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A new record of the freshwater bivalve *Pisidium amnicum* (Family: Sphaeriidae) from Qena Governorate, Upper Egypt

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ABSTRACT

Family Sphaeriidae was neglected in North Africa and studies on this group of benthic organisms are very limited compared to other taxa. The originality of this work is drawn from the fact that this was the first time to record a member of the Family Sphaeriidae in Egypt. In addition, to our knowledge, this is the first record of *Pisidium amnicum* in Egypt. The current work was conducted to enhance the faunal knowledge and determine the actual conservation status of Genus *Pisidium* (Pfeiffer, 1821), *Pisidium amnicum* (Müller, 1774), which was collected from the River Nile in Qena Governorate. The shell of these individuals is up to 11 mm I length; it inhabits slow-flowing rivers; has a subtriangular shape in the adult; ornamented with very fine striations, giving it a shiny aspect. It has a thick appendicular at the top of each valve and numerous pores covering the internal surface. The hinge plate is arched but hardly or not at all thickened. These bivalves also have a relatively small outer demibranch. Although, externally, all the age classes resemble each other, the shape of their ligament-pit is different; it is either long or narrow. Data on this context is highly required to address the impact of the human increasing pressure on habitat loss and anthropogenic transformation of habitats of *Pisidium amnicum* in the Mideterranean biodiversity.

INTRODUCTION

The family Sphaeriidae includes the smallest freshwater bivalves and is distributed worldwide. **Kuiper (1983)** stated that the origin of *Pisidium* is certainly Mesozoic, and their centre of evolution lies without doubt in the Holarctic Region. Biodiversity of freshwater ecosystems is suffering a continuous loss reaching an alarming rate, and still limited information is known about the functional role of most of this biodiversity **(Korniushin, 2000; Vaughn & Hakenkamp, 2001)**. Although freshwater burrowing bivalves have the potential to strongly influence ecosystem processes, the afore- mentioned authors pointed that the ecosystem roles of burrowing freshwater bivalves have been particularly understudied.

Unfortunately, this concept is also applied to the bivalves of Africa. Research on the Sphearidae of Africa, up till the present, has been limited to a few taxonomic studies

conducted and published many years ago. An account of the freshwater molluscs of the Belgian Congo **(Pilsbry & Bequaert, 1927)** reported 9 species of *Pisidium* from Africa at that stage. Moreover, they predicted that Africa would doubtlessly prove to have more species of this genus when special methods for collecting aquatic minutiae are employed. It is therefore not surprising that a total of 20 species were reported for Africa by **Mandahl-Barth (1988)**. With regard to South Africa **Connolly (1939)** reported the following three species of the genus *Pisidium*: *P. ovampicum* (Ancey, 1890), *P. langleyanum* (Melvill & Ponsonby, 1891), and *P. costulosum (*Connolly, 1931). Two and a half decades later, seven species were reported by **Kuiper (1964)** in his contribution towards knowledge of the South African species of the genus *Pisidium*. The four additional species added to the list of **Connolly (1939)** by this author comprised *P. casertanum* **(Poli, 1791)**, *P. pirothi* **(Jickeli, 1881)**, *P. viridarium* **(Kuiper, 1956)**, and *P. harrisoni* **(Kuiper, 1964)**. **Kuiper (1964)** assumed that *P. langleyanum, P. costulosum* and *P. harrisoni* are Southern African endemics, while the others are also known to occur elsewhere in Africa. Another species, *P. (Parapisidium) reticulatum*, was reported from the Okavango Delta, Botswana **(Appleton *et al.*, 2003)**. In his account of the Mollusca of Southern Africa, **Appleton (2002)** noted that, 8 species of *Pisidium* have been reported from South Africa of which 6 are represented in the database of the National Freshwater Snail Collection (NFSC) of South Africa. No records have been found of either *P. harrisoni* or *P. reticulatum* in the present database.

With respect to the fact that they can utilise habitats such as springs, small creeks and peat bogs where no other bivalves can survive, **Korniushin (2000)** perceived the investigation of *Pisidium* species important, not only for understanding the structure and history of the fauna, but also because they could be used for monitoring environmental conditions. It was recorded that the representatives of this genus can serve as intermediate hosts for trematode parasites **(Cannon, 1972; Rantanen *et al.*, 1998)**. Nevertheless, the role of local representatives of this genus in the epidemiology of mollusc-borne parasitic diseases has not yet been investigated. Though little is also known about the conservation status of the South African Sphaeriidae, yet **Herbert (1998)** considered that *P. harrisoni* may meet the criteria for Red listing. Moreover, it was reported, elsewhere in the world, that native burrowing bivalves are declining at a catastrophic rate **(Vaughn & Hakenkamp, 2001)**. A significant decrease of species richness and density of gastropods and bivalves is attributed to climatic warming, a phenomenon that could be observed in the river system in France **(Mouthon & Daufresne, 2006)**.

This is an account of the habitats and geographical distribution of *P. langleyanum*, currently the *Pisidium* species, with the largest number of records in the database of the NFSC of South Africa. The possible effect of climatic changes on the geographical distribution of *P. langleyanum* and the conservation status of *Pisidium* species in South Africa was briefly discussed.

Pisidium is a genus of freshwater bivalves belonging to the family Sphaeriidae that includes the smallest bivalves on Earth. Despite their small size, *Pisidium* species can be used for bioindication studies **(Horsák 2001)**. The usefulness of these species as markers of metals and organic pollution has been proved repeatedly **(Ingram *et al.*, 1953; Wurtz, 1955; Anderson, 1977; Gadzała-Kopciuch *et al.*, 2004; Alhejoj *et al.*, 2017)**.

This genus is cosmopolitan and occurs in temporary and permanent aquatic environments. Along with Dreissenidae, Sphaeriidae is the only family of bivalves

inhabiting subterranean habitats **(Culver 2012; Prié 2019)**. Their occurrence in caves has been reported by a number -albeit few- of authors from different localities; *Pisidium casertanum* **(Poli, 1791)**, *Pisidium personatum* **(Malm, 1855)** from Scotland (**Knight, 2018 and Knight & Wood, 2000**), *Pisidium zoctanum* **(Poli, 1876)**, *Sphaerium tasmanicum* **(Woods, 1876)** from Australia **(Kuiper, 1983 and Korniushin, 2000)**, *Pisidium crimeana* (**Stadnichenko, 1980**) from Ukraine (**Vargovitsh and Anistratenko 2016 & Vinarski and Kantor 2016)**, *Pisidium subterranea* **(Zhadin, 1932)** from Caucasus (**Vinarski & Kantor, 2016 and Voode, 2017**), *Pisidium cavatica* (**Zhadin, 1952**), *Pisidium ljovushkini* **(Starobogatov, 1962**) and *Pisidium hallae* (**Kuiper, 1983**).

In North Africa, studies on the freshwater clams are still rare. Notably, in Morocco, few studies have been conducted on the distribution of *Pisidium* species, where only seven species were reported **(Kuiper, 1972)** and extreme environments, such as caves were not prospected **(Rassam *et al.*, 2020)**.

A review of the recent literature on the freshwater malacofauna in Egypt has shown that family Sphaeriidae was not considered to be represented in the molluscan fauna of Egypt **(Damme, 1984; Neubert, 1998; Brown, 2005; Ibrahim *et al.*, 2006; Thompson *et al.*, 2009; Hussein *et al.*, 2011; Abd Elwakeil *et al.*, 2013; Choubisa & Sheikh, 2013; Abdel - Gawad & Mola, 2014; Lotfy & Lotfy, 2015)**.

The aim of this paper was to record for the first time the occurrence of Sphaeriidae species in Upper Egypt and to describe the particularities of these individuals that have not yet been mentioned.

MATERIALS AND METHODS

The present study was carried out in the faculty of Science at Qena city, South Valley University, Egypt. Six valve specimens of *pisidium* sp. were collected from the River Nile at Qena city (26.17^0 N, 32.7^0 E) during spring 2019.

In nature, the snails were found in common association with one or more other molluscan bivalve's genera.

This work is the first step towards future exploration of Sphaeriidae in Egypt.

The shells were examined under microscope. The valves were then immersed in a bath of 5% commercial Chlorox (sodium hypochlorite) to dissolve the remaining organic matter, washed in a solution of distilled water and dried at room temperature before being coated and examined by SEM.

For the identification of the different parts of the sphaeriid shells, the terminology adopted in the study of **Kuiper (1983)** was used as follows:

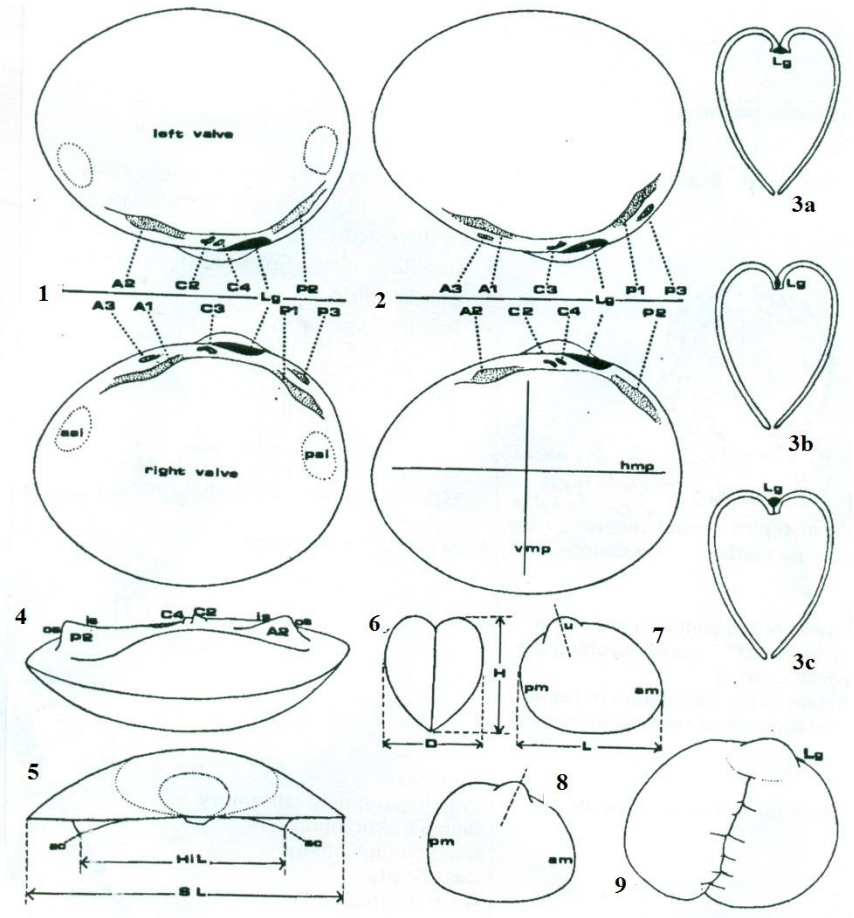

Fig. 1. Terminology of sphaeriid shells. - 1, Dentition: AI, A2, A3, anterior lateral teeth; C2, C3, C4, cardinal teeth; PI, P2, P3, posterior lateral teeth; Lg, ligament and ligament-pit. Adductors: aai, anterior adductor impression; pai, posterior adductor impression. - 2, Reversed dentition. Median plans: vmp, vertical median plan; hmp, horizontal median plan. - 3, Situation of ligament (Lg) and ligament-pit: Sa, introverted; Sb, enclosed; *Se*, extraverted ligament-pit and protruding ligament. - 4, Ventral view on hinge, left valve: is, inner or proximal slope of laterals; os, outer or distal slope of laterals. - 5, Measuring of ratio hinge-length (HiL) and shell-length (SL); ac, apex or cusp. - 6, Height index (H.i.) = 100.H:L. Convexity index *(Cl.)* of single valve: 100.D:2H. Descriptive terms of convexity: C.I. inferior to 30 = shell flat or compressed; C.i. between 30 and 40 = moderately or slightly convex, tumid, swollen; CJ. between 40 and SO= inflated, globose, globular or ventricose; C.i. more than *SO* =very or extremely tumid, inflated or ventricose. - 7, Beak or umbo (u) inclined backward (opisthogyrous); am, anterior or front margin of the shell; pm, posterior margin. -8, Beak inclined forward (prosogyrous). – 9, Diphyoidic shell.

RESULTS AND DISCUSSION

The physical factors were recorded where the water temperature ranged from 15 to 28.5°C, pH ranged from 6.74 to 7.8, dissolved Oxygen ranged from 5.4 to 7.6 ppm, conductivity ranged from 0.22 to 0.98 ms and TDS ranged from 150 to 890 mg/L.

Morphological studies of the shell of the collected specimens revealed that the individuals belonging to one species of genus *Pisidium*.

Genus *Pisidium* are small bivalves (usually <10 mm) that belong to the subfamily, Sphaeriinae, family Sphaeriidae; Superfamily, Sphaerioidea; Order, Sphaeriida;, Superorder, Imparidentia; Subterclass, Euheterodondata; Infreaclass, Heterconchia;

Subclass, Autobranchia; Class, Bivalvia. They inhabit fine deposits in a variety of freshwater ecosystems. The shells of some of the species of these bivalves present considerable variation, most often linked to the hydrological and physico-chemical characteristics of the environment in which they live **(Saunders & Kling, 1990; Funk & Reckendorfer, 2008)**.

This phenomenon is particularly remarkable in *Pisidium casertanum* **(Poli, 1791)**, being the most common and cosmopolitan of the genre, and raising one of these alleged forms or varieties to species rank that often gives rise to debate **(Dyduch-Falniowska, 1983; Kuiper, 1983; Piechocki, 1989; Araujo & Korniushin, 1998; Gloer & Zettler, 2005)**. On the contrary, polymorphism is quite limited in other species such as *Pisidium henslowanum* **(Sheppard, 1823)**, *P. supinum* **(Schmidt, 1851)** or *P. milium* **(Held, 1936)**. For several years, shells with an appendiculum (a more or less oblique fold located close to the top of each valve) resembling *P. supinum* or *forma plicata* of *P. casertanum* **(Zeissler, 1962)** have been observed in rivers and canals, but they present specific characters. To fix the identification, the collected species need a lot of studies including anatomy of the soft parts and molecular.

DESCRIPTION

The shell of these individuals has a subtriangular shape in the adult (Fig. 2), ornamented with very fine striations, giving it a shiny aspect, a thick appendiculum at the top of each valve and numerous pores covering the internal surface (Fig. 5). The hinge plate is arched but, hardly or not at all, thickened (Figs 4 & 5). Morphometric results of the six specimens collected showed that they have a length ranging between 3.49 and 1.91 mm and height between 2.93 and 1.62 mm. The shell is silky with slight striations, and the umbo is narrow and located posteriorly. The shape of the shell is sub-angulated; the most extreme point of the anterior part is located lower than the middle of the shell height. The anterior part is clearly longer than the posterior part. The hinge is thicker, more or less wide. The ligament pit is long. The left valve has two long cardinal teeth, the lower (C2) and the uppermost (C4) are parallelly located, C4 overlaps C2 at anterior end, C3 is long and slightly curved. All individuals found in the present work are exactly similar to the description given by other authors **(Adam, 1960; Piechocki, 1989; Killeen *et al*., 2004)** (Figs.4 & 5).

These bivalves also have a relatively small outer demibranch **(Korniushin & Hackenberg, (2000)**. Although, externally, all the age classes resemble each other, the shape of their ligament-pit is different; being long and narrow in the present species. Comparing this criterion and the shape of the shell of the present species with the most closely *P. supinum* and *P. casertanum* forma *ponderosa*, the results revealed difference in the length of ligament and shape of shell. On the other hand, comparing these results with those of *P. amnicum* described in the studies of **Timm (1975, 1976)**, **Kuiper (1983)**, **Korniushin (1991, 1996, 2002)** and **Voode (2017)**; the present species found in Egypt are confirmed to be *Pisidium amnicum*.

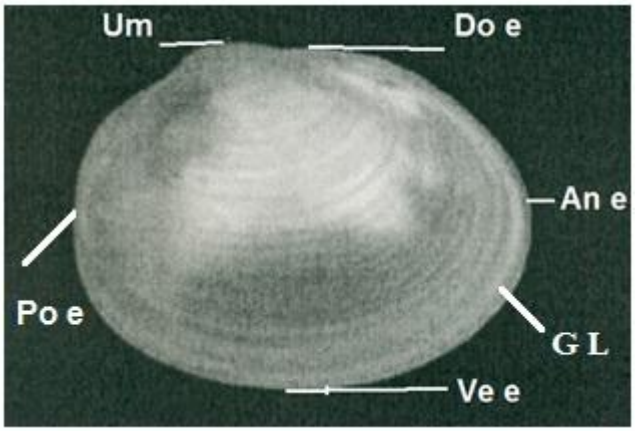

Fig. 2. Lateral view of the left valve of *Pisidium amnicum* showing the smooth structure of the exterior surface (um= Umbo; Do e= Dorsal end; An e= Anterior end; Ve e= Ventral end; Po e= Posterior end and G L= Growth Lines). (1 cm = 1 ml)

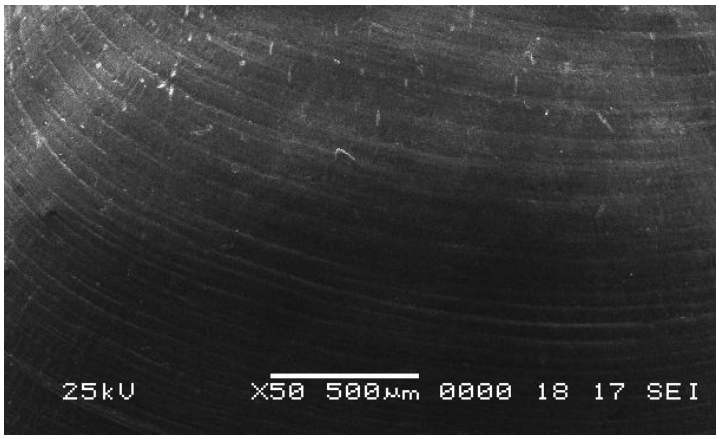

Fig. 3. SEM of the surface of valve of *Pisidium amnicum* showing very fine growth lines

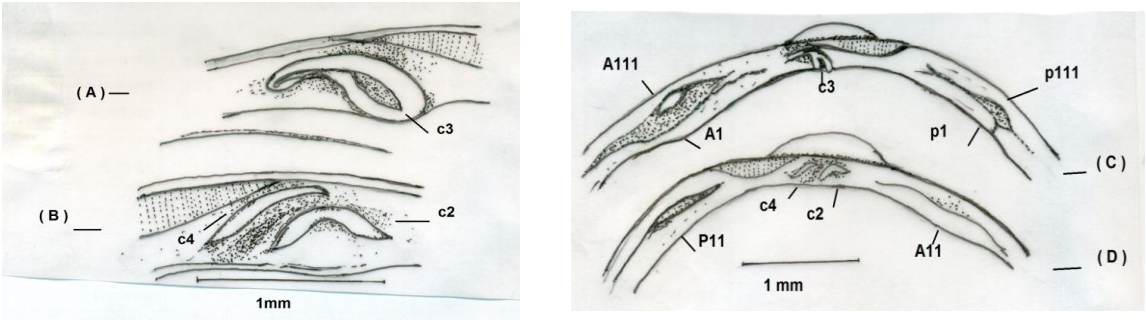

Fig. 4. Diagrammatic drawing of the hinge teeth of *Pisidium amnicum*: **(A)** C3 – cardinal tooth of the right valve; (**B**) C2, C4 – cardinal teeth of the left valve; **(C)** AI, AIII – anterior lateral teeth of the right valve; PI, PIII – posterior lateral teeth of the right valve; **(D)** AII – anterior lateral tooth of the left valve; PII – posterior lateral tooth of the left valve.

Terminology adapted from **Timm (1975)**

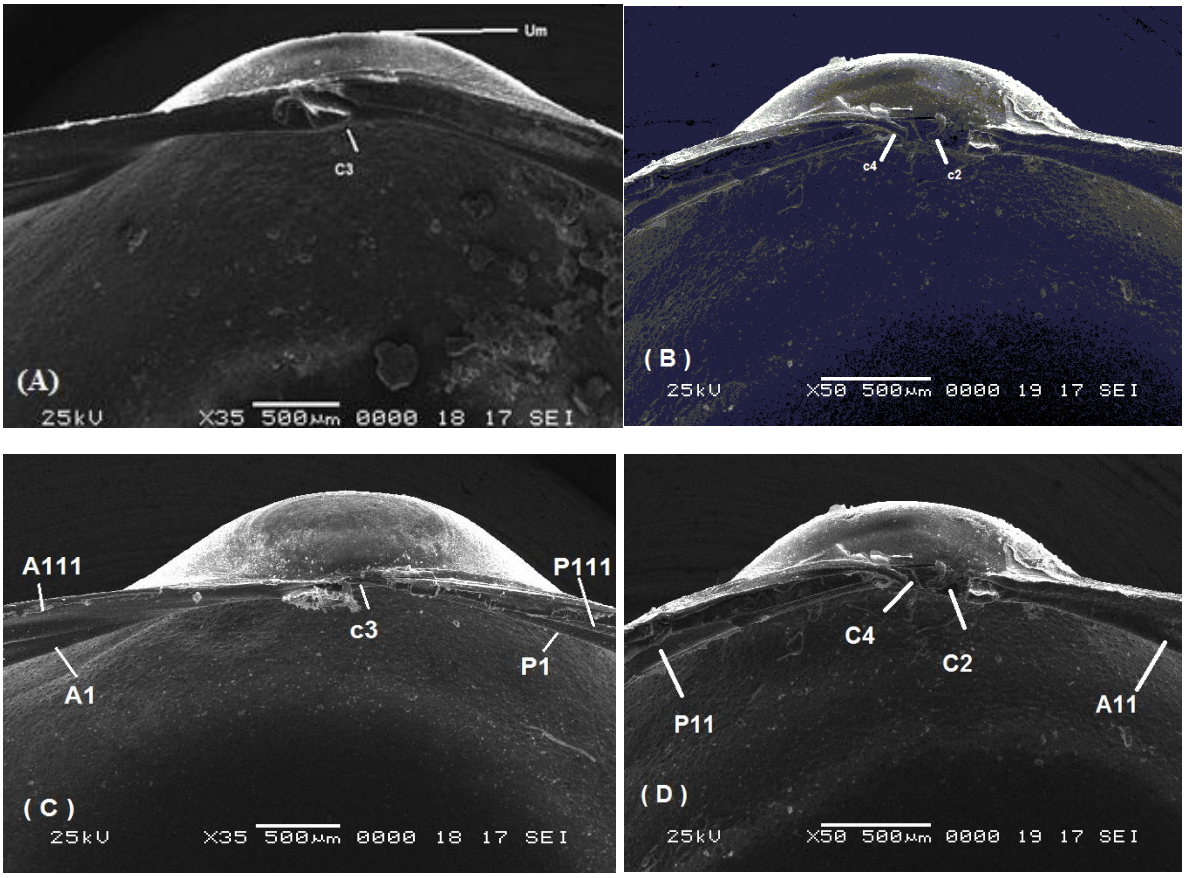

Fig. 5 SEM of the hinge teeth of *Pisidium amnicum*: **(A)** C3 –cardinal tooth of the right valve; (**B**) C2, C4 – cardinal teeth of the left valve; **(C)** AI, AIII – anterior lateral teeth of the right valve; PI, PIII – posterior lateral teeth of the right valve; **(D)** AII – anterior lateral tooth of the left valve; PII – posterior lateral tooth of the left valve. Terminology adapted from **Timm (1975)**

CONCLUSION

In general, the Sphaeriidae family is neglected in North Africa, and studies on this group of benthic organisms are very limited compared to other taxa. The originality of this work consists in recording, for the first time, a member of the Sphaeriidae family in North Africa from the River Nile at Qena Governorate, Egypt, and to the best of our knowledge; it is the first record of *P.amnicum*. This is important in order to enhance our faunal knowledge and to determine the actual conservation status of *Pisidium* species. Moreover, this need becomes urgenly recommended to address the human increasing pressure, including habitat loss and anthropogenic transformation of habitats of *Pisidium* species (e.g. rivers, lakes and springs) in a Mediterranean biodiversity.

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