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SOME MORPHOMETRIC RECORDS ON *Sinanodonta woodiana* AND *Lamellidens marginalis* (MOLLUSCA: BIVALVIA) FROM CENTRAL REACHES OF INDUS RIVER, PAKISTAN

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Bivalvia has an extremely important position in our ecosystem as biofilters, bioindicators for environmental quality and most of all source of pearls. They play important role in foodweb. However, the taxonomic work regarding identification of bivalves species is quite scanty due to lack of taxonomic expertise. They play important role in food web. Total 556 specimens were collected from Chashma Barrage, Jinnah Barrage and Dhair Yaruwala (River Indus) for their taxonomic characterization. The identification of the specimens was made on the basis of morphological and morphometric characters using vernier caliper. Identification of the specimens was done by using recent identification keys and diagrammatic description. We found bivalves belonging to 1 family 2 genera and 2 species, *Sinanodonta woodiana* and *Lamellidens marginalis* are being reported for the first time from River Indus, Pakistan. Although both species are important for pearl production yet *Lamellidens marginalis* are edible and of commercial importance. This is a baseline study to get the basic information about the bivalves of River Indus near Chashma Barrage, Jinnah Barrage and Dhair Yaruwala which will be important in various applied fields like pearl culture. Our results reveal the bivalve species in the central reaches of River Indus, Punjab, Pakistan

Keywords: Taxonomy, identification, Dhair Yaruwala, Chashma Barrage, Jinnah Barrage, River Indus.

INTRODUCTION

Mussels (Class Bivalvia, Phylum Mollusca) are ancient in origin and are worldwide in distribution (Graf and Cummings, 2007). Freshwater mussels belong to Order Unionoida are among the most varied familiar and plentiful animals in freshwaters (Cope *et al.,* 2008). They are constituting an important part of aquatic food web (Vaughn *et al.,* 2008), supporting both aquatic ecosystems and their biodiversity (Sharma, 2010). Two species of freshwater mussels, viz. *Sinanodota woodiana* (Dharya Yaruwala, and Jinnah Barrage) and *Lamellidons marginalis* (Dharya Yaruwala, have been recently reported from littoral waters of Indus River (Shaifullah *et al.,* 2017). *Lamellidons marginalis* has been previously reported from Zhob and Jafferabad Districts (Kaker *et al.,* 2017) and Kotri Barrage (Burdi *et al.,* 2009) yet *Sinanodota woodiana* is not reported from any other region. It appears that the Indus River populations are isolated populations of these species. The present study is based upon the hypothesis that the present samples of these species are distinct isolated ecotypes. The present paper reports ecotype variability based upon morphometric observations on shell size and shape.

MATERIALS AND METHODS

***Sampling and Identification*:** Three localities, viz. Jinnah Barrage (32. 57 °NL; 71. 30°E), Chasma Barrage (32.434 °NL; 71.379 °E) and Dhair Yaruwala (32.409 °NL; 71.371°E) were visited (Novermber, 2011 – May 2012) and 528 fresh bivalvia samples were hand-picked from littoral region of the Indus River (Fig. 1) using services of professional divers. Samples were packed in ice containers, to the laboratory, and preserved in 70% alcohol. All specimens were identified up to species level based on typological species concept following Rao (1989) and Preston (1915). Specimen of *Sinandonta woodiana* {n 32: Dhair Yaruwala (18) and Jinnah Barrage (14)} and *Lamellidens marginali* (n 11: Dhair Yaruwala) were separated, identified, reconfirmed (Daniel L. Graf Carnegie Museum of Natural History) and were subjected to morphometric studies, viz., shell length, shell width and width using a Vernier caliper (minimum count: 0.01 mm) following Guarneri *et al.* (2014). The mean, standard error of mean and ratios between different variables were calculated using usual statistical techniques following Ludwig *et al.,* 1988.

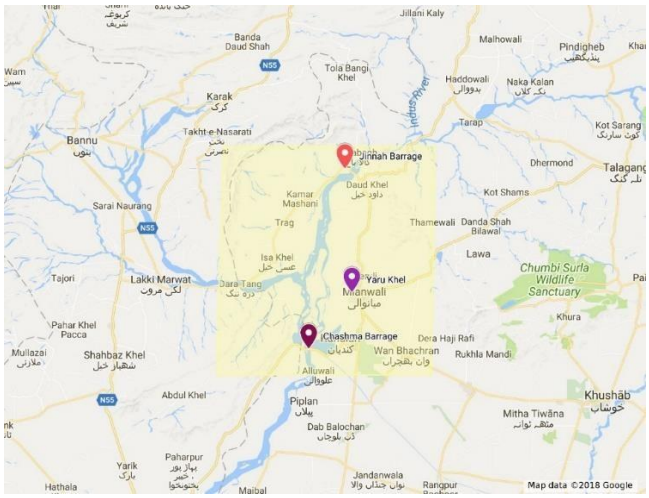

Figure 1. Map of Indus River, Mianwali

Figure 2. ***Sinanodonta woodiana*** **(Lea, 1834) (Morphotype 1)**

RESULTS

The morphometry of the bivalve specimens was carried out and the summary of the data was recorded for length, width and height and their inter-relationship (Table 1).

Taxonomic characterization of the bivalves on the basis of morphometrics

Family Unionidae Fleming, 1928: All the specimens are freshwater bivalvia belonging to the same family Unionidae. The shell is nacreous, inequilateral, inequivalve. The sizes are usually large but variable in size thickness and shape. The umbonal area is mostly pearly and corrugately sculptured. The hinge plate consists of two cardinal and two posterior lamellar teeth in left valve and single cardinal and single lamellar tooth in right. The ratio between shell length and shell width lies between 14-17mm and the ratio between shell height and shell width ranges from 15mm-19mm. This family is represented by two genera and two species from the Upper River Indus, District Mianwali and is been reported for the first time in Pakistan.

Sinanodonta woodiana **(Lea, 1834)**

Species description: There are a number of morphotypes on the basis of the variation in the colouration patterns of the given species that have been shown (Fig. 2 to Fig. 11). The nacre is white and the periostracum is black and white. The teeth and swellings are absent with hinge plate that is uniformly thin (Fig. 2). The shells are transparent with green rays on the periostracum with the dorsal margin (Fig. 3). The shell is thicker with brown to chocolate brown in colour having green tinge in the nacre which is more pronounced at the margins (Fig. 4).

Figure 3. ***Sinanodonta woodiana*** **(Lea, 1834) (Morphotype 2)**

Table 1. Checklist of the Species of the Class Bivalvia in River Indus Mianwali

Class	Order	Family	Genus	Species
Bivalvia	Unionoida	Unionidae	Sinanodonta	*Sinanodonta woodiana*
			Lamellidens	*Lamellidens marginalis*

Figure 4. ***Sinanodonta woodiana*** **(Lea, 1834) (Morphotype 3)**

Figure 5. ***Sinanodonta woodiana*** **(Lea, 1834) (Morphotype 4)**

Figure 6. ***Sinanodonta woodiana*** **(Lea, 1834) (Morphotype 5)**

Figure 7. ***Sinanodonta woodiana*** **(Lea, 1834) (Morphotype 6)**

Figure 8. ***Sinanodonta woodiana*** **(Lea, 1834) (Morphotype 7)**

Figure 9. ***Sinanodonta woodiana*** **(Lea, 1834) (Morphotype 8)**

Figure 10. ***Sinanodonta woodiana*** **(Lea, 1834) (Morphotype 9)**

Figure 11. ***Lamellidens marginalis*** **(Lamarck, 1819)**

The shell is pale and thin with pearly or whitish nacre however the periostracum outside is glossy light brown with concentric growth lines with greenish patterns giving shell an overall yellowish or greenish brown colour (Fig. 5). The shells of the specimens of are fragile and the periostracum is mostly brown with the white or bluish nacre (Fig. 6). The shell is thicker with brown colour having green striations. The shell is pale and thin with pearly or whitish nacre however the periostracum outside is glossy light brown with concentric growth lines with greenish patterns giving shell an overall yellowish or greenish brown colour (Fig. 7). The

shells are transparent with green rays on the periostracum with the dorsal margin (Fig. 8). The shell is smooth and shiny. It is chestnut, dark brown, or black in older individuals. Periostracum is chocolate brown and nacre is orange in the beak cavity and is usually iridescent. The periostracum is from light brown to chocolate brown with a whitish beak. The nacre is greenish at the margins white in the center and brown in the umbo (Fig. 9). The mean length of the *S. woodiana* ranged with least from 61mm to maximum 192mm. The mean height ranged from 40mm to 121mm and the mean width of the shells of S. woodiana varied from 24mm to 63mm. The SL/SW ratio ranged from 2.25mm-3.04mm. The SH/SW ranged from 1.56mm-1.92mm. The SL/SH of the shells ranged from 1.37mm - 1.62mm. (Table 2).

***Lamellidens marginalis* (Lamarck, 1819)**

Species description: The color of the periostracum is chocolate brown while the nacre is milky white. The shell is oval in shape, however narrow at the posterior end, (Fig. 11) which is in confirmation with the previous literature (copy right 2016.biologydisccussion.com). While comparing it with the *Lamellidens marginalis* the mean length of the specimen sample from only one station was 90mm with a mean height of 52mm and mean width of 35mm the shell length/ Shell width is similar to the *S. woodiana* however SH/SW is 1.48 and SL/SH is 1.73. The maximum specimen size was found 90 mm in length, 52 mm in height and 35mm in width. (Table 2).

Table 2. Some morphometric values of two bivalve species from Indus River Mianwali.

S. woodiana	**Mean**	**Standard deviation**	**Coefficient of Variation**
Length	142.12	36.99	0.26
Height	93.38	21.80	0.23
Width	51.62	9.02	0.17
Shell length/shell width	2.75		
Shell height/shell width	1.81		
Shell length/shell height	1.52		
L. marginalis			
Length	90.00	1.00	0.01
Height	52.00	1.00	0.02
Width	35.00	1.00	0.03
Shell length/shell width			
Shell height/shell width	1.48		
Shell length/shell height	1.73		

In Jinnah barrage and Chashma Barrage no specimen belonging to species *L. marginalis* was found throughout the six months (Table 3; Fig. 12) showing the area has low species density.

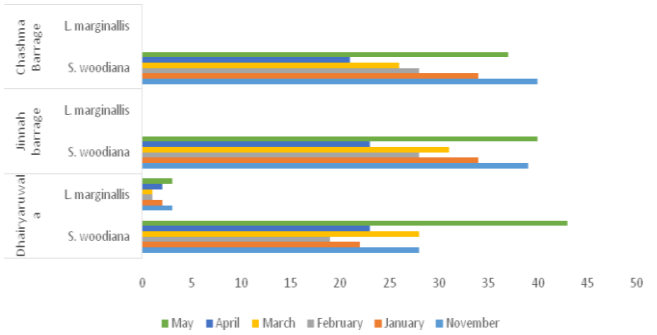

Figure 12. Species abundance (x-axis) at three stations (y-axis) at River Indus during different calendar months

DISCUSSION

The shell shapes of the Chinese pond mussel (*Sinanodonta woodiana*) were studied to estimate the morphological difference inside and between two populations of *S. woodiana* using elliptic fourier analysis showing morphological variation among the two populations which might be the result of some fundamental genetic roots (Demayo *et al.*, 2012). The species of *Anodonta (Sinanodonta) woodiana* is generally confused with the *A. arcaeformis*due to the similarities in the morphological parameters with the periostracum which is from light brown to chocolate brown with a whitish beak. The nacre is greenish at the margins white in the centre and brown in the umbo. The anterior margin is roundly pointed while the posterior margin is rounded. The hinge line is straight with circular striations. The embryonic shell is thinner than at the margins.https://search.yahoo.com/search?p=Anodonta+arcaeformis&fr=yset_widemail_chr_win&type=default According to USFWS, (2015) the size of the specimens may reach to 300mm.

The *Sinanodonda woodiana* is native to temperate and tropical eastern Asia. This species is currently found in at least fifteen European countries including Romania, Czech Republic, Belgium, Hungary, France, Slovakia, Austria, Poland, Ukraine, Italy, Germany, Serbia, Bulgaria, Moldova, Spain and Sweden as well as in some Indonesian islands (exact location unclear), Dominican Republic, USA (New Jersey), and Costa Rica (Cummings 2011, pers. comm.) and *L. marginalis* has been reported from lower and upper Gangetic plains in India and Bangladesh, Sri Lanka, Myanmar (Rao, 1989; Ramakrishna and Dey 2007) and Terai region of Nepal (Nesemann *et al.*, 2007). The population status of these species has been reported as least concern (Madhyastha *et al.*, 2010).

S. woodiana named as Chinese pond mussel and *L. marginalis* has been reported for the first time from the three different stations i.e., Dhairyaruwala, Jinnah barrage and Chashma Barrage of the River Indus after revisions in the taxonomy of the previously reported ten species (Shafiullah *et al.,* 2017). *L. marginalis* has previously been reported from River Indus, Sindh, in fairly good numbers. Total 175 specimens were sampled from Dhairyaru wala out of which only 12 specimens belonged to the *L. marginalis,* with few numbers in different months, while the rest of the 163 specimens belonged to *S. woodiana*, showing maximum species density in the months of May, April and March respectively and the results are in accordance with Burdi *et al.,* (2009). The low numbers of *L. marginalis* in this region might be due to *S. woodiana* (Lea, 1834) (the Chinese pond mussel) which is a known invasive species of the Unionidae (Lopes-Lima *et al.,* 2017) however in other parts of the South east Asia the population status of this species has been reported as least concern (Madhyastha *et al.,* 2010). S. *woodiana* may affect native mussel populations, including the negative impact via cross-resistance of host fishes (Sousa *et al.,* 2014; Donrovich *et al.,* 2017). Adult *Sinanodonta* species effectively compete with indigenous species for food, space, and host fishes. Not only this, they modify natural ecosystems by influencing physical, chemical and biological parameters of the water environment (Bolotov *et al*., 2016). The members of the genus *Lamelledins* are of economic importance as they are being used for the pearl culture in Bangladesh, however in Pakistan they are not being harvested and cultured for the human benefit and are reduced in numbers in certain parts.

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Conflict of Interest: The authors declare that there is no conflict of interest.

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