits the origin and development of mesonephros and gonads, inhibits the differentiation of Müllerian ducts, but stimulates their development after their differentiation. Collenot's studies and works of other authors revealed that in urodeles (and likewise in genera *Xenopus*, *Bufo*, *Discoglossus* and *Alytes*, i.e. in lower anurans) estradiol benzoate has a feminizing effect, testosterone propionate has no effect or provokes a paradoxical, i.e. also feminizing effect, whereas in higher anurans (Ranidae, Hylidae) a masculinization occurs by action of testosterone, and estradiol benzoate provokes a temporary feminization in lower concetrations and a paradoxical phenomenon, i.e. masculinization in higher concetrations. Thus the importance of genetic substrate is observed in response to hormonal effect — the species show specific differences in the reactions. In most vertebrates a reversal of homogametic sex is possible by action of homologous hormone to heterogametic sex (Gallien, 1962). This would correspond with the situation in amphibians: in Ranidae where the male sex is heterogametic, a masculinization of the female sex proved possible, whereas in urodeles where the female sex is heterogametic, the situation is vice versa, i.e. a feminization of the male sex is brought about.

Soon also the question arose as to the dissimilarity or identity of sexual hormones with sexual inductors of cortex and medulla of the primitive embryonic gonad. For example in urodeles the graft of the male embryonic gonad has a masculinization effect, whereas the male sexual hormone has not. The return to genetic sex after a temporary sex reversal by action of sexual hormones also gives evidence against the identity of sexual hormones and sexual inductors. The sexual hormones might be factors inhibiting cortex and medulla temporarily. In urodeles testosterone would *inhibit* medulla and thus cortex would be temporarily dominant and a paradoxical effect would result.

Primarily these problems have induced us to apply sexual hormones as soon as possible (e.g. Collenot in his experiments started to apply hormones as late as 1—2 days after the larvae started to feed) in order to find out eventually the differences which would manifest themselves in the development by an early or later application of hormones and which should suggest something about the relationship of sexual hormones to sexual inductors.

MATERIAL AND METHODS

Fertilized eggs of *Triturus vulgaris* L. (V) and *Triturus alpestris* Laurenti (A) were obtained under laboratory conditions in the spring of 1968 and in each species were divided into two basic groups. In the first group the eggs were left intact in their membranes (+), in the second group the membranes were removed mechanically from them (—). The first group was subdivided into four series to which the hormone was administered for the first time a) in the stage of gastrula (G), b) in the stage of neurula (N), c) in the stage of tail bud (B) and d) immediately after hatching from egg membranes (L). Each of these series was further subdivided into yet another four ones, according to concentration and type of hormone. The female hormone — estradiol benzoate — was administered in two concentrations, 50γ/litre (0 50) and 250γ/litre (0 250) and the male hormone — testosterone propionate — also in two concentrations, 50γ/litre (T 50) and 250γ/litre (T 250). Apart from these experimental series a control series was separated from the group of intact eggs and reared in tap water. Likewise, except the group d), the eggs with removed membranes were subdivided into relevant series and a control series (Ka), which was kept in water with absolute alcohol added in the concentration (0.5 ml of absolute alcohol per 1 litre of water) corresponding with the concentration of alcohol in experimental series. (It becomes evident from our experiments as well as from Gallien's work (1944, 1954), that this concentration of alcohol does not affect the differentiation of gonads of animals studied.)

The indicated symbols designate individual experimental series according to the following diagram: AG — T 250 means *Triturus alpestris* (A) reared from eggs deprived of their membranes (—) to which the hormone testosterone propionate (T) was administered in the concentration 250γ/litre in the stage of gastrula (G). The control series of the intact eggs in *Triturus alpestris* is designated AK and in *Triturus vulgaris* VK. Both hormones applied were provided by the SPOFA enterprise in crystallic state and were dissolved in absolute alcohol in the ratio of 25 mg of hormone per 50 ml of alcohol. From the beginning of application the hormones were placed permanently in the rearing water environment, namely till metamorphosis at 48 hour intervals. The eggs with removed membranes were transferred to Holtfreter's solution diluted 1 : 8, to which the corresponding amount of hormone was added in the given stage. The eggs and larvae were kept at about 18° C and in natural daylight, in plastic boxes covered with a transparent top. At the stage of metamorphosis the boxes were propped in such a way that a part of their bottom was not covered with water. Thus the animals undergoing metamorphosis were facilitated to leave the water environment.

The average number of eggs at the time when the hormone started to be administered was somewhat lower than 25 in the series of intact eggs and somewhat lower than 15 in the series of eggs with removed membranes.

From each series two specimens were collected at 14-day intervals, two specimens at 6 week intervals and two specimens at 10 week intervals after hatching from egg membranes and likewise in the series coming from the intact eggs. Collected specimens were fixed in Bouin's fixation fluid and later prepared for anatomic and histological studies. Histological sections of urogenital system, 8 μm thick, were stained by Heidenhain's ferric hematoxylin. The specimens collected from the series at the time immediately before and after metamorphosis were dealt with in analogous manner. The age given in weeks (if not stated otherwise) indicates the period since the hatching i.e. the life span of larva. To obtain the absolute age of animal two weeks of embryonic development should be added.

RESULTS

A. *Triturus vulgaris* L.

The development of eggs and larvae of *Triturus vulgaris* was traced in 28 experimental series and in one control series (VK). The total number of live specimens at the time when the hormone started to be administered to the experimental series, was 525. Under normal conditions *Triturus vulgaris* reaches the metamorphosis at about the 15th week of larval life. Under laboratory conditions, however, it can be reared with great difficulty and usually does not develop till the stage of metamorphosis.

Due to the fact that specimens were collected from the control series VK more often than from the other series, the control series did not last until the 15th week; last specimens could be taken from it in the 10th week. The animals in experimental series succumbed faster than in the control series. An average course in these series appears to have highest mortality in the first four weeks and thereafter the number of animals falls linearly to zero in the 11th week. However, there are certain differences between individual types of series. Primarily the series coming from the eggs with removed membranes are far more sensitive to the hormonal treatment than the series from intact eggs; they do not survive the 7th week after the hormone administration has been started. The difference in the effect of hormones and in their concentration is not distinct. Both concentrations have practically the same fatal effect, higher concentrations are a little more toxic than lower concentrations. The effects of both hormones is nearly the same in the first month, in a later period the larvae reared in the solution of estradiol benzoate survive longer.

Macroscopic investigation of sexual differentiation and development of urogenital system in larvae of *Triturus vulgaris* is practically impossible until the 10th week. Therefore the sexual differentiation was studied in histological sections. In 2-week-old larvae no difference is observed between animals coming from the control series and from the experimental series. In transverse histological sections of these larvae dorsal mesentery above the alimentary tract is found. Under it, between primary ureters, are the primordial gonocytes. Histological sections of urogenital system of 3-4-5-week-old larvae are practically the same as in 2-week-old larvae, only the number of primordial gonocytes increases.

The first sexually differentiated animal from the control series was 6 weeks old. It was a female with developed ovaries and small fat bodies (Fig. 1). All other control animals 7-8-9 weeks old were females with better and better developed ovaries (Figs 2 and 3). The development of the fat body and kidneys proceeded slowly. The last control animals were collected in the 10th week and the histological sections of these animals revealed that they were females again (Fig. 4).

Collections made in the second week in experimental series did not yield results different from those in the control series. Further collection in these series in the sixth week provided only the following specimens from the series: VN + O50, VB + O 50, VB — O 250, VL — O 50 and also from the series: VN + T 50, VL + T 50. All experimental specimens, according to histological sections, were females. The section of their ovaries showed several primary oocytes. Fig. 5 represents a typical section of a female from the series VB + O 250, showing two gonads, of which the right gonad has one large oocyte, the left gonad has two oocytes. The kidneys of this animal have dilated kidney ducts. Fig. 6 shows a section of a female from the series VN + T 50. To the right is a weakly developed mesonephros, to the left are only its foundations. Under the mesonephros there are two small gonads with several oogonia. The fat body is undeveloped, the arrows point to cell clusters from which fat bodies originate.

The third collection in experimental series (10th week) could be made only in the series VB + O 50; VL + O 50. The series kept in testosterone propionate did not survive until this period. In this case only females were found which had well developed and small ovaries, but considerably affected and disarranged kidneys with strongly dilated kidney ducts. The Müllerian ducts which should have been on the outer sides of kidneys, were not differentiated. Fat bodies of these animals were already well developed.

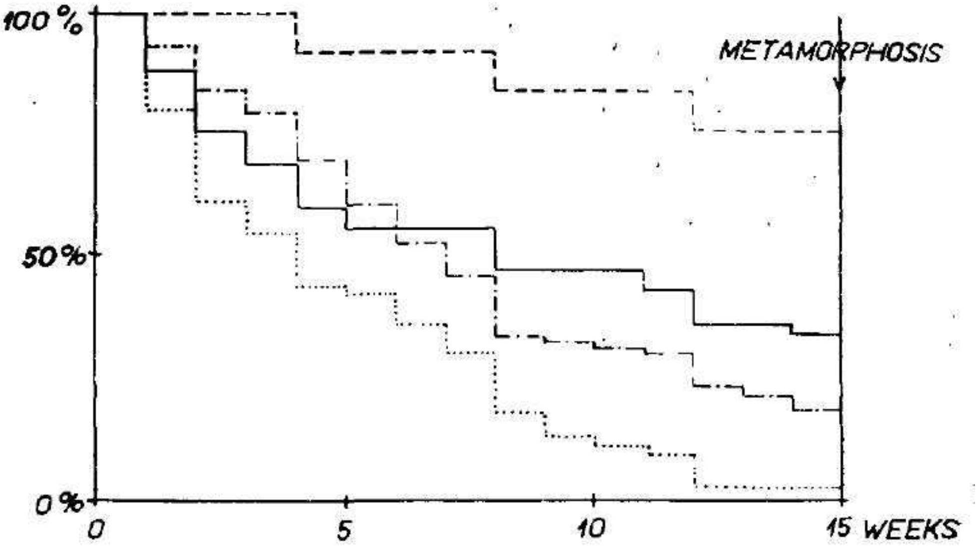
A considerable damage of kidneys is apparently the cause of frequent edemas which could be observed in larvae of *Triturus vulgaris* at the time prior to their death.

B. *Triturus alpestris* Laurenti

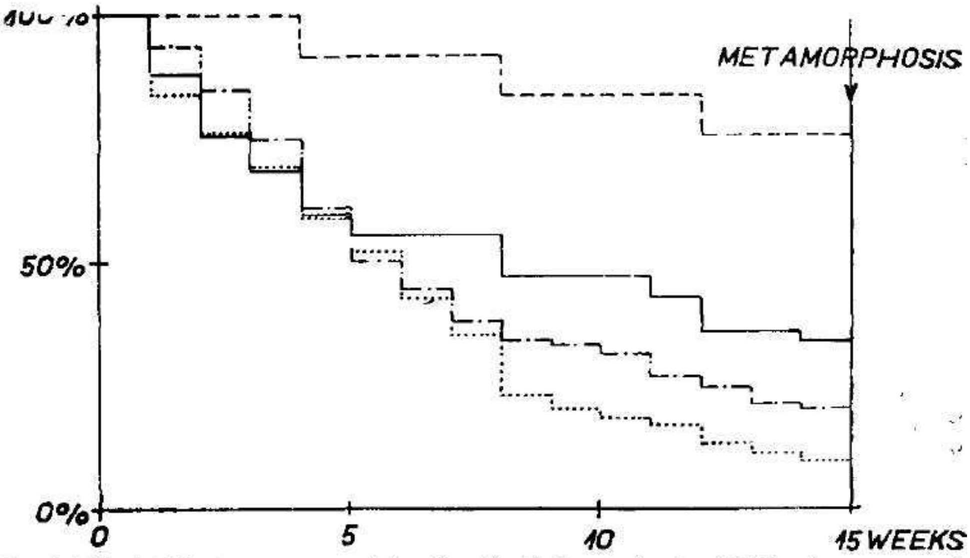
Also in this species the development of eggs and larvae was studied in 28 experimental series, one control series (AK) and in one control series with alcohol (AKa) from eggs with removed membranes. The total number of animals in the experimental series at the time when the hormone was started to be administered to them, was 583. In both control series the initial number was 40.

Triturus alpestris reaches metamorphosis in about the 15th week of larval life. In the control series AK and AKa 33% of larvae from the initial number reach the stage of metamorphosis. In case that no collection would be made, the number of larvae reaching metamorphosis would be about 55%. The animals reared in solutions of sexual hormones reach the stage of metamorphosis to a considerably smaller extent, in our case (i.e. in regular collection) only in 12%. However, considerable differences between individual series could be observed. Primarily the series reared from eggs with removed membranes are more sensitive to hormonal treatment than the series reared from intact eggs. The toxic and pathologic effects of both hormones are manifested in them much more strongly, and some of these series do not live long enough to reach the stage of metamorphosis and some of them die in the first two weeks. Those animals which developed from the series of eggs with removed membranes and which live till metamorphosis, do not undergo metamorphosis and gradually succumb (the few last ones at the age of 6 months). *Triturus alpestris* is more sensitive to testerone propionate than to estradiol benzoate. The series develop in both hormones concurrently till the eighth week of larval life, but later the series reared in testosterone propionate show a higher mortality. A higher concentration of hormone has a stronger toxic effect than the lower concentration, but the differences begin to be manifested till after the eighth week of larval life. The level and extent of pathologic effects on *Triturus alpestris* varied directly with the total time of hormone application.

The total development of animals in individual principal series is presented in graphs 1 and 2. The axis x bears marks designating time expressed



Graph 1. Dashed line (- - - - - - - - - -) describes the ideal control series, in which not a single animal would succumb naturally, steps on this line correspond with collection of specimens. Full line (——————) describes the actual course in control series. The difference between the former and latter lines gives the number of dead animals in percentage.
Dot-and-dashed-line (- . - . - . - . -) represents the development in experimental series from intact eggs.
Dotted line (. . . . .) represents the development in experimental series from eggs with removed membranes.



Graph 2. Dashed line (- - - - - - - - - - -) describes the ideal control series. Full line (——————) describes the actual course in control series.
Dot-and-dashed line (- . - . - . - . - . -) represents the development in experimental series reared in estradiol benzoate solution. Dotted line (. . . . .) represents the development in experimental series reared in testosterone propionate solution.

in weeks since the moment when the embryos or larvae were administered the hormone, the axis y bears marks designating number in % of surviving animals relevant to their initial number at the moment when the hormone started to be administered. The graph represents different ages of embryos or larvae which differ in the absolute period of development. This difference which is not more than 11 days (from the stage of gastrula till the hatching from the egg membranes) cannot be apparent from the graphs because the reading is done in weeks.

A quantitative survey of the initial condition and of metamorphosis is presented in Table 1, in which only those series are given which lived till the 15th week, i.e. the period when metamorphosis should have normally occurred. The following animals from 12 series did not live till this period: AG + O 50, AG + T 50, AG — T 50, AG+ T 250, AN — O 50, AN + O 50, AN — O 250, AN — T 50, AN — T 250, AB — T 50, AB — T 250 and AL + T 250. Column 1 represents the number of animals in individual series at the initial time of hormonal application, Column 2 represents the number of animals (a total of 79) which lived till the 15th week, Column 3 gives the number of those animals (a total of 40) which underwent metamorphosis and Column 4 the span (in weeks) in which metamorphosis occurred in the given series. Other columns state the sex of animals which were histologically investigated. At metamorphosis a time dispersal in both hormones occurred and the period of metamorphosis was considerably extended.

Table 1.

series	1	2	3	4	♀	♂	♂ +	undiff.
AG + 050	25	3	0	—			1	
AG + 0250	28	6	0	—		3		
AG — 0250	15	2	0	—				
AN + 050	25	3	0	—	1		1	
AN + 0250	26	4	3	22	2			
AN + T50	27	9	9	15—24	2		1	1
AN + T250	25	1	0	—			1	
AB + 050	25	10	5	17—21	1	1		
AB — 050	13	2	0	—			1	
AB + 0250	25	6	2	19—22		1	1	2
AB — 0250	10	2	0	—				
AB + T50	25	8	6	15—22	1		1	1
AB + T250	25	1	0	—	1			
AL + 050	25	10	6	16—19	2		1	
AL + 0250	25	6	4	16—19	2		1	
AL + T50	25	6	5	14—19	1	3	1	1

Table I shows that the total period of hormonal application considerably influences the metamorphosis. Thus, from the larvae to which hormone has been administered as early as in the stage of gastrula not a single animal undergoes metamorphosis; on the other hand, from larvae to which hormone has been administered only after hatching and which live till the 15th week, nearly 70% of animals undergo metamorphosis.

The external pathologic symptoms in dead animals reared in solutions o both hormones can be observed since about the fourth week. They are roughl similar in both hormones: at an early stage they are manifested primaril as swellings of abdominal cavity, later, in particular around metamorphosis as distinct edemas on neck, extremities and tail. Although in most case punctures were made, the mortality of animals with edemas was high.

The first collection of experimental animals conducted after the secon week of larval stage yielded histological sections similar to sections o *Triturus vulgaris*.

The second collection, which was done after the sixth week of larval lif brought about similar conclusion both in larvae from the control series an in larvae from the series reared in hormonal solutions. The sexual differentiation in *Triturus alpestris* did not occur yet, the gonads of larvae examine were small, sometimes more, sometimes less developed (Figs 7, 8, 9). Becaus the results in both hormones differed in a later period of larval life, they wil be dealt with separately.

a) Series reared in estradiol benzoate

The sexual differentiation in *Triturus alpestris* normally occurs at abou the tenth week of larval life and is usually completed before metamorphosis In the control series only in one animal an originating differentiation of gona to ovary could be observed in the 10th week. In other cases only undifferentiated gonads were found at a later stage. A typical case of undifferetiate gonad from a 10-week-old larva is depicted in Fig. 10. Macroscopically th gonads resemble thin white bands situated under the fat bodies.

In larvae reared in the estradiol benzoate solution a distinct sexual differentiation occurs as early as in the 10th week, namely in both hormona concentrations. Of the total number of 27 larvae 6 were females, 9 males 11 had undifferetiated gonads and one gonad was intersexual. At metamorphosis 18 animals consisted of 8 females, 4 males and 6 intersexual types i.e. at this time the gonads were fully differentiated. It is apparent from th survey given in Table 2, that the ratio of females to males and to intersexe was 2 : 2 : 1.

Anatomical and histological observations showed that the ovaries of females were normal. In their interior a central cavity was visible, which in som cases was completely filled up with oocytes situated in cortex.

Table 2

series	age	ovary	testes	undiffer-entiated	intersex	total
O 50	11 weeks	3	1	6	1	11
O 50	15 weeks	4	0	0	4	8
O 250	10 weeks	3	8	5	0	16
O 250	15 weeks	4	4	0	2	10
total		14	13	11	7	45

The testes of males had homogenous structure, contained gonia with clear, lumpy nuclei which were mostly inactive, but in some cases spermatogonia were dividing synchronously in some of the testicular zones. Fig. 11 depicts a characteristic histological section of urogenital system of a male from the series AG + O 250 which was killed at metamorphosis. The figure depicts besides two small gonads, heavily damaged kidneys, dilated kidney ducts, hypertrophic Wolffian duct (marked by arrows), to the left one glomerular capsule with many dark granula which form an almost compact mass. Such damages of kidneys elucidate the presence of edemas as well as the high mortality, observed in animals reared in the estradiol benzoate solution.

The gonads of intersexual types have a basic homogenous structure resembling testes and contain gonia which are in a premeiotic condition. Moreover, in the gonads there are primary oocytes inside the testicular tissue. A typical section is depicted in Figs 12 and 13. The section come from an animal 18 weeks old, from the series AL + O 50 whose gonad (to the left) has one oocyte in testicular tissue. In Fig. 12 also considerable dilatation of kidney ducts is visible which take the form of cavities 0.3 mm in diameter.

Estradiol benzoate also affects the development of Müllerian ducts. In control animals these ducts are already differentiated at metamorphosis and have the shape of white filaments and their inside diameter is about 20 μm. In animals reared in the given hormone these ducts are not discernible at metamorphosis.

b) Series reared in testosterone propionate

Testosterone propionate has a more fatal effect on the cultivated animals than estradiol benzoate. Animals of the species *Triturus alpestris* succumb in it soon and frequently and many edemas are found in them before death.

The sexual differentiation in newts reared in testosterone propionate is retarded. Although first cases of sexually differentiated animals are found as early as in the 10th week of larval life, the differentiation is not so advanced as in the preceding case. Of the 25 larvae 10 weeks old 5 were females, 1 male and 19 had undifferentiated gonads. At metamorphosis there were 5 females, 4 males, 3 intersexual types and 3 specimens with undifferentiated gonads among 15 animals examined. The beginning of sexual differentiation as well as the beginning of metamorphosis display a considerable dispersal. In Table 3 a quantitative survey of results is presented, showing that the ratio of females to males and to intersexual types is approximately 2 : 1 : 1. Ovaries could be macroscopically identified in females. In histological sections of their gonads primary oocytes of different size were found. Figs 14 and 15, depicting the section of an animal 10 weeks old from the series AB — T 50, show in ovaries primary oocytes surrounded by follicular cells; in Fig. 14 a hypertrophy of Müllerian ducts which are about 500 μm in diameter is outstanding. Another typical case is a female with relatively small ovaries containing a few oocytes in section (Fig. 16). The female came from the series AB + T 250 and was killed before metamorphosis. The Müllerian ducts are indiscernible, but the pathologically deformed kidneys with exceptionally dilated kidney ducts are visible.

The histological sections of male gonads have demonstrated that this is the case of testicular tissue. Fig. 17 represents a section of male from the series AL + T 50, showing well developed testes as well as fat bodies. The larger gonad of this male has a secondary genital cavity. Fig. 18 represents a part of the larger gonad of this newt killed before metamorphosis. The interstitial cells, which are typical elements of stroma, have oval compact nuclei; the nuclei of spermatogonia with dispersed dusty chromatin are inactive.

Table 3

series	age	ovary	testes	undiffer-entiated	intersex	total
T 50	10 weeks	3	1	17	0	21
T 50	15—17 weeks	3	4	3	3	13
T 250	10 weeks	2	0	2	0	4
T 250	15—17 weeks	2	0	0	0	2
total		10	5	22	3	**40**

The example of gonads of intersexual animals can be seen in Fig. 19a It is a section of animal from the series AL + T 50, 26 weeks old. Testi (to the right), primary oocytes with lamp-brush chromosomes inside testicular tissue (to the left). Fig. 20 illustrates an enlargment of the histologica section of this gonad. Beside spermatogonia there are 2 primary oocytes The figure shows that the animal has a considerably hypertrophic Wollfian ducts with inside diameter of 200 μm; also its kidney ducts are considerably dilated.

DISCUSSION AND CONCLUSION

Triturus vulgaris

The life span of all experimental series reared in solutions of estradiol benzoate and testosterone propionate was not more than 10 weeks, average life span varied around 4 weeks.

Triturus vulgaris is not too sensitive to the difference in concentrations of applied hormones. A higher concentration has an equally fatal effect as a lower concentration, it induces only slightly increased mortality. This animal, however, is very sensitive to the removal of the membranes from the eggs. Animals reared from eggs with removed membranes succumb faster than those reared from intact eggs and do not live longer than 6 weeks

Triturus vulgaris is more sensitive to testosterone propionate than to estradiol benzoate. In early stages, i.e. in the first four weeks of larval life *the mortality in both hormones is nearly equal, but in subsequent four* weeks the series reared in the testosterone propionate solution die out, while the series reared in the estradiol benzoate solution survive.

In both hormones most dead animals have large edemas, particularly since the fourth week onwards. It may be concluded that both hormones have a toxic effect on larvae of *Tritutus vulgaris* and that testosterone propionate has more pronounced lethal effects. These conclusions correspond with the observations made under analogous conditions by Collenot

1965) while studying *Triturus helveticus*, which is closely related with the species studied.

The average course in experimental series shows that the number of deaths is the highest in the first four weeks of larval life; in the fifth week only about 15% of the initial number of animals survive after hormonal treatment. In the subsequent weeks the number of animals linearly diminishes to zero in the tenth week of larval life.

According to Collenot's table of *Triturus helveticus*, the sexual differentiation of this species, if compared with *Triturus alpestris*, has a relatively fast course and is practically completed in the 7th week. Our results obtained in studying *Triturus vulgaris* are similar. The histological studies of larvae from the control series VK revealed a distinct ovary with several oocytes in a section of a 6-week-old larva. In all larvae from the control series which were histologically investigated and which were 6—10 weeks old, distinct ovaries were found, mostly filled out with embryonic connective tissue and containing primary oocytes of different size. The largest oocyte was 50 μm in diameter. Identical results were obtained in all histologically investigated larvae from experimental series. A total of 26 animals were studied and in all of them well developed ovaries were found both in larvae treated with estradiol benzoate and larvae treated with testosterone propionate. In the latter case ovaries were less developed on an average than in the former case. From the qualitative aspect these observations correspond with the results achieved in *Triturus helveticus* by Collenot who obtained a complete feminization of genetically male gonads while rearing *Triturus helveticus* in different concentrations of both hormones. With estradiol benzoate, according to Collenot a normal effect is achieved similarly as in the case of experiments conducted by Burns (1938) with *Ambystoma punctatum*, by Gallien (1950 a, 1954) with *Pleurodeles waltlii* and by Asayama & Miyamori (1957) with *Hynobius nebulosus*. After Collenot a total feminization in animals reared in testosterone propionate gives evidence of paradoxical effect. Similar results were obtained by Gallien (1950 b, 1954) in *Pleurodeles waltlii*, by Foote (1940, 1941) in *Ambystoma maculatum*, *A. tigrinum*, *A. opacum*, by Mintz (1947) in *Ambystoma mexicanum*, by Asayama & Matsuzaki (1958) in *Triturus pyrrhogaster*, by Chieffi (1962) in *Triturus cristatus carnifex*, by Hanaoka (1941) in *Hynobius retardatus* and by Pisano (1951) in *Triturus cristatus*.

Also in our case exclusively females were found in experimental series, both in testosterone propionate and estradiol benzoate, but the fact that also in the control series only females were found does not allow us to anticipate a total feminization. It is quite possible that by random selection of specimens from the control series only females were collected, but it may be also supposed that males are far more sensitive to laboratory rearing conditions than females and that they succumb earlier. Further results obtained by investigating urogenital system correspond with the results obtained by Collenot. In animals reared in the estradiol benzoate solution dilated kidney ducts are found. Pathological changes in kidneys are apparently the cause of frequent edemas and subsequent death. In animals reared in the testosterone propionate solution the pathogenic effects are more marked. This hormone induces inhibition and pathogenic phenomena in tissues coming from nephritic blastema and has a toxic effect on them. Collenot also observed such pathogenic phenomena caused by testosterone propionate even in cases when this hormone was administered in the concentration 10γ/litre.

Due to the exceptionally high mortality of larvae of *Triturus vulgaris* and because they succumbed in a relatively short time it is dificult to estimate the influence of the total period of hormonal treatment and especially its beginning upon their development. The fifth week since the application of hormones has been started marks the survival of 0% of animals in the series VG, of 25% in the series VN, of 37% in the series VP and of 27% in the series VL. It may be concluded that the lethal effects of hormones are the greater the earlier the hormone is applied. No influence of the beginning of hormonal treatment upon the development of urogenital system of *Triturus vulgaris* has been shown in histologic sections. Certain variations in the development of organs can be also observed in specimens from the control series and the variations in histological preparations in experimental animals, completely correspond with the variations in control animals.

Triturus alpestris

About 55% animals from the initial number would have lived till matemorphosis in the control series if no collection would have been done. This value fully corresponds with Collenot's data (1965), while in the experimental series our results are different. If the animals had not been collected, about 25% animals would have lived till metamorphosis, while Collenot reports 50—60%.

It is possible that some difference resulted from the fact that in our case we started to apply the hormones in earlier stages of development. It may be gathered that the development of *Triturus alpestris* is influenced by the given hormone and that both hormones have toxic effects, although less marked than in *Triturus vulgaris*. A detailed analysis shows that the series reared in both concentrations of the two hormones behave till the fifth week almost similarly as the control series, thereafter the number of animals in the experimental series begins to diminish, the decrease being faster in higher concentration. In the series coming from the eggs with removed membranes the high mortality is manifested in the first two weeks after the hormones started to be applied. Larvae of *Triturus alpestris* are more sensitive to testosterone propionate than to estradiol benzoate. Until the 8th week the experimental series in both hormones develop similarly, but thereafter a higher mortality occurs in the series reared in testosterone propionate.

External symptoms on dead animals are similar to those found in *Triturus vulgaris*, they are frequent edemas which appear in about the fourth week. The animals which died in the period around metamorphosis have distinct edemas on neck, extremities and tail. These symptoms fully correspond with Collenot's observations.

A detailed survey on the conditions of individual series prior to metamorphosis, i.e. till 15th week, is given in Table 1.

It should be noted that out of the 28 experimental series 16 series amounting to 79 animals survived till this period. Of these 16 series 11were reared in estradiol benzoate and 5 in testosterone propionate. From the total number of 16 series in 12 of them were animals coming from intact eggs and only in 4 from eggs which had their membranes removed. From the total number 79 animals which survived till 15th week, i.e. till normal metamorphosis only 40 underwent metamorphosis, but none which came from eggs with removed membranes. The Table also shows that the available material does not provide sufficient basis for the estimation of the influence of early application of sexual hormones upon sexual differentiation or sexual inversion. Our experiments do not allow us to presume anything about the relationship of sexual hormones to sexual inductors of cortex and medulla of primitive gonad.

Animals reared in the estradiol benzoate solution develop till the stage of metamorphosis somewhat longer than in normal case. The earliest metamorphosis occurs in the 16th week of larval life, but many larvae undergo metamorphosis as late as in the 22nd week. The stage of metamorphosis, as a rule, sets in later in larvae kept in a higher concentrations of this hormone. A relatively high percentage of animals succumb at metamorphosis, the cause of death being kidney damage manifested externally in edemas on neck, extremities and tail. The distinct sexual differentiation occurs as early as in the 10th week of larval life in both hormonal concentrations used. Of the total number 27 larvae aged 10 weeks there were 6 females, 9 males, 11 undifferentiated specimens and 1 intersex. At metamorphosis out of 18 experimental animals 8 were females, 4 males and 6 intersexual animals. The results obtained are in full harmony with Collenot's conclusions. Besides males and females intersexual types appear. At metamorphosis the gonads are differentiated. While in this study the ratio of females to males and to intersexes was found to be 2 : 2 : 1, the ratio found by Collenot was 2 : 0 . 5 : 0 . 2, i.e. a clear predominance of females. Even if we supposed that all undifferentiated gonads found in 10-week-old larvae would differentiate in ovaries, the predominance of females over other types would not be so big as that found by Collenot.

The anatomical and histological observations reveal that the female ovaries are normal. In their interior we see the central cavity which is in some cases filled out with oocytes situated in cortex. The male testes have a homogenous structure, contain gonia with clear lumpy nuclei. The nuclei are mostly inactive, but in some cases synchronous division of spermatogonia are to be seen in some of the testicular zones. The gonads of intersexual types have a basic homogenous structure similar to testes and contain gonia which are in one of premeiotic conditions. Apart from this, primary oocytes occur inside the testicular tissue in gonads. Apparently this is the case of partly feminized males.

Besides its influence on metamorphosis, sexual differentiation and its damaging effect on kidneys estradiol benzoate also affects the development of secondary sexual characters, particularly the development of Müllerian ducts. In control animals at metamorphosis these ducts are already differentiated, have the shape of white filaments and their inside diameter is about 20 μm. In animals reared in estradiol benzoate these ducts are not yet visible at metamorphosis. This finding is similar to that made by Collenot who states that estradiol benzoate inhibits a full or partial differentiation of Müllerian ducts.

Testosterone propionate has a more fatal effect on reared animals than estradiol benzoate. Its pathogenic effects are quite clear. The animals succumb in it earlier and more often. A higher concentration of this hormone ha a more fatal effect than the lower concentration.

Only 5 experimental series out of 14 reached metamorphosis, i.e. the 15t week od larval life. Metamorphosis started somewhat sooner, some of th newts underwent metamorphosis as early as in the 14th week, but in man cases the metamorphosis occurred later, even as late as in the 24th week Only animals reared in a lower concentration of testosterone propionat underwent metamorphosis and shortly afterwards most of them succumbed These animals had strong edemas on neck, extremities and tail.

The data obtained with this hormone differ considerably from Collenot results. The latter states that about 75% of animals reach metamorphosis whereas in our case it would be about 20% if no collection vere made Collenot does not mention the considerably prolonged period in whic metamorphosis occurs. The greatest difference from his observations is th occurrence of intersexual animals in our study.

The sexual differentiation in newts reared in testosterone propionate i retarded. Although the first cases of sexually differentiated animals can b found as early as in the 10th week of larval life, the differentiation is no so advanced as in estradiol benzoate. Of the 25 larvae aged 10 weeks 5 wer females, 1 male and 19 specimens had undifferentiated gonads. At metamorphosis there were 5 females, 4 males, 3 intersexes and 3 specimens wit undifferentiated gonads among 15 animals investigated. The differentiatio is apparently not completed in all animals in this stage.

Collenot reared *Triturus alpestris* in three concentrations of testosteron propionate: 50γ/litre, 100γ/litre and 500γ/litre. The difference in his result with various concentrations is very small, in our case also the quantitativ dependence upon concentration is not marked. Our results, however, considerably differ, both qualitatively and quantitatively, from Collenot' results. He records a large number of undifferentiated gonads and the remaining animals are females. The present study revealed also males and intersexual specimens among experimental animals in quite considerable numbers The ratio between females, males, intersexes and types with undifferentiate gonads was 2 : 1 : 1 : 1, while Collenot reports 3 : 0 : 0 : 5.

In females the ovaries could be identified macroscopically. The surfac of ovary is distinctly granulated, in histological sections of ovaries primar oocytes of various size are found. In other animals the gonads could no be macroscopically classified, they appeared as fine bands deposited beneat fat bodies. In some cases they were reduced to filaments. Anatomical observations were always complemented by histological study. In cross sectio the undifferentiated gonad appears as a small lobe attached to fat body b the stem of mesentery. The lobe is primarily composed of connective tissu in which a small number of primordial gonocytes is to be found. Since th gonads are small, it is difficult to determine whether these are cortical o medullary gonocytes. Intersexual gonads show identical structure wit intersexual gonads of animals reared in estradiol benzoate. Their characte also indicates that this is the case of partly feminized males, i.e. paradoxic effect of hormone.

Testosterone propionate induces considerable damages of mesonephro which can also be observed macroscopically as swellings and even disruptio of tissue, and strongly influences the differentiation and development

Müllerian ducts. At metamorphosis these ducts show strong hypertrophy, are expanded along their length, mostly in the region of gonad and towards cloaca. In some preparations from the stage of metamorphosis a considerable hypertrophy of Wolffian ducts, which are very small in control animals, is also to be seen.

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The plates with figures will be found at the end of this issue.

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RECENSE — REVIEWS

O. Kuhn (1967): Amphibien und Reptilien. Katalog der Subfamilien und **höher Taxa** mit Nachweis **der ersten Auftretens.** Gustav Fischer Verlag-Stuttgart. — 124 stran, cena DM 44.—

Prioritní pravidla platí pro nadčeledi, čeledi, podčeledi a triby a nověji jsou požadována i pro vyšší systematické kategorie. Přesto chybí i v nových základních herpetologických dílech citace jmen autorů, kteří tyto jednotky stanovili. Prof. Kuhn začal tudíž shromažďovati názvy těchto taxonů a jména autorů, kteří je stanovili. Vypisoval i jednotlivé odchylky od správných názvů, v herpetologii a palaeoherpetologii.

Na str. 1—10 podává přehled názorů na vývoj systému obojživelníků a plazů od Linnéa po recentní návrh Mertensa a Wermutha. Na str. 11—41 je přehled názvů podčeledí a čeledí obojživeelníků jak recentních, tak fosilních, při čemž validní názvy a všechny názvy vyšších taxonomických kategorií jsou tištěny kursivou, názvy skupin známých jen jako fosilních jsou označeny +. Od str. 42—122 pokračuje tento přehled pro třídu plazů. Práce je zakončena dovětkem Dr. H. Wermutha, týkajícím se pravidel k vytváření jmen pro čeledi (resp. nadčeledi, podčeledi, triby), na str. 123—124.

Katalog je nesmírně cennou studií, která nás seznamuje nejen s autory a roky popisů (a samozřejmě i pramenem, kde byl popis uveřejněn) jednotlivých výše zmíněných kategorií, ale dává i přehled o vývoji názorů na herpetologický systém. O časových nárocích na podobné studie dává zčásti představu nutnost excerpce okolo 5000 literárních pramenů, jak udává prof. Kuhn v úvodu. I když pochopitelně podobné studium ukázalo, že řada jmen je vůbec nomenklatoricky neplatných, jiné názvy již vžité musí být podle Kuhna nahrazeny novými (na př. +Amphicoela Noble (1924 ?) 1931 je preokupováno názvem Amphiocelia Owen 1860, proto Kuhn 1967 navrhuje pro tento podřád název Archaeococela atd.) čímž mohou vzniknout určité obtíže, práce Kuhnova je vyjímečně záslužným přínosem pro stabilitu nomenklatury ve dvou třídách obratlovců a bylo by si jen přáti, aby tato činnost nalezla následovníky i pro jiné skupiny.

O. Oliva

Beiträge zur Neotropischen Fauna. Begründet 1956 von E. Titschack und H.—W. Koepcke. Herausgegeben von W. E. Ankel, Giessen und Santa Marta, J. Illies, Schlitz, **E. F. Kilian,** Giessen und Valdivia, H. W. Koepcke, Lima, E. Marcus, Sao Paulo und L. Szidat, Buenos Aires. Redakce: J. Illies und H. W. Koepcke.

Až dosud vyšlo (1967) 5 svazků, svazek I. byl tvořen 4 sešity a vycházel od r. 1956—59 svazek II. tvořily rovněž 4 sešity a vycházel od r. 1960—1962. Svazek III. vyšel v letech 1963—1964, skládaly jej rovněž 3 sešity, svazek IV. v letech 1964—1965, složený ze 3 sešitů, svazek V. v r. 1967, máme k dispozici sešit 2. Jeho obsahem (str. 71—132) je práce V. Sadowskyho o litorálních žralocích z okolí Sao Paulo v Brazilii, dále do něj přispěli W. Sattler studií o biologii netropických larev jepic (Emphemeroptera, Polymitarcidae), Jay M. Savage a R. W. Heyer o proměnlivosti a rozšíření rosniček rodu Phyllomedusa, D. St. Quentin o rodu Gomphoides Selys (Odonata) v neotropické oblasti. Časopis je určen pro publikování originálních faunistických i systematických prací a monografií, pokud se týkají neotropické oblasti. Práce jsou publikovány německy, anglicky, španělsky nebo portugalsky.
Cena 2. sešitu V. svazku (84 stran, 29 obr.) činí 32 DM, pro předplatitele celé serie DM 28.—
Vydává Gustav Fischer Verlag, Stuttgart.

O. Oliva

Mac Arthur R. H. and E. O. Wilson: The Theory of Island Biogeography. Monographs in Population Biology 1, Princeton University Press, Princeton, 203 pp., 60 figs., 1967. Price $ 3.95.

Biogeography has long remained an empirical science, accumulating information about the distribution of taxa and the taxonomic composition of biotas, and aiming to solve special problems, particularly those connected with past distributional histories of taxa and major changes in the composition of biotas. Most of the research has been taxonomic in origin, related to special taxa, special times or special places, and no general quantitative theory has been developed, mainly because of the complexity of the basic biological processes (such as dispersal invasion, competition, adaptation and extinction) influencing the distributional patterns.

The authors of the reviewed book, one an ecologist, the other a taxonomist and zoogeographer, felt that it was already possible to make an attempt at formulating a general theory o biogeography at the species level, to correlate it with the population theory of distribution and genetics of populations, and to describe the basic rules by mathematical models The islands were chosen first since their multiplicity and variation provide a good testing ground for evolutionary hypotheses, and since island biotas are much simpler and more comprehensible than the continental and oceanic ones

The authors begin with a consideration of relation between the area and number of species, and develop an extensive model of the equilibrium of species, discussing not only the basic concept of equilibrium, but also saturation and turnover in species on a single island, methods of measurement of colonization rates and turnover, calculation of the shape of the immigration curve based on faunal differences among islands, etc Next the influence of life table parameters of individual organisms on the immigration and extinction rates of populations are considered, an elaborate survivorship model is presented, situations preventing the colonist from successful invasion are discussed, and the whole "strategy of colonization" is described The role of stepping stones in dispersal and exchange of species is then analyzed, and the evolutionary changes following colonization (such as the modes of natural selection, the founder effect, adaptation to a new environment, displacement and convergence of competing species, speciation and radiation, etc) are considered A glossary of terms and a list of references are added

Such treatment of a biogeographical subject is certainly unorthodox In the authors own words " biogeography appears to us to have developed to the extent that it can be reformulated in terms of the first principles of population ecology and genetics In order to achieve this restatement, it might be necessary to deemphasize for the moment the traditional problems concerning the distribution of higher taxa and the role of geological change in the determination of their distribution and to turn instead to detailed studies of selected species " The traditional biogeographer will probably be frustrated by the amount of mathematical argument involved in development of a general theory (and by suggestions for experimental manipulation of island biotas as well) However, the purely theoretical mathematical chapters are in balance with those providing empirical evidence for the authors' conclusions, so that the book is well comprehensible even for a more traditional taxonomist or biogeographer who is not familiar with mathematical expression of the population theory. This pioneer study may become a landmark in the history of biogeography by its interdisciplinary approach, introduction of suitable quantitative models and an emphasis on interpretative reasoning and prediction.

P Štys

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ
ročník XXXIV

Vydává Čs. společnost zoologická v Academii, nakladatelství ČSAV, Vodičkova 40,
Praha 1 - Nové Město, dod. pú. 1.
Tiskne Státní tiskárna, n. p., závod 4, Praha 10 - Vršovice, Sámova 12, dod. pú. 101.
ozšiřuje Poštovní novinová služba *Objednávky a předplatné PNS* — ústřední expedice tisku
dministrace odborného tisku Jindřišská 14, Praha 1. Lze také objednat u každé pošty nebo
doručovatele.
Cena jednoho výtisku 10 Kčs, v předplacení (4 čísla ročně) 40 Kčs, $ 5,60, £ 2,6,10
Toto číslo vyšlo v květnu 1970.

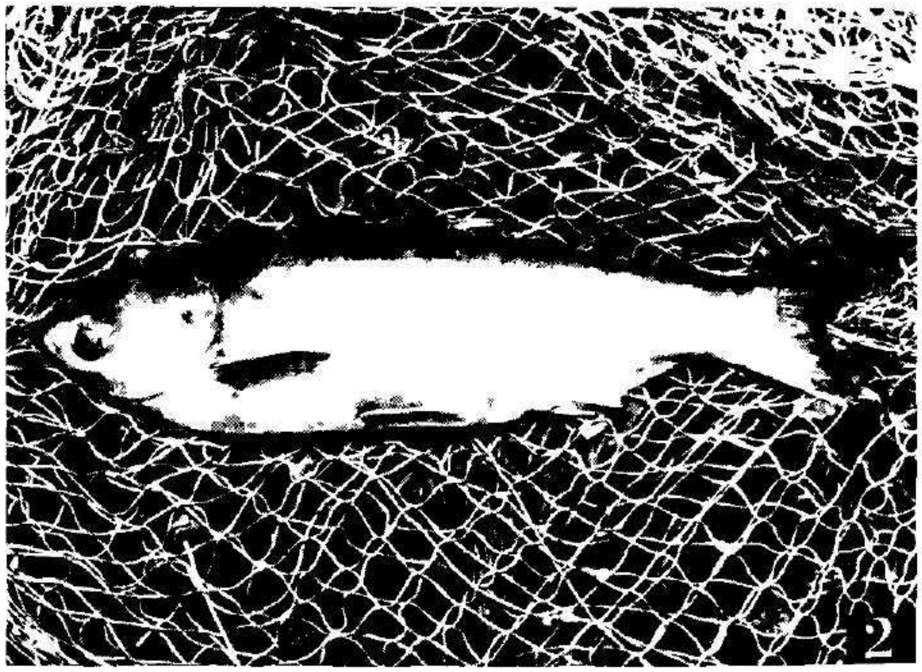

Photo 1: Part of the Danube river where the silver carp was caught
Photo 2. Silver carp from the Danube river — general view

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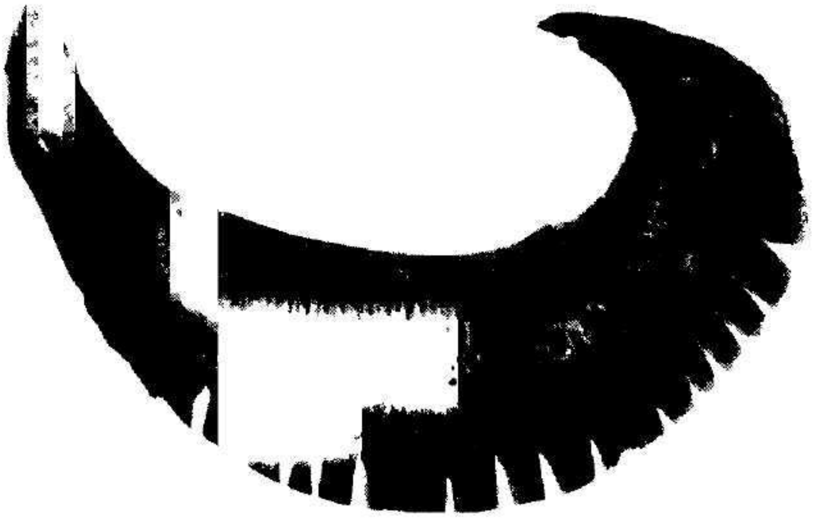

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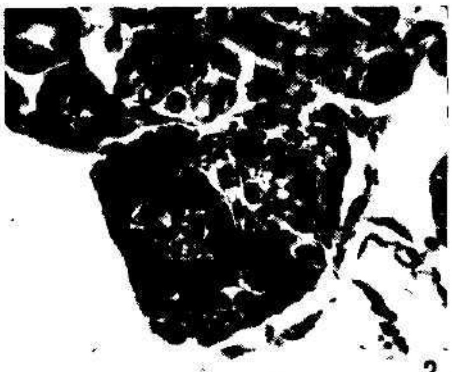
Photo 3: The scale of silver carp from the Danube river
Photo 4: The left branchial arch of silver carp

Úlehlová L., F. Sládeček: Effects of estradiol **benzoate and testosterone propionate on sexual** differentiation in Triturus vulgaris and Triturus alpestris.

Plate I.


1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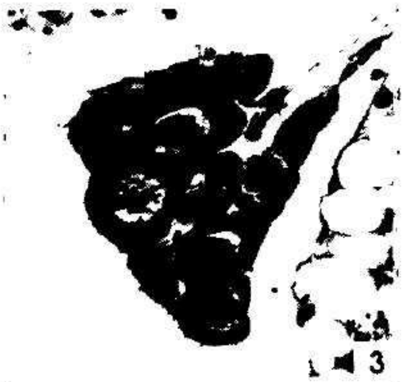
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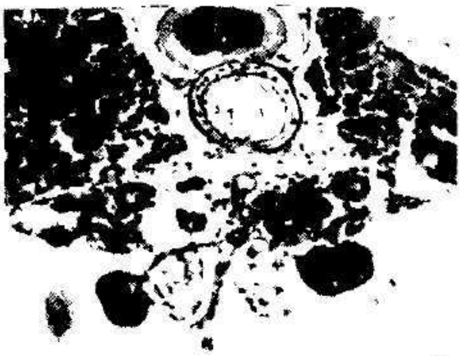
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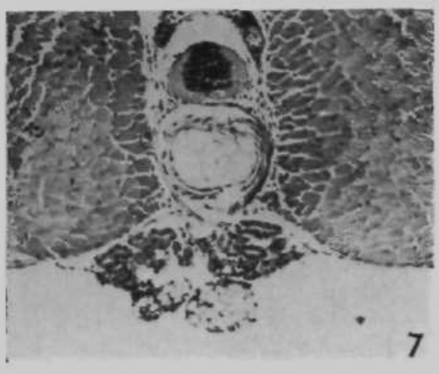
Abbreviations: T. v. = *Triturus vulgaris*
T. a. = *Triturus alpestris*
OB = estradiol benzoate
TP = testosterone propionate

Fig. 1 T. v. control, 6 weeks, ♀; Fig. 2 T. v. control, 7 weeks, ♀; Fig. 3 T. v. control, 9 weeks, ♀ Fig. 4 T. v. control, 10 weeks, ♀; Fig. 5 T. v. OB 250, 6 weeks, ♀; Fig. 6 T. v. TP 50, 6 weeks, *Úlehlová L., F. Sládeček:* Effects of estradiol benzoate and testosterone propionate on sexual differentiation in Triturus vulgaris and Triturus alpestris

Plate II.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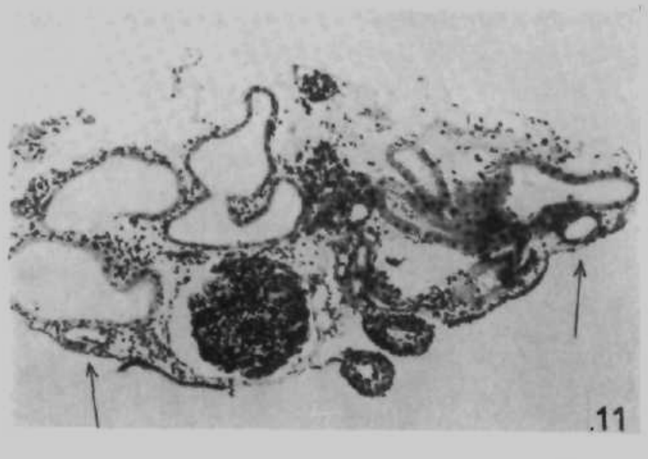
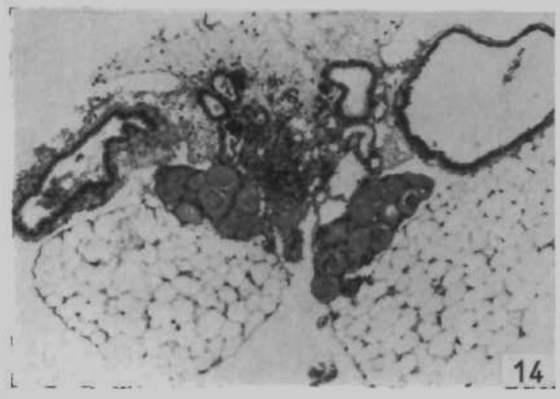

.11

Fig. 7 T. a. control, 6 weeks, undifferentiated gonads; Fig. 8 T. a. OB 50, 6 weeks, undifferentiated gonads; Fig. 9 T. a. OB 50, 6 weeks, undifferentiated gonads; Fig. 10 T. a. control, 10 weeks, undifferentiated gonad; Fig. 11 T. a. OB 250, metamorphosis, ♂, arrows mark hypertrophic Wolffian ducts.

Úlehlová L., F. Sládeček: Effects of estradiol benzoate and testosterone propionate on sexual differentiation in Triturus vulgaris and Triturus alpestris

Plate III.


12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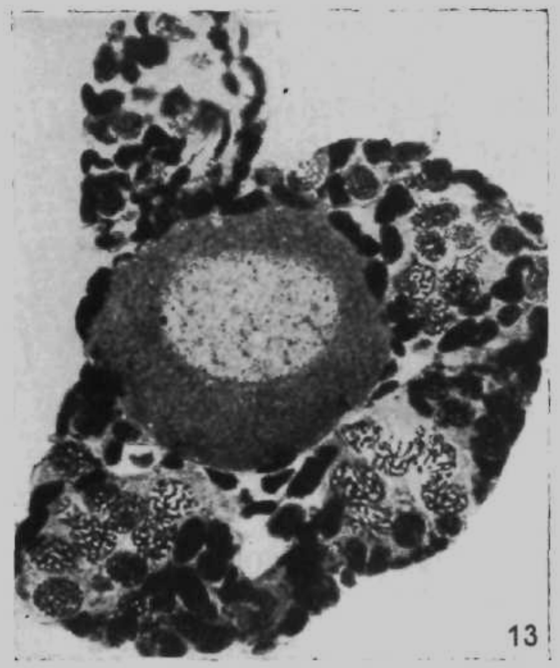
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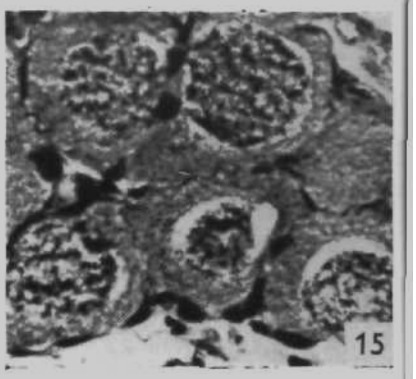
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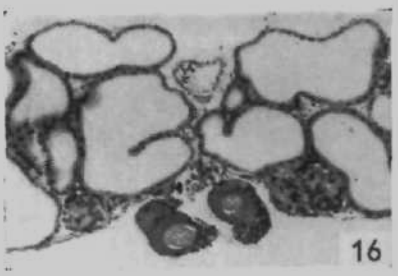
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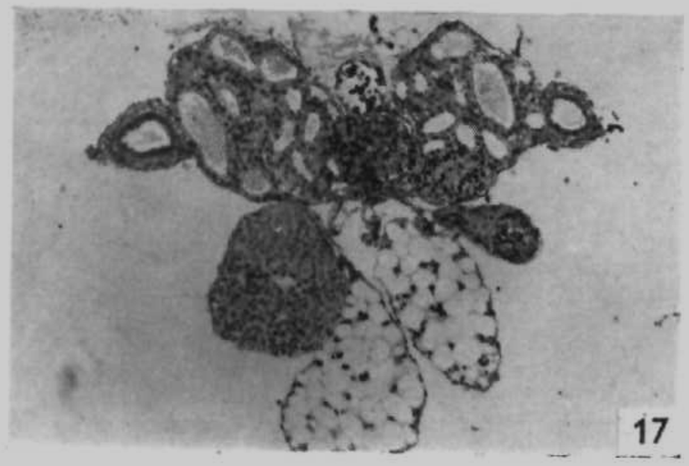
Fig. 12 T. a. OB 50, 18 weeks, ♂; Fig. 13 T. a. OB 50, 18 weeks, ♂; Fig. 14 T. a. TP 50, 10 weeks, ♀; Fig. 15 T. a. TP 50, 10 weeks, ♀; Fig. 16 T. a. TP 250, before metamorphosis, ♀.

Úlehlová L., F. Sládeček: Effects of estradiol benzoate and testosterone propionate on sexual differentiation in Triturus vulgaris and Triturus alpestris

Plate IV.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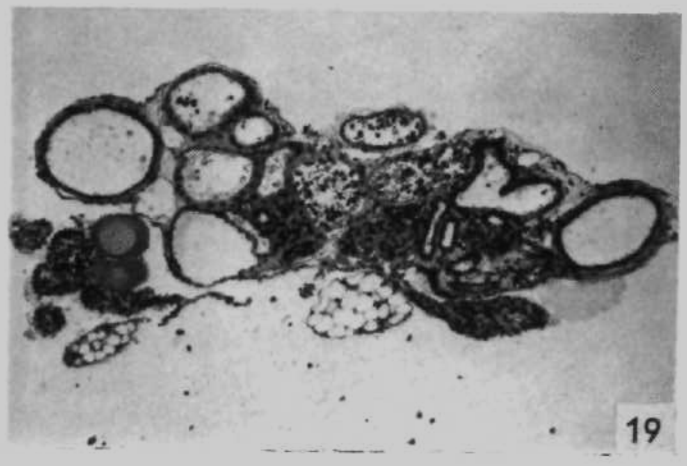
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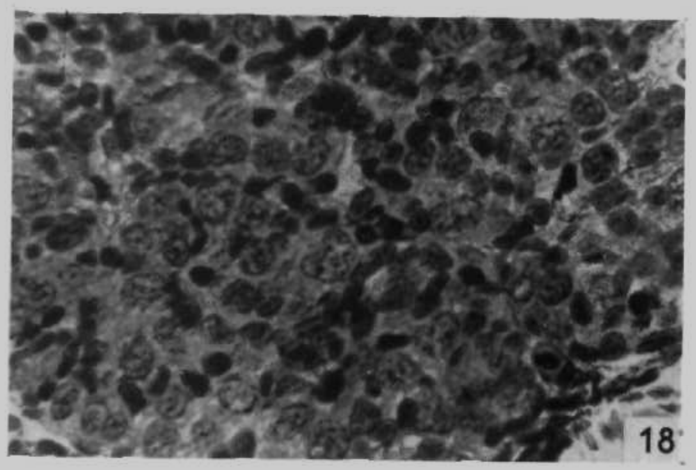
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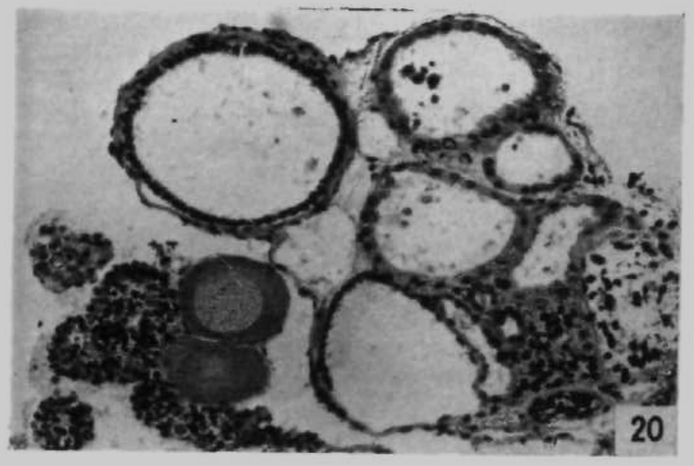
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Coulter G. W. 1970

Gill-net selection of Lates mariae Stdr. (nile perch) in Lake Tanganyika.

Věst. Čs. spol. zool. **34** : 81—89

Dalela R. C., P. C. Garg 1970

Studies on the endoskeleton of Ompok bimaculatus (Bloch). Part I — The skull.

Věst. Čs. spol. zool. **34** : 90—106

Holčík J., O. Pár 1970

First record of the Silver Carp — Hypophthalmichthys molitrix (Valenciennes, 1844) in the Danube river.

Věst. Čs. spol. zool. **34** : 107—109

Laupy M. 1970

Zur Kenntnis der Bodenfauna zweier Teiche im Blatná-Gebiet.

Věst. Čs. spol. zool. **34** 110—120

Nalbant T., J. Holčík, K. Pivnička 1970

A new Loach, Cobitis granoei olivai ssp. n., from Mongolia, with some remarks on the Cobitis elongata-bilseli-macrostigma group (Pisces, Ostariophysi, Cobitidae).

Věst. Čs. spol. zool. **34** : 121—128

Sriwastwa V. M. S. 1970

Functional anatomy of digestive organs of a fresh-water fish Rhynchobdella aculeata (Ham.). Part I A Morphology

Věst. Čs. spol. zool. **34** : 129—135

Sriwastwa V. M. S. 1970

Functional anatomy of digestive organs of a fresh-water fish Rhyncho bdella aculeata (Ham.). Part I B Histology.

Věst. Čs. spol. zool. **34** : 136—142

Úlehlová L., F. Sládeček 1970

Effects of estradiol benzoate and testosterone propionate on sexual differentiation in Triturus vulgaris and Triturus alpestris.

Věst. Čs. spol. zool. **34** : 153—156

Holčik J., O, Pár: First record of the Silver Carp — Hypophthalmichthys molitrix (Valenciennes, 1844)

3

4

Nalbant T.,J. Holčík, Pivnička K: A new Loach, Cobitis **granoei** olivai, ssp. n., from Mongolia, with some remarks on the Cobitis elongata-bilseli-macrostigma group (Pisces, Ostariophysi, *Cobitidae*)

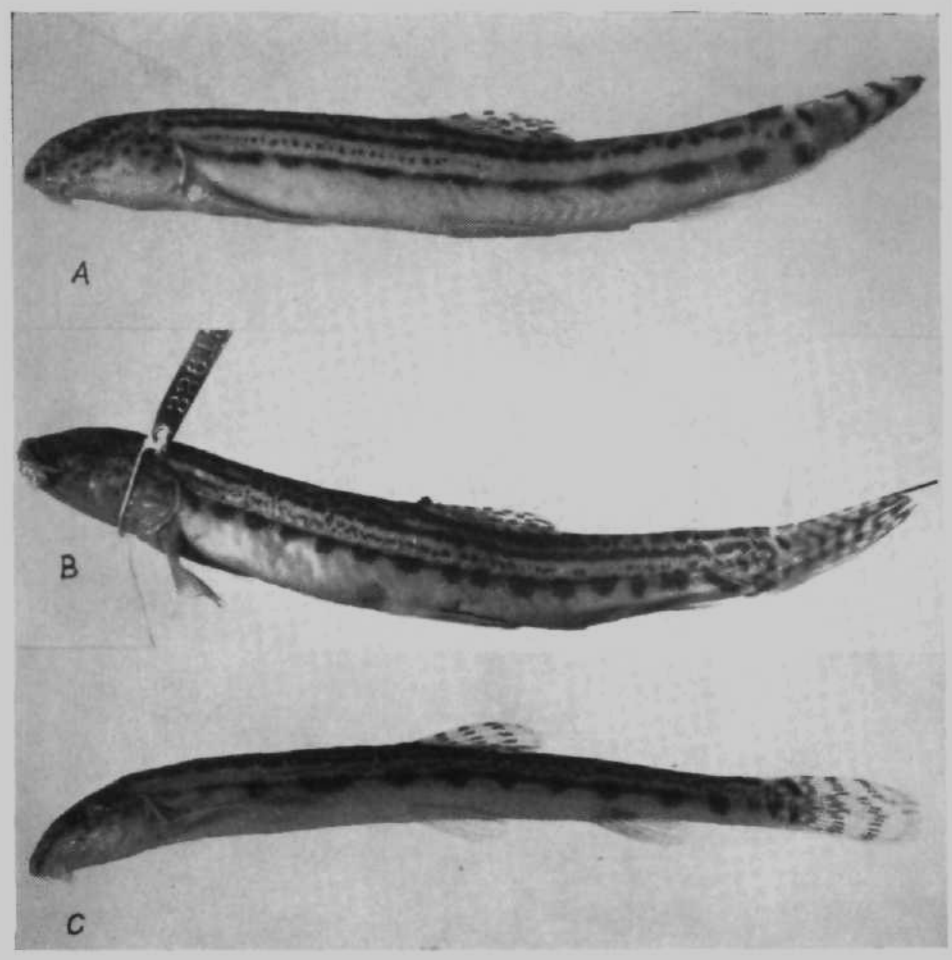

Fig. 1A — male of *Cobitis dolichorhynchus* Nichols, SU 32613, Fung-Hwa River, Ningpo, Chekiang province, China, B — female of the same species, same locality and data. Photo from the archives of the Academy R. S. R., Bucarest. C — *Cobitis granoei olivai* new subspecies. Holotype, male, SNM RY-2093. Photo by J. Holčík.