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The bivalve *Placuna* (*Indoplacuna*) *miocenica* from the Middle Miocene of Siwa Oasis, Western Desert of Egypt: Systematic paleontology, paleoecology, and taphonomic implications

Ahmed M. El-Sabbagh [a], Magdy M. El Hedeny [a, b, *], Mohammed A. Rashwan [c], Abdel Aal A. Abdel Aal [a]

[a] Department of Geology, Faculty of Science, Alexandria University, Alexandria 21568, Egypt
[b] Deanship of Scientific Research, King Saud University, Riyadh, Saudi Arabia
[c] Department of Biology and Geology, Faculty of Education, Alexandria University, Alexandria 14037, Egypt

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ABSTRACT

The present study investigated the epifaunal, free lying bivalve *Placuna* (*Indoplacuna*) *miocenica* (Fuchs, 1883) encountered in the Middle Miocene Marmarica Formation of Siwa Oasis, Western Desert, Egypt, in terms of systematic paleontology, paleoecology and taphonomy. Well to moderately preserved shells of this species were collected from three sections. They have been found embedded in sandy, marly and chalky limestones. Although they are extremely thin and fragile, they occurred as complete disarticulated and articulated valves. Specimens of *P.* (*I.*) *miocenica* are highly accumulated in the north Siwa section forming a coquinoid band (30 cm thick). In addition, they are generally distributed sporadically in different stratigraphic levels within the three studied sequences. Taphonomic observations indicated that these shells were affected by encrustation, bioerosion, disarticulation, fragmentation and abrasion. Moreover, valves of this species suffered minor chipping along their fragile margins. The occurrence of the studied species associated with oysters and other benthic faunal assemblages within carbonate sediments revealed shallow, low energy, warm and intertidal environments with periods of relatively agitated conditions.

1. Introduction

After the Burdigalian, an extensive marine transgression took place in the earliest Middle Miocene (Haq et al., 1988; Hardenbol et al., 1998; Piller et al., 2007; Gerdes et al., 2010; Mutti et al., 2010). It covers much of the Mediterranean region, including the carbonate-dominated shelf of the northern Western Desert of Egypt (Said, 1990; Issawi et al., 2009). This event had occurred at the same time with a global warming event (McGowran, 1979). These conditions led to the development of Middle Miocene carbonate platform in North Egypt, and strongly influenced the marine life on continental shelves.

Siwa Oasis is situated in the northwest of the Western Desert of Egypt between longitudes 25° 05` and 26° 18` E and latitudes 29° 05` and 29° 24` N (Fig. 1). It is laying 12–18 m below sea level and has a surface area greater than 800 Km^2 (Said, 1962). Siwa Oasis is surrounded by Middle Miocene carbonates of the Marmarica Formation (Said, 1962). The mega-invertebrate fossils extracted from the Marmarica Formation yielded a highly diversified macrofaunal assemblage (e.g., echinoids, bivalves, gastropods). These fauna are occurred either scattered or bank-forming beds. Despite the large number of studies that had examined these successions (Fuchs, 1833; Said, 1962, 1990; Gindy and El-Askary, 1969; Gindy, 1970; El-Shazly and Abdel-Hamid, 2001; Abdel Fattah et al., 2013), little is known about the detailed systematic paleontology studies, stratigraphic position, paleoecology and taphonomic analyses of these fauna.

Compared to other taxa, bivalves are rather better preserved. Although Anomiid bivalves are rarely preserved in strata due to their thin and brittle shells that facilitate their fragmentation, *Placuna* (*Indoplacuna*) *miocenica* (Fuchs, 1883) is one of the most common and predominant anomiid bivalve species in sediments of the Middle Miocene of Siwa Oasis. Shells of this species are studied

* Corresponding author. Deanship of Scientific Research, King Saud University, Riyadh, Saudi Arabia.
E-mail address: mmelhedeny@gmail.com (M.M. El Hedeny).

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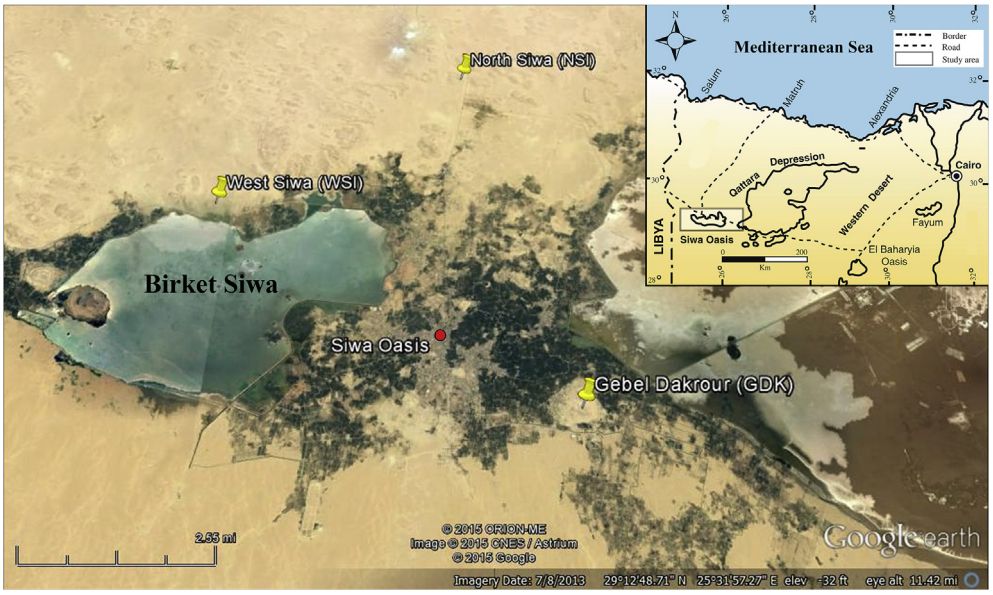

Fig. 1. A Google earth satellite image showing the sections analyzed in Siwa Oasis. The key map modified after Abdel Fattah et al. (2013).

in three sections; north Siwa (NSI), west Siwa (WSI) and Gebel Dakrour (GDK) that located south east of Siwa. Since Fuchs (1883), several authors have recorded this species in the Marmarica Formation of the Siwa Oasis (e.g., Said, 1962; El-Shazly and Abdel-Hamid, 2001; Abdel-Fattah et al., 2013). However, there is no any detailed study regarding its occurrence and paleoecology.

The aim of the present contribution is to describe and discuss the occurrences of the bivalve *Placuna* (*I.*) *miocenica* within the Middle Miocene Marmarica Formation of Siwa Oasis, Western Desert, Egypt, with emphasis on its systematic paleontology, paleoecology, and taphonomic implications.

2. Straigraphy

Miocene succession covers the northern part of the Western Desert of Egypt form an extensive plateau known as the Marmarica Plateau (Said, 1962, 1990). It extends from the Salum area to the western side of the Nile Valley and is limited northward by the Mediterranean coastal plain and southward by the Qattara and Siwa depressions (Fig. 1). The surface of this plateau is of Middle Miocene age and is composed of a shallow marine biogenic carbonate sequence with clastic intercalations (i.e., the Marmarica Formation). The sediments of this formation are unconformably overlying the fluviomarine Lower Miocene Moghra Formation (Said, 1962).

In Siwa Oasis, the Marmarica Formation is widely exposed, containing several oyster banks and reefal beds. In the three studied outcrops, the Marmarica Formation increases in thickness from about 67 m at WSI section to about 77 m at NSI section, and to a maximum thickness of about 83 m at GDK section (Fig. 2). The similarities among these sections may reveal uniform depositional conditions over an extensive marine platform (Gindy and El-Askary, 1969; Abdel Fattah et al., 2013). The Marmarica Formation is subdivided into two units (Fig. 2). The lower unit is made up of fossiliferous shale, marl, limestones and coquina beds. Limestones are marly, sandy and cross-bedded. At some intervals, shale and marl beds are delineated on top by *Thalassinoides* trace fossil suits, forming the *Glossifungites* ichnofacies (Plate 1.3, 1.4). The lower unit has a thickness of about 42 m at west Siwa, 46 m at north Siwa and 54 m at Gebel Dakrour sections (Fig. 2). In contrast, the upper unit consists of fossiliferous and non-fossiliferous chalky limestones. Its thickness ranges from about 31 m at NSI and 29 m at GDK to 25 m at WSI section (Fig. 2). It is worthy to mention that the present lower unit is coeval to the Oasis and Siwa Escarpment members while the upper unit is equivalent to El Diffa Plateau Member (*sensu* Gindy and El-Askary, 1969).

These two rock units contain bivalves (e.g., oysters, pectinids and others), gastropods, echinoids, sponges and bryozoans (Plates 1 and 2). The diversity and abundance of these macrofaunal assemblages vary from bed to bed and from one section to another. The fauna are essentially present scattered in sediments although there are many bank-forming strata are recorded. *P. (I.) miocenica* are well distributed in the three studied sections as scattered and/or accumulated bands (Plates 1 and 2). The recorded macrofossils may suggest a Langhian to Serravallian (Middle Miocene) age.

3. Systematic paleontology

All specimens are housed at Geology Department, Faculty of Science, Alexandria University. The classification of pelecypods is introduced according to the scheme proposed by the Treatise on Invertebrate Paleontology (Moore, 1969). Measurements were made using a digital calliper (accurate to 0.1), recorded in millimeter scale and taken on each specimen whenever possible: Length (L): maximum shell length measured parallel to the hinge axis; Height (H): maximum shell height perpendicular to length; Width (W): maximum inflation of both valves (Fig. 3). Measurements of right and/or left valves of some selected specimens are presented in Table 1.

Superfamily: Anomioidea Rafinesque, 1815
Family: Placunidae Yonge, 1977
Genus: *Placuna* Lightfoot, 1786
Type species: *Anomia placenta* Linnæus, 1758
Subgenus: *Indoplacuna* Vredenburg, 1924
Type-species: *Placuna* (*Indoplacuna*) *sindiensis* Vredenburg, 1924

Vredenburg (1924) erected the subgenus *Placuna* (*Indoplacuna*) to include shells having a raised region occupying part of the interval between the chondrophore ridges and owing to the presence