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Juliana Lake: A Wetland in an Urban Environment[1]

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ABSTRACT

Of all the remaining natural habitats of Benghazi's urban area (NE Libya), perhaps the most threatened are its *karst* lakes and coastal salt marshes (locally known as Sebkha). Juliana Lake stands out as one example of a fragile ecosystem that is steadily shrinking and exposed to dredging, infilling and, consequently, possible damage to its aquatic organisms, and the inevitable loss of its renowned biodiversity. Several 19th & 20th–century traveller's sketches and maps, soil maps, photographs and satellite images provide the bases for change in the size and magnitude of the lake and its adjacent areas over time.

Assessment of the sediment composition and texture of material accumulating at the bottom of the lake reveals mixtures of Sebkha sediments such as salty clay, silt, and clayey sand, while sediments at the surface and around the lake are represented by quite soft whitish to yellowish and scattered patchy limestones of unknown affinity. Terra-rossa and Quaternary caliche are present also, but calcarenites cover considerable part of the studied area. The bio-micro components of these sediments are described and a number of small-sized benthic foraminifera have been identified. Macrofauna, which are primarily presented by recent benthic seashells belonging to phylum mollusca, have also been investigated and several species have been identified to the species level wherever possible. Other calcareous biotic components are predominantly shell fragments of molluscs, echinoderms and calcareous coralline red algae. It is concluded that the distribution, diversity and abundance of the total benthic organisms recovered in this survey reflect the habitat's richness in nutrients and consequently providing important food source for fish, birds, and mammals.

It is argued that environmentally based planning strategies can preserve the fragile landscapes of Benghazi and, furthermore, ensure a more sustainable form of future urban development. In this context, urban planners should review routine urban planning practices affecting Juliana wetland and other natural landscapes of Benghazi, and adjust them to integrate nature into the urban scene of current and future development plans.

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1. Introduction

Coastal Libya in general is endowed by the existence of a wide range of interesting and lively landscapes resulting from a warm Mediterranean climate, an extensive stretch of sandy beaches, Jabal al-Akhdar unique geology and geomorphology, and a multitude of other picturesque natural habitats supporting an exciting biodiversity in many sites scattered throughout the country. Such wealth of natural heritage provides not only recreational facilities for local citizens and visitors alike, but also many opportunities for scientific research and a rewarding link with history and identity. However, negligence and increased human activity threaten many of these unique landscapes and their rich ecological diversity, which, left unabated, could lead to serious diminishing of their distinct natural quality and ecological importance. In many ways, this natural wealth of biodiversity, landforms and other features of scientific interest is taken for granted and left without legal and communal protection. The result was a failure to realize how easily it can be lost, perhaps forever. Therefore, sustainable development of the coastal regions' physical and biological diversity becomes an urgent matter in need of serious ecological maintenance and strong legal and communal protection. One positive approach towards ensuring the survival of the various elements of the natural heritage is through designation of areas of special natural and scientific value as 'nature reserves'. Designation as national "nature reserves" of many sites within this variety of natural landscapes will provide the legal protection necessary, and a tool for the systematic periodic evaluation of numerous sites of ecological importance at the local, regional and national levels utilizing specified criteria developed for this purpose. Criteria for the decision to designate a particular site as a 'nature reserve' depend on its own landscape and biodiversity merits and on the likelihood of human impact on the natural values attached to it, as well as the proper means by which adverse impacts can be avoided or mitigated.

Since the onset of modern urban planning projects in Libya in the mid-sixties of the last century, the city of Benghazi and its immediate surroundings have been undergoing phenomenal transformation that resulted in undesirable infringements on the natural environment. The site occupied by the modern city of Benghazi has been chosen to highlight urban and environmental peculiarities and transformations of a city deeply rooted in history for over two and a half millennia. It is argued that environmentally based planning strategies that integrate nature into the urban scene of Benghazi development plans can preserve its fragile landscapes and, furthermore, ensure a more sustainable form of future urban development. Focus of the present paper is Juliana Lake, the most prominent of the city's Karst lakes and Sebkha formations, and to

[1] The authors presented an earlier version of this work as a poster session: "Juliana Lake: A Benghazi wetland in distress!" *European Geosciences Union (EGU) General Assembly* 2013 Vienna | Austria | 07 – 12 April 2013.

emphasize its environmental attributes and ultra-sensitivity to alteration and change.

2. Methodology and objectives

Overall aims of the present paper are to identify the adverse anthropogenic impacts that may lead to the ultimate destruction of Lake Juliana natural habitat and to encourage environmental awareness and the sensible use of this special natural site through the integration of any new developments in its immediate area with principles of conservation and preservation of the natural environment. The study also aims to highlight its significance for conservation and values in providing special opportunities for study and research.

Assessment of the site is based on the landscape approach, which is suitable for planning and regulatory purposes, and provides information more urgently needed by decision makers to enable them develop appropriate strategies and plans to ensure conservation and sustainable use of the sites. For collecting information and materials at the landscape level relevant to particular site's protection and restoration, we depend on the following sources and fieldwork:

i. Evidence of changes in wetland extension and magnitude through examination of historical sketches, some dating from the early 19th-Century, as well as later sketches, maps, satellite images and photographs available for urban saltmarsh/wetland habitats.

ii. Assessment of sediment composition and texture of material accumulating at the surface and bottom of lake and their biotal components.

iii. For wetlands` landscape ecology data, some published biodiversity sources were used.

3. Geographical site information

Juliana Lake, also known as Benghazi Lake , is located at coordinates 32°05'19.68" N 20°03'18.81" E in the small coastal suburb of Juliana southwest of old Benghazi, at the southwestern tip of Lake 23rd of July, which is connected to Benghazi old harbor (Fig. 1).

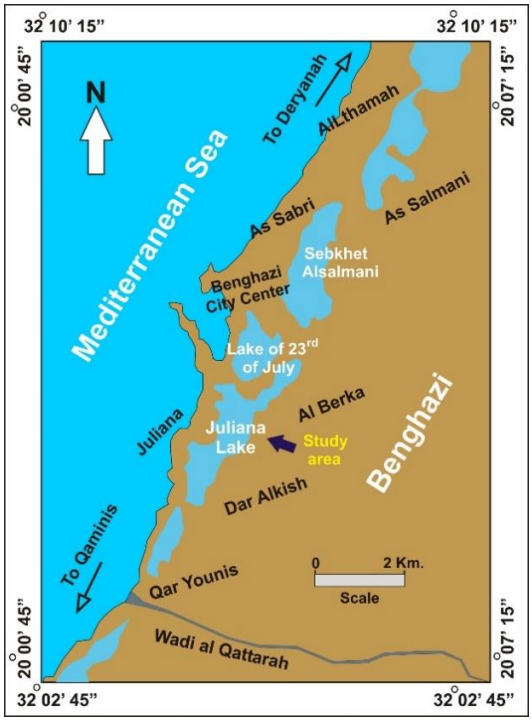

Fig. 1. Location map of Juliana Lake and other similar wetlands that extend along the coastal side of Benghazi City.

The lake represents one of the major wetlands that once extended along the city of Benghazi. Linked to Benghazi historic CBD through Juliana Bridge, this permanent saline/brackish lagoon is currently occupying an approximate area of some 1.6 km square (about 160 hectares) (Fig. 2). The selection of the site based primarily on the lake's significant ecological functions, biodiversity roles and its unique landscape features that made it one of the distinguishing landmarks of the city. It also stands out as one example of a fragile ecosystem that is steadily shrinking and exposed to dredging and, consequently, possible damage to its aquatic organisms, and the inevitable loss of its renowned biodiversity. Several 19th & 20th–century traveler's sketches and maps, photographs and satellite images provide the bases for change in the size and magnitude of the lake and its adjacent areas over time.

Fig. 2. Juliana Lake looking northwest, with Benghazi skyline in the upper right hand corner of the picture.

Historically, a continuous belt of karst lakes and salt marshes defined the northeastern, eastern, southern, and southwestern limits of the old city. This elongated stretch of urban wetlands continues beyond the old city limits in northeasterly and southwesterly directions for tens of miles. Lakes and marshes in the Greater Benghazi area are fed by an extensive system of underground channels, i.e., the legendary Lethe River and a group of surface karst lakes; including Ain Zayana, Budezira, Maqarin, etc. (sketch in Goodchild, 1962).

For most of the city's long history, the city's extensive wetlands provided a valuable source of salt, which was exported to other places. Their almost uninterrupted juxtaposition in space served as effective natural defensive barriers for the city until the Italians built a defensive wall shortly after their occupation of the city in 1911. In addition to their cultural and scenic roles, these urban wetlands also provided many valuable ecological and biodiversity services. Equally important, they served as natural flood control mechanisms and alleviated flood hazard during rainy seasons.

4. Wetland Loss

Juliana Lake once covered much bigger area than its present meager 160 hectares. Known during the Italian occupation of Libya as "*Salina della Giuliana*", the lake formed the southwestern extent of three adjoining large Sebkha flats that encircled the old town for most of its history. The other two were *Salina della Punta*, later transformed into an artificial lake (23rd of July Lake) with an opening to the old port, and Sebkhet (*Salina) Selmani* which disappeared altogether at the start of urban planning activities in the mid Sixties of the last century. The old town, housing the old quarters of the traditional Islamic city and the modern residential and commercial section initiated by the Italians, was connected to the suburb of Sidi Husein and beyond southwards to Al Berka through a causeway constructed during the Turkish era at the interchange of the latter two Sebkha flats. The huge loss of Sebkha flats makes what remains of Juliana Lake the only surviving natural wetland inside the area of historical Benghazi.

Historic, cultural and aesthetic value of Benghazi natural wetlands is obvious. Up to the middle of the 20th Century, the urban area of Benghazi clearly maintained a harmony that existed between the builders of the town and their natural environment, perhaps since ancient times when the Greeks abandoned the site of

their westernmost settlement in Cyrenaica, Euspiredes,[2] which was built on a mound overlooking ancient Lake Tritonis from the north and east early in the 6th Century BC. Its successor (Berenice) was relocated on the strip of land between the Mediterranean Sea and the two lakes, which became known in modern times as Sebkhet Selmani and Sebkhet Punto. The revival of the site in modern times happened in the middle of the 15th Century when Benghazi occupied the same site, inheriting the same natural settings and preserving them until the onset of the era of modern urban planning in the second half of the twentieth century. Large areas of natural wetlands in Benghazi area had disappeared over the past half century, and those remaining few areas become threatened by urban development encroachments and other human activities. Examination of historical sketches dating from early 19th century, which depict the vast expanse of Sebkhet Alsalmani to the east of the old city and its connections to Sebkhet Eusperides (Zreriia)/AlLthama to the northeast and Sebkhet Alkish and Juliana lake to the southwest (Beechey Brothers sketch of 1828 quoted in Bulugma, 1964) reveal a dramatic change in their size and magnitude over the past half century. While Sebkhet Alsalmani infilled and disappeared completely in the mid-1960`s, Sebkhet Eusperides (Zreriia)/AlLthama were targeted for development as artificial lakes with connections to the open sea. Juliana Lake faced similar destiny and lost a sizeable chunk of its former extension to the northeast, to what had become known as Sebkhet Alkish, now constricted into a small sewage polluted pool squeezed between two major roads near the Sports City in Alkish area. Juliana Lake also targeted for proposed urban development plans as one of the so-called Benghazi Seven Lakes Project and similar investment plans.

Google images available since 2002 show that what remains of this historic special urban wetland is steadily shrinking, affected by ongoing anthropogenic activities, which could play detrimental role in its evolution and ultimate fate. This study only investigated characteristics of the relationship between wetland change and urban development. However, wetland changes maybe also due to natural factors such as persistent draught, climate change, hydrologic factors, etc.

5. Biodiversity site information

Juliana Lake presents a fine example of a unique ecosystem, harboring both feeding and roosting areas for a range of wintering waterfowl, in addition to a variety of aquatic and terrestrial plant species. It was listed among the 20 Libyan wetlands with the highest scores between 2005 and 2010 for landscape ecology criteria considered, i.e., species richness, abundance, and regional importance (Atlas of Wintering Waterbirds of Libya: 2005-2010)**.** According to the compilers of the Atlas, their "… survey encompassed six years of data collection over 110 wetlands in Libya. Although basic information was collected on each wetland visited, the main indicator used to assess the state of the ecosystems surveyed was the waterbird community. By using abundance and diversity of the Libyan waterbird community, it is possible to sketch preliminary patterns of wetland biological value, to assess levels of wetland degradation and loss, and to evaluate the importance (in heritage terms) of one of the most threatened ecosystems of the Mediterranean" (Atlas, p. 29).

In fact, wetlands in the greater Benghazi area extending from Sebkhet Qanfuda in the southwest to Sebkhet Alkuz in the northeast emerged prominent in average abundance of water birds counted in Libya from 2005 to 2010. The Atlas of Wintering Waterbirds of Libya: 2005-2010 ranked Juliana Lake, referring to it as "Sabkhat Julyanah", first in bird species richness, computed as the total number of waterbird species observed on the wetland, and third in overall water bird abundance and regional importance (Atlas, Table 5, p. 30)**.** Also In terms of the annual number of bird species sighted in more than 50 Sebkha wetland sites[3], Juliana Lake scored the highest mean (33 species), followed by Sebkhet AlLthama and Sebkhet Esselawi (32 species), and Ain Zayyana Lake (25 species), all located in Benghazi site (Atlas, p. 26**).**

This quality of relatively high wintering bird species` richness gave Juliana wetland the status of natural site of national importance providing habitat for many waterfowl species including: "Black-headed Gull; Black-necked Grebe ; Coot; Cormorant; Dunlin; Flamingo; Kentish Plover; Little Stint; Pintail; Pochard; Ringed Plover; Shoveler; Slender-billed Gull; Teal; Whiskered Tern. As well as a potential site of national importance for: Black-winged Stilt; Grey Heron, Mediterranean Gull; Moorhen; Redshank; Sanderling; Sandwich Tern; Wigeon" (Atlas, p. 43).

6. Sediments and biotal components of Juliana Lake

The surface sediments at, and around, Juliana Lake comprise patches of terra rossa (reddish soil) mixed with very fine calcitic-sand and diverse constituents of clay. Alkali salt grains with diverse constituent of clay have been noted also. Yellowish to reddish calcarenites (clastic limestone) are also common and some samples have been collected and petrographically examined. The results, however, point to characterization of these recent calcareous sediment by a particle range of 0.5–2.00 millimeters in diameter and most clasts and matrix are calcareous although some quartz have also been noted. The sands maybe are brought ashore by marine-waves and then blown by winds. Evidence for the wind-blown origin can be found in fairly steep crossbeds observed in some road cuts within and around Benghazi City and along the sides of the mouth of Wadi al Qattarah at Garyounis area of western Benghazi (see Fig. 1).

Several meters thick of quite good exposure of calcarenites (limestone with grain size range between 62 microns to 2 millimeters) have been examined around Juliana Lake. Here, several samples have been collected and examined for their litho-and bio-clasts components. The results, however, show that the shell fragments are predominantly made of remains of calcareous coralline red algae, spines of echinoids and small-sized micro-seashells (Fig. 3). Small benthic foraminifera belonging to suborders Miliolina (calcareous porcellaneous tests) and Rotaliina (calcareous hyaline tests) are present and show disaggregation of tests. The lithoclasts, however, are primarily calcareous grains ranging in size between 1 to 2 millimeters. Quartz sand grains are present in variable amounts.

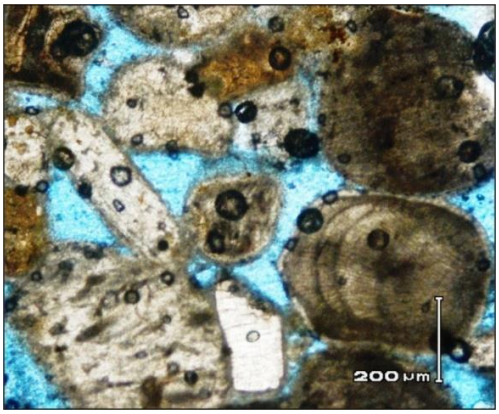

Fig. 3. Photomicrograph showing calcarenites with remains of calcareous red algae (right side) and spines of echinoids (lift side).

Patches of limestone of unknown affinity have been noted on the surface outside the wetland site and a spot sample has been collected and analyzed using a binocular microscope. The limestones are referring to wackestone and packstone (*sensu* Dunham, 1970), the bioclasts components, on the other hand are generally expressed using terms recommended by Flügel (2010) and Tucker

[2] Euspiredes, the westernmost city built by the Greeks in Cyrenaica in the middle of the Seventh Century BC, and became a member of the Pentapolis.

[3] Selected mainly from coastal areas in northeastern Libya, but included also few others located in desert areas.

(2011). In general, these components are mostly represented by remains of fossil macrofauna belonging to phylum mollusca and phylum echinodermata. Quaternary caliche also covers few parts around the study area. It is presented by carbonaceous crust of grayish to yellowish dolomitic limestone, with fine-grained to microcrystaline and includes remnants of recrystallized gravel and molluscan casts. Field investigation has reveled that large quantities of bottom sediments, which have been brought-up by artificial mechanical means to the surface, are forming disconnected artificial ridges along some sides of the Juliana Lake. These sediments are extremely rich by recent benthic and macro-seashells which are primarily belonging to phylum mollusca (Fig. 4). Additional micro- and macro-seashells are found in abundance and diversity and about 200 specimens have been collected from the nearby Juliana sand-coast. They have been examined, and several species have been identified using terms proposed by Vaught (1989) and Clarkson (1993). It has been found that all recovered macrofauna are represented by frequent gastropods (marine slugs and snails), pelecypods (clams, oysters and scallops) and rare scaphopods (toothshells) (Plates 1 & 2). They represent few cosmopolitan species but their majority belongs to the Mediterranean region. Some species, though, are restricted to North Africa and they are normally quite large.

Fig. 4. Bottom sediments with mollusca seashells at the sides of Juliana Lake.

Recent micro-seashells, however, are also abundant in the sediments of Juliana sand-coast but show less diversity. The majority of these micro-seashells are representing by small tests of benthic foraminifera (single-celled organisms less than 2 mm in size) and numerous species have been identified based on the terms of Loeblich and Tappan (1987) and Cimerman and Langer (1991). Selected examples of these fauna have been identified and illustrated in Plate 3. As with the case of surface sediments (see above), the bottom sediments of Juliana Lake, are also rich by individuals belonging mainly to peneroplids, miliolids, ammoniids and elphidiids. Normally, these groups of benthonic foraminifera live on either soft (sandy- muddy) or hard (rocky) shallow bottoms and are commonly found in shallow marine environment (Murray, 1973). Some genera, however, are quite common in several restricted habitat such as lagoons, brackish estuaries or salt marshes along the shore (Murray, 1991).

In addition to the above-mentioned benthonic foraminifera, smooth and delicate small-sized carapaces of ostracods (small-sized Crustacean) and other micro-calcareous benthic seashells are quite common in the study sediments. The distribution, diversity and abundance of the total benthonic organisms recovered in this survey reflect that the local habitat of the Juliana Lake were rich in nutrients and consequently providing an important food source for fishes, birds, and mammals. In fact, without these benthic organisms, these larger animals would not be able to survive.

7. Environmental awareness and conservation issues

In addition to the site's extreme value for biodiversity and scientific research, its aesthetic, educational and cultural potentials are unlimited as well. The wetland provides a very good example for environmental awareness and conservation education, and its accessibility within city limits makes it suitable for non-consumptive recreation activities such as bird watching, walking and bicycle riding for local residents and schoolchildren. In fact, its former sandy western edges once provided ideal place for playing golf and other sports.

Existing land use in areas surrounding Juliana Lake is in the form of extensive urban development, including multiple-story residential buildings, villas, commercial activities, a bridge, and major roads running parallel to the wetland from north to south and east to west. Along with continued rapid urban development near the lake, ecological damages caused by other human activities within the site proper are becoming more obvious. Significant negative changes occurring in recent years include excessive dredging in some parts of the lake, and infilling in other parts, which resulted in severe shrinkage in water area of the lake and its possible fragmentation into two parts or more. Other threats now occurring at a large scale include:

- *Solid waste and trash dumping*
- *Possible wastewater and sewage pollution*
- *Dredging debris from bottom of lake piled on the western shores and middle of lake.*
- *Plant removal and destruction*
- *Its far southwest corner is currently used as heavy trucks depot for unloading and loading building materials like sand and gravel*
- *Impact of increased human disturbance (the removal of the protective metal fence encircling the whole wetland is the latest of such interferences!)*
- *Presence of building activity within the site*
- *Evidence of bird hunting is also noticeable.*

Perhaps the extreme threat comes from unsound urban planning projects, which aim to change the status of urban natural wetlands into artificial ones with direct open link to the sea. At present, no management status exists for the lake, neither any national nor any international conservation and preservation statuses exist as far as we know!

8. Conclusion

The remarkable wetland of **Juliana Lake** is a living example of an environmentally sensitive area currently under serious threat. It is the largest remaining wetland located within the city limits and a reminiscent of the long, almost continuous stretch of marshes that once defined its northeastern and southwestern limits. Unfortunately, wetlands space loss continues in, and around the city of Benghazi. Since there has been little systematic effort to measure, document, and assess the condition of coastal and inland wetlands in Benghazi and its environs, pollution and encroachments of all kinds on the fragile ecosystems of wetlands of the city will continue. The ultimate fear facing Juliana wetland is dredging occurred over the past few decades, which could transform the original natural wetland into an artificial one. Thus, a reevaluation of the potentialities of Benghazi's unique site calls for different development scenarios for the area that takes into account landscape ecology approaches, and the need to integrate nature into the urban scene of, perhaps, a long environmentally neglected city. It is recommended that more specialized and detailed landscape ecological studies need to be undertaken by specialists to fully assess the peculiarities of Juliana Lake. Similar survey work should also be completed for other natural habitats in the region to fully understand their original functions and values, and assess recent alteration trends and consequences.

We think of urban habitats as valuable natural heritage sites worthy of preservation for the sake of current and future generations. Thus, our main aim remains to draw attention to the lack of protection of urban wetlands and to call for the immediate official declaration of Juliana Lake as an urban nature reserve, strictly protected by laws and regulations.

PLATE 1

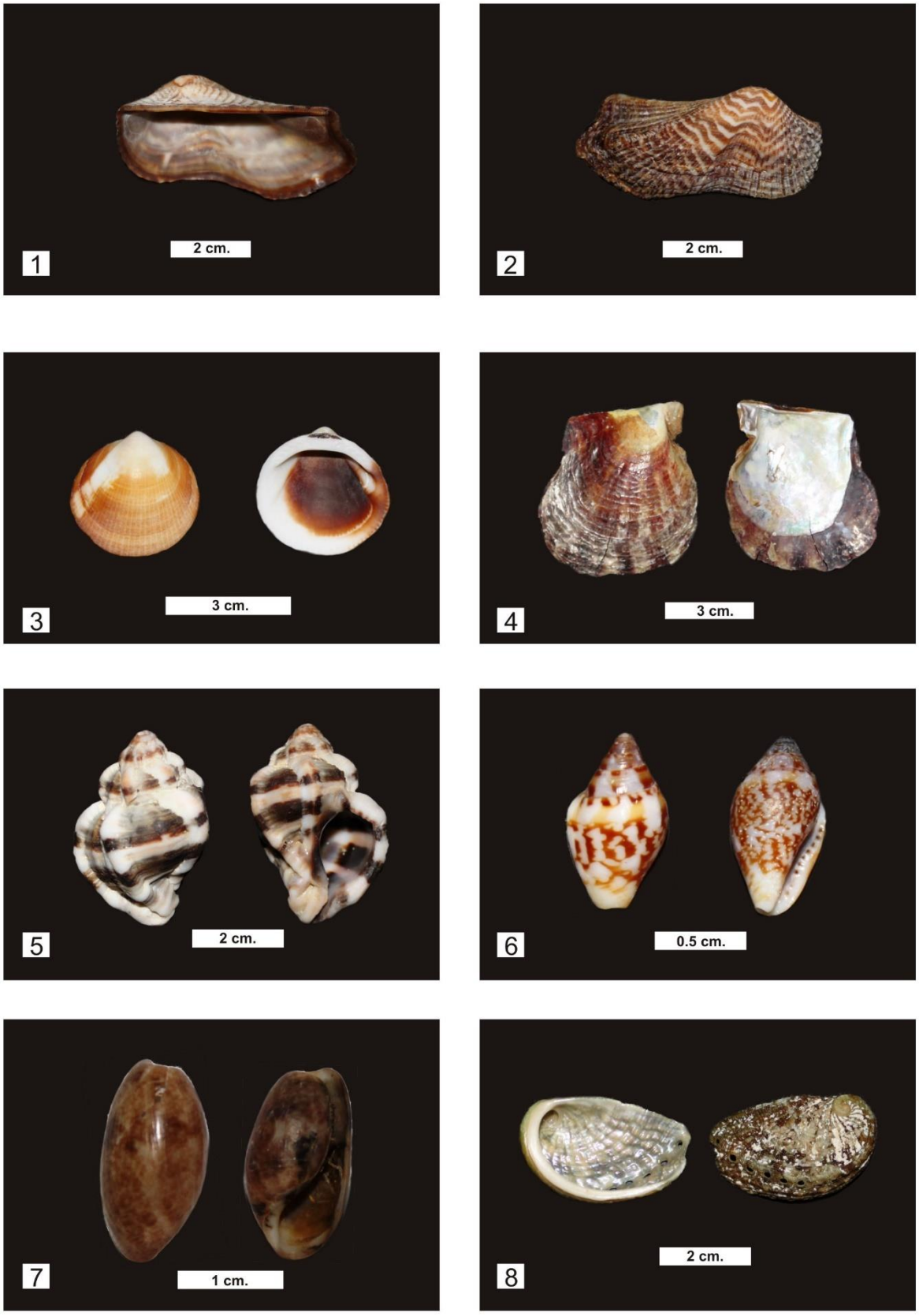

Plate 1, shows selected examples of phylum mollusca. Figs. 1 & 2: External and internal views of *Arca zebra* (Swainson, 1833); Fig. 3: External and internal views of *Glycymeris violascens* (Lamarck, 1819); Fig. 4: External and internal views of *Pinctada* cf. *radiata* (Leach, 1818); Fig. 5: External views of *Tranculariopsis*? cf. *trunculus* (Linnaeaus, 1758); Fig. 6: External views of *Columbella reustica* (Linnaeaus, 1758); Fig. 7: External views of *Bulla ampulla* (Linnaeaus, 1758); Fig. 8: External and internal views of *Haliotis* cf. *lamellosa* (Lamarck, 1822).

PLATE 2

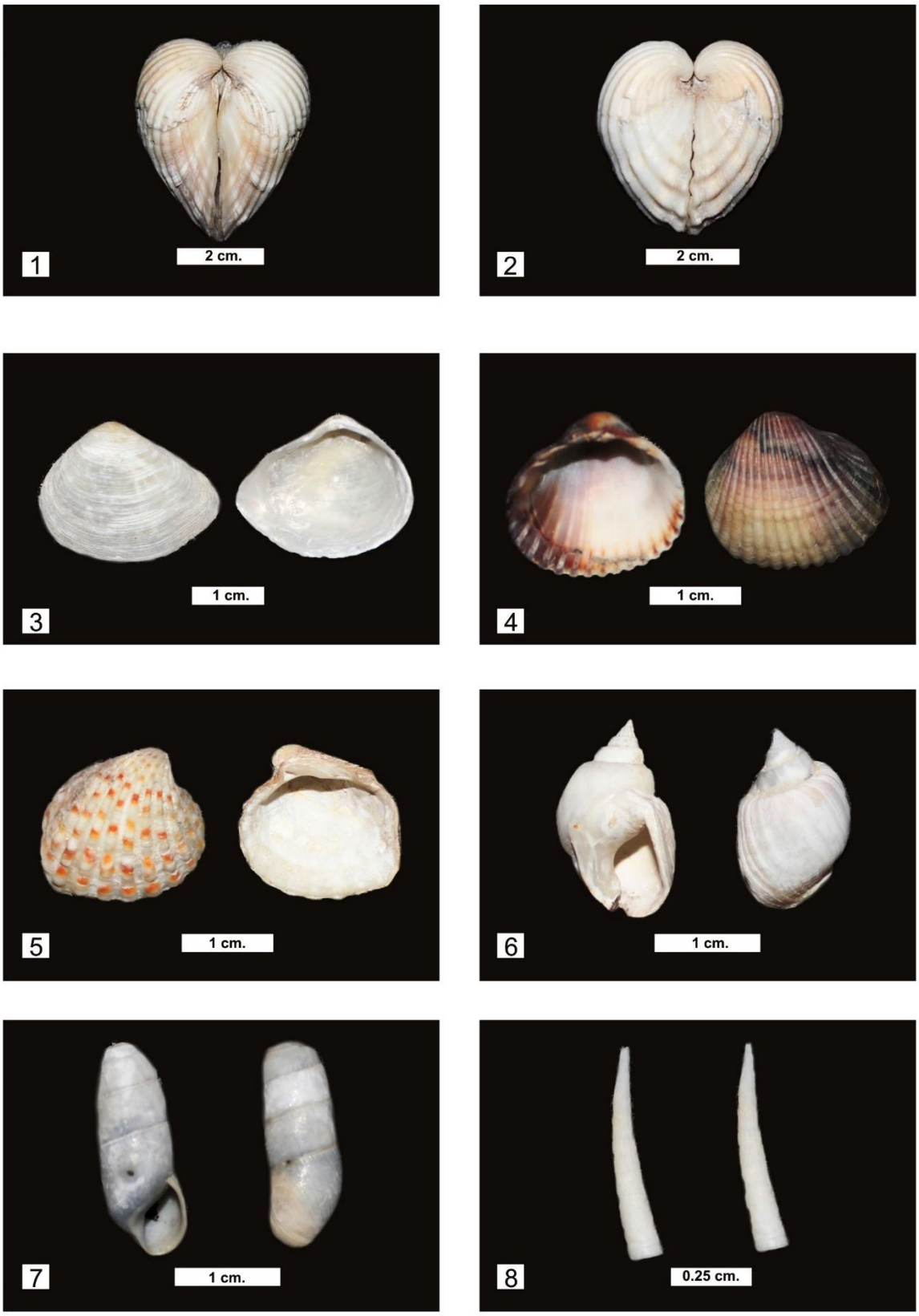

Plate 2, shows selected examples of phylum mollusca. Figs. 1 & 2: Side views of *Cardium edule* (Linnaeaus, 1758); Fig. 3: External and internal views of *Tellina* cf. *laevigata* (Linnaeaus, 1758)*;* Fig. 4: External and internal views of *Cerastoderma* sp.; Fig. 5: External and internal views of *Cardites antiquata* (Linnaeaus, 1758); Fig. 6*:* External views of *Babylonia* cf. *spirata* (Linnaeaus, 1758); Fig. 7: External views of *Rumenia decollate* (Linnaeaus, 1758); Fig. 8: External views of *Dentalium vulgare* (Da Costa, 1778).

PLATE 3

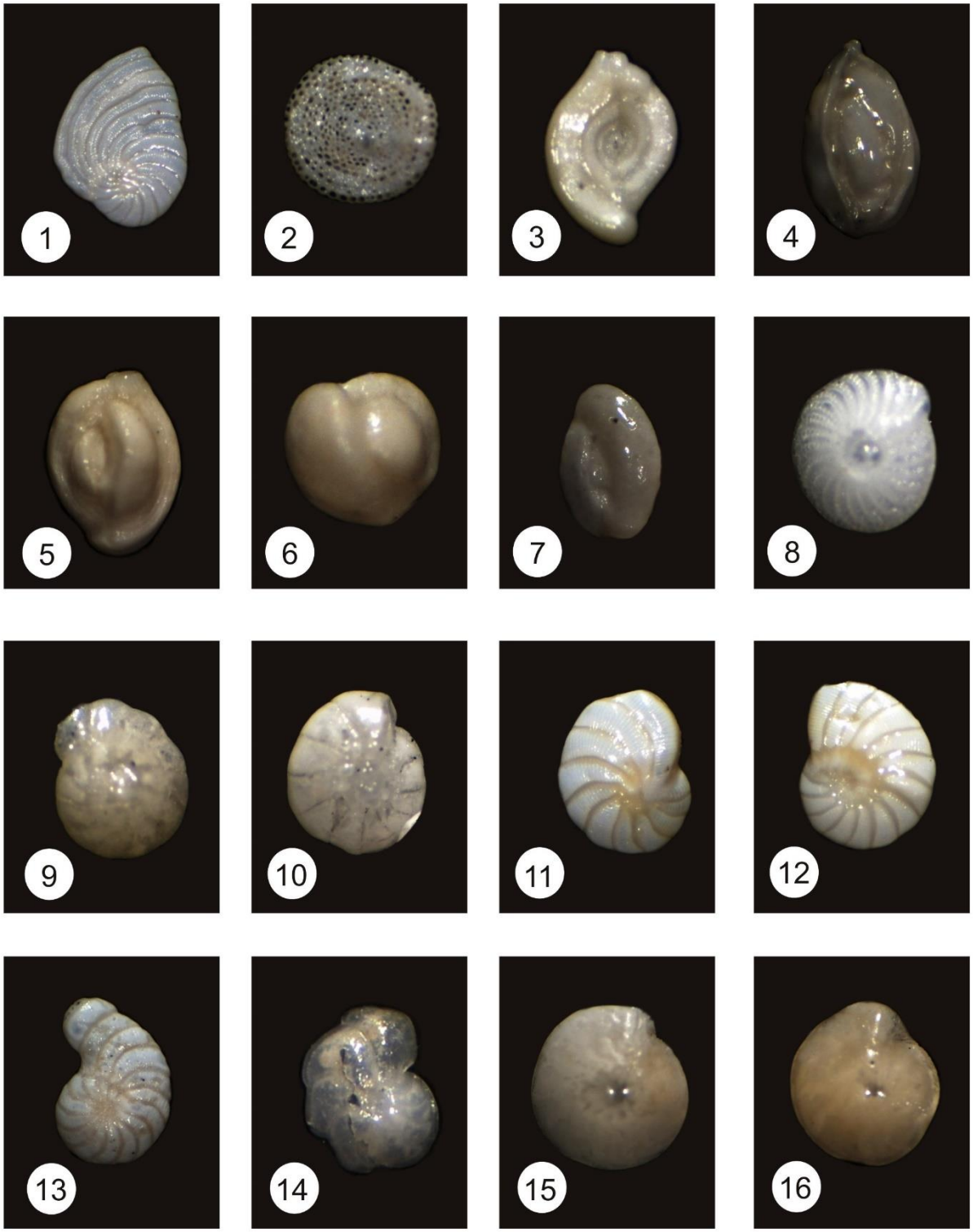

Plate 3, shows selected examples of small benthic foraminifera. Magnification is ranging between X55-X 65 for all figures. Fig. 1: Side view of *Peneroplis planatus* (Fichteli and Moll, 1798); Fig. 2: Side view of *Amphisorus hemprichii* Ehrenberg, 1841; Fig. 3: Side view of *Spiroloculina* cf. *depressa* D' Orbigny, 1826; Fig. 4: Side view of *Quinqueloculina* sp; Fig. 5: Side view of *Adelosina carinata-striata* Winesner, 1923; Fig. 6: Side view of *Triloculina* sp; Fig. 7: Side view of *Quinqueloculina* cf. *seminula* (Linnaeaus, 1758); Fig. 8: Side view of *Eliphidium* cf. *crispum* (Linnaeaus, 1758); Figs. 9 & 10: Side views of *Ammonia* cf. *inflata* (Seguenza, 1862); Figs. 11 & 12: Side views of *Peneroplis* cf. *pertusus* (Forskål, 1775); Fig. 13: Side view of *Peneroplis* sp; Fig. 14: Side view of *Lobatula lobatula* (Walker and Jacob, 1798); Figs. 15 & 16: Side views of *Amphistegina* cf. *lessonii* D' Orbigny, 1826.

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