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Detection of the presence of both species *Sinanodonta woodiana* and *Sinanodonta lauta* in the recent sediment of Southern Iraq

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Abstract

The selection of the study area was influenced by the recent discovery of new pelecypod species documented for the first time in southern Iraq. Sixteen samples were collected from seven locations situated on both banks of the Euphrates River, northwest of Basrah Governorate. An analysis was conducted to identify the types of sediments at these sites, alongside the various shell species present in the region. The findings revealed that mud sediments predominated over other sediment types, which included silt and sandy mud. Within the study area, two pelecypod species were identified: *Sinanodonta lauta* and *Sinanodonta woodiana*, along with a barnacle species, *Amphibalanus subalbidus*. The presence of these species suggests that the area has been influenced by environmental changes that transpired towards the Late Holocene period, as all identified species interduced from outside the region's native ecosystem.

Keywords: *Sinanodonta woodiana*, *Sinanodonta lauta*, Southern Iraq, Barnacle, Freshwater Pelecypoda.

الكشف عن وجود النوعين *Sinanodonta woodiana* و *Sinanodonta lauta* في الرواسب الحديثة من جنوب العراق

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الخلاصة

تم اختيار منطقة الدراسة اعتمادا على اكتشاف أنواع جديدة من المحاريات تم توثيقها لأول مرة في جنوب العراق. وقد تم جمع ستة عشر عينة من سبعة مواقع تقع على ضفتي نهر الفرات، شمال غرب محافظة البصرة. وأجري تحليل لتحديد أنواع الرواسب في هذه المواقع، إلى جانب أنواع الاصداف المختلفة الموجودة في المنطقة. وكشفت النتائج أن الرواسب الوحلية تغلبت على أنواع الرواسب الأخرى، والتي شملت الغرين والوحل الرملي. وفي منطقة الدراسة، تم تحديد نوعين من المحاريات: *Sinanodonta lauta*، و *Sinanodonta woodiana* ، إلى جانب نوع من البرنقيل البحري، *Amphibalanus subalbidus*. ويشير وجود هذه الأنواع إلى أن المنطقة تأثرت بالتغيرات البيئية التي حدثت نحو فترة الهولوسين المتأخرة، حيث أن جميع الأنواع التي تم تحديدها قدمت من خارج النظام البيئي الأصلي للمنطقة.

1. Introduction

Southern Iraq constitutes the southern section of Mesopotamia, a region delineated by the Tigris and Euphrates river system[1]. Southern Mesopotamia is characterized by its alluvial plains, primarily shaped by the Tigris and Euphrates rivers [2] which have been created through the accumulation of silt from the rivers, as well as by marshlands, lagoons, and reed banks located in the far southern part adjacent to the Arabian Gulf [1] [3]. The Quaternary period, particularly the late Pleistocene and Holocene period, has seen significant changes in these fluvial systems due to climatic shifts and tectonic activities. These changes have led to the formation of various depositional environments that are crucial for understanding the habitat of molluscs [2]. These deposits exhibit characteristics indicative of a history of active sedimentation with low salinity conditions[4][5], which are favorable for freshwater mollusc species[6]. The study of molluscs has gained great importance in Iraq, [7] provided an account of molluscs found in southern Iraq, while[8] documented various bivalve species present in the region. Subsequently, [9] contributed to the inventory of Iraqi molluscs by identifying five additional marine species. More recently, [10] reported the presence of the freshwater mussel *Sinanodonta woodiana* in Iraq. Furthermore, [11] expanded the list of marine molluscs in Iraq. Finally, [12] provided a thorough overview of both freshwater and marine bivalves recorded in Iraq throughout history.

This study aims to identify the occurrence of mollusc species in contemporary sediments that have been observed for the first time in southern Iraq, along with the implications of their presence.

2. Materials and methods

2.1 Study area

The study area is located between latitudes (30^{0}57'40"N and 30^{0}57'20"N) and longitudes (47^{0}15'15"E and 47^{0}15'45"E), it represents the northern part of the Al Madina district, which is located in the northwest of Basrah Governorate in southern Iraq. It is adjacent to the Euphrates River, as shown in Figure 1.

2.2 Sampling

Sixteen samples were collected from seven sites distributed on the shore banks of the Euphrates River in the study area during July 2023, as illustrated in Figure1. The selection of depths for collecting samples from the seven sites was based on the occurrence of pelecypoda shells there. There the sediments samples and shells specimens were extracted from a depth of between 0.35m and 0.75m using a shovel. The sediment samples were collected from the same depths of the samples in the sites in order to identify the sediments type in which the shells were found.

2.3 Laboratory procedures

To determine the sediments types present in the study area, 100 grams of sediments were collected from each sample in site, and a grain size analysis was conducted using wet sieving with a 0.0625 mm sieve. This method allowed for the separation of sand from silt and clay, facilitating the subsequent Pipette analysis as outlined by [13].

As for the pelecypoda shells, they were visible and large in size, ranging from 12 to 17 cm, which makes them identifiable with the naked eye. They were collected from the sediments, cleaned of any sediment residue attached to them, and dried in order to prepare them for classification. The valves of shells were photographed from both the outside and the inside. The identification of the pelecypods species and their taxonomy based on[14], [15] and [16].

The study area prominently featured the presence of barnacles, which were easily observable on the surfaces of both shells and solid sediments at the various sites examined. The barnacle species is identified according to [17].

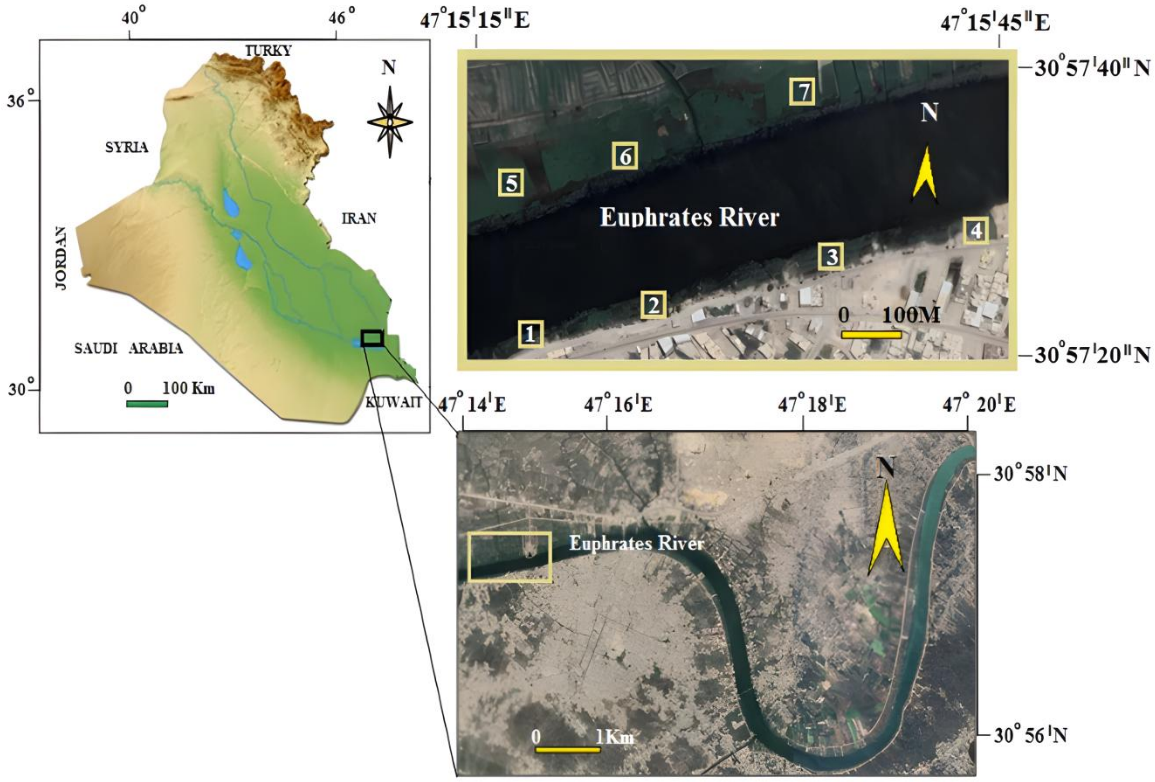

Figure -1 The study area and the sites selected for sampling

3. Results

3.1 Sediments

The grain size analysis results [13] for the samples collected from the investigated sites indicate the existence of three sediment types: silt, sandy mud, and mud, as detailed in Table 1. Among these, mud emerged as the predominant sediment, accounting for 81% of the total samples analyzed, while silt comprised 13%, and sandy mud represented the smallest fraction at 6%.Mud was found in all depths. Overall, the sediments types suggest that their deposition occurred in a low-energy sedimentation environment [18].

3.2 Pelecypoda species

This study provides documentation of the *Sinanodonta lauta* (Martens, 1877) within Iraq. While, the species *Sinanodonta woodiana* (Lea, 1834) had been previously identified in central Iraq by [10], as shown in Figure 2. The shells were observed to be devoid of any organic remnants and were found across all locations, manifesting both as intact shells and as individual valves, as illustrated in Table 2.

Table 1- The texture of sediment samples collected from the study area

Number of Sample	Site	Sample depth (m)	Sediment texture
1	1	0.35	Sandy mud
2		0.5	Mud
3		0.75	Mud
4	2	0.40	Mud
5		0.65	Mud
6	3	0.45	Mud
7		0.70	Mud
8	4	0.35	Silt
9		0.74	Mud
10	5	0.36	Mud
11		0.75	Mud
12	6	0.50	Mud
13		0.75	Mud
14	7	0.40	Silt
15		0.60	Mud
16		0.75	Mud

3.3 Barnacle species

Barnacle shells were observed throughout all sites within the study area , Figure 3, commonly affixed to the shells of pelecypods as shown in Figure 2 and on various hard substrates as they appear in the Figure 4, forming aggregates. The predominant species identified was *Amphibalanus subalbidu*s (Henry,1973), Figures 3 and 4 show the shells assemblages of the species. This species has also been documented in various locations along the banks of Shatt Al-Arab by [19].

4. Discussion

Sinanodonta woodiana (Lea, 1834) and *Sinanodonta lauta* (Martens, 1877) are both freshwater pelecypods species that inhabit a variety of aquatic environments. The species *Sinanodonta woodiana* also known as the Chinese pond mussel, is native to East Asia but has been introduced to various regions around the world, including Europe and North America[20][21], the species has been observed in various sediment types, primarily preferring muddy substrates but also found in sandy environments[20].Also It thrives in various freshwater habitats, including; Lentic Habitats, such as lakes, ponds, and oxbows and Lotic Habitats, Including slow-flowing rivers, streams, and canals. *Sinanodonta woodiana* (Lea, 1834) has been found in diverse environments like fishponds, abandoned mining pools, and rice paddy channels in Southeast Asia[20] [22][23]. The initial collection of *Sinanodonta woodiana* (Lea, 1834) occurred from freshwater sources in Iraq in Hilla River, an eastern tributary of the Euphrates River located in the central region of Hilla city [10]. *Sinanodonta lauta* (Martens, 1877) is another species within the same genus and like *Sinanodonta woodiana*(Lea, 1834), it is part of the Unionidae family and has been observed in similar habitats [10] [24]. *Sinanodonta lauta* (Martens, 1877) has also been recorded in various freshwater systems outside its native range, including large rivers and lakes in European Russia and Siberia. It shares habitats with other mussels, indicating its adaptability to different ecological conditions [22] [23].

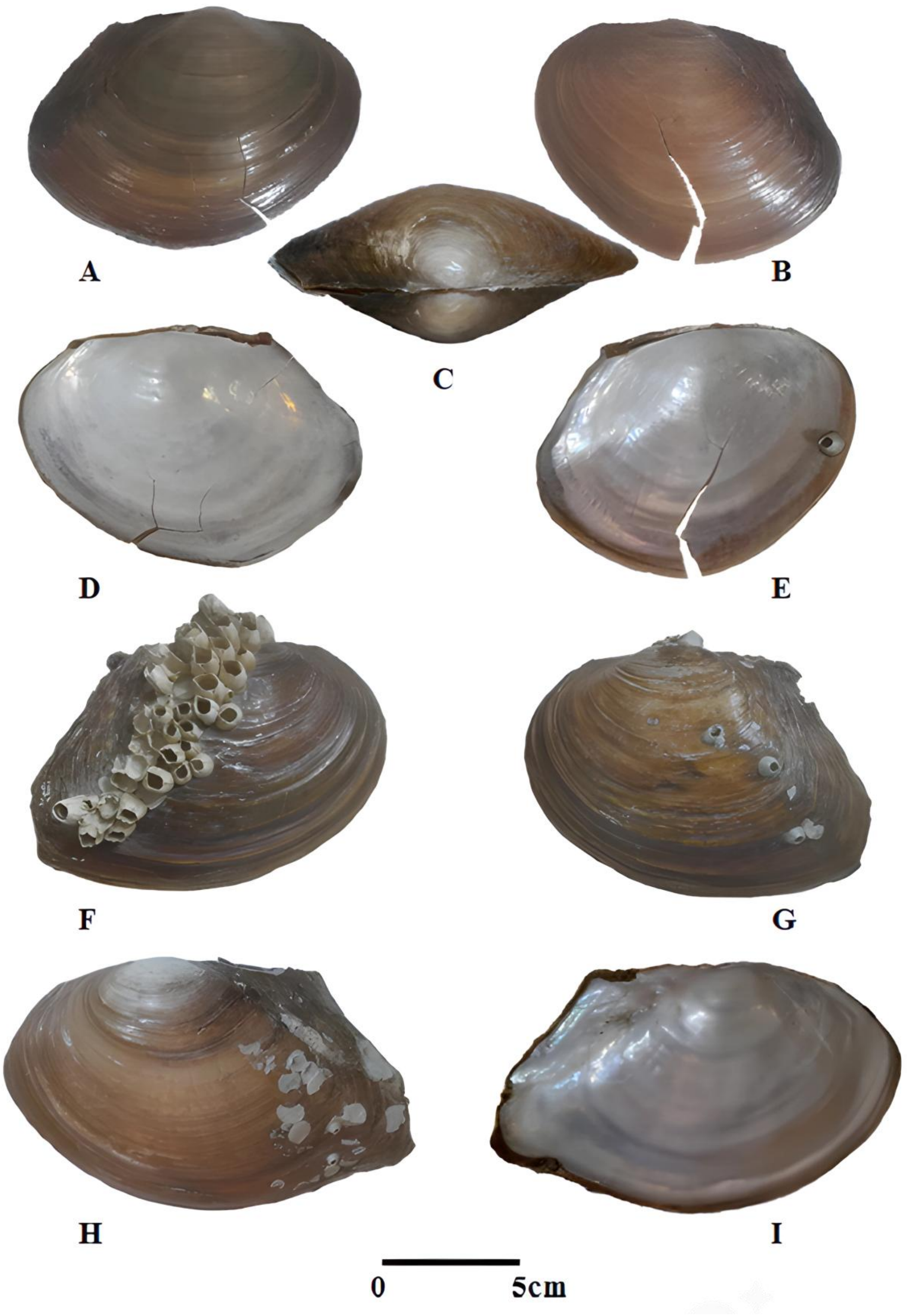

Figure -2 A-G: *Sinanodonta woodiana* (Lea, 1834); A. Right valve(exterior view);B. Left valve(exterior view);C. Dorsal view(Umbonal view); D. Right valve(interior view); E. Left valve(interior view); F. Right valve(exterior view); G. Left valve(exterior view); H-I: *Sinanodonta lauta* (Martens, 1877); H. Left valve(exterior view); I. Left valve(interior view).

Table 2- Pelecypods species and number of shells and valves in the study area sites

Site	Sample depth (m)	*Sinanodonta lauta*		*Sinanodonta woodiana*	
		Shell	**Valve**	**Shell**	**Valve**
1	0.35	1	0	3	2
	0.5	2	1	2	1
	0.75	0	0	4	0
2	0.40	1	1	2	1
	0.65	0	1	3	3
3	0.45	2	1	3	0
	0.70	0	1	2	1
4	0.35	3	1	1	0
	0.74	2	2	2	1
5	0.36	1	2	1	0
	0.75	3	2	2	1
6	0.50	1	1	1	0
	0.75	3	1	0	1
7	0.40	2	1	0	1
	0.60	2	2	0	0
	0.75	3	1	0	1

Figure -3 *Amphibalanus subalbidus* (Henry,1973)

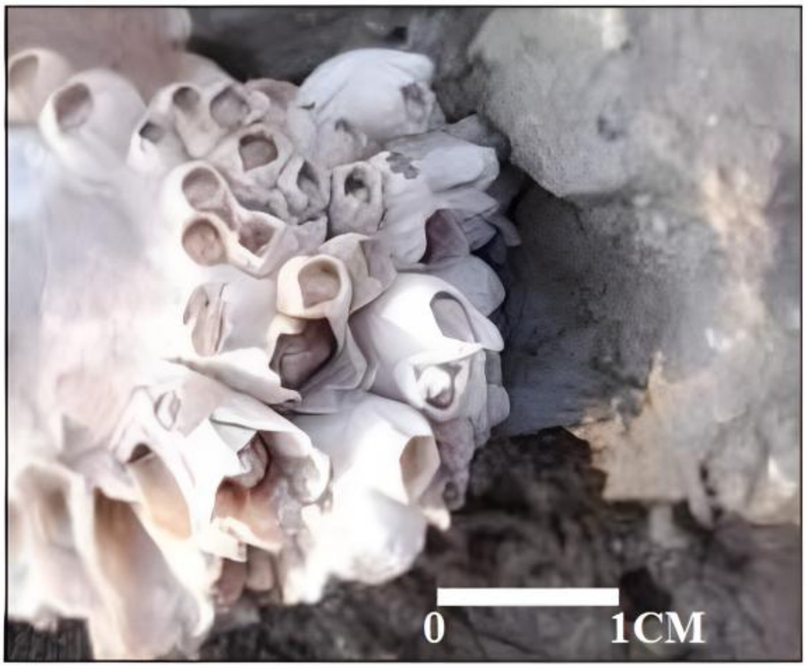

Figure -4 *Amphibalanus subalbidus* (Henry,1973) fixed on hard sediments

The Holocene was characterized by a warming climate following the last ice age. This warming led to changes in precipitation patterns, temperature, and overall ecosystem dynamics, which in turn affected freshwater habitats where both *Sinanodonta woodiana* (Lea, 1834) and *Sinanodonta lauta* (Martens, 1877) are found. Which in turn contributed to the use of the two types in detecting environmental changes. In the Holocene, *Sinanodonta woodiana* (Lea, 1834) has been utilized in palaeoenvironmental studies. Its calcareous shells serve as archives for reconstructing past environmental conditions, allowing to infer climatic and hydrological changes over time [24]. The species has been found in various sediment layers, contributing to understanding of historical biodiversity and environmental shifts in freshwater ecosystems. In the Holocene context, *Sinanodonta lauta* (Martens, 1877) also contributes to the understanding of freshwater ecosystems, particularly in terms of its habitat preferences and ecological roles. Studies have suggested that it may occupy similar niches as *Sinanodonta woodiana* (Lea, 1834) , leading to further implications for conservation and management of freshwater biodiversity[25] [26]. *Sinanodonta woodiana* (Lea, 1834) has shown adaptability to varying environmental conditions, which has allowed it to thrive in diverse habitats, including ponds, lakes, and rivers. During the Holocene, as temperatures increased, *Sinanodonta woodiana* (Lea, 1834) expanded its range into new areas, particularly in Europe and North America, where it became an invasive species. Its ability to tolerate a wide range of bottom sediments, including both sandy and muddy substrates, facilitated its establishment in various freshwater ecosystems[20]. The warming climate likely enhanced habitat suitability for *Sinanodonta woodiana* (Lea, 1834), as it can thrive in warmer waters, therefore this adaptability contributed to its demographic success in invaded regions[20]. In contrast, *Sinanodonta lauta* (Martens, 1877) appears to have a more restricted habitat range and may not have adapted as successfully to the changing conditions of the Holocene. While it shares some ecological similarities with *Sinanodonta woodiana* (Lea, 1834), its distribution is more limited, primarily found in its native East Asian habitats. The specific impacts of Holocene climate changes on *Sinanodonta lauta* (Martens, 1877) are less documented, but it is likely that the same warming trends that benefited *Sinanodonta woodiana* (Lea, 1834) may have posed challenges for *Sinanodonta lauta* (Martens, 1877), particularly if its habitat preferences are narrower[27] [28].

In the current study the presence of both *Sinanodonta woodiana* (Lea, 1834) and *Sinanodonta lauta* (Martens, 1877) in recent sediment of study area underscores the complex dynamics of freshwater ecosystems in the area.The study area impacted by the waters of the two rivers, namely the Karkheh River, which flows into the Hawizeh Marsh southeast of the city of Amara, which in turn feeds the Tigris River north of Qurna and the Shatt al-Arab south of Qurna, while the Karun River flows into the Shatt al-Arab south of the city of Basra. Thus, water of the Shatt al-Arab consist of water of the four rivers, the Tigris, Euphrates, Karkheh and Karun, which are affected by the natural phenomenon of tides and mix accordingly with sea water, which causes the water levels in Shatt to rise or fall according to that phenomenon, which in turn affects the quality of the water in the Shatt al-Arab[29].

This overlap in water sources not only affects the quality of water but also affects the nature of the types of organisms that can be found under such conditions. This can be observed in the study area, as the species *Sinanodonta woodiana* (Lea, 1834) was known in Iraq in the city of Hillah [10], and the species was also recorded in Turkey [30]. As for the species *Sinanodonta lauta* (Martens, 1877), its presence has been documented in Iran [27]. The presence of the species in areas close to Iraq, where water sources reach the region, is evidence of their migration from there. What confirms the effect of the water source in transporting the species to the study area is the presence of Barnacle shells, known for their marine environment, and it has been identified as the species *Amphibalanus subalbidus* (Henry, 1973) has been identified as an alien species that has been introduced to the area. This species marks its initial occurrence outside its native habitat in the Western Atlantic and is believed to have become established in the lower reaches of the Euphrates, Tigris, and Karoon rivers [17].

The presence of *Sinanodonta woodiana* (Lea, 1834) and *Sinanodonta lauta* (Martens, 1877) with barnacle shells which resting on them indicates that the species have been settled for some time in southern Iraq. The large sizes of the species shells and their presence in most of the sites in the study area also indicate this, especially since the shells found in the study area were completely empty of any organic remains. As for the numbers of shells and valves of the species, the presence of the species *Sinanodonta woodiana* (Lea, 1834) was predominant, and this may be due to the species' ability to adapt to the environmental changes that occurred during the end of the Holocene [20].

5. Conclusions

- The prevalence of muddy sediments within the study area.
- This study marks the first recorded of the species *Sinanodonta lauta* (Martens, 1877) in Iraq, particularly in the southern region.
- The species *Sinanodonta woodiana* (Lea, 1834) has been documented in southern Iraq.
- The occurrence of pelecypod species in the study area suggests their susceptibility to climatic shifts during the Holocene epoch, including increased temperatures and their establishment beyond their native environments.
- The *Sinanodonta woodiana* (Lea, 1834) and *Sinanodonta lauta* (Martens, 1877) accompanied by barnacle shells indicates that these species have been residing in southern Iraq for a considerable duration, likely during the Late Holocene.

- The identification of both *Sinanodonta woodiana* (Lea, 1834) and *Sinanodonta lauta* (Martens, 1877) in the recent sediments of the study area underscores the intricate dynamics of freshwater ecosystems present in it.

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