A new low-latitude late Paleocene-early Eocene radiolarian biozonation based on unitary associations: applications for accreted terranes

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ABSTRACT: The late Paleocene – early Eocene sequences of DSDP Leg 10 Sites 86, 94, 95, and 96, Leg 43 Site 384 and ODP Leg 171B Hole 1051A have been re-sampled and re-examined for radiolarians. A new late Paleocene to early Eocene low-latitude radiolarian zonation suited for the correlation of accreted terranes is established by using the Unitary Association (UA) method. This method has the property of attributing equal weight to each species occurrence, which has the advantage of not being dependant on a limited set of key datums. Twenty-two UAs have been erected and correlated to the existing age models (given by nannofossils, planktonic foraminifera and radiolarians) for each site. The 22 UAs have been united into seven Unitary Associations Zones (UA Zones) (JP10- JE4) to increase lateral traceability. Herein we present the resulting composite range chart and correlation between the studied cores.

The position of the UA Zones in the Paleogene timescale of Berggren et al. (1995) have been estimated using a general consensus correlation with calcareous microfossil groups and the existing radiolarian zonation. Reproducible radiolarian events identified in the present work are bound to directly tied and compiled absolute ages given by Nigrini et al. (2006) and Sanfilippo and Nigrini (1998a). The RP zones (Sanfilippo and Nigrini 1998a) and the UA Zones are consistent. Unitary Associations permit to distinguish supplementary zonal subdivisions within RP7 and RP6.

Topotypes from DSDP Leg 10 have been illustrated using mainly SEM imaging to facilitate the identification of re-crystallized forms.

INTRODUCTION

A common problem in biostratigraphic data established from different stratigraphic records is that the sequence of appearances and disappearances of fossil taxa is contradictory from one record to the other. In other words, a direct stratigraphic representation of the correlation lines between these records will show numerous crossovers. This may be due to many different factors such as preservation, incorrect identification and biogeographic constraints. In some cases, diachronous first or last appearances can be estimated when absolute ages for the sections are independently known (Johnson and Nigrini 1985; Moore et al. 1993; Nigrini and Caulet 1992). As a consequence of biogeographically controlled variations in species ranges, various zonations can be found for different realms: Tropics (Sanfilippo and Nigrini 1998a); South Pacific (Hollis 1993, 2002, Hollis et al. 2005); Antarctic (Caulet 1991, Lazarus 1992); Norwegian/Greenland Sea (Goll and Bjorklund 1989); North Pacific (Morley and Nigrini 1995, Shilov 1995); Boreal (Kovlova 1999). Herein we present a new biochronology for the low-latitude Atlantic late Paleocene to early Eocene, constructed by means of Unitary Associations (Guex 1977, 1991). The study is based on all available literature and re-sampled material from DSDP Leg 43 Site 384, (Nishimura 1992), ODP Leg 171B Hole 1051A, (Sanfilippo and Blome 2001) and DSDP Leg 10 Sites 86, 94, 95 and 96 (Foreman 1973 and Sanfilippo and Riedel 1973) (text-fig. 1).

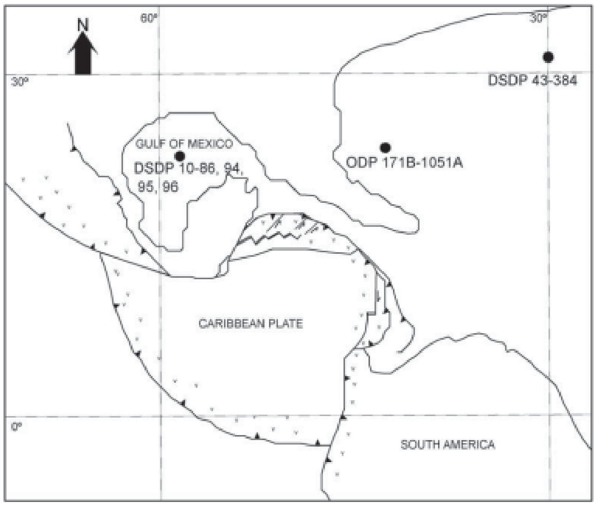
We discuss the biostratigraphic correlation resulting from our new scale with the existing radiolarian (Sanfilippo and Nigrini 1998a), planktonic foraminifera (Berggren et al. 1995) and nannofossil (Bukry 1973, 1975; Okada and Bukry 1980) zonations. The positions of the established UA Zones are estimated in the Paleogene timescale (Berggren et al. 1995).

Paleogene biochronology and its application in accreted terranes

The tropical Paleocene- early Eocene radiolarian record is discontinuous. Preservation is often variable both overall and can affect individual species differently. Foreman (1973), Riedel and Sanfilippo (1970) and Sanfilippo and Riedel (1973) established a zonation ranging from the latest Paleocene to the early Eocene based on fauna from the Gulf of Mexico (DSDP Leg 4 and DSDP Leg 10). The interval between the Cretaceous/Paleogene boundary and the latest Paleocene zone *(Bekoma bidartensis* Zone (RP7 Sanfilippo and Nigrini 1998a, the lower boundary being defined by the FO of *B. bidartensis)* was referred to as the unzoned interval (Foreman 1973, Sanfilippo et al. 1985). Nishimura (1987, 1992) reduced this interval by describing a new upper Paleocene zone preceding RP7 based on material from DSDP Legs 43 and 93 in the northwest Atlantic (RP6 *Bekoma campechensis* Zone, the lower boundary being defined by the FO of *B. campechensis).* This zone is locally sub-dividable into three sub-units.

Sparse low-latitude (<30°) early Paleocene assemblages have been reported from land sections: California (Foreman 1968), Ecuador (Keller et al. 1997) and Cuba (Florez Abin 1983; Florez Abin and Fernandez 1985). Hollis (1993) proposed a zonation for the early Paleocene based on land sections in New Zealand. Re-examination of these sections in addition to DSDP Sites 208, 277, 1121, resulted in extending this mid-latitude South Pacific zonation into the middle Eocene (Hollis 1997, 2002; Hollis et al. 2005; Strong et al. 1995).

Sanfilippo and Nigrini (1998a) reviewed the tropical zonation, adopted Hollis' zone code system and deduced mean numerical ages for zonal boundary events using the geomagnetic polarity time scale (Cande and Kent 1995) via correlation with calcareous microfossils. The zonation of Sanfilippo and Nigrini (1998a) is



TEXT-FIGURE 1
Paleogeographic reconstruction of the late Paleocene (56 Ma) (simplified from Pindell et al. 2005) showing the location of DSDP and ODP sites sampled for this study (large circles).

constructed using the datum method which is the standard in Cenozoic micropaleontology. The subdivisions are interval zones which are defined as intervals separated by the first occurrence, last occurrence or evolutionary transitions of species.

During our extended work along the convergent margin of Costa Rica we studied Paleocene-Eocene radiolarian cherts and siliceous mudstones. In the field these rocks are often indistinguishable from Mesozoic radiolarites. Radiolarian assemblages are extracted with dilute HF and show preservation characteristics similar to Mesozoic radiolarians that have undergone burial diagenesis. In geologically complex regions where good preservation is biased towards robust taxa, there are difficulties in applying interval zones established in ocean cores with well preserved markers. For example in the Herradura Block, Nicoya Pennisula and Osa-Caño Accretionary Complex (dated as late Paleocene-late Eocene) we rarely find more than the cephalo-thorax of *Bekoma* spp. and consequently, they cannot be used as markers (Bandini et al. this volume; Diserens et al. 2003). In some cases the use of secondary zonal events which are usually based on readily preserved taxa (Sanfilippo and Nigrini 1998a) can overcome this difficulty. The order of these events is although not often regionally reproducible within ocean cores (Sanfilippo and Blome 2001). Given these contradictory occurrences, the consistency of these events as zonal markers needs to be established. The Unitary Association method provides an option for overcoming both of these problems, by 1) giving equal chronologic weight to all considered taxa and 2) establishing maximum co-existences of species (deduced from several sections), that can be used as a reference tool to evaluate the order and reproducibility of various events and their importance as zonal markers (see 2.3). The occurrence data of taxa in six stratigraphic sections is compiled and presented in a composite UA range chart in order to facilitate the correlation of accreted terranes.

MATERIALS AND METHODS

Samples

The goal of this study is to produce a low-latitude late Paleocene to early Eocene radiolarian zonation based on Unitary Associations and to enhance documentation of stratigraphically useful taxa from topotypic material. To do this, we studied all available literature on deep-sea sections in the circum-Caribbean and temperate Atlantic regions. Previously reported preservation, abundance, core recovery, signs of reworking, hiatuses, presences of topotypes and the ages given by calcareous microfossils were taken into consideration. Out of the 195 samples reviewed, 167 samples have been re-studied. Although core recovery of DSDP Leg 10 is relatively poor compared to present day operations, topotype imagery was carried out on 44 samples from Sites 86, 94, 95, 96 (Foreman 1973; Sanfilippo and Riedel 1973). 121 samples were selected from ODP Leg 171B Site 1051A, (partially from previously unstudied intervals) as it contains a well preserved, nearly complete Paleocene –Eocene radiolarian record (Sanfilippo and Blome 2001). Two samples were taken from the well preserved late Paleocene sequence of DSDP 43 Site 384 (Nishimura 1992). Additional data was incorporated from the literature. The full occurrence data set for all samples is available as a supplement to this paper at [Pangaea database at WWDC-Mare].

Preparation method

Samples were sieved at 40µm following procedures published by Sanfilippo et al. (1985). Two to four strewn slides were made per sample. Residues were then dried and prepared for SEM and transmitted light imaging (Jackett and Baumgartner, in press). SEM imaging of Paleogene topotypes was carried out in order to accurately compare re-crystallized radiolarians from accreted terranes with the literature. Species used for biostratigraphy were recorded as either absent or present. All material is lodged in the Museum of Geology, Lausanne, Switzerland (coll. No. MGL 96,257-96,456).

Analytic method

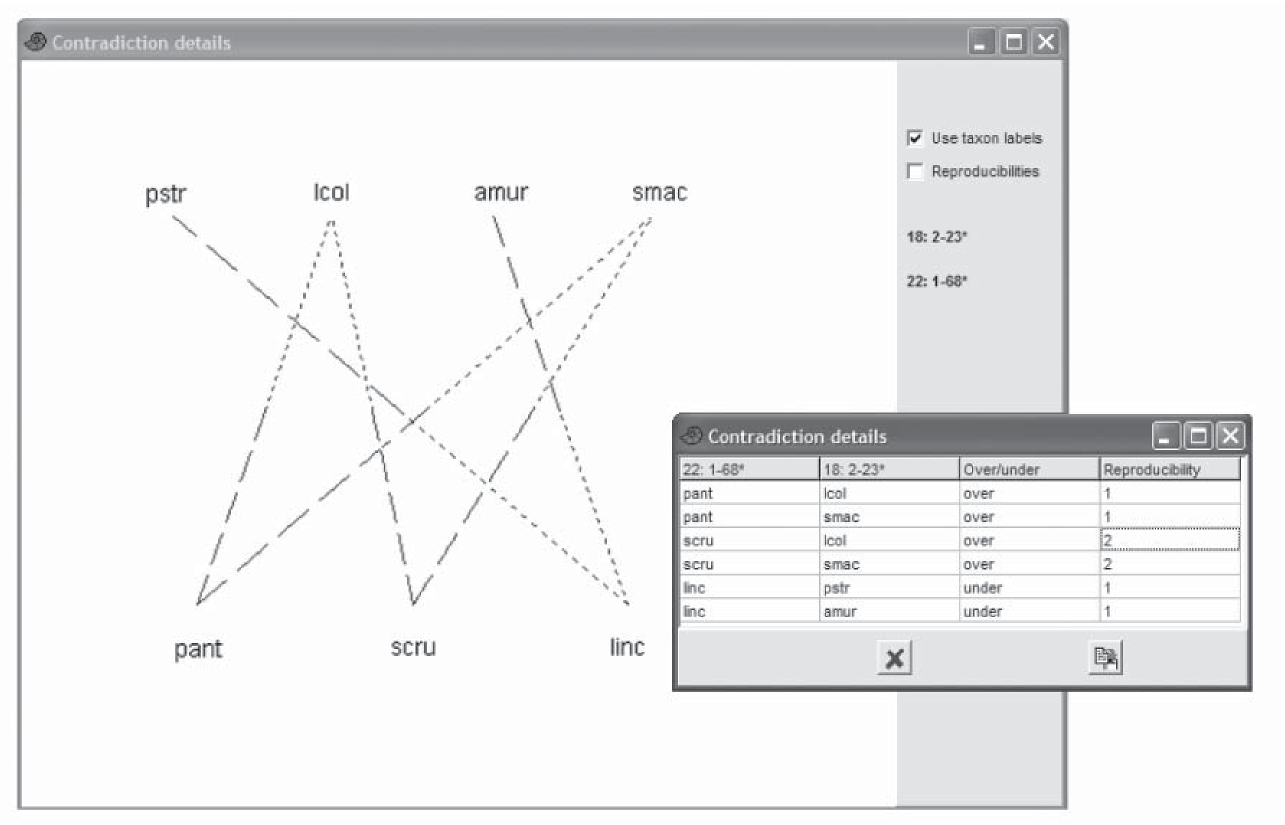
General considerations

Over 200 radiolarian species have been identified from 6 stratigraphic sections. Species thought to be long-ranging but only occurring sporadically in exceptionally well-preserved samples, such as *Corythomelissa* and *Saturnalis* were not considered. They cannot be used as markers and their real existence interval is not reflected in raw biostratigraphic data. In a given section a single occurrence of such taxa cannot reasonably be interpreted as a significant distribution and only leads to false superpositional constraints with other taxa, which create unnecessary contradictions. In addition, for the results to be meaningful the taxonomy of each species needs to be uniform. Therefore species with confused concepts have not been included, such as *Pterocodon? tenellus* and *Clathrocyclas.* 112 taxa have been retained to construct the zonation.

Building unitary associations

Radiolarian biochronology presented in this paper has been established using the Unitary Association (UA) method (Guex 1977, 1991) and the software UAgraph (Hammer, Guex and Savary). This method is a deterministic mathematical model designed to construct a discrete sequence of co-existence intervals of species. The program considers two categories of relationships between species:

1) Co-existence ('edges', in A terminology): If the ranges of two species overlap in at least one section, they are considered as co-existing in time. Also, the co-existence in time of two species showing no co-occurrence in given sections can be logically as-



TEXT-FIGURE 2
Screen capture from UAgraph showing a contradictory superpositional relationship between maximal cliques 18 and 22 (the concerned species are expressed with their respective codes). The superpositional relationship between species belonging to the respective cliques are shown as differentially dotted lines. The program calculates the relative support for superpositional relationships for taxa pairs in the entire data set. Poorly supported relationships are incrementally converted to co-existences (implied range extensions) until between group superposition conflicts are gone.

sumed if the species display an opposite order of appearance in two or more sections when they are both present. Therefore, co-existence of species in time can be deduced without observed co-occurrences. Such co-existences are said to be 'virtual'.

2) Superpositional relations ('arcs', in UA terminology): If the ranges of two species, A and B, never overlap and if the two species appear systematically in a given order when both present in a section, a superpositional relationship can be established (e.g. A above B). When compiling several sections, collections of mutually co-existing species ('cliques', in UA terminology) can be deduced by examining and arranging a matrix of all species-species co-existences. A clique is maximal if the set of species is not contained in a larger co-existing set.

The UAgraph program (Hammer, Guex and Savary) calculates the relative chronologic constraints of each pair of maximal cliques by considering the existing superpositional relationships between the species of the respective cliques. In certain cases two or more pairs of species indicate contradictory superpositional relationships between two maximal cliques ('inter-clique contradiction'). These contradictions are treated by ignoring the superpositions that are less reproducible in the whole dataset. (e.g. see text-figure 2). A detailed description of the computing process is given in Guex 1991.

Ranges of the species generating superpositional contradictions can be improved by re-examination of the samples. This can lead to an extension of the ranges of some taxa thereby replacing initial superpositional relationships by real co-existences or it can lead to changing the taxonomic assignment of some taxa. Ideally, it is better to revise the original data, using the information calculated by the program as a guide, than to let the contradictions be removed automatically.

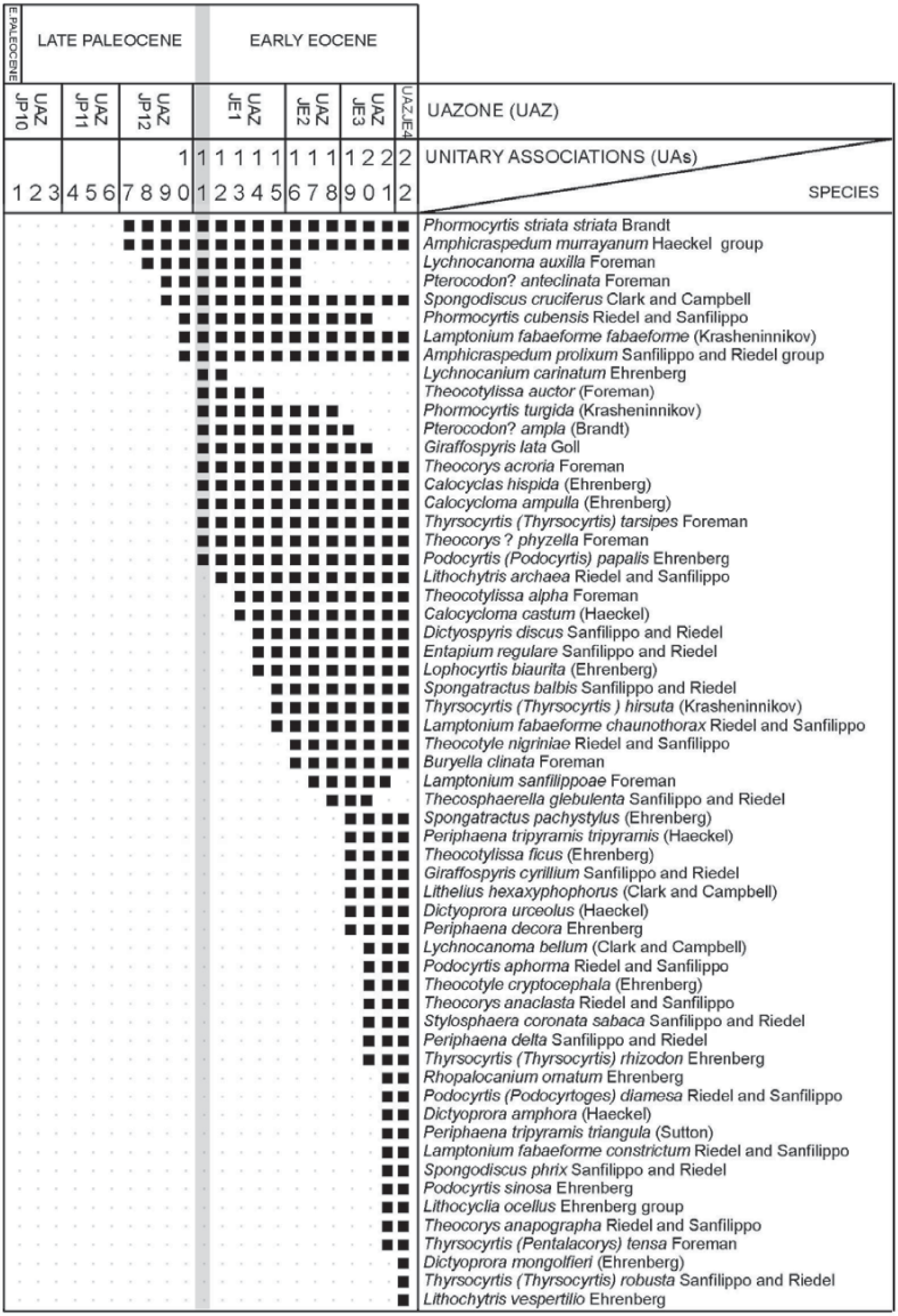
A Unitary Association is a maximal clique defined by the first and last occurrences of the taxa restricted to it. UAs can be united to produce UA Zones with an increased lateral traceability. In our particular problem, constructing UAs allowed us to: 1) date assemblages in accreted terranes where many of the more delicate species within the assemblages are often absent 2) locate critical intervals which are particularly problematic in order to re-examine them, 3) solve contradictions by ignoring less reproducible relationships, which may be due to a poor stratigraphic record, biogeographic constraints or misidentification.

RESULTS

UA Zone description

The composite range chart representing the succession of the calculated 22 discrete sequences (UAs) of co-existing species is shown in text-figure 3. These have been grouped into seven UA Zones (JP10 to JE4). Zone labels are defined after the initials of the first author followed by the one of the epoch. The UA method produces discrete sequences in which the first or last occurrence of taxa may occur anywhere within the association. As a consequence such a zonation cannot be precisely superimposed on a

TEXT-FIGURE 3
Composite range chart of taxa versus the identified UAs. Shaded line equals location of the Paleocene/ Eocene boundary within UA1 1.



TEXT-FIGURE 3 (*continued*)
Composite range chart of taxa versus the identified UAs. Shaded line equals location of the Paleocene/ Eocene boundary within UA1 1.

zonation defined on individual events. Unitary Associations can be strictly identified in certain intervals of some sections. When these intervals have been correlated to existing zonations (Berggren et al. 1995; Bukry 1973, 1975; Okada and Bukry 1980, Sanfilippo and Nigrini 1998a), they provide attachment points and permit a comparison. These relations are individually illustrated in text-figure 4 for each studied core. A synthesis of UA correlations to the Paleogene timescale (Berggren et al. 1995) has been tentatively constructed. In table 1, these results are expressed using UAs as reference. The correlations of the UAs to absolute ages are shown both as a two step process via calcareous microfossils (Sanfilippo and Nigrini 1998a) and using individual radiolarian events directly tied to the paleomagnetic timescale (Nigrini et al. 2006).

Several radiolarian datums appear to be moderately diachronous within the UA framework, such as the FO of *Theocotyle cryptocephala* (FO UA20 (CP11) in Site 1051A and FO UA 22 (CP12) in Site 94). Additional stratigraphically extensive sections would be required to establish the magnitude and relevance of this diachroneity.

UAZ JP 10 (UA1, UA2 and UA3)

UAZ JP 10 is characterized by the association of *Buryella* sp. A n.sp., *Lamptonium?* sp. A n.sp., *Theocorys?* sp. aff. *T.acroria, Anthocyrtis?* sp. aff. *A. mespilus* and *Thyrsocyrtis? annikae* with *Lychnocanoma? costata, Lamptonium? colymbus, Spongurus? irregularis, Buryella tetradica, Siphocampe? quadrata, Dorcadospyris platyacantha* group, *Orbula comitata, Lamptonium? incohatum, Lychnocanoma anacolum, Hexacontium palaeocenicum* and *Phormocyrtis striata exquisita*. The lower boundary is presently unknown.

Samples: UA1 is found in samples ODP 171B-1051A-73x-2w (23-25cm) to ODP 171B-1051A-65x-1w (52-53cm). UA2 is found in samples ODP 171B-1051A-64x-5w (76-78cm) to ODP 171B-1051A-63x-2w (28-30cm) and DSDP 43-384-11-3 (130-132cm) to DSDP 43-384-10-6 (38-40cm). UA3 is found in samples ODP 171B-1051A-62x-4w (42-44cm) to ODP 171B-1051A-61x-4w (40-42cm) and DSDP 43-384-10-5 (38-40cm) to DSDP 43-384-9-3 (38-40cm).

Approximate correlation: CP3-4, P1-4 and RP6.

UAZ JP11 (UA4, UA5 and UA6)

UAZ JP 11 is characterized by the association of *Lychnocanoma? pileus, Phormocyrtis striata praexquisita, Bekoma? demissa demissa, Orbula comitata* and *Lychnocanoma? costata* with *Dendrospyris golli, Dendrospyris fragoides, Orbula discipulus, Bekoma divaricata, Thecosphaera larnacium, Carposphaera subbotinae, Periphaena heliastericus, Lithelius foremanae, Spongodiscus quartus bosoculus, Circodiscus circularis, Stylotrochus nitidus Thecosphaerella rotunda* and *Pterocodon poculum.*

Remarks: A hiatus of circa 1 Ma occurs between the base of ODP 171B-1051A-58x-CC and ODP 171B-1051A-59x-1w (identified by the absence of nannofossil zone CP6 (Shipboard Scientific Party 1998)), and could explain why UA5 and UA6 are undetermined in this site.

Samples: UA4 is found in samples ODP 171B-1051A-61x-2w (33-35cm) to ODP 171B-1051A-59x-4w (50-51cm). UA5 is found in samples DSDP 43-384-9-1 (38-40cm) to DSDP 43-384-8-5 (36-38cm) and DSDP 10-86-8-4 (119-125cm) to DSDP 10-86-8-1 (114-116cm). UA6 is found in samples 10-86-8-3 (40-42cm) to 10-86-8-1 (80-82cm).

Approximate correlation: CP5-6, P4 and RP6.

UAZ JP12 (UA7, UA8, UA9 and UA10)

UAZ JP 12 is characterized by the association of *Bekoma? demissa robusta, Stylosphaera macrosphaera, Buryella pentadica, Cromyomma riedeli, Amphipternis alamedaensis, Lychnocanium* sp. A, *Bekoma campechensis, Lamptonium? colymbus, Lamptonium? incohatum, Lychnocanoma anacolum* and *Bekoma divaricata* with *Bekoma bidartensis, Spongodiscus quartus quartus, Phormocyrtis striata striata, Amphicraspedum murrayanum* group, *Lychnocanoma auxilla, Pterocodon? anteclinata, Spongodiscus cruciferus, Phormocyrtis cubensis, Lamptonium fabaeforme fabaeforme* and *Amphicraspedum prolixum* group.

Samples: UA7 is found in sample DSDP 43-384-7-6- (36-38cm) and in sample ODP 171B-1051A-58x-6w (96-97cm). UA8 is found in samples DSDP 43-384-7-4- (38-40cm) to DSDP 43-384-7-3- (36-38cm). UA9 is found in samples DSDP 43-384-7-2- (38-40cm) to DSDP 43-384-6-1- (38-40cm) and ODP 171B-1051A-58-x2w (34-36cm) to ODP 171B-1501A-57x-4w (96-98cm). UA10 is found in samples ODP 171B-1051A-57x-3w (38-40cm) to ODP 171B-1051A-56x-5w (37-38cm).

Approximate correlation: CP6-8b, P4-5, RP6-7

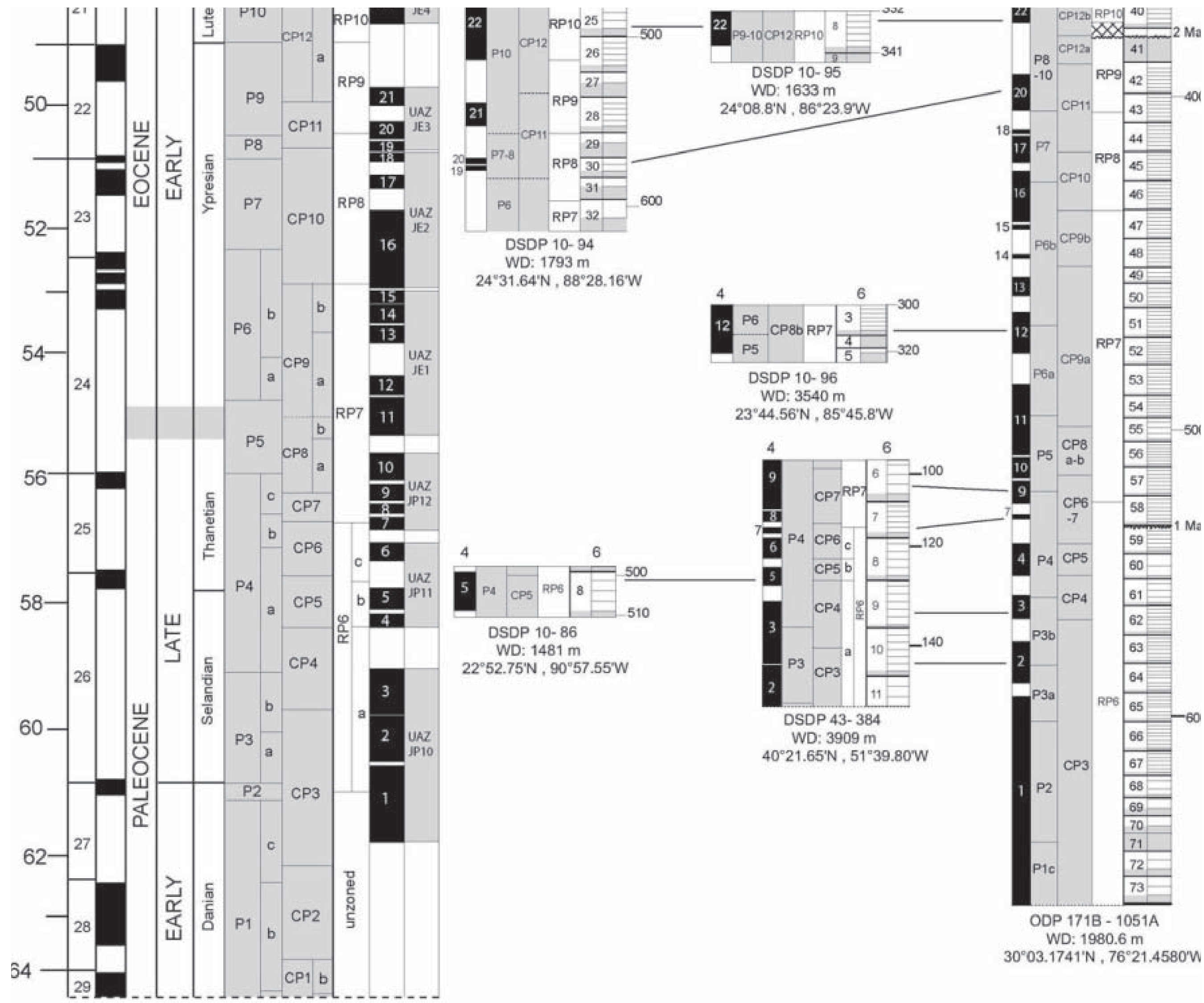
UAZ JE1 (UA11, UA12, UA13, UA14 and UA15)

UAZ JE1 is characterized by the association of *Bekoma? oliva, Stylosphaera goruna, Spongurus? irregularis, Hexacontium? palaeocenicum, Dendrospyris golli* and *Pterocodon poculum* with *Lychnocanium carinatum, Theocotylissa auctor, Phormocyrtis turgida, Pterocodon? ampla, Girafospyris lata, Theocorys acroria, Calocyclas hispida, Calocycloma ampulla, Thyrsocyrtis (Thyrsocyrtis) tarsipes, Theocorys? phyzella, Podocyrtis (Podocyrtis) papalis, Lithochytris archaea, Theocotylissa alpha, Calocycloma castum, Dictyospyris discus, Entapium regulare, Lophocyrtis biaurita, Spongatractus balbis, Thyrsocyrtis (Thyrsocyrtis) hirsuta* and *Lamptonium fabaeforme chaunothorax.*

Remarks: The base of the carbon isotope excursion and the benthic foraminifera extinction have been recorded in core ODP 171B-1051A-55x (at 512.90 mbsf and 512.80 mbsf, respectively) (Norris and Rohl 1999). These events are placed at 55.5Ma (Berggren et al. 1995) and occur with UA11 herein. Determination of nannofossil biostratigraphic datums in this interval was hampered by poor preservation (Shipboard Scientific Party 1998). The Paleocene/ Eocene boundary lies between the record of Sites 96 (nannofossil zone CP8b) and 384 (nannofossil zone CP8a).

Samples: UA1 1 is found in samples ODP 171B-1051A-56x-4w (37-38cm) to ODP 171B-1051A-53x-5w (34-36cm). UA12 is found in samples ODP 171B-1051A-52x-5w (42-44cm) to ODP 171B-1051A-51x-3w (56-58cm) and DSDP 10-96-5-1 (1 14-116cm) to DSDP 10-96-3-1 (41-43cm). UA13 is found in samples ODP 171B-1051A-50x-3w (56-58cm) to ODP 171B-1051A-49x-3w (14-16cm). UA14 is found in sample ODP 171B-1051A-48x-5w (33-35cm). UA15 is found in sample ODP 171B-1051A-47x-5w (45-47cm).

Approximate correlation: CP8a-9b, P5-6b, RP7



TEXT-FIGURE 4
Correlation of cores based on UAs and an estimate of UAs and UA Zones in the Paleogene timescale (Berggren et al. 1995). 1: Planktonic foraminifera (Berggren et al. 1995), 2: Calcareous Nannofossils (Bukry 1973, 1975; Okada and Bukry 1980), 3: Radiolaria (Sanfilippo and Nigrini 1998a), 4: Unitary Associations (this study), 5: estimate position of UAs and UA Zones in the Paleogene timescale, 6: cores and cores sections, shaded areas represent poor core recovery. Nannofossil data from: DSDP 10 Bukry 1973, DSDP 43 Berggren et al. 2000 and ODP 171B Shipboard Scientific Party zonation assignment 1998. Foraminifera data from: DSDP 10 Shipboard Scientific Party, DSDP 43 Berggren et al. 2000 and ODP 171B Shipboard Scientific Party zonation assignment 1998. Radiolarian RP zone data from: DSDP 10 Foreman 1973, Sanfilippo and Riedel 1973, DSDP 43 Nishimura 1992, Sanfilippo and Nigrini 1998b, ODP 171B Sanfilippo and Blome 2001. Right hand side of cores is mbsf. Wavy lines in core sections represent previously reported hiatuses. Dashed lines within existing zonations indicate a tentative boundary placement. Correlation lines link common occurring UAs.

UAZ JE2 (UA16, UA17 and UA18)

UAZ JE2 is characterized by the association of *Stylotrochus alveatus, Bekoma bidartensis, Lychnocanoma auxilla, Pterocodon? anteclinata* and *Phormocyrtis turgida* with *Theocotyle nigriniae, Buryella clinata, Lamptonium sanfilippoae* and *Thecosphaerella glebulenta.*

Samples: UA16 is found in samples ODP 171B-1051A-47x-4w (56-58cm) to ODP 171B-1051A-45x-5w (84-86cm). UA17 is found in samples ODP 171B-1051A-45x-3w (26-28cm) to ODP 171B-1051A-44x-5w (48-50cm). UA18 is found in sample ODP 171B-1051A-44x-3w (40-42cm).

Approximate correlation: CP9b-1 1, P6b-7, RP7-8

UAZ JE3 (UA19, UA20 and UA21)

UAZ JE3 is characterized by the association of *Lamptonium pennatum, Buryella tetradica, Phormocyrtis striata exquisita, Thecosphaera larnacium, Carposphaera subbotinae, Spongodiscus quartus quartus, Phormocyrtis cubensis, Pterocodon? ampla,, Girafospyris lata Lamptonium sanfilippoae* and *Thecosphaerella glebulenta* with *Spongatractus pachystylus, Periphaena tripyramis tripyramis, Theocotylissa ficus, Girafospyris cyrillium, Theocotyle cryptocephala, Lithelius hexaxyphophorus, Dictyoprora urceolus, Periphaena decora, Lychnocanoma bellum, Podocyrtis aphorma, Theocotyle cryptocephala, Theocorys*

UAZ (this study)	UA	Nannofossils	Consensus correlation		Planktonic foraminifera	Consensus correlation		Radiolarians	Consensus correlation		Absolute ages (Ma)	
											ODP 199	Compiled
UAZ JE4	UA22	CP12b (1051A), CP12 (95), CP12 (1051A)	CP12	**CP12**	P8-10 (1051A), P9-10 (95), P10 (94)	P8-10	**P8-10**	RP10-11 (1051A), RP10 (95), RP10-11 (94)	RP10-11	**RP10-11**	48.13-49.91	~49.00
UAZ JE3	UA21	CP11 (94)	CP11	**CP11**	P10 (94)	P10	**P7-10**	RP9 (94)	RP9	**RP8-9**		
	UA20	CP11 (94), CP11 (1051A)	CP11		P7-8 (94), P8-10 (1051A)	P7-10		RP8 (94), RP9 (1051A)	RP8-9			~50.30
	UA19	CP11 (94)	CP11		P7-8 (94)	P7-8		RP8 (94)	RP8		53.07-51.37	
UAZ JE2	UA18	CP11 (1051A)	CP11	**CP9b-11**	P7(1051A)	P7	**P6b-7**	RP8 (1051A)	RP8	**RP7-8**		
	UA17	CP10-11 (1051A)	CP10-11		P7 (1051A)	P7		RP8 (1051A)	RP8			~52.85
	UA16	CP9b-10 (1051A)	CP9b-10		P6b-7 (1051A)	P6b-7		RP7-8 (1051A)	RP7-8		53.07-51.37	
UAZ JE1	UA15	CP9b (1051A)	CP9b	**CP8a-CP9b**	P6b (1051A)	P6b	**P5-P6b**	RP7 (1051A)	RP7	**RP7**		
	UA14	CP9b (1051A)	CP9b		P6b (1051A)	P6b		RP7 (1051A)	RP7			
	UA13	CP9a (1051A)	CP9a		P6b (1051A)	P6b		RP7 (1051A)	RP7			
	UA12	CP9a (1051A) CP8b (96)	CP8b-9a		P6a-b (1051A) P5-6 (96)	P5-6		RP7 (1051A) RP7 (96)	RP7			
	UA11	CP8a-b-9a (1051A)	CP8a-9a		P6b (1051A)	P6b		RP7 (1051A)	RP7			
UAZ JP12	UA10	CP8a-b (1051A)	CP8a-b	**CP6-8b**	P5-6 (1051A)	P5-6	**P4-5**	RP7 (1051A)	RP7	**RP6-7**		
	UA9	CP6-7 (1051A), CP7-8a (384)	CP6-8a		P4-5 (1051A), P4 (384)	P4-5		RP7 (1051A), RP7 (384)	RP7			
	UA8	CP7 (384)	CP7		P4 (384)	P4		RP7 (384)	RP7			~56.9
	UA7	CP6-7 (1051A), CP6 (384)	CP6-7		P4 (1051A), P4 (384)	P4		RP6 (1051A), RP7 (384)	RP6-7		53.07-51.37	
UAZ JP11	UA6	CP6 (384)	CP6	**CP5-6**	P4 (384)	P4	**P4**	RP6c (384)	RP6	**RP6**		
	UA5	CP5 (384), CP5 (86)	CP5		P4 (384), P4 (86)	P4		RP6b (384), RP6 (86)	RP6			
	UA4	CP5 (1051A)	CP5		P4 (1051A)	P4		RP6 (1051A)	RP6			
UAZ JP10	UA3	CP4 (1051A), CP3-4 (384)	CP3-4	**CP3-4**	P3 (1051A), P3-4 (384)	P3-4	**P1-4**	RP6 (1051A), RP6a (384)	RP6	**RP6**		
	UA2	CP3 (1051A), CP3 (384)	CP3		P3 (1051A), P3 (384)	P3		RP6 (1051A), RP6a (384)	RP6			
	UA1	CP3 (1051A)	CP3		P1-3 (1051A)	P1-3		RP6 (1051A)	RP6			

TABLE 1
Cross-correlation between UA results and existing zonations in study sections. Nannofossils from Bukry 1973, 1975; Okada and Bukry 1980; Planktonic Foraminifera from Berggren et al. 1995 and Berggren et al. 2000; Radiolarian zones from Foreman 1973, Sanfilippo and Riedel 1973 and Sanfilippo and Blome 2001; Absolute ages for Paleogene radiolarian stratigraphic datums from ODP 199 (datums used: FO of *Phormocyrtis striata striata, Buryella clinata, Theocotylissa ficus* and *Lithochytris vespertilio)* from Nigrini et al. 2006 and compiled absolute ages from Sanfilippo and Nigrini 1998a. Note the diachronous occurrence of *Phormocyrtis striata striata* between the Atlantic and Pacific Oceans.

anaclasta, Stylosphaera coronata sabaca, Periphaena delta, Thyrsocyrtis (Thyrsocyrtis) rhizodon, Rhopalocanium ornatum, Podocyrtis (Podocyrtoges) diamesa, Dictyoprora amphora, Periphaena tripyramis triangula, Lamptonium fabaeforme constrictum, Spongodiscus phrix, Podocyrtis sinosa, Lithocyclia ocellus group, *Theocorys anapographa* and *Thyrsocyrtis (Pentalacorys) tensa.*

Remarks: Calcareous nannofossils indicate a hiatus of circa 2 Ma between cores 171B-1051A-40X-CC, and 171B-1051A-41X-CC (Shipboard Scientific Party 1998). Sanfilippo and Blome (2001) confirmed this hiatus with radiolarians stating that most of RP9 and RP10 are missing. Herein UA21 is missing from this core, but it has been identified in DSDP 10-94. Detecting this hiatus in DSDP 10-94 is hampered by large coring gaps in core 27 through to core 29. For further discussion on the correlation and significance of late early Eocene hiatuses see Aubry (1995), Norris et al. (2001) and Sanfilippo and Blome (2001).

Samples: UA19 is found in sample DSDP 10-94-30-2 (114-116cm). UA20 is found in sample DSDP 10-94-30-1 (34-35cm) and ODP 171B-1051A-43x-5w (34-36cm) to ODP 171B-1051A-42x-3w (116-118cm). UA21 is found in samples DSDP 10-94-28-5 (43-45cm) to DSDP 10-94-28-2 (42-44cm).

Approximate correlation: CP1 1, P7-10, RP8-9

UAZ JE4 (UA22)

UAZ JE4 is characterized by the association of *Dictyoprora mongolfieri, Thyrsocyrtis (Thyrsocyrtis) robusta* and *Lithochytris vespertilio.*

Samples: UA22 is found in samples DSDP 10-95-8-6 (43-45cm) to DSDP 10-95-8-1 (42-46cm) and DSDP 10-94-26-4 (43 -45cm) to DSDP 10-94-24-3 (44-46cm) and ODP 171B-1051A-40x-5w (76-78cm) to ODP 171B-1051A-40x-3w (50-52cm).

Approximate correlation: CP12, P8-10, RP 10-11

SUMMARY AND CONCLUSION

The aim of this study is to establish a new late Paleocene to early Eocene low-latitude radiolarian zonation suited for the correlation of accreted terranes. Biostratigraphic data from six cores drilled in the Atlantic Ocean and in the Gulf of Mexico has been compiled and problematic intervals re-examined. Out of the 195 samples considered, 167 samples have been re-studied. Topotypes from DSDP 10 have been imaged by SEM to facilitate the identification of re-crystallized forms found in accreted terranes.

The Unitary Association method has been chosen to carry out this work as it has the property of attributing equal weight to each species occurrence. This approach has the advantage of not being dependant on a limited set of key datums. It is based on a deterministic mathematical model designed to construct a discrete sequence of co-existence intervals of species. Twenty two Unitary Associations have been erected and correlated to the existing age models (given by nannofossils, planktonic foraminifera and radiolarians) for each site. The 22 UAs were united into seven UA Zones (JP10- JE4) to increase lateral traceability. A general consensus correlation with calcareous microfossil groups has been made and used to estimate the position of the UA Zones on the Paleogene timescale. The RP zones and the UA Zones display good correlation. Unitary Associations permit to distinguish supplementary zonal subdivisions within RP7 and RP6.

SYSTEMATIC PALEONTOLOGY

Taxonomic notes are given for new species and when taxonomic clarification is required. For other taxa only reference to the author, the first illustration, new combination (if applicable), a paper defining the present species concept and the species code used in this study are given. Taxa are listed in alphabetical order. Species without codes were not considered in the biostratigraphy.

Amphicraspedum murrayanum Haeckel group
Plate 4, figures 1, 2

Amphicraspedum murrayanum HAECKEL group 1887, p. 523, pl. 44, fig. 10. – HOLLIS 2006, pl. 1, fig. 1

Distinguishing characters: Forms assigned to this species-group include variable morphotypes having an inflated middle part of the test which partially belong to *Amphicraspedum murrayanum*. Distinguished from *A. prolixum* group by its generally shorter test which is more inflated in its median part.

Species code: **amur**

Amphicraspedum prolixum Sanfilippo and Riedel
Plate 4, figures 3-5

Amphicraspedum prolixum SANFILIPPO and RIEDEL group 1973, p. 524, pl. 10, figs. 7-11; pl. 28, figs. 3, 4

Species code: **apro**

Amphipternis alamedaensis (Campbell and Clark)
Plate 3, figure 22

Phormocampe (Cyrtocorys) alamedaensis CAMPBELL and CLARK 1944, p. 37, pl. 7, fig. 41. – HOLLIS 1997, p. 67, pl. 15, figs. 15, 16

Species code: **asti**

Amphipternis clava (Ehrenberg)
Plate 3, figures 22, 21

Lithocampe? clava EHRENBERG 1873, p. 238; 1875, p. 76, pl. 4, fig. 2. – FOREMAN 1973, p. 430, pl. 7, figs.16, 17; pl. 9, figs. 2, 7

Species code: **acla**

Amphisphaera minor (Clark and Campbell)
Plate 3, figure 13

Stylosphaera minor CLARK and CAMPBELL 1942, p. 27, pl. 5, figs. 1, 2, 12; Sanfilippo and Riedel 1973, p. 486, pl. 1, figs. 1-5; pl. 22, fig. 4

Species code: **amin**

Anthocyrtis mespilus Ehrenberg
Plate 1, figure 5

Anthocyrtis mespilus EHRENBERG 1854, pl. 36, fig. 13; 1875, p. 66, pl. 6, fig. 4.
Anthocyrtis? sp. aff. *A. mespilus* Ehrenberg group. – NISHIMURA 1992, p. 331, pl. 6, figs. 12- 13

Species code: **ames**

Axoprunum pierinae (Clark and Campbell)
Plate 3, figure 14

Lithatractus pierinae CLARK and CAMPBELL 1942, p. 34, pl. 5, fig. 25. – Hollis 2002, p. 291, pl. 1, fig. 10

Species code: **apie**

Bathropyramis magnifica (Clark and Campbell)
Plate 1, figure 16

Sethopyramis (Cephalopyramis) magnifica CLARK and CAMPBELL 1942, p. 72, pl. 8, figs. 1, 5, 9. – HOLLIS et al. 1997, p. 57, pl. 6, fig. 22

Species code: **bmag**

Bekoma bidartensis Riedel and Sanfilippo
Plate 1, figure 12

Bekoma bidartensis RIEDEL and SANFILIPPO 1971, p. 1592, pl. 7, figs. 1-7

Species code: **bbid**

Bekoma campechensis Foreman
Plate 1, figure 11

Bekoma campechensis FOREMAN 1973, p. 432, pl. 3, fig. 24; pl. 10, figs. 1, 2

Species code: **bcam**

Bekoma? demissa demissa Foreman
Plate 1, figure 7

Bekoma? demissa demissa FOREMAN 1973, p. 432, pl. 3, fig. 22; pl. 10, fig. 5

Species code: **bdem**

Bekoma? demissa robusta Nishimura
Plate 1, figure 6

Bekoma? demissa robusta NISHIMURA 1992, p. 333, pl. 6, figs. 2, 3

Species code: **brob**

Bekoma divaricata Foreman
Bekoma divaricata FOREMAN 1973, p. 433, pl. 3, fig. 23; pl. 10, figs. 3, 4

Species code: **bdiv**

Bekoma? oliva Nishimura
Plate 2, figure 4

Bekoma? oliva NISHIMURA 1992, p. 333, pl. 5, figs. 10, 11; pl. 13, fig. 6

Species code: **boli**

Buryella sp. A
Plate 1, figures 21-23

Description: Shell of 5 segments with the lumbar stricture externally expressed. Cephalis subspherical with few circular pores. Collar stricture not externally expressed but with a vertical pore. Third and fourth segments are of comparable width, both conical with one to three rows of circular pores arranged quincuncially. Few unarranged pores are present. The test displays maximum width on the fourth segment and gradually narrows towards the aperture. Fifth segment inverted with 3 rows of circular pores.

Distinguishing characters: This species differs from *Buryella tetradica* by having five segments and by the presence of few quincuncially arranged pores. It differs from the sub-species *B. tetradica* var. A described by Sanfilippo and Blome (2001, p. 210, figs. 8d, 8e) by the third and fourth segments displaying similar proportions and only two to five rows of pores arranged quincuncially, not in longitudinal rows. It differs from *Buryella pentadica* by having an externally expressed lumbar stricture and by the third and fourth segments having similar proportions.

Occurrence: Late early Paleocene to late Paleocene of ODP 171B-1051A

Species code: **bbru**

Buryella clinata Foreman
Plate 2, figure 17

Buryella clinata FOREMAN 1973, p. 433, pl. 8, figs. 1-3; pl. 9, fig. 19

Species code: **bcli**

Buryella pentadica Foreman
Plate 1, figures 14, 15

Buryella pentadica FOREMAN 1973, p. 433, pl. 8, fig. 8; pl. 9, figs. 15, 16

Species code: **bpen**

Buryella tetradica Foreman
Plate 2, figure 20

Buryella tetradica FOREMAN *s.s.* 1973, p. 433, pl. 8, figs. 4- 5; pl. 9, figs. 13, 14

Distinguishing characters: A sub-species of *Buryella tetradica* [Pl. 2, fig. 21], tabulated as *B. tetradica* var. A by Sanfilippo and Blome (2001, p. 210, figs. 8d, 8e), differs from *B. tetradica s.s.* by the fourth segment being transversely segmented. This sub-species has herein not been included in the biostratigraphy.

Species code: **btet**

Calocyclas hispida (Ehrenberg)
Plate 2, figure 1

Anthocyrtis hispida EHRENBERG 1873 p. 216, pl. 8, fig. 2; 1875, pl. 8, fig. 2. – FOREMAN 1973, p. 434, pl. 1, figs. 12-15; pl. 9, fig. 18

Remarks: Includes forms tabulated by Sanfilippo and Blome

PLATE 1

All scale bars equal 100µm.

1 *Orbula comitata* Foreman. ODP 171B-1051A-61x-4w (40-42cm)

2 *Orbula discipulus* Foreman. DSDP 10-86-8-4 (119-125cm)

3 *Lychnocanoma? pileus* Nishimura. ODP 171B-1051A-68x-1w (60-62cm)

4 *Lychnocanoma? costata* Nishimura. ODP 171B-61x-4w (40-42cm)

5 *Anthocyrtis?* sp. aff. *A. mespilus* Ehrenberg. ODP 171B-1051A- 67x-1w (34-36cm)

6 *Bekoma? demissa robusta* Nishimura. ODP 171B-1051A-68x-1w (60-62cm)

7 *Bekoma? demissa demissa* Foreman. DSDP 10-86-8-4 (119-125cm)

8 *Lamptonium? colymbus* Foreman. ODP 171B-1051A-58x-7w (16-18cm)

9 *Lamptonium?* sp. A n.sp. ODP 171B-1051A-67x-2w (40-42cm)

10 *Lamptonium pennatum* Foreman. ODP 171 B-1051 A-58x-7w (16-18cm)

11 *Bekoma campechensis* Foreman. ODP 171B-1051A-58x-2w (36-38cm)

12 *Bekoma bidartensis* Riedel and Sanfilippo. ODP 171B-1051A-56x-3w (76-78cm)

13 *Pterocodon poculum* Nishimura. DSDP 43-384-6-3 (102-109cm)

14 *Buryella pentadica* Foreman. ODP 171 B-1051 A-67x-2w (40-42cm)

15 *Buryella pentadica* Foreman. ODP 171 B-1051 A-67x- 1w (34-36cm)

16 *Bathropyramis magnifica* (Clark and Campbell). ODP 171B-1051A-67x-1w (34-36cm)

17 *Phormocyrtis striata praexquisita* Nishimura. ODP 171B-1051A-67x-1w (34-36cm)

18 *Phormocyrtis striata exquisita* (Kozlova). ODP 171B-1051A -58x-7w (16-18cm)

19 *Phormocyrtis striata striata* Brandt. ODP 171B-1051A-44x-7w (8-10cm)

20 *Lychnocanoma auxilla* Foreman. DSDP 10-96-3-5 (42-44cm)

21 *Buryella* sp. A n. sp. ODP 171B-1051A-67x-2w (40-42cm)

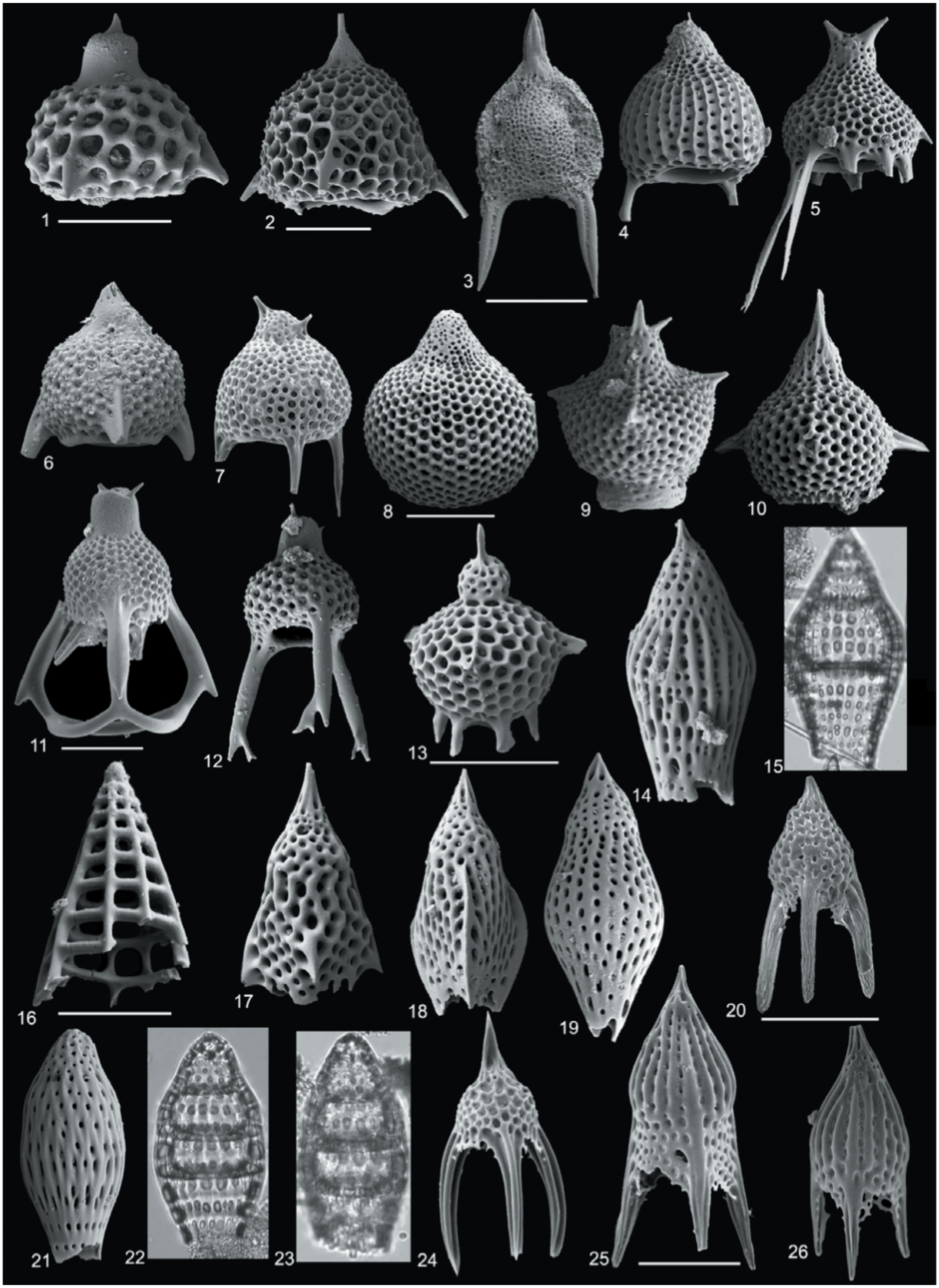
22 *Buryella* sp. A n. sp. ODP 171B-1051A-67x-1w (34-36cm)

23 *Buryella* sp. A n. sp. ODP 171B-1051A-67x-5w (40-42cm)

24 *Lychnocanoma anacolum* Foreman. DSDP 10-86-8-4 (119-125cm)

25 *Lychnocanium carinatum* Ehrenberg. DSDP 10-96-3-5 (42-44 cm)

26 *Lychnocanium* sp. A. ODP 171B-1051A-58x-2w (34-36cm)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(2001, p. 211, fig. 8m) as a sub-species *(Calocyclas hispida* var. A.)

Species code: **chis**

Calocycloma ampulla (Ehrenberg)
Plate 2, figure 2

Eucyrtidium ampulla EHRENBERG 1854, pl. 36, figs. 15a-c. – EHRENBERG 1873, p. 225. – EHRENBERG 1875, p. 70, pl. 10, figs. 11, 12; FOREMAN 1973, p. 434, pl. 1, figs. 1-5

Species code: **camp**

Calocycloma castum (Haeckel)
Plate 2, figure 3

Calocyclas casta HAECKEL 1887, p. 1384, pl. 73, fig. 10. – FOREMAN 1973, p. 434, pl. 1, figs. 9, 10

Species code: **ccas**

Carposphaera subbotinae (Borisenko)
Plate 3, figure 4

Cenosphaera subbotinae BORISENKO 1958, p. 85, pl. 5, figs. 5-7. – ABELMANN 1990, p. 691, pl. 1, fig. 9

Species code: **csub**

Circodiscus circularis (Clark and Campbell)
Plate 4, figs. 10, 12

Porodiscus (Trematodiscus) circularis CLARK and CAMPBELL 1942, p. 42, pl. 11, figs. 2, 6, 10. – KOZLOVA 1999, pl. 9, fig. 2

Species code: **ccir**

Cromyomma riedeli Nishimura
Plate 3, figure 7

Cromyomma riedeli NISHIMURA 1992, p. 322, pl. 1, figs. 6, 7; pl. 11, fig. 7

Species code: **cred**

Dendrospyris fragoides Sanfilippo and Riedel
Dendrospyris fragoides SANFILIPPO and RIEDEL 1973, p. 526, pl. 15, figs. 8–13; pl. 31, figs. 13, 14

Species code: **dfra**

Dendrospyris golli Nishimura
Dendrospyris golli NISHIMURA 1992, p. 330, pl. 3, figs. 1, 2; pl. 12, fig. 11

Species code: **dgol**

PLATE 2

All scale bars equal 100µm.

1 *Calocyclas hispida* (Ehrenberg) *s.s.* DSDP 10-94-25-3 (113-115cm)

2 *Calocycloma ampulla* (Ehrenberg). ODP 171B-1051A-56x-4w (37-38cm)

3 *Calocycloma castum* (Haeckel). ODP 171B-1051A-44x-7w (8-10cm)

4 *Bekoma? oliva* Nishimura. DSDP 10-86-8-4 (119-125cm)

5 *Lithochytris archaea* Riedel and Sanfilippo. ODP 171B-1051A-44x-7w (8-10cm)

6 *Thyrsocyrtis (Thyrsocyrtis) tarsipes* Foreman. DSDP 10-96-3-5 (42-44 cm)

7 *Theocotyle nigriniae* Riedel and Sanfilippo. ODP 171B-1051A-44x-7w (8-10cm)

8 *Theocotylissa ficus* (Ehrenberg). DSDP 10-94-25-3 (113-115cm)

9 *Theocotylissa auctor* (Foreman). DSDP 10-96-3-5 (42-44 cm)

10 *Theocotylissa alpha* (Foreman). ODP 171B-1051A-44x-7w (8-10cm)

11 *Thyrsocyrtis (Thyrsocyrtis) rhizodon* Ehrenberg. ODP 171B-1051A-44x-7w (8-10cm)

12 *Lamptonium fabaeforme fabaeforme* (Krasheninnikov). ODP 171B-1051A-54x-5w (40-42cm)

13 *Lamptonium fabaeforme chaunothorax* Riedel and Sanfilippo. ODP 171 B- 1051 A-44x-7w (8-10cm)

14 *Pterocodon? ampla* (Brandt). DSDP 10-96-3-5 (42-44cm)

15 *Phormocyrtis turgida* (Krasheninnikov). ODP 171 B- 1051 A-52x-5w (42-44cm)

16 *Phormocyrtis cubensis* (Riedel and Sanfilippo). ODP 171B-1051A-44x-7w (8-10cm)

17 *Buryella clinata* Foreman. ODP 171B-1051A-44x-7w (8-10cm)

18 *Lychocanoma bellum* (Clark and Campbell). ODP 171B-1051A-44x-7w (8-10cm)

19 *Lithochytris vespertilio* Ehrenberg. DSDP 10-94-25-3 (113-115cm)

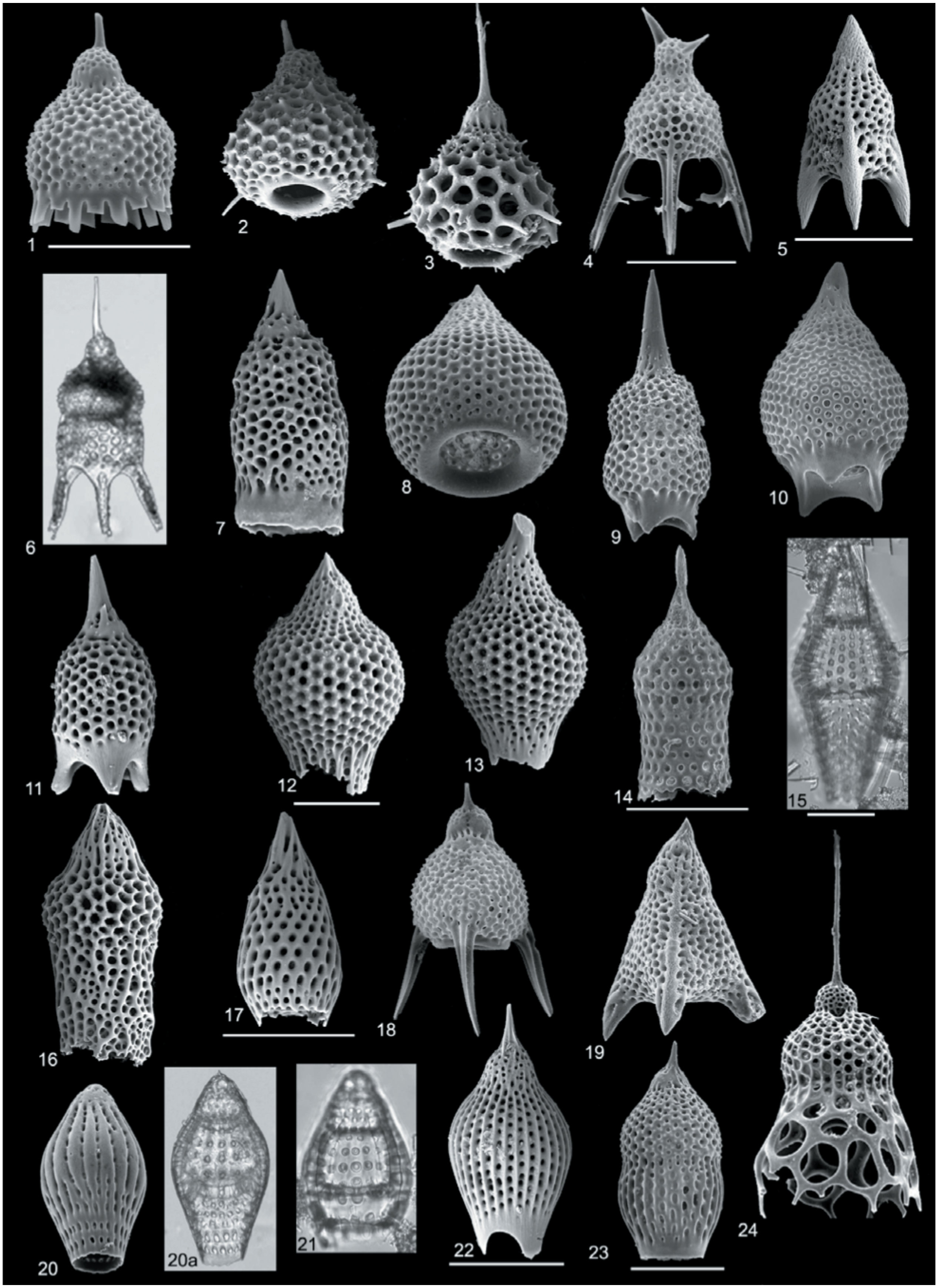
20 *Buryella tetradica* Foreman *s.s.* DSDP 10-96-3-5 (42-44cm)

21 *Buryella tetradica* Foreman var. A. ODP 171B-1051A-65x-5w (40-42cm)

22 *Podocyrtis papalis* (Ehrenberg). ODP 171 B-1051 A-44x-7w (8-10cm)

23 *Theocorys? phyzella* Foreman. DSDP 10-96-3-5 (42-44cm)

24 *Theocorys acroria* Foreman. DSDP 10-96-3-5 (42-44cm)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Dictyoprora amphora (Haeckel)
Plate 3, figure 18

Dictyocephalus amphora HAECKEL 1887, p. 1305, pl. 62, fig. 4. – NIGRINI 1977, p. 250, pl. 4, figs. 1, 2

Species code: **damp**

Dictyoprora mongolfieri (Ehrenberg)
Eucyrtidium mongolfieri EHRENBERG 1854, pl. 36, fig. 18. – NIGRINI 1977, p. 250, pl. 4, fig. 7

Species code: **dmon**

Dictyoprora urceolus (Haeckel)
Plate 3, figure 17

Dictyocephalus urceolus HAECKEL 1887, p. 1305. – NIGRINI 1977, p. 251, pl. 4, figs. 9, 10

Species code: **durc**

Dictyospyris discus Sanfilippo and Riedel
Dictyospyris discus SANFILIPPO and RIEDEL 1973, p. 527, pl. 16, figs. 4-8; pl. 32, figs. 4-7

Species code: **ddis**

Dorcadospyris platyacantha (Ehrenberg) group
Plate 4, figure 17

Petalospyris platyacantha EHRENBERG 1873, p. 247; 1875, pl. 22, fig. 8. – SANFILIPPO and RIEDEL 1973, pl. 17, figs. 11-15; pl. 33, fig. 2

Species code: **dpla**

Entapium regulare Sanfilippo and Riedel
Entapium regulare SANFILIPPO and RIEDEL 1973, p. 492, pl. 2, figs. 10-19; pl. 24, figs. 1-3

Species code: **ereg**

Girafospyris cyrillium Sanfilippo and Riedel
Girafospyris cyrillium SANFILIPPO and RIEDEL 1973, p. 528, pl. 18, figs. 1-3; pl. 33, fig. 3

Species code: **gcyr**

Girafospyris lata Goll
Plate 4, figure 16

Girafospyris lata GOLL 1969, p. 334, pl. 58, figs. 22, 24–26

Species code: **glat**

Hexacontium? palaeocenicum Sanfilippo and Riedel
Plate 3, figure 5

Hexacontium? palaeocenicum SANFILIPPO and RIEDEL 1973, p. 492, pl. 4, fig. 2; pl. 24, fig. 4

Species code: **hpal**

PLATE 3

All scale bars equal 100µm.

1 *Thecosphaera larnacium* Sanfilippo and Riedel. ODP 171B-1051A-56x-4w (37-38cm)

2 *Thecosphaera larnacium* Sanfilippo and Riedel. ODP 171B-1051A-44x-5w (48-50cm)

3 *Thecosphaerella glebulenta* Sanfilippo and Riedel. ODP 171B-1051A-42x-4w (22-23cm)

4 *Carposphaera subbotinae* (Borisenko). DSDP 43-384-7-6 (119-125cm)

5 *Hexacontium? palaeocenicum* Sanfilippo and Riedel. ODP 171B-1051A-57x-6w (40-42cm)

6 *Thecosphaerella ptomatus* Sanfilippo and Riedel. ODP 171B-1051A-67x-1w (34-36cm)

7 *Cromyomma riedeli* Nishimura. ODP 171B-1051A-65x-5w (40-42cm)

8 *Pseudostaurosphaera* sp. ODP 171B-1051A-44x-7w (8-10cm)

9 *Spongatractus pachystylus* (Ehrenberg). DSDP 10-94-32-CC

10 *Stylosphaera coronata coronata* Ehrenberg. ODP 171B-1051A-47x-7w (28-30cm)

11 *Stylosphaera macrosphaera* Nishimura. ODP 171B-1051A-61x-4w (40-42cm)

12 *Stylosphaera goruna* Sanfilippo and Riedel. ODP 171B-1051A-67x-1w (34-36cm)

13 *Amphisphaera minor* (Clark and Campbell). ODP 171B-1051A-67x-2w (40-42cm)

14 *Axoprunum pierinae* (Clark and Campbell). ODP 171B-1051A-58x-7w (16-18cm)

15 *Saturnalis circularis* Haeckel. DSDP43-384-7-6 (119-125cm)

16 *Saturnalis* sp. A aff. *trochoides* Haeckel. DSDP 43-384-6-3-(102-109cm)

17 *Theocampe urceolus* (Haeckel). DSDP 10-94-32-CC

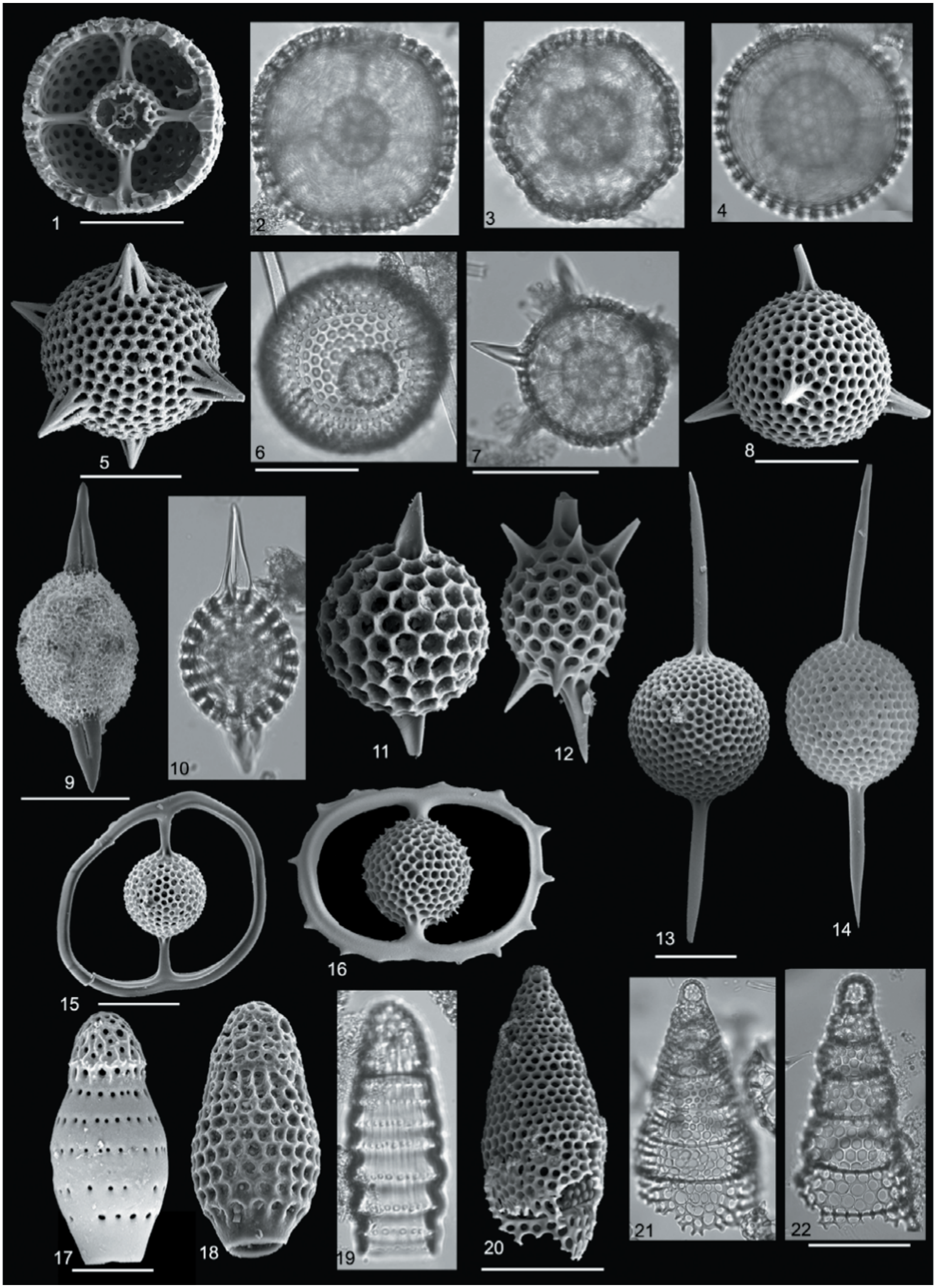
18 *Theocampe amphora* (Haeckel). DSDP 10-94-32-CC

19 *Siphocampe altamontensis* (Campbell and Clark). ODP 171B-1051A-64x-2w (51-52cm)

20 *Amphipternis clava* (Ehrenberg). ODP 171B-1051A- 67x-1w (34-36cm)

21 *Amphipternis clava* (Ehrenberg). ODP 171B-1051A-59x-2w (36-38cm)

22 *Amphipternis alamedaensis* (Campbell and Clark). DSDP 43-384-6-3 (102-109cm)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Lamptonium? colymbus Foreman
Plate 1, figure 8

Lamptonium? colymbus FOREMAN 1973, p. 435, pl. 6, fig. 2; pl. 11, figs. 15, 19

Species code: **lcol**

***Lamptonium?* sp. A**
Plate 1, figure 9

Description: Large shell of three segments, inflated thorax bearing three pronounced wings. Sparsely perforate subspherical cephalis. The majority of specimens have only one horn which is never observed complete. By-spines, arising from the massive shell material on the cephalis or the uppermost part of the thorax, are observed in some specimens. The wings extend outward from the upper third of the thorax. The shape of the thorax varies somewhat depending on the position of the wings, from inflated pyriform to conical proximally and inflated distally. The subcylindrical, fragile abdomen consists of a hyaline band, varying in width proximally and a porous part extending distally. Pores on this part are circular to sub-circular, irregular in size and distribution.

Distinguishing characters: This species is distinguished from *Lamptonium? colymbus* by having more prominent thoracic wings and a distinctive abdominal hyaline band. It differs from *Lamptonium pennatum* by the higher position of the wings on the thorax, having an abdominal hyaline band not a fringe and in the nature of the apical horn.

Occurrence: Late early Paleocene to late Paleocene of ODP 171B-1051A

Species code: **lmar**

Lamptonium? incohatum Foreman
Lamptonium? incohatum FOREMAN 1973, p. 436, pl. 6, fig. 1; pl. 11, fig. 18

Species code: **linc**

Lamptonium fabaeforme chaunothorax Riedel and Sanfilippo
Plate 2, figure 13

Lamptonium (?) fabaeforme (?) chaunothorax RIEDEL and SANFILIPPO 1970, p. 524, pl. 5, figs. 8-9

Species code: **lcha**

Lamptonium fabaeforme constrictum Riedel and Sanfilippo
Lamptonium (?) fabaeforme (?) constrictum RIEDEL and SANFILIPPO 1970, p. 523, pl. 5, fig. 7

Species code: **lcon**

Lamptonium fabaeforme fabaeforme (Krasheninnikov)
Plate 2, figure 12

Cyrtocalpis fabaeforme KRASHENINNIKOV 1960, p. 296, pl. 3, fig. 11. – RIEDEL and SANFILIPPO 1970, p. 523, pl. 5, fig. 6

Species code: **lfab**

PLATE 4

All scale bars equal 100µm.

1 *Amphicraspedum murrayanum* Haeckel group. ODP 171B-1051A-44x-7w (8-10cm)

2 *Amphicraspedum murrayanum* Haeckel group. ODP 171B-1051A-56x-4w (37-38cm)

3 *Amphicraspedum prolixum* Sanfilippo and Riedel group. DSDP 10-94-25-3 (113-115cm)

4 *Amphicraspedum prolixum* Sanfilippo and Riedel group. DSDP 10-96-3-5 (42-44cm)

5 *Amphicraspedum prolixum* Sanfilippo and Riedel group. ODP 171B-1051A-44x-7w (8-10cm)

6 *Spongurus? irregularis* Nishimura. ODP 171B-1051A-57x-6w (40-42cm)

7 *Spongurus? irregularis* Nishimura. DSDP 43-384-7-6 (119-125cm)

8 *Spongodiscus cruciferus* (Clark and Campbell). DSDP 10-94-25-3 (113-115cm)

9 *Spongodiscus americanus* Kozlova . ODP 171B-1051A-66-CC

10 *Circodiscus circularis* (Clark and Campbell). DSDP 43-384-7-6 (119-125cm)

11 *Spongodiscus quartus quartus* (Borisenko). DSDP 10-96-3-5 (42-44cm)

12 *Circodiscus circularis* (Clark and Campbell). DSDP 10-96-3-5 (42-44cm)

13 *Stylotrochus nitidus* Sanfilippo and Riedel. ODP 171B-1051A-44x-7w (8-10cm)

14 *Periphaena heliastericus* (Clark and Campbell). DSDP 10-86-8-4 (119-125cm)

15 *Periphaena tripyramis triangula* (Haeckel). DSDP 10-94-32-CC

16 *Girafospyris lata* Goll. DSDP 10-96-3-5 (42-44cm)

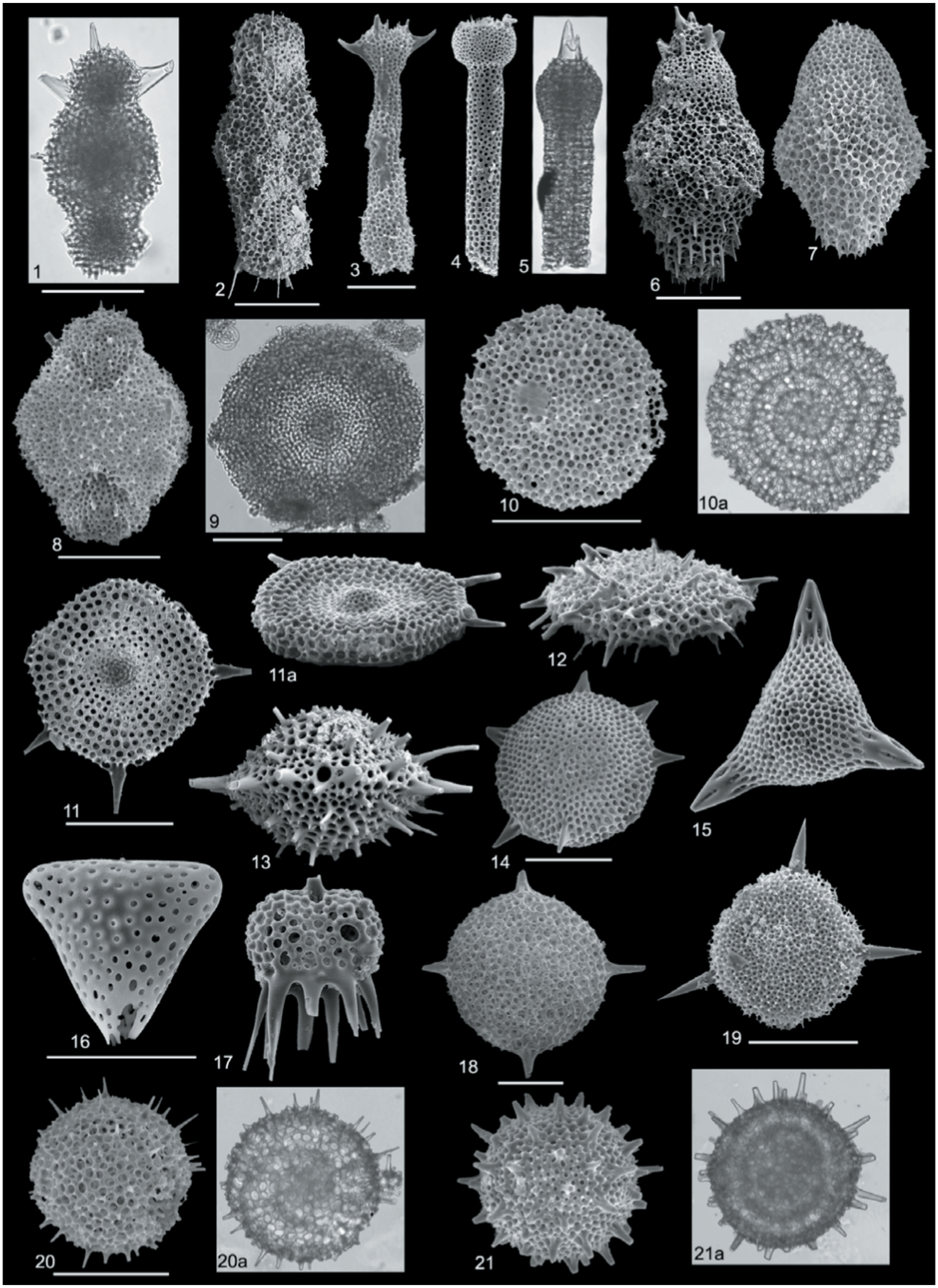
17 *Dorcadospyris platyacantha* (Ehrenberg) group. DSDP 10-96-3-5 (42-44cm)

18 *Spongodiscus rhabdostylus* (Ehrenberg) group. ODP 171B-1051 A-58x-7w (16-18cm)

19 *Spongodiscus rhabdostylus* (Ehrenberg) group. DSDP 10-94-25-3 (113-115cm)

20 *Lithelius foremanae* Sanfilippo and Riedel. ODP 171B-1051A-58x-2w (34-36cm)

21 *Lithelius hexaxyphophorus* (Clark and Campbell). DSDP 10-94-25-3 (113-115cm)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Lamptonium pennatum Foreman
Plate 1, figure 10

Lamptonium pennatum FOREMAN 1973, p. 436, pl. 6, figs. 3-5; pl. 11, fig. 13

Species code: **lpen**

Lamptonium sanfilippoae Foreman
Lamptonium sanfilippoae FOREMAN 1973, p. 436, pl. 6, figs. 15- 16; pl. 11, figs. 16-17

Species code: **lsan**

Lithelius foremanae Sanfilippo and Riedel
Plate 4, figure 20

Lithelius foremanae SANFILIPPO and RIEDEL 1973, p. 522, pl. 7, figs. 1-6; pl. 26, figs. 4, 5

Species code: **lfor**

Lithelius hexaxyphophorus (Clark and Campbell)
Plate 4, figure 21

Stylosphaera hexaxyphophora CLARK and CAMPBELL 1942, p. 28, pl. 6, figs. 4, 5, 7, 11, 12. – SANFILIPPO and RIEDEL 1973, p. 522, pl. 7, figs. 7-9; pl. 26, figs. 6-7

Species code: **lhex**

Lithochytris archaea Riedel and Sanfilippo
Plate 2, figure 5

Lithochytris archaea RIEDEL and SANFILIPPO 1970, p. 528, pl. 9, fig. 7

Species code: **larc**

Lithochytris vespertilio Ehrenberg
Plate 2, figure 19

Lithochytris vespertilio EHRENBERG 1873, p. 239; 1875, pl. 4, fig. 10; RIEDEL and SANFILIPPO 1970, p. 528, pl. 9, figs. 8- 9

Species code: **lves**

Lithocyclia ocellus Ehrenberg group
Lithocyclia ocellus EHRENBERG group 1854, pl. 36, fig. 30; 1873, p. 240; RIEDEL and SANFILIPPO 1973, p. 744, pl. 2, figs. 7- 8

Species code: **loce**

Lophocyrtis biaurita (Ehrenberg)
Eucyrtidium biaurita EHRENBERG 1873, p. 226; 1875, p. 70, pl. 10, figs. 7- 8. – FOREMAN 1973, p. 442, pl. 8, figs. 23-26

Species code: **lbia**

Lychnocanium carinatum Ehrenberg
Plate 1, figure 25

Lychnocanium carinatum EHRENBERG 1875, p. 78, pl. 8, fig. 5. – NISHIMURA 1987, p. 727, pl. 3, fig. 11, *non* 6

Distinguishing characters: Lychnocanium is defined by two thick walled first segments bearing an apical horn, a slightly to heavily ribbed thorax from which extend three solid feet and usually a thin-walled third segment connecting them. *Lychnocanium* Ehrenberg differs from *Lychnocanoma* Haeckel by having a smaller cephalis and a ribbed thorax.

Species code: **lcar**

***Lychnocanium* sp. A**
Plate 1, figure 26

Theopodium sp. aff. *Lychnocanium carinatum* Ehrenberg. – NISHIMURA 1992, p. 354, pl. 7, fig. 11. – JIANBING and AITCHISON 2002, p. 150, pl. 2, fig. 6

Distinguishing characters: This form is distinguished from *Lychnocanium carinatum* Ehrenberg by its shorter feet and very finely latticed shell below the thorax. Feet are slender and triradiate. It is thought that *Lychnocanium carinatum* originated from this form by elongation of the legs and development of a third segment.

Occurrence: Late early Paleocene to late Paleocene of ODP 171B-1051A and late Paleocene of DSDP 43-3 84

Species code: **lyca**

Lychnocanoma anacolum Foreman
Plate 1, figure 24

Lychnocanoma anacolum FOREMAN 1973, p. 437, pl. 1, fig. 19; pl. 11, fig. 7

Species code: **lana**

Lychnocanoma auxilla Foreman
Plate 1, figure 20

Lychnocanoma auxilla FOREMAN 1973, p. 437, pl. 2, fig. 6; pl. 11, figs. 1, 2

Species code: **laux**

Lychnocanoma bellum (Clark and Campbell)
Plate 2, figure 18

Lychnocanium bellum CLARK and CAMPBELL 1942, p. 72, pl. 9, figs. 35, 39. – FOREMAN 1973, p. 437, pl. 1, fig. 17; pl. 11, fig. 9

Species code: **lbel**

Lychnocanoma? costata Nishimura
Plate 1, figure 4

Lychnocanoma? costata NISHIMURA 1992, p. 342, pl. 6, figs. 4-6

Species code: **lcos**

Lychnocanoma? pileus Nishimura
Plate 1, figure 3

Lychnocanoma? pileus NISHIMURA 1992, p. 344, pl. 6, figs. 7, 8; pl. 13, fig. 5

Species code: **lpil**

Orbula comitata Foreman
Plate 1, figure 2

Orbula comitata FOREMAN 1973, p. 437, pl. 3, fig. 11; pl. 10, figs. 7, 8

Species code: **ocom**

Orbula discipulus Foreman
Plate 1, figure 1

Orbula discipulus FOREMAN 1973, p. 438, pl. 3, fig. 10 ; pl. 10, figs. 9, 10

Species code: **odis**

Periphaena decora Ehrenberg
Periphaena decora EHRENBERG 1873, p. 246; 1875, pl. 28, fig. 6. – SANFILIPPO and RIEDEL 1973, p. 523, pl. 8, figs. 8-10; pl. 27, figs. 2-5

Species code: **pdec**

Periphaena delta Sanfilippo and Riedel
Periphaena delta SANFILIPPO and RIEDEL 1973, p. 523, pl. 8, figs. 11, 12; pl. 27, figs. 6, 7

Species code: **pdel**

Periphaena heliastericus (Clark and Campbell)
Plate 4, figure 14

Heliodiscus heliastericus CLARK and CAMPBELL 1942, p. 39, pl. 3, figs. 10, 11. – KOZLOVA 1999, p. 87, pl. 34, figs. 2, 11, 12; pl. 40, fig. 4

Species code: **phel**

Periphaena tripyramis triangula (Sutton)
Plate 4, figure 15

Phacotriactis triangula SUTTON 1896, p. 61 (unillustrated)
Triactis tripyramis triangula RIEDEL and SANFILIPPO 1970, p. 521, pl. 4, figs. 9, 10 – SANFILIPPO and RIEDEL 1973, p. 523, pl. 9, figs. 10, 11

Species code: **ptri**

Periphaena tripyramis tripyramis (Haeckel)
Triactiscus tripyramis HAECKEL 1887, p. 432, pl. 33, fig. 6 – SANFILIPPO and RIEDEL 1973, p. 523, pl. 9, figs. 7-9

Species code: **ptrp**

Phormocyrtis cubensis (Riedel and Sanfilippo)
Plate 2, figure 16

Eucyrtidium cubense RIEDEL and SANFILIPPO 1971, p. 1594, pl. 7, figs. 10, 11

Species code: **pcub**

Phormocyrtis striata exquisita (Kozlova)
Plate 1, figure 18

Podocyrtis exquisita Kozlova *in* KOZLOVA and GORBOVETS 1966, p. 106, pl. 17, fig. 2. – FOREMAN 1973, p. 438, pl. 7, figs 1-4, 7-8; pl. 12, fig. 5

Species code: **pexq**

Phormocyrtis striata praexquisita Nishimura
Plate 1, figure 17

Phormocyrtis striata praexquisita NISHIMURA 1992, p. 346, pl. 9, figs. 1-3

Species code: **ppra**

Phormocyrtis striata striata Brandt
Plate 1, figure 19

Phormocyrtis striata Brandt *in* WETZEL 1935, p. 55, pl. 9, fig. 12. – FOREMAN 1973, p. 438, pl. 7, figs. 5, 6, 9

Species code: **pstr**

Phormocyrtis turgida (Krasheninnikov)
Plate 2, figure 15

Lithocampe turgida KRASHENINNIKOV 1960, p. 301, pl. 3, fig. 17 – FOREMAN 1973, p. 438, pl. 7, fig. 10; pl. 12, fig. 6

Species code: **ptur**

Pterocodon? ampla (Brandt)
Plate 2, figure 14

Theocyrtis ampla Brandt *in* WETZEL 1935, p. 56, pl. 9, figs. 13–15. – FOREMAN 1973, p. 438, pl. 5, figs. 3-5

Species code: **ptam**

Pterocodon? anteclinata Foreman
Pterocodon? anteclinata FOREMAN 1975, p. 621, pl. 9, figs. 32-34

Species code: **pant**

Pterocodon poculum Nishimura
Plate 1, figure 13

Pterocodon poculum NISHIMURA 1992, p. 350, pl. 8, figs. 1-3; pl. 13, fig. 13

Species code: **ppoc**

Podocyrtis (Lampterium) sinuosa Ehrenberg
Podocyrtis sinuosa EHRENBERG 1873, p. 253; 1875, pl. 15, fig. 5 – RIEDEL and SANFILIPPO 1970, p. 534, pl. 11, figs. 3, 4

Species code: **psin**

Podocyrtis (Podocyrtoges) aphorma Riedel and Sanfilippo
Podocyrtis (Lampterium) aphorma RIEDEL and SANFILIPPO 1970, p. 534, pl. 11, fig. 2

Species code: **paph**

Podocyrtis (Podocyrtoges) diamesa Riedel and Sanfilippo
Podocyrtis (Podocyrtis) diamesa RIEDEL and SANFILIPPO 1970, p. 533, pl. 12, fig. 4, *non* figs. 5, 6

Species code: **pdim**

Podocyrtis (Podocyrtis) papalis Ehrenberg
Plate 2, figure 22

Podocyrtis papalis EHRENBERG 1847, p. 55, fig. 2. – SANFILIPPO and RIEDEL 1973, p. 531, pl. 20, figs. 11-14, pl. 36, figs. 2, 3

Species code: **ppap**

Rhopalocanium ornatum Ehrenberg
Rhopalocanium ornatum EHRENBERG 1847, fig. 3; 1854, pl. 36, fig. 9. – FOREMAN 1973, p. 439, pl. 2, figs. 8-10; pl. 12, fig. 3

Species code: **rorn**

Saturnalis circularis Haeckel
Plate 3, figure 15

Saturnalis circularis HAECKEL 1887, p. 131 (unillustrated). – NIGRINI 1967 p. 24, pl. 1, fig. 9

Saturnalis* sp. A aff. *S. trochoides Haeckel
Plate 3, figure 10

Saturnalis sp. A aff. *S. trochoides* HAECKEL 1887, p. 132 (unillustrated);
Saturnalin with spiny ring, SANFILIPPO and RIEDEL 1973, pl. 22, fig. 3

Siphocampe altamontensis (Campbell and Clark)
Plate 3, figure 19

Tricolocampe (Tricolocamptra) altamontensis CAMPBELL and CLARK 1944, p. 33, pl. 7, figs. 24, 26. – LING 1991, p. 320, pl. 1, fig. 12

Siphocampe? quadrata (Petrushevskaya and Kozlova)
Lithamphora sacculifera quadrata PETRUSHEVSKAYA and KOZLOVA 1972, p. 539, pl. 30, figs. 4–6

Species code: **squa**

Spongatractus balbis Sanfilippo and Riedel
Spongatractus balbis SANFILIPPO and RIEDEL 1973, p. 518, pl. 2, figs. 1-3; pl. 25, figs. 1, 2

Species code: **sbab**

Spongatractus pachystylus (Ehrenberg)
Plate 3, figure 9

Spongosphaera pachystyla EHRENBERG 1873, p. 256; 1875, pl. 26, fig. 3. – SANFILIPPO and RIEDEL 1973, p. 519, pl. 2, figs. 4-6; pl. 25, fig. 3

Species code: **spac**

Stylosphaera coronata coronata Ehrenberg
Plate 3, figure 10

Stylosphaera coronata EHRENBERG 1873, p. 258; 1875, pl. 25, fig. 4; SANFILIPPO and RIEDEL 1973, p. 520, pl. 1, figs. 13-17; pl. 25, fig. 4

Species code: **scor**

Stylosphaera coronata macrosphaera Nishimura
Plate 3, fig. 11

Stylosphaera coronata macrosphaera NISHIMURA 1992, p. 325, pl. 1, figs. 3, 4; pl. 11, fig. 1

Species code: **smac**

Stylosphaera coronata sabaca Sanfilippo and Riedel
Stylosphaera coronata sabaca SANFILIPPO and RIEDEL 1973, p. 521, pl. 1, fig. 18; pl. 25, figs. 7, 8

Species code: **ssab**

Stylosphaera goruna Sanfilippo and Riedel
Plate 3, figure 12

Stylosphaera goruna SANFILIPPO and RIEDEL 1973, p. 521, pl. 1, figs. 20-22; pl. 25, figs. 9, 10

Species code: **sgor**

Spongodiscus americanus Kozlova
Plate 4, figure 9

Spongodiscus americanus Kozlova *in* KOZLOVA and GORBOVETZ 1966, p. 88, pl. 14, figs. 1, 2

Species code: **same**

Spongodiscus cruciferus (Clark and Campbell)
Plate 4, figure 8

Spongastericus cruciferus CLARK and CAMPBELL 1942, p. 50, pl. 1, figs. 1-6, 8, 10, 11, 16-18. – SANFILIPPO and RIEDEL 1973, p. 524, pl. 11, figs. 14-17; pl. 28, figs. 10, 11

Species code: **scru**

Spongodiscus phrix Sanfilippo and Riedel
Spongodiscus phrix SANFILIPPO and RIEDEL 1973, p. 525, pl. 12, figs. 1, 2; pl. 29, fig. 2

Species code: **sphr**

Spongodiscus rhabdostylus (Ehrenberg) group
Plate 4, figures 18, 19

Spongosphaera rhabdostylus EHRENBERG 1873, p. 256; 1875, pl. 26, figs. 1, 2; SANFILIPPO and RIEDEL 1973, p. 525, pl. 13, figs. 1-3; pl. 30, figs. 1, 2

Remarks: This species-group includes forms having 3 or 4 bladed or conical strong radial spines. The oldest specimens in this work from ODP leg 171B tend to have 4 conical radial spines.

Species code: **srha**

Spongodiscus quartus bosoculus Sanfilippo and Riedel
Spongodiscus quartus bosoculus SANFILIPPO and RIEDEL 1973, p. 525, pl. 12, figs. 8-10; pl. 29, fig. 7

Species code: **sbos**

Spongodiscus quartus quartus (Borisenko)
Plate 4, figure 11

Staurodictya quartus BORISENKO 1958, p. 96, pl. 2, fig. 5. – SANFILIPPO and RIEDEL 1973, p. 525, pl. 12, figs. 6, 7; pl. 29, figs. 5, 6

Species code: **spqu**

Spongurus? irregularis Nishimura
Plate 4, figures 6, 7

Spongurus? irregularis NISHIMURA 1992, p. 327, pl. 2, figs. 7-9; pl. 12, figs. 3, 7

Species code: **sirr**

Stylotrochus alveatus Sanfilippo and Riedel
Stylotrochus alveatus SANFILIPPO and RIEDEL 1973, p. 525, pl. 13, figs. 4, 5; pl. 30, figs. 3, 4

Species code: **salv**

Stylotrochus nitidus Sanfilippo and Riedel
Plate 4, figure 13

Stylotrochus nitidus SANFILIPPO and RIEDEL 1973, p. 525, pl. 13, figs. 9-14; pl. 30, figs. 7-10

Species code: **snit**

Theocorys acroria Foreman
Plate 2, figure 24

Theocorys acroria FOREMAN 1973, p. 439, pl. 5, figs. 11–13; pl. 12, fig. 2

Species code: **tacr**

Theocorys anaclasta Riedel and Sanfilippo
Theocorys anaclasta RIEDEL and SANFILIPPO 1970, p. 530, pl. 10, figs. 2, 3

Species code: **tana**

Theocorys anapographa Riedel and Sanfilippo
Theocorys anapographa RIEDEL and SANFILIPPO 1970, p. 530, pl. 10, fig. 4

Species code: **tanp**

Theocorys? phyzella Foreman
Plate 2, figure 23

Theocorys? phyzella FOREMAN 1973, p. 440, pl. 5, fig. 8; pl. 12, fig. 1

Species code: **tphy**

Theocorys? sp. aff. ***T. acroria*** Foreman
Theocorys? sp. aff. *T. acroria* Foreman. – NISHIMURA 1992, pl. 4, fig. 7

Species code: **tafa**

Thecosphaera larnacium Sanfilippo and Riedel
Plate 3, figure 1, 2

Thecosphaera larnacium SANFILIPPO and RIEDEL 1973, p. 521, pl. 3, figs. 4-6; pl. 25, figs. 13, 14

Species code: **tlar**

Thecosphaerella glebulenta Sanfilippo and Riedel
Plate 3, figure 3

Thecosphaerella glebulenta SANFILIPPO and RIEDEL 1973, p. 521, pl. 3, figs. 12, 13; pl. 26, fig. 1

Species code: **tgle**

Thecosphaerella ptomatus Sanfilippo and Riedel
Plate 3, figure 6

Thecosphaerella ptomatus SANFILIPPO and RIEDEL 1973, p. 521, pl. 3, figs. 14-18; pl. 26, fig. 2

Species code: **tpto**

Thecosphaerella rotunda (Borisenko)
Thecosphaera rotunda BORISENKO 1960, p. 222, pl. 1, fig. 3; pl. 3, figs. 2, 3. – SANFILIPPO and RIEDEL 1973, pl. 3, figs. 7-11; pl. 36, fig. 3

Species code: **trot**

Theocotyle cryptocephala (Ehrenberg)
Eucyrtidium cryptocephalum EHRENBERG 1873, p. 227; 1875, p. 70, pl. 11, fig. 11. – SANFILIPPO and RIEDEL 1982, p. 178, pl. 2, figs. 4-7

Species code: **tcry**

Theocotyle nigriniae Riedel and Sanfilippo
Plate 2, figure 7

Theocotyle cryptocephala (?) nigriniae RIEDEL and SANFILIPPO 1970, p. 525, pl. 6, fig. 5, *non* 6

Species code: **tnig**

Theocotylissa alpha Foreman
Theocotylissa alpha FOREMAN 1973, p. 441, pl. 4, figs. 13-15, *non* 14; pl. 12, fig. 16 Plate 2, figure 10

Species code: **talp**

Theocotylissa auctor Foreman
Plate 2, figure 9

Theocotyle (Theocotylissa) auctor FOREMAN 1973, p. 441, pl. 4, figs 8-10; pl. 12, fig. 13

Species code: **tauc**

Theocotylissa ficus (Ehrenberg)
Plate 2, figure 8

Eucyrtidium ficus EHRENBERG 1873, p. 228; 1875, pl. 11, fig. 19 – SANFILIPPO and RIEDEL 1982, p. 180, pl. 2, figs. 19, 20

Species code: **tfic**

Thyrsocyrtis? annikae Nishimura
Thyrsocyrtis? annikae NISHIMURA 1992, p. 356, pl. 7, figs. 4-6 Species code: **tann**

Thyrsocyrtis (Pentalacorys) tensa Foreman
Thyrsocyrtis hirsuta tensa FOREMAN 1973, p. 442, pl. 3, figs. 13-16; pl. 12, fig. 8

Species code: **tten**

Thyrsocyrtis (Thyrsocyrtis) hirsuta (Krasheninnikov)
Podocyrtis hirsutus KRASHENINNIKOV 1960, p. 300, pl. 3, fig. 16. – SANFILIPPO and RIEDEL 1982, p. 173, pl. 1, figs. 3, 4

Species code: **thir**

Thyrsocyrtis (Thyrsocyrtis) rhizodon Ehrenberg
Plate 2, figure 11

Thyrsocyrtis rhizodon EHRENBERG 1873, p. 262; 1875, p. 94, pl. 12, fig. 1. – SANFILIPPO and RIEDEL 1982, p. 173, pl. 1, figs. 14-16

Species code: **trhi**

Thyrsocyrtis (Thyrsocyrtis) robusta Riedel and Sanfilippo
Thyrsocyrtis hirsuta robusta RIEDEL and SANFILIPPO 1970, p. 526, pl. 8, fig. 1

Species code: **trob**

Thyrsocyrtis (Thyrsocyrtis) tarsipes Foreman
Thyrsocyrtis (Thyrsocyrtis) tarsipes FOREMAN 1973, p. 442, pl. 3, fig. 9; pl. 12, fig. 14, Plate 2, figure 6

Species code: **ttar**

ACKNOWLEDGMENTS

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