Systematics and paleoecology of the foraminifer *Neoeponides duwi* (Nakkady) from the Paleocene of Egypt

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ABSTRACT: The holotype of *Neoeponides duwi* (Nakkady 1950), originally described as a variety of *Discorbis pseudoscopos* Nakkady, is re-described and re-figured. This species appears to have no phylogenetic relationship with *D. pseudoscopos*. *Neoeponides duwi* is recorded in Paleocene shelf sediments in the Middle East and, assigned to *Eponides pseudoelevatus*, in West Africa. In Egypt, *N. duwi* typically occurs in inner to middle shelf deposits, but it has also been found dominant (up to 60% of the benthic assemblage) in transgressive deposits in deeper parts of the basin. Its distribution pattern, the association with highly variable and occasionally extremely high plankton/benthos ratios (>99.5% plankton) and with TOC-enriched laminated dark sediments, suggests an opportunistic response to limited and/or variable oxygenation at the seafloor.

INTRODUCTION

A first account of the taxonomy and stratigraphic distribution of Maastrichtian to early Eocene foraminifera in Egypt was provided by Nakkady (1950). From five outcrops close to the Red Sea and the Gulf of Suez, Nakkady recorded a total of 168 species and varieties of which 19 species and 17 varieties were considered new. Most of the newly described species and varieties, largely consisting of benthic taxa, were subsequently observed in numerous other localities in Egypt and elsewhere in North Africa and the Middle East (e.g. Reiss 1952; LeRoy 1953; Said and Kenawy 1956; Aubert and Berggren 1976; Salaj et al. 1976; Luger 1985; Saint-Marc and Berggren 1988; Speijer 1994; Schnack 2000). Despite the central position of the work of Nakkady (1950) in subsequent micropaleontological studies in the region, the taxonomy of many of the species he erected are poorly constrained: descriptions are generally very brief and the illustrations rather sketchy. Consequently, there is a need for clarification of the taxonomic status of his species, particularly of the common ones and those that have biostratigraphic, paleoecologic, or paleogeographic value.

In an earlier paper, the taxonomic status and biostratigraphic value of *Globanomalina luxorensis* (Nakkady 1950) in Tethyan deposits was extensively discussed with respect to recognizing the interval of the Paleocene-Eocene thermal maximum and related biotic changes (Speijer and Samir 1997). In this paper, another of Nakkady's species with an interesting distribution pattern is discussed. This species was originally defined as *Discorbis pseudoscopos* var. *duwi* Nakkady 1950, which holotype was derived from the lowermost Paleocene shales of Gebel Duwi, Red Sea coast, Egypt (text-fig. 1) (Nakkady 1950). We refer to this species as *Neoeponides duwi* and confirm the observation of Nakkady (1950) that this taxon is abundant in a few levels within the basal Paleocene shales in the Gebel Duwi section. Recently, *Neoeponides duwi* was also recognized as a common to abundant species in Paleocene shallow shelf deposits in southern central Egypt (Anan and Sharabi 1988; Hewaidy 1994; Schnack 2000). In the deeper shelf deposits in the Nile Valley, this species is usually absent, except for an interval comprising the Danian-Selandian transition, where it dominates

(up to 60%) the benthic foraminiferal assemblages (Speijer and Schmitz 1998; Speijer in press). Speijer and Schmitz (1998) interpreted this dominance as reflecting lowstand deposition after a ~150m relative sea-level fall. Additional data on the distribution of *N. duwi*, which is occasionally associated with extremely high P/B ratios and TOC-enriched sediments, suggested that the brief dominance of *N. duwi* in the Nile Valley rather represents a transgressive phase after a 50-100m relative sea-level fall (Speijer in press). The unusual dominance of *N. duwi* associated with the Danian-Selandian transition and the possible relationship between its distribution and sea-level changes is the rationale for the taxonomic and paleoecologic evaluation presented here. Holo- and topotypes of this species, deposited in the Natural History Museum, London, were studied in the summer of 1999. Additional material from central and southern Egypt (documented by Schnack 2000) and from eastern Egypt (Gebel Aweina, Gebel Duwi, Gebel Nezz, Gebel Qreiya; Speijer in press) was investigated for comparison. Biostratigraphic denotations follow the concepts of Berggren et al. (1995).

SYSTEMATIC PALEONTOLOGY

Class GRANULORETICULOSEA De Saedeleer 1934
Order FORAMINIFERIDA Eichwald 1938
Suborder ROTALIINA Lankester 1885
Superfamily DISCORBACEA Ehrenberg 1838
Family ROSALINIDAE Reiss 1963
Subfamily ROSALININAE Reiss 1963

Genus *Neoeponides* Reiss 1960

The position of *Neoeponides* in this systematic classification is uncertain. Hottinger et al. (1990) pointed out that *Neoeponides* lacks the typical Rosalinid features of a large folium and sutural notch. Similarly, these authors noted that this genus also lacks the typical umbilical features of the Eponidae and the Discorbidae and suggested that *Neoeponides* should probably be placed within a new family, a view corroborated also by Hauser and Keller-Grünig (1993).

Neoeponides duwi (Nakkady)

Plate 1, figures 2a-c, 3, 4, 5a-b, 6, 7

Discorbis pseudoscopus var. *duwi* NAKKADY 1950, p. 689, pl. 90, figs. 5-7.*Eponides pseudoelevatus* GRAHAM, DE KLASZ and RÉRAT 1965, p. 76, pl. 1, figs. 14a-c. (Holotype from the Paleocene of Gabon).*Eponides pseudoelevatus* Graham, De Klasz and Rérat. - PETTERS 1982, p. 74, pl. 7, figs. 7-8.*Discorbis pseudoscopus duwi* Nakkady. - ANAN and SHARABI 1988, pl. 2, fig. 15.*Discorbis duwi* Nakkady. - HEWAIDY 1994, fig. 13, nos. 7, 9 (not no. 8, which is a *Lenticulina*) (without description).NOT *Discorbis pseudoscopus duwi* Nakkady. - ANAN 1998, p. 373, fig. 3, no. 11. (it concerns a specimen of a species referred to as *Gavelinella guineana* Petters and Adegoke [cf. Petters 1982; Speijer et al. 1996])*Discorbis duwiensis* Nakkady. - SCHNACK 2000, p. 49 of appendix, pl. 7, figs. 15, 16.

Description: A large trochospiral species with prominent septal elevations on the spiral side. Radial wall structure with large pores on both sides. Umbilical side convex with a deep umbilicus surrounded by thickened nodes of poreless clear shell material on the inner side of the radial, slightly curved septal sutures. Towards the peripheral margins the umbilical sutures become flush with the surface. Spiral side convex to flattened with about two to two-and-a-half whorls visible, about 8-9 chambers in the last whorl. Chambers slightly to strongly overlapping, with septal sutures arched and slightly to strongly oblique. These sutures as well as the spiral structure show ridge-like elevations, in the central part fusing together. The angular peripheral margin is slightly to strongly keeled. The aperture is a low arched extra-umbilical to umbilical opening, bordered by a lip. In the umbilical area the aperture is covered by a thickened but short extension of the last chamber.

Remarks: *Neoeponides duwi* was originally described as a variety of *Discorbis pseudoscopus* Nakkady (holotype: Plate 1, figs. 1a-c). Anan (1998) considered *D. pseudoscopus* as the precursor species of *N. duwi*. However, *D. pseudoscopus*, a species usually recorded as *Anomalinoidea umboniferus* (Reuss), or *Anomalina umbonifera* is smooth, strongly flattened and has different umbilical features and thus cannot be considered as a close relative of *N. duwi*. The species *N. duwi* fits well within the generic concept of *Neoeponides* as defined by Reiss (1960) and discussed by Hottinger et al. (1990) and Hauser and Keller-Grünig (1993). Loeblich and Tappan (1987) provide a different view on the generic characters of *Neoeponides* and its systematic position (Hottinger et al. 1990; Hauser and Keller-Grünig 1993). Typical aspects of *Neoeponides* differentiating also the present species from *Eponides* are the large pores, the absence of an apertural bipartitor and the presence of a true umbilicus (Hauser and Keller-Grünig 1993). *Neoeponides duwi* differs from *Neoeponides elevatus* (Plummer) in its usually less convex spiral side, higher chambers, more numerous chambers per whorl, the presence of a keel, and its more raised spiral sutures. In a previous paper, this species was referred to as *Discorbis duwi* (Speijer and Schmitz 1998). *Rotalia(?) aegyptiaca* Leroy 1953 from Maastrichtian deposits in central Egypt may be a precursor of *N. duwi*. It differs in its more flattened test, weakly raised spiral sutures and the absence of thickened nodes around the umbilicus.

Biogeography: This species has previously been observed in the Middle East and in western Africa. In the Middle East it was recorded in southern and central Egypt (Hewaidy 1994; Schnack 2000), in eastern Egypt (Gebel, Aweina, Gebel Duwi,

TEXT-FIGURE 1

Studied localities (triangles) in Egypt where *Neoeponides duwi* is observed.

Gebel Nezzi, Gebel Qreiya; Nakkady 1950 and this study), in western Jordan (Futyan 1976 as *Valvulineria duwi*). In western Africa it has been recorded as *Eponides pseudoelevatus* in Paleocene deposits of the Niger delta (Petters 1982) and in Gabon, Cameroon, and Nigeria (Graham et al. 1965). Probably the subspecies *Eponides pseudoelevatus lysi* (Graham, De Klasz and Rérat 1965) also falls within the range of variation of *N. duwi*. *Neoeponides duwi* has not yet been observed in the part of north Africa between these regions.

Stratigraphic distribution: *Neoeponides duwi* appears to have been an exclusively Paleocene species. In Egypt, *N. duwi* ranges from the Danian (Zone P1) to the Selandian (Zone P4). In eastern Egypt, it was observed in Zones P1b to P3a (Schnack 2000; Speijer, in press). In southern Egypt, it appears to range slightly higher, into Zone P4 (Anan and Sharabi 1988; Hewaidy 1994), although figure 3, No. 11 in Anan (1998) suggests that a superficially similar species, referred to as *Gavelinella? guineana* by Speijer et al. (1996) is included within the taxonomic concept and thus may have stretched the stratigraphic range. In western

Jordan, Futyan (1976) indicated the presence of *N. duwi* in lower to upper Paleocene deposits. Current studies on four Paleocene sections in western Jordan confirmed the occasional presence of *N. duwi* within Zones P1c to P3a (E. Guasti pers. comm., 2002). In western Africa it was recorded in Paleocene rocks without further biostratigraphic differentiation (Graham et al. 1965; Petters 1982).

Paleoecology and paleobathymetry: In central and southern Egypt, this species particularly flourished within low diversity faunas (<15 species) of the inner to middle shelf (Hewaidy 1994; Schnack 2000). It occurs in the platform facies of the lower Paleocene Abu Tartur plateau as well as in marls and shales of more basinal facies. Occasionally, it occurs as the most abundant species (up to 60%) of the benthic foraminiferal assemblage, like in Danian/Selandian transition (Subzone P3a) deposits in the Nile Valley (Speijer, in press). This unusual domination, sometimes in combination with very high P/B ratios (>99.5% planktics) and TOC-enriched laminated dark-brown marl beds with abundant fish-remains, suggests an opportunistic mode of life of a species being able to respond rapidly to environmental perturbations. This interpretation however, would seem at odds with the rather large and thickly calcified tests of *N. duwi*. Assemblages containing *N. duwi*, recorded as "*Eponides pseudoelevatus*" are commonly found in various basins in western Africa too (Graham et al. 1965; Petters 1982). There, this species occurs in undifferentiated neritic deposits, but the general paucity of planktic foraminifera in the Paleocene west-African basins (e.g. Petters 1982) suggests that *N. duwi* generally occupied the shallower end of the neritic realm, like in Egypt.

CONCLUSIONS

The re-study of holotype material indicates that *Neoeponides duwi* is not closely related to *Discorbis pseudoscopos*, in contrast to the suggestions by Nakkady (1950) and Anan (1998). In Egypt, the species ranges from the lower Paleocene Zone P1 into the upper Paleocene Zone P4. In the Paleocene of West Africa the species has been recorded as *Eponides pseudoelevatus*. In Egypt and possibly in West African basins too, *Neoeponides*

duwi typifies inner to middle neritic deposits. In Egypt, it is particularly abundant, composing up to 60% of the benthic assemblages, in transgressive beds associated with the Danian-Selandian transition.

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PLATE 1

Scale bars 100µm

1a-c Holotype of the species described as <i>Discorbis pseudoscopos</i> Nakkady (Natural History Museum, London No. P41731) 2a-c Holotype of <i>Neoeponides duwi</i> (Nakkady) (Natural History Museum, London No. P41733). Note the poor visibility of the umbilical features, compared to nos. 4 and 5 3 <i>Neoeponides duwi</i>. Specimen with poorly developed raised sutures (Gebel Duwi, sample DU95D/S 40) 4 <i>Neoeponides duwi</i>. Specimen showing well-developed raised sutures on spiral side, sutural thickenings around the umbilicus and position of aperture	bordered by a distinct lip. (Gebel Duwi, sample DU95D/S 39A) 5a-b <i>Neoeponides duwi</i>. Specimen showing sutural thickenings around open umbilicus and close up of the interiomarginal aperture in umbilical-extraumbilical position. (Gebel Duwi, sample DU95D/S 39A) 6 <i>Neoeponides duwi</i>. Large specimen with distinct ridge on the spiral suture (Gebel Aweina, sample O95D/S +19-24) 7 <i>Neoeponides duwi</i>. Specimen with relatively flat spiral side and well-developed raised sutures (Gebel Qreiya, sample 271185/40)

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