

Comparative Study Of Swim Bladder In Some Siluroids Fishes

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Abstract: The present study focuses on the structural differences of swim bladder between some fishes of order Siluriformes. Four fishes from the family Schilbeidae two from family Bagridae, two from siluridae and one from Sisoridae were taken up observation. A collective information of the swim bladder and their differences between closely related families would be useful for taxonomic correlation and position in further studies. Remarkable differences of the swim bladder were found between the same families described here, though their habitat and feeding behaviour were same. Although the swim bladder was almost similar in *Ompok bimaculatus* and *Wallago attu*, in *Mystus cavasius* it bears two horn like projections on its anterior corners and in *Rita rita* of the same family Bagaridae two tube like outgrowths or diverticulum run downwards from the posterior corners of the swim bladder. The swim bladder species of the family Sisoridae *Laguvia ribeiroi ribeiroi* was bilobed, situated in two lateral cavities. The four species of the family schilbeidae showed much differences in the structure of organ concerned. It was interesting to note that in some species the swim bladder was greatly reduced whereas in *Pseudeutropius aetherinoids* it was developed and resembled the swim bladder of *Ompok* and although they were kept in different families.

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Introduction

The swim bladder or air bladder or gas bladder, one of the most characteristic organs of fishes is a hollow, oval shaped sac, situated in the abdominal cavity, below the vertebral column between the alimentary tract and kidneys.

The swim bladder acquires a glistening silvery shine and lies either free in the abdominal cavity or sometimes remain attached most intimately by firm and short tissues to the vertebral column, the walls of the abdomen and the intestine. It may be single chambered with a common lumen inside or it may be double chambered with a simple constriction. In many Siluroids it is more or less completely enclosed in osseous capsule formed by the vertebrae.

In many species of fish, the swim bladder remains connected to the gut and the fish can use this connection to control the amount of gas in the swim bladder, this is known as physostomous or open type swim bladder. These fish mostly live in shallow waters and swallow air at the surface of water. This air is then passed into the gut and then into the swim bladder.

In other species the connection with the gut is closed and no gas can be passed from the gut to the swim bladder, this is called the closed type or physoclistous swim bladder. These fish are able to

control the amount of gas in their swim bladder by means of one or more areas where the membrane is very thin and richly supplied with capillaries. These areas facilitate the gas exchange through the capillaries and the membrane by the formation of a gas secreting complex which comprises of a glandular secretory epithelium – the gas gland and rete mirabile i.e a bundle of close lying arterial and venous capillaries that diffuse gases between one another. The swim bladder helps the fish to attain neutral buoyancy, i.e. the ability to use little or no energy to stay at particular levels of water through the expansion (inflation) and contraction (deflation) of the swim bladder due to varying gas pressures (Schmidt and Nielson, 1997). The volume of the swim bladder is controlled by the expansion and contraction of muscles (Eissele, 1922).

The occurrence of swim bladder in Teleosteans is very irregular and shows some extra-ordinary modifications in its shape, size and location in the fish. The organ is unique and versatile owing to its variable structure and functionality and hence is a reason of attention from the past and even the present research is an approach to reveal the mysteries of its morphological diversity.

Woodland (1911, 1913) investigated the structure of the gas gland and rete mirabilia (rete mirabile) associated with the swim bladder in some teleostean fishes. He also presented notes on the structure and mode of action of the 'oval' in the Pollack (*Gadus pollachius*) and mullet (*Mugil chelo*) respectively. Scholander (1956) made observations on the gas gland in living fish. Dehadrai (1957) studied the swim bladder of mugilidae. Fahlen (1959) gave an account of the rete mirabile in the swim bladder of *Coregonus lavaretus*. Wittenberg *et al* (1964) have studied the unique structure of the gas secreting complex in the swim bladder of the bluefish, *Pomatomus saltatrix*. Jasinski (1965) reported the vascularization of the swim bladder in fishes, such as *Acipenser stellatus*, *Thymallus thymallus*, *Esox lucius* and *Umbra krameri*.

The relationship of shape and size of the swim bladder with the taxonomy or systematic position of the fish has been observed by Marshall (1960) in deep sea fishes, Greenwood (1963) in African Notopteridae, Ahmad (1971) in certain Sciaenoid fishes, Evans (1975) in four species of Western Atlantic *Peristedion*, Sujatha and Dutt (1985) in Sillaginidae, Hemalatha and Rajkumar (1996) in Cypriniformes.

The subject of swim bladder morphology and its correlation with the weberian ossicles and inner ear or auditory organ has been taken up by Starks (1908), Evans (1925,1930), Nelson (1949), Srivastava (1956), Karandikar and Masurekar (1954), O'connell (1955), Nayak and Bal (1955), Dehadrai (1957, 1959), Sinha (1962), Jasinski (1964), Mahajan (1967), Dixit and Sharma (1970), Allen *et. al.* (1976), Laming and Morrow (1981), Barimo and Fine (1998). The morphological aspect of the swim bladder has been a subject of attention from the very beginning. Some of the major contributions in this field are by:

Morris (1985), Kerr (1908), and Tracy (1911) presented a preliminary statement on the morphology of the swim bladder in teleosts. Hora (1920) threw light on the modifications of swim bladder in hillstream fishes. Ballantyne (1927), Evans (1929), Goodrich (1930), Trewavas (1933), Hora (1937), Fange (1945), Jones and Marshall (1953) are the earliest contributors to the field of swim bladder morphology. Other important contributions are those of Srivastava (1956) in *Hilsa ilisha* and *Gadusia chapra*; Fange (1958) in *Argentina silus*; Fange and Wittenberg (1958) in *Opsanus tau*; Walters (1960) in *Velifer hypselopterus*; Dehadrai (1960) in *Ilisha indica*; Nelson (1961 a, b) in Catastomidae and Serrasalminae respectively; Saxena and Kumar (1963) in *Mystus seenghala*; Nielson and Munk (1964) in a deep sea fish, *Bassogigas profundissimus*; Jullano and Santos (1965) in Labyrinth fishes; Capen (1967) in mesopelagic fishes; Fahlen (1967 a,b) in *Coregonus lavaretus* and *Chupea harengus* respectively; Dutt and

Thankam (1968) in Sciaenidae; Popova (1970) in *Cyprinus carpio*; Horn (1970) in Stromateoid fishes; Green (1971) in *Eucinostomous gula* and *C. argenteus*; Fahlen (1971) in genus *Salmo*; Marshall (1972) in deep sea teleosts; Butler and Percy (1972) in Myctophids; Evans (1973) in Triglidae; Crawford (1974) in *Dallia pectoralis*; Kleckner (1974) in some mesopelagic fishes; Gupta (1977) in *Bagarius bagarius*; Neighbors (1980) in Myctophidae.

Kahata (1981) observed differences in the swim bladder of three fishes of genus *Tribolodon*. Cruz-Hofling *et al.* (1981) gave an account of the morphological and histochemical observations on the swim bladder of obligate water breathing and a facultative air breathing fish. The swim bladder morphologies of nineteen species of midwater fishes have been studied by Neighbors and Nafpaktitis (1982). Ono and Poss (1982) traced out the structure and innervations of the swim bladder in *Cynoscion regalis*. Shao *et al.* (1986) compared the swim bladder morphology of various species from the family Sillaginidae.

The other information available regarding the morphological details of the swim bladder are from the works of Paulin (1988) in Gadiformes; Honghua *et al.* (1988) in *Pagasius sutchi*; Whitehead and Blaxter (1989) in Clupeoid fishes; Liem (1989) worked on the morphological diversity of respiratory gas bladders in teleosts. Neighbors (1992) in Lanternfishes of family Myctophidae; Jay (1993) in *Macruronus novaezelandie*; Moitra and Munshi (1997) in some air breathing fishes. Graham (1997) presented a review on the respiratory gas bladders in different fishes.

Some recent investigations and elaboration on the subject is presented by Dallas and Page (2003) in *Percina*; Yamada *et al.* (2004) in *Anguilla japonica*; Carpenter *et al.* (2004) in *Kurtus gulliveri*; Finney *et al.*, (2006) in *Danio rerio*; Clemens and Stevens (2007) in *Coregonus hoyi* and *Coregonus artedii*; Tibbetts *et al.* (2007) in *Oxyporamphus convexus* and Lechner and Ladich (2008) in some European catfishes.

The detailed description of the swim bladder in reported the present paper has been lacking since now. The differences reported in swim bladder even between the species of the same family is very interesting and can be correlated to other factors of habitat or taxonomic position. Thus the present study may provide useful for the further research in this field.

Materials And Method

About 09 specimens of fish belonging to order Siluriformes and different families were chosen for the present study. Live or freshly trapped fishes were collected from the fish markets of Khagaria, Katihar,

Kahalgaoon and Bhagalpur during different seasons of the year. They were immediately dissected in order to observe the organ concerned and its vascular supply in its natural condition.

For the study of gross anatomy, mid ventral and lateral dissections of the fishes were made. The live specimens were first anaesthetized in MS₂₂₂ and then dissected to study the structure and position, attachment and vascular network of the swim bladder. The swim bladder was exposed by removing the alimentary canal and fat surrounding them.

For further morphological studies, digital images of the fish, its swim bladder in situ and after removing it from the body cavity. Images of gas gland and the rete mirabile (i.e. the gas secreting complex) and the oval or the gas reabsorbing apparatus were taken with a Canon Power Shot A2000 digital camera. Further detailed studies of these vascularized smaller areas were made through a Binocular Microscope and images were also taken.

The swim bladder length along with the length and weight of the fish was carefully measured using a top pan balance and measuring scale. The morphometric details of the various fish studied during the present work are given in Table-1.1.

Given below is the list of different fishes that were examined during the present work for the study of their swim bladder according to the classification of Berg (1940) with some modifications as suggested by Jayaram (1981):

Order – Siluriformes

Family - Siluridae

- (1) *Ompok bimaculatus*
- (2) *Wallago attu*

Family – Bagridae

- (3) *Mystus cavasius*
- (4) *Rita rita*

Family – Sisoridae

- (5) *Laguvia ribeiroi ribeiroi*

Family - Schilbeidae

- (6) *Ailia coila*
- (7) *Clupisoma garua*
- (8) *Eutropiichthys vacha*
- (9) *Pseudeutropius atherinoides*

Observations

***Ompok bimaculatus* (Bloch)**

Ompok bimaculatus is a fresh water teleost belonging to family Siluridae of the order Siluriformes (Plate - I, fig. 1). The swim bladder of *Ompok bimaculatus* is a single chambered, tongue shaped structure, i.e. it acquires almost the form of an inverted triangle having rounded off corners. The anterior portion is broader than the posterior end. It occupies almost the entire length and breadth of the body cavity. It is supported on its dorsal side by the ventral surface of vertebral column. Its ventral side has a

bulging surface or convex surface with a depression in its central region (Plate - I, fig. 4). The pneumatic duct or ductus pneumaticus arises from the anterior region of this depression and connects the swim bladder with the oesophagus. It remains attached to the vertebral column extending from the 2nd to the fourth vertebrae. The swim bladder is milky white in colour and has a smooth surface (Plate - I, fig. 5). The wall of the bladder is thick and hard in nature. There is no distinct demarcation of the swim bladder wall into the tunica externa and tunica interna. A thin epithelial layer covers the outer surface of the swim bladder. This epithelial layer is very thin and transparent in nature. As the swim bladder is attached to the oesophagus by the pneumatic duct, it is physostomous in nature.

The rete mirabile and gas gland is not observed in this organ. The internal compartmentalization of the swim bladder is visible even from the outside, in the form of a central longitudinal depression. When the swim bladder is cut open, it shows the presence of three chambers or compartments divided internally by both a longitudinal as well as transverse septa. The longitudinal septa divides the swim bladder into left and right chambers and the transverse septa forms the upper transverse chamber. The lateral chambers do not communicate with each other directly but they remain connected to the upper transverse chamber. Thus, all the three chambers communicate with each other internally.

***Wallago attu* (Bloch & Schn.)**

Wallago attu is a fresh water teleost belonging to family Siluridae of the order Siluriformes (Plate - II, fig. 1). In *Wallago attu* the swim bladder is a large, thick walled, opaque and milky white, heart shaped structure with its anterior end relatively broader than the posterior (Plate - II, fig. 2 & 4). The posterior end slightly tapers downwards towards the tip (Plate - II, fig. 3 & 4). The organ remains attached to the vertebral column extending from the second vertebrae to the fourth vertebrae. It remains in the body cavity of the fish, as the largest organ, centrally located as a large inflated sac occupying about three fourth of the body cavity. Ventrally the swim bladder has an outward bulging surface i.e. convex surface. It has a Y-shaped depression in the central region of the swim bladder (Plate - II, fig. 3). From the middle of this 'Y' arises the ductus pneumaticus that connects the bladder with the oesophagus (Plate - II, fig. 3). Though the swim bladder wall is thin and has a single membrane, a transparent layer remains attached to the outer surface of bladder wall in its close association. It does not expose its inner content from outside (Plate - II, fig. 4). The wall of the swim bladder is very thick and does not rupture easily. The swim bladder is physostomous type as it is connected to the oesophagus via a pneumatic duct.

Internally the swim bladder is divided into three chambers. These chambers are incomplete and intercommunicate with each other. The internal partition is along the same Y-shaped depression (Plate - II, fig. 5). These chambers form two lateral compartments on the left and right sides and one on the upper side of the swim bladder. The left and right chambers are not interlinked with each other i.e. they have no passage between them but both these chamber open on anterior side and remain connected to the upper transverse chamber. Thus, all the three compartments communicate with each other directly or indirectly. The upper half of the bladder remains attached or lodged in the cavities of the post-temporal bone.

***Mystus cavasius* (Ham. & Buch.)**

Mystus cavasius is a fresh water teleost belonging to family Bagridae of the order Siluriformes (Plate - III, fig. 1). The swim bladder of *Mystus cavasius* is a large, thick walled organ with a milky white appearance. It is almost heart shaped in structure with broader anterior end as compared to the posterior region (Plate - III, fig. 2). It is situated medially in the anterior region of the body cavity occupying nearly half of its length. It remains attached to the ventral surface of the vertebral column on its dorsal side extending from the posterior region of the post temporal bone up to the tenth vertebra. Its ventral surface is slightly convex and dorsal surface is more or less flat. The pneumatic duct arises on the ventral surface is connected to the oesophagus. A pair of curved horn like outgrowth or diverticulum are situated at both the anterior corners of the swim bladder (Plate - III, fig. 2 & 3). These horns remain hidden under the post - temporal bones and are not visible until the bone is broken to expose these horns. The wall of the anterior horns is thinner and transparent as compared to the rest portion of the swim bladder. The swim bladder wall is very thick, fibrous and opaque in nature. A thin layer of epithelium remains attached to its wall externally.

The cavity of the swim bladder is divided into a short anterior and an elongated posterior compartment by means of a primary transverse septum. This transverse septum is incomplete laterally. A longitudinal septum further divides the cavity into a right and left compartment. In the posterior compartment there are four to five, short secondary septa arising from the floor of the bladder, on either side of the longitudinal septum. These lateral septa are also incomplete and they end before the roof and the lateral walls. In *M. cavasius* the median longitudinal septum of the anterior compartment is incomplete, facilitating communication between the lateral compartments (Plate - III, fig. 4).

***Rita rita* (Ham.)**

Rita rita is a fresh water teleost belonging to family Bagridae of the order Siluriformes (Plate - IV, fig.1). In *Rita rita* the swim bladder is a large, thick walled rectangular organ (Plate - IV, fig. 2). The anterior corners have a bulging surface while the mid-ventral region is rather depressed. From the posterior corners of the swim bladder two tubes like out growths or diverticulum run downwards, one on each side (Plate - IV, fig. 3 & 4). On its dorsal surface the bladder remains fixed to the ventral side of the vertebral column, extending from the third vertebrae. The anterior bulbous portion remains lodged in the depression of the post-temporal bone that supports the structure anteriorly. It is milky white in colour and occupies the central position of the body cavity as the largest organ (Plate - IV, fig. 2 & 3). The large, inflated sac is typical in structure due to its posterior out growths or diverticulum. These diverticula descend downwards and their posterior ends remain hidden under the muscles which can be exposed only after a careful dissection. The right diverticula is slightly longer than the left diverticula (Plate- IV, fig. 4). There is a T-shaped depression in the middle of the swim bladder and the pneumatic duct arises from the middle portion of this depression that connects it with the oesophagus. This pneumatic duct is for the passage of air from the mouth to the swim bladder. Hence, it is physostomous in nature. The rete mirabile and the gas gland is not present. The swim bladder is very tough and thick in nature. A thin transparent epithelial layer remains attached to its outer wall in its close contact.

The swim bladder is divided internally into several chambers. The internal compartmentalization is incomplete dividing the whole area into three chambers. These chambers intercommunicate with each other. The anterior or the upper compartment is the largest occupying almost more than half of the total space while the other two lateral compartments occupy the remaining half portion of the swim bladder. The partition is thus formed by a T-shaped septa. The two lateral compartments do not communicate with each other directly and open upwards into the anterior transverse compartment.

***Laguvia ribeiroi ribeiroi* (Hora)**

Laguvia ribeiroi ribeiroi is a fresh water teleost belonging to family Sisoridae of the order Siluriformes (Plate - V, fig. 1). In *Laguvia ribeiroi ribeiroi* the swim bladder is a white coloured, double chambered or bilobed structure situated in the anterior half of the body (Plate - V, fig. 2). The chambers are bean or kidney shaped structures placed laterally close to each other (Plate - V, fig. 3, 4 & 5). These chambers remain lodged in two lateral pouches or cavities and remain separated from each other by a bony element (Plate - V, fig. 4). However, both the chambers remain

connected to each other through a narrow transverse channel situated on the anterior and inner curvature. From the middle of this junction or channel arises the pneumatic duct that connects it to the oesophagus and therefore the swim bladder is of physostomous type.

***Ailia coila* (Ham. & Buch.)**

Ailia coila is a fresh water teleost belonging to family Schilbeidae of the order Siluriformes. In *Ailia coila* (Plate - VI, fig. 1) the swim bladder is tubular shaped, whitish structure which is transversely placed on the ventral surface of the vertebral column (Plate - VI, fig.2). The structure is highly reduced as compared to the body length and is fused with the parapophyses of the fourth and fifth vertebrae. The two ends of the swim bladder are slightly curved upwards. These lateral ends are very thin and they remain in the recesses behind the vertebral column. Altogether the swim bladder assumes a horse shoe shape (Plate - VI, fig. 3). It bears no connection to the oesophagus and is physoclistous in nature. It is assumed that the swim bladder in *Ailia coila* has lost its hydrostatic function due to its reduced size and absence of air filled sac. The rete mirabile and the gas gland is also absent. Thus, there is no mechanism for filling in and absorption of gases in the swim bladder.

***Clupisoma garua* (Ham. & Buch.)**

Clupisoma garua is a fresh water teleost belonging to family Schilbeidae of the order Siluriformes (Plate - VII, fig. 1). In *Clupisoma garua* the swim bladder is a rather reduced structure and appears like that of a maize grain (Plate - VII, fig.2). Ventrally the organ is very deeply seated, much below the alimentary canal and a thick band of muscles. It remains attached to the vertebral column on its dorsal side. It is slightly longer in length than its breadth. It is broader on its posterior end as compared to the anterior region. It is brownish white in colour. It is longitudinally placed in the body cavity in very close association with few anterior vertebrae. The anterior region of the swim bladder bears a 'V-shaped' notch or groove (Plate - VII, fig. 3). It bears no connection with the alimentary canal and may be called physoclistous. There is no mechanism for filling in of air or reabsorption of gas because the rete mirabile or gas gland area is also absent. Thus, the swim bladder is a reduced, deeply seated organ and seems to have no hydrostatic function. It is made up of muscular tissue and does not appear as an air filled sac structure. Hence, the tunica externa or tunica interna is not present.

***Eutropiichthys vacha* (Ham. & Buch.)**

Eutropiichthys vacha is a fresh water teleost belonging to family Schilbeidae of the order Siluriformes (Plate - VIII, fig. 1). In *Eutropiichthys vacha* the swim bladder is greatly reduced, white coloured structure. It is situated in close association to the ventral surface of the anterior vertebrae. It is placed at right angles to the vertebral column forming a circular loop (Plate - VIII, fig. 2 & 3). Dorsally the loop is incomplete, forming a thin necklace like structure around the vertebrae. The bladder is not enclosed by bony covering but is supported dorsally by bony extensions of anterior vertebrae (Plate - VIII, fig. 3). It is made of fibrous muscles. It is assumed that the air – filled sac may have been obliterated by fibrous tissue. There is no sign of any connection with the oesophagus. The gas secreting complex or the rete mirabile and the gas gland are absent. The structure seems to have lost its function due to its reduced form.

***Pseudeutropius atherinoides* (Bloch)**

Pseudeutropius atherinoides is a fresh water teleost belonging to family Schilbeidae of the order Siluriformes (Plate - IX, fig.1). In *P. atherinoides* the swim bladder is oval in shape. It is a slightly longer in length than its breadth. It lies freely in the abdominal cavity (Plate - IX, fig.2) and is supported anteriorly by bony vertebral elements. It is pale brown in colour and its wall is almost transparent in appearance. The internal partitions can be visible even from the outside (Plate - IX, fig.4). There is a longitudinal depression in the middle of its ventral surface. Laterally, the regions of the body wall in contact with the bladder are devoid of internal musculature. Thus, it is nearly cutaneous and therefore visible from outside. It is externally marked as 'lateral cutaneous area' (LCA) (Plate - IX, fig.3). This area is very apparent in this fish and position of the swim bladder is visible externally on both the lateral sides. It appears in the form of blister like translucent area just above the pectoral fins (Plate - IX, fig.3). It bears no connection with the oesophagus and is physoclistous in nature but the gas secreting complex is not visible. The walls of the bladder are thick and the ventral surface appears bulged while the dorsal surface is more or less flat.

The internal cavity of the swim bladder shows both longitudinal and transverse partitions. These partitions are formed by the arrangement of short and incomplete 4-5 transverse septa and one longitudinal septa. The internal arrangement of compartmentalization is similar to that of *Mystus cavasius*. These compartments intercommunicate with each other and form one transverse and two lateral compartments by short and incomplete septa.

Table -1.1 Table Showing The Relationship Between Body Weight, Body Length And Swim Bladder Length Of Different Fish Species

Order	Family	Name of fish	Body weight (g)	Total length (cm)	Standard length (cm)	Swim bladder length (cm)	Swim bladder / Standard Length (%)
Siluriformes	Siluridae	<i>Ompok bimaculatus</i>	22.7	22.8	19.3	2.6	13.47
		<i>Wallago attu</i>	20.1	18.2	16.1	1.5	9.31
	Bagridae	<i>Mystus cavasius</i>	35	19.8	15.3	3.1	20.26
		<i>Rita rita</i>	62.1	16.2	12.4	1.8	14.51
	Sisoridae	<i>Laguvia ribeiroi ribeiroi</i>	2.0	5.9	4.8	0.6	12.5
		<i>Ailia coila</i>	5.5	7.5	6.3	0.7	11.11
	Schilbeidae	<i>Clupisoma garua</i>	73.1	21.5	17.5	0.7	4.0
		<i>Eutropiichthys vacha</i>	19.2	15.2	12.1	0.6	4.95
		<i>Pseudeutropius atherinoides</i>	3.5	7.9	6.4	0.8	12.5

Result And Discussion

Two species of the family Siluridae have been taken up for the study of swim bladder morphology, *Ompok bimaculatus* (Plate - VI, fig.1) and *Wallago attu* (Plate - VII, fig.1). The shape of the swim bladder in both the species is similar i.e. heart shaped. It is single chambered, thick walled and milky white in colour. The structure remains attached to the oesophagus by a pneumatic duct and hence is physostomous in nature. Internally the swim bladder is divided into three compartments by septa which are incomplete and intercommunicate with each other.

Swim bladder morphology of two species from the family Bagridae i.e. *Mystus cavasius* and *Rita rita* have been taken up in the present study. The structure varies in its shape and size in both the species. The shape of the swim bladder in *Mystus cavasius* is again heart shaped. It is similar to the members of the family Siluridae like *Ompok bimaculatus* and *Wallago attu* but a pair of small curved horns are visible in the anterior corners of the swim bladder of *M. cavasius* (Plate - VIII, fig.3). The shape of the swim bladder in *Rita rita* is almost rectangular and a pair of diverticula arises from the posterior corners of bladder (Plate - IX, fig.3). Thus, the shape varies in both the genus and the origin of horns or lateral diverticula is also opposite. However, the swim bladder is milky white and thick walled in appearance in both these species. They are physostomous and bear a connection via a pneumatic duct to the oesophagus. The internal compartmentalization is again different. The swim bladder of *Mystus cavasius* are divided into four compartments divided by a longitudinal as well as transverse septum. The posterior compartment is further divided by four

short secondary septa which are incomplete. The internal compartment of *Rita rita* is similar to that of the species of family Siluridae i.e. three compartments, two lateral and one anterior. They are incompletely divided by septa. However, no secondary septa were visible in these fishes as is found in *Mystus cavasius*. Similar observations has been described in *Mystus cavasius* by Hemalatha and Rajkumar (1996). But the presence of a pair of anterior horns or diverticulum has not been mentioned earlier in *Mystus cavasius*. It is assumed that at the time of release of gas from the compressed gas bladder, the exertion of extra pressure on the gas is possible through loose septa which stand as partition media in between chambers (Shafi, 2000). The presence of two posterior diverticula as observed in *Rita rita* has also been earlier reported in *Rita crucigera* by Bridge (1968). As expected the rete mirabile and gas gland complex is absent. It may be assumed that the development of lateral diverticula might increase the volume of the organ and hence its efficiency.

The swim bladder of *Laguvia ribeiroi ribeiroi* of the family Sisoridae is double chambered structure, the two chambers are placed laterally close to each other in two cavities and remain connected by a transverse channel but it is not encapsulated as in *Sisor rhabdophorus* (Mahajan, 1967) of the same family.

The swim bladder in the members of family Schilbeidae shows various form and shape in its different genera. The shape of the swim bladder in *Ailia coila* is tubiform horse-shoe shaped (Plate- XI, fig.3) whereas, in *Clupisoma garua* it is maize grain shaped (Plate- XII, fig.3), in *Eutropiichthys vacha* it forms a semi-circular loop around the anterior

vertebrae (Plate - XIII, fig. 3), in *Pseudeutropius atherinoides* it is heart-shaped (Plate - XIV, fig.2). In all these species the swim bladder are deeply seated and much reduced in form except in *P. atherinoides* where it is a large heart shaped structure. Thus, it may be assumed that the organ has lost its hydrostatic function in case of *A. coila*, *E. vacha* and *C. garua*. Absence of rete mirabile and gas gland complex confirms to this assumption. However, the swim bladder in *P. atherinoides* is similar to that of genus *Mystus* of the family Bagridae and also to *Ompok bimaculatus* and *Wallago attu* of the family Siluridae. The internal compartmentalisation of *P. atherinoides* is similar to that of *Mystus cavasius*. The variability in the shape of swim bladder in family Schilbeidae was unique in the sense that no other family studied here showed such variability.

In the past several authors have correlated swim bladder with the taxonomic position of the fish: Marshall (1960), Greenwood (1963), Popova (1970), Ahmad (1971), Evans (1975), Dzhumaliyev (1978), Sujatha and Dutt (1985), Hemalatha and Rajkumar (1996). Gopalakrishan *et al.* (1970) have quoted that the fundamental similarities among animals are deep seated and the various internal structures show remarkable resemblances, though the animals may superficially look entirely unlike each other. Cain (1971) has ascertained that reliance on a single character will not only group together unrelated forms but may even get us into a position where we can produce no diagnosis at all. Though most of them are of the view that the method of classification of fishes based entirely on the external characters, especially the fin ray count, may not be accurate and so the study of internal structures as tools for establishing taxonomy should be given due consideration.

However, dependence on certain internal factors, apart from external features might create confusion regarding the pre-established tools of classification. If both external and internal features like fin-ray count, presence or absence of scales and swim bladder etc. might be used as tool it would be inappropriate. For e.g. the swim bladder of scaleless fishes and hence grouped under order Siluriformes. Both the features oppose each other hence these fishes could not be grouped together. It remains a question which of the tools is to be selected. If the morphological features of

the swim bladder is considered in this context why not other organs be also compared. Thus, the introduction of swim bladder as a tool for the determination of taxonomic position does not seem appropriate.

the order Siluriformes showed a reduced swim bladder and therefore the swim bladder percentage calculated was also lesser. The lowest value measured was for *C. garua* (4%),

Conclusion

The focus of the study was to show the wide variation of Swim bladder in the fishes belonging to same order. The classic research describes the morphology of the swim bladder in two species of family Bagridae (*Rita rita*, *Mystus cavasius*). In *Rita rita* two diverticulum diverge downwards from the swim bladder and *Mystus cavasius* two horn like outgrowths protrude from the anterior corners.

The two species of family siluridae *Ompok bimaculatus*, *Wallago attu* shows similar type of swim bladder whereas, in *Laguvia ribeiroi ribeiroi* the structure is bilobed and relatively smaller. The other four species of the family schilbeidae shows remarkable differences in the structure of swim bladder. In *Ailia coila* it is greatly reduced, in *Chupisoma garua*. it is maize shaped; In *Pseudeutropius atherinoides* it is oval and developed, almost similar to the swim bladder of fishes from siluridae family.

Thus, the reporting of the organ in these particular fishes showing differences in the species of same family has been lacking in previous works. So the research might be useful for further correlation of swim bladder and its changes to other factors.

Abbreviation Used In Fig.

BV: Blood vessels
 DP: Ductus pneumaticus or pneumatic duct
 Ki: Kidney
 LH: Lateral horn or diverticulum
 Li: Liver
 O: Operculum
 S: Septa
 SB: Swim bladder
 St: Stomach
 TC: Transverse channel
 VC: Vertebral column

PLATE - I: Swim bladder of *Ompok bimaculatus*

PLATE - I



Fig.1



Fig.2



Fig.3

Explanation Of Figures

Fig.1: *Ompok bimaculatus* Nat. x 3/4

Fig.2: Ventral view of the body cavity with swim bladder in situ Nat. x 3/4

Fig.3: Enlarged view of the swim bladder Nat. x 1.5

PLATE – II: Swim bladder of *Wallago attu*

PLATE - II



Fig. 1



Fig. 2

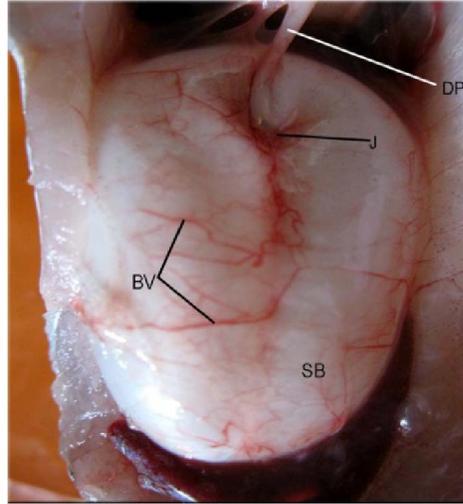


Fig. 3

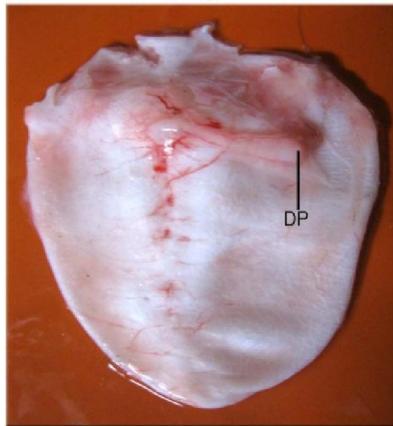


Fig. 4

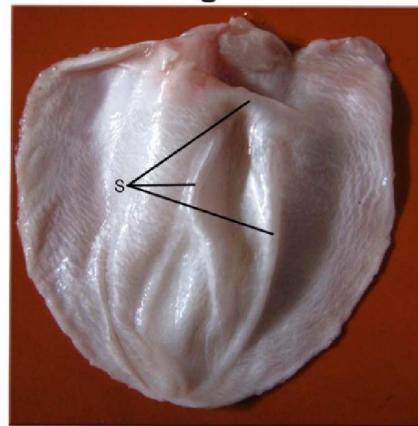


Fig. 5

Explanation Of Figures

Fig.1: *Wallago attu* Nat. x 3/4

Fig.2: Ventral view of body cavity with swim bladder and associated organ in situ Nat.x 3/4

Fig.3: Enlarged view of the air filled swim bladder in situ Nat. x 5

Fig.4: Enlarged view of swim bladder after removal from body cavity Nat. x 4.5

Fig.5: Internal view of the swim bladder showing partitions formed by septa. Nat. x 4.5

PLATE – III: Swim bladder of *Mystus cavasius*

PLATE - III



Fig. 1



Fig. 2

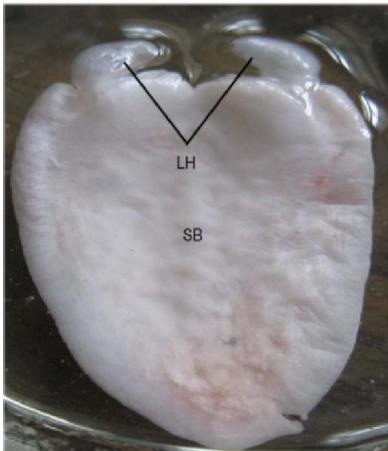


Fig. 3

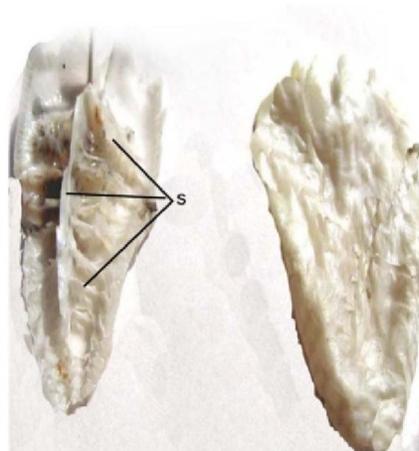


Fig. 4

Explanation Of Figures

Fig.1: *Mystus cavasius* Nat. x 3/4

Fig.2: Ventral view of the body cavity with intact swim bladder. Nat. x 3/4

Fig.3: Swim bladder after its removal from body. Nat. x 2.5

Fig.4: Swim bladder cut open to show inner compartmentalization. Nat. x 2.5

PLATE - IV: Swim bladder of *Rita rita*

PLATE - IV



Fig. 1

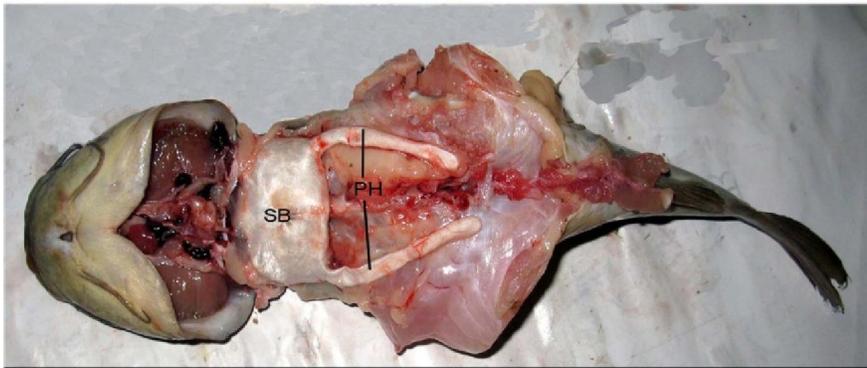


Fig. 2

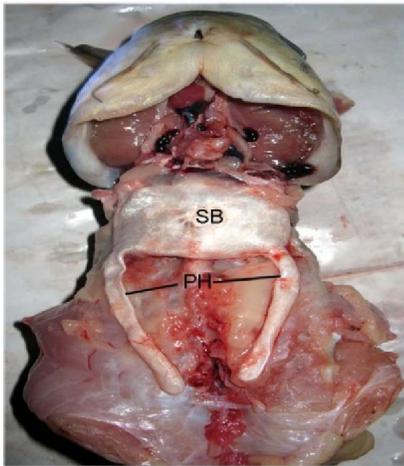


Fig. 3

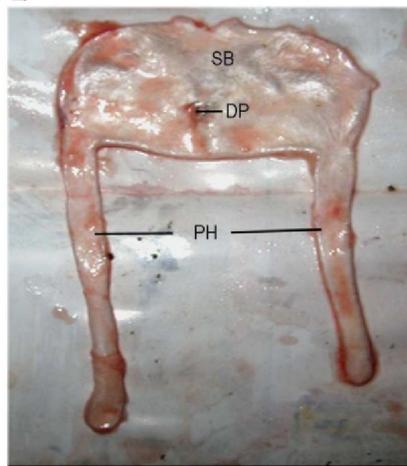


Fig. 4

Explanation Of Figures

Fig.1: *Rita rita* Nat. x 3/4

Fig.2: Ventral view of body cavity with swim bladder in situ Nat. x 3/4

Fig.3: Enlarged view of swim bladder with posterior diverticulum Nat.

Fig.4: View of swim bladder after removal from body cavity Nat. x 1.5

PLATE – V: Swim bladder of *Laguvia ribeiroi ribeiroi*

PLATE-V.



Fig. 1



Fig. 2



Fig. 3

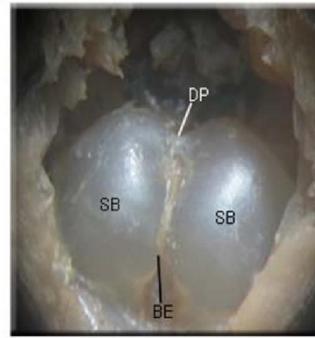


Fig. 4

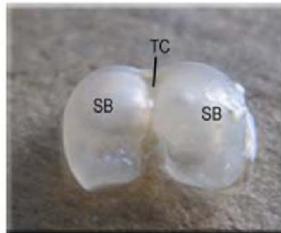


Fig. 5

Explanation Of Figures

- Fig.1: *Laguvia ribeiroi ribeiroi* Nat. x 2.5
 Fig.2: Ventral view of the bilobed swim bladder in situ Nat. x 2.5
 Fig.3: Close-up of swim bladder in situ Nat. x 2
 Fig.4: Enlarged view of the swim bladder in the body cavity Nat. x 6
 Fig.5: Swim bladder after its removal from the body cavity Nat. x 4

PLATE - VI: Swim bladder of *Ailia coila*

PLATE - VI



Fig. 1



Fig. 2



Fig. 3

Explanation Of Figures

Fig.1: *Ailia coila* Nat. x 1.75

Fig.2: Ventral view of the body cavity with swim bladder in situ Nat. x 2.25

Fig.3: Enlarged view of the reduced swim bladder of *Ailia coila* Nat. x 2

PLATE - VII: Swim bladder of *Clupisoma garua*

PLATE - VI



Fig.1

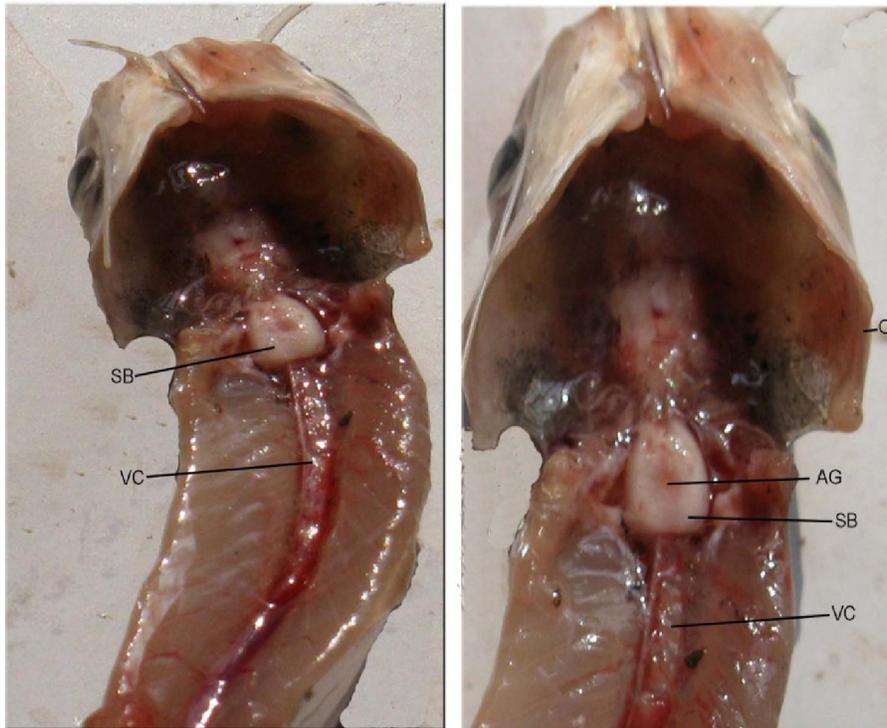


Fig.2

Fig.3

Explanation Of Figures

Fig.1: *Clupisoma garua* Nat. x 3/4

Fig.2: Ventral view of the body cavity with swim bladder in situ Nat. x2

Fig.3: Close - up view of the reduced swim bladder in situ Nat. x 3

PLATE - VIII: Swim bladder of *Eutropiichthys vacha*

PLATE - VIII



Fig.1



Fig.2

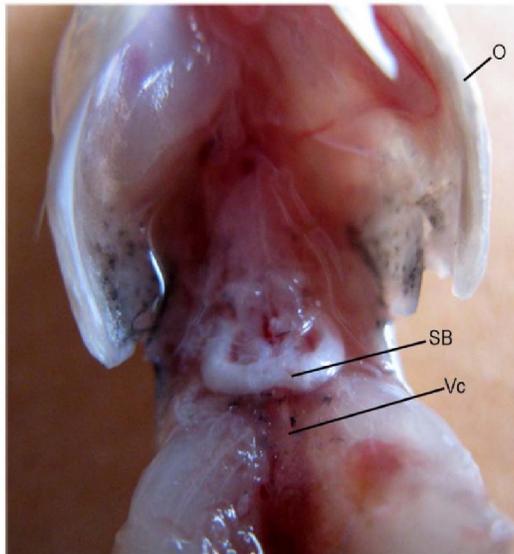


Fig.3

Explanation Of Figures

Fig.1: *Eutropichthys vacha* Nat. size

Fig.2: Lateral view of the body cavity with swim bladder in situ Nat. x 1.5

Fig.3: Enlarged or close-up view of the swim bladder Nat. x

PLATE –IX: Swim bladder of *Pseudeutropius atherinoides*

PLATE - IX



Fig. 1



Fig. 2



fig. 3



Fig. 4

Explanation Of Figures

Fig.1: *Pseudeutropius atherinoides* Nat. x 1.5

Fig.2: Lateral view of the body cavity with swim bladder in situ Nat. x 1.5

Fig.3: External view of the swim bladder before dissection Nat. x 2

Fig.4: Enlarged view of swim bladder in situ Nat. x 4

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