Apical disc

1. Ocular and genital plates form a contiguous ring in adults: no (0); yes (1).
2. Genital plates subdivided into a mass of small platelets: no (0); yes (1).
3. Ocular plates very elongate and extended: no (0); yes (1).
4. Gonopores open within genital plate (0); open in distal membranous gap (1).
5. periproctal plates: contiguous pavement (0); separated and embedded in membrane (1).

Ambulacra

7. Smaller elements reduced to minute, ovate accessory plates: no (0); yes one is (1); yes both are (2).
8. On oral surface smaller ambulacral plates occluded from adradial suture: no (0); inner plate occluded (1); both elements occluded (2).
9. On aboral surface primary element occluded from the adradial suture: no (0); yes (1).
10. On oral surface triads heterogeneous and tending to form multicomponent elements: no (0); yes (1).
11. Primary element divided medially into two pieces: no (0); yes (1).
12. On oral surface, pore-pairs marginal (0); forming a band removed from the adradial suture (1).
13. Pore-pairs adorally forming a broad marginal phyllode; no (0); yes (1).
14. Only one accessory plate on ambital and adoral elements: no (0); yes (1).
15. All pores/tube-feet equally developed (0); some pore-pairs reduced (1).
16. Pore-pairs in three discrete columns at ambitus and aborally: no (0); yes (1).

Peristome

17. Buccal plates present: no (0); yes (1).
18. Plates arranged uniserially (0); biserially (1) in each half ambulacrum.
19. Buccal notches: absent (0); feeble (1); well developed (2).

Interambulacra

20. Membranous gaps present orally in interambulacral zones: no (0); yes (1).
21. Membranous gaps present adapically in interambulacral zones: no (0); yes (1).

Tuberculation

22. Primary tubercles: non-crenulate (0); crenulate (1).
23. Areole not sunken (0); sunken (1).
24. Oral tubercles much larger than aboral: no (0); yes (1).
25. Multiple equal tubercles on interambulacral plates: no (0); yes (1).
26. Distinct adradial column of tubercles: no (0); yes (1).

Spines and pedicellariae

27. Oral spines end: in rounded point with fleshy sac (0); in hyaline hoof (1); in flattened blade (2).
28. Primary spines central lumen: empty (0); filled with coarse mesh (1).
29. Sphaeridia: on both accessory plates (0); on inner plate only (1).
30. Tridentate pedicellariae: open blade-like valves with contiguous edges (0); with involute neck and wide lateral gap (1).
31. Ophicephalous pedicellariae: absent (0); present (1).
32. Dactylous pedicellariae: absent (0); present (1).

Teeth

33. CLNP/LLNP system differentiated: no (0); yes (1).
34. CLNP/LLNP system of *Calverisoma*-type (see JENSEN, 1982): no (0); yes (1).
35. Teeth, shape of tip: acuminate (0); rounded (1).

Table 7: Extended set of characters used in the analysis shown in Fig. 1.2 (no. 3) (modified from SMITH "*The Echinoid Directory*", 12.11.2003).

		1	11111	11112	22222	22223	33333
	12345	67890	12345	67890	12345	67890	12345
Pelanechinus	10000	01101	00100	00110	00000	00??0	00?0?
Kamptosoma	0?101	12000	00010	01000	01010	12000	0100?
Hemiphormosoma	01001	02200	01000	00010	00111	00000	00?00
Phormosoma	01001	02000	00000	00010	00111	00000	00000
Paraphormosoma	00000	02110	00000	00010	00000	00010	00?00
Hygrosoma	00010	02000	00000	00010	00111	01010	10101
Sperosoma	01010	11100	11001	00010	00001	01010	10101
Tromikosoma	01011	11100	01001	00000	00001	01010	10?01
Echinothuria	10000	02200	01000	10010	00010	11??0	?????
Hapalosoma	10000	02100	01100	10011	10010	11110	01111
Asthenosoma	11000	02200	01100	10010	10011	01110	00111
Araeosoma	10010	02200	01100	10111	10001	11111	01111
Calveriosoma	10010	02200	01100	10111	10011	11?11	00111
Retzneiosoma	?????	?2200	01?00	1????	110?1	100??	????0

Table 8: Character matrix for the analysis shown in Fig. 11 (no. 3) (data from MORTENSEN, 1935; SMITH & WRIGHT, 1990; and SMITH, "*The Echinoid Directory*", 12.11.2003).

Retzneiosoma jaseneki Kroh, nov. gen. et nov. sp.

(Fig. 10; Pl. 9, Figs. 1-12; Pl. 10, Figs. 1-8)

v. 2004a echinothurioid – Kroh: 231
(Early Badenian: Lafarge quarry, Retznei, Stmk)

Type-material:
Holotype: NHMW 2003z0071/0001
Locus typicus: Retznei [Lafarge quarry (formerly Perlmoser)], Styria, Austria.
Stratum typicum: grey marls overlying the Weissenegg Fm.
Age: Early Badenian (Langhian, Middle Miocene)
Derivatio nominis: Named after Manfred Jasenek (Vienna), who collected and donated the holotype.

Diagnosis:
Echinothuriid with trigeminate ambulacra with single large primary plate reaching from adradial to perradial suture and smaller, ovate demiplates positioned along the horizontal sutures; demiplates occluded from both adradial and perradial sutures; pores arranged in three vertical rows; primary tubercles crenulate and perforate; tubercles arranged in distinct adradial columns in the aboral interambulacra; in ambital ambulacra plates with one and two primary tubercles alternate, adapical ambulacral plates bear only a single primary tubercle; membranous gap in aboral interambulacra; hollow, smooth primary spines terminating in a tapering, rounded tip.

Material:
Early Badenian (Langhian) – Retznei [Lafarge quarry (formerly Perlmoser)], Styria, Austria
NHMW: 2 specimens and several disarticulated ossicles [NHMW 2003z0071/0001 (holotype) and 2003z0071/0002 (fragmented specimen), 2003z0071/0003 (isolated spines and coronal plates)]

Dimensions (in mm):

Inv. no.	TL	TW	TH
NHMW 2003z0071/0001	78	60	-

Description:
Size and shape: Test fragile, with imbricated coronal plates. Large flanges are developed internally on both ambulacral and interambulacral plates. The single complete specimen has a largest test diameter of about 78 mm. Both outline and profile are unknown.
Apical disc: unknown
Ambulacral: Ambulacra moderately wide reaching about 50 % of interambulacral width at the ambitus. Ambulacral plates low and horizontally elongated. The arrangement of the ambulacral plates is that of pseudocompound triads. In each triad there is one large demiplate (further called primary plate) extending from perradial to adradial suture and two small, subequal demiplates situated obliquely along the horizontal sutures, about one third the length of the primary plate from the adradial suture. These smaller demiplates have no contact to the adradial or perradial sutures (Fig. 10.A, 10.B). Each demiplate bears a single well developed pore pair (the preservation is not good enough to identify the type). The pore pair on the primary plate lays adradially of the smaller demiplates. The pores form three vertical series.

Tuberculation of the ambulacra is denser than on the interambulacra. Primary plates with one and two large primary tubercles alternate on the aboral side (Fig. 10.A; oral side unknown). Secondary tubercles and miliaries obscured.
Interambulacra: The interambulacra are wide, about two times as wide as the ambulacra at the ambitus. The interambulacral plates are low, and up to ten times wider than high. Between individual interambulacral plates of the aboral side there are small but distinct gaps interpreted as membranous gaps as oc-

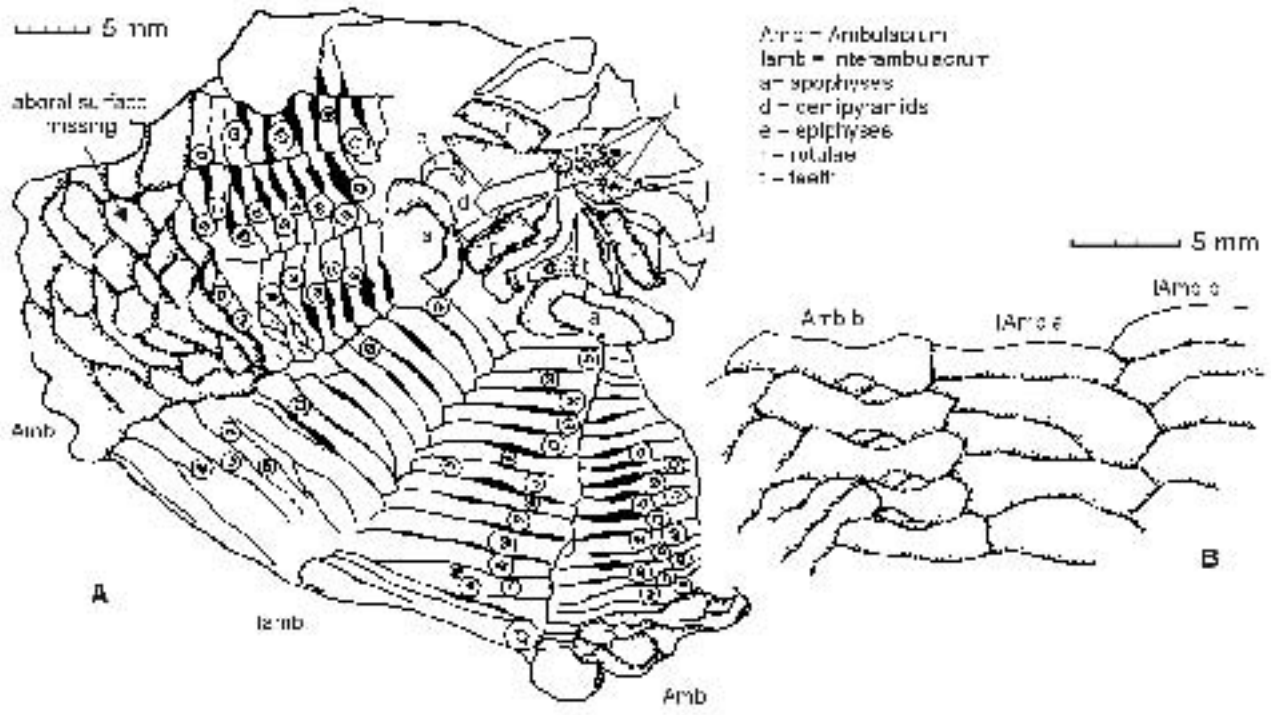

Figure 10: *Retzneiosoma jaseneki* Kroh, nov. sp.: aboral view showing imbricate plates, "membranous" gaps, and aboral tuberculation (A). Notice that large parts of the aboral surface are missing exposing the lantern and the inside of the oral surface (B; showing ambulacral plating).

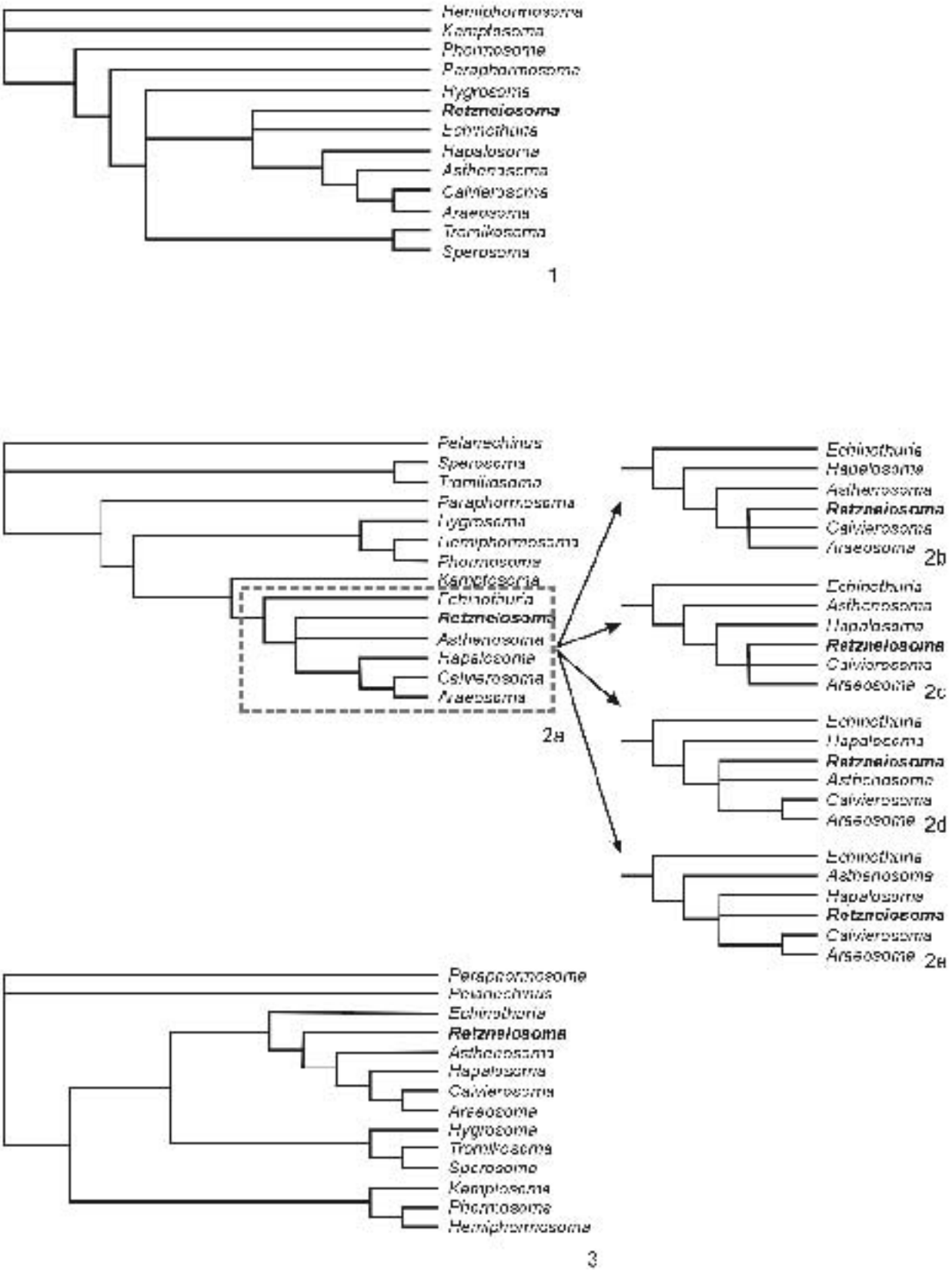

Figure 11: Cladistic analysis of *Retzneiosoma* utilising published characters and data matrices for the order Echinothurioida (Smith & Wright, 1990; Smith, "*The Echinoid Directory*", 12.11.2003). The placement of the new genus *Retzneiosoma* on the echinothurioid tree proposed by Smith & Wright (1990) (no. 1, single most parsimonious tree), Smith ("*The Echinoid Directory*", 12.11.2003) (nos. 2a-e, five equally parsimonious trees), and a single most parsimonious tree (no. 3) resulting from a modified set of characters (tabs. 6, 7).

curring in most members of the subfamily Echinothuriinae. The tuberculation is very spares. Each plate bears only a single primary tubercle, which takes up the full height of the plate. The tubercles are situated close to the adradial suture and form a more or less well defined vertical row (Fig. 10.A). Closer to the ambitus some of the primary tubercles may be situated outside this vertical row, lying more interradially. In some instances there may be more than one primary tubercle per plate. Oral tuberculation unknown.

Lantern and perignatic girdle: The lantern belongs to the aulodont type, with broad, longitudinally grooved teeth, and moderately open foramen magnum. The teeth have acuminate distal tips. The auricles have the form of broad inverted U's.

Primary spines: Primary spines attached to the single complete specimen are poorly preserved and their microstructure is obliterated by pyritization. In no instance a terminal hoof could be observed. Bulk samples from the same level from which the unique complete specimen was recovered yielded several cm long well preserved spines that are tentatively assigned to the same taxon. Additionally fragmented coronal plates with large crenulate perforate primary tubercles similar to those of the complete specimen were found in these bulk samples.

The spines have crenulate bases which fit in size very well to the tubercles observed in the complete specimen. The bases are moderately large, stout and have the shape of a small bucket. The shaft of the spines is very smooth with extremely narrow longitudinal slits which are barely visible, except in high magnification. These slits correspond to the borders between individual wedges of which the spine is construed as seen in cross-section (Pl. 9, Figs. 5-6). There are about 33 to 35 of these wedges which are attached to a hollow cylinder. The cylinder shows regularly arranged perforations forming a reticulate pattern (Pl. 9, Figs. 8-9). The central lumen is empty.

Discussion:

The systematic placement of the new genus has been discussed above. Extant species of the Echinothuriinae occur in the tropical and temperate regions all around the world. Most species are confined to deep sea habitats, although some species of *Asthenosoma* (e.g. *A. ijimai*) are also found in shallow depth. The echinothuriids are epibenthic scavengers, which seem to ingest mainly macroplant debris (Mortensen, 1935).

Apart from *Echinothuria floris* Woodward from the Santonian of England of which 8 specimens are known (Smith & Wright, 1990) *Retzneiosoma jaseneki* is the only other fossil echinothurioid known from "complete" tests. Disarticulated material, mainly spines, have been reported from the Santonian of France ("*Phormosoma" homoei* Lambert, 1907a), the Maastrichtian and Danian of Denmark ("*Araeosoma" mortenseni* Ravn, 1928, "*A." brunnichi* Ravn, 1928 and "*Asthenosoma" striatissimum* Ravn, 1928) and the Netherlands (*Echinothuria* ? sp., Jagt, 2000; Smith & Jeffery, 2000), the Miocene of Sardinia ("*Phormosoma" lovisatoi* Lambert, 1907a), and the Pliocene of New Zealand (*Araeosoma* aff. *thetidis* (Clark), Fell, 1966b; spine and test fragment).

The holotype of *Retzneiosoma jaseneki* is a largely complete, albeit crushed, corona with few spines and the lantern still associated. The specimen is pyritized and aboral and oral plates lie directly on top of each other. Since these animals are highly fragile and prone to rapid disintegration burial must have been fast or even take place while the animal was still alive. The oral side of the holotype is the side still attached to the sediment. It could not be examined without destroying the specimen.

Occurrence:

Austria: Early Badenian (Langhian)

Styrian Basin: Retznei (Lafarge quarry), Styria (Kroh, 2004b; [NHMW])

Infraclass Acroechinoidea Smith, 1981
Order Diadematoida Duncan, 1889
Family Diadematidae Peters, 1853

Diadematidae indet.

("*Diadema desori* Reuss, 1860")

(Pl. 8, Figs. 1-25)

mentioned as Diadematidae indet.:

? 1866a *Diadema* oder *Echinus* – Suess: 99
v. 1999 Diadematidae indet. – Kroh & Harzhauser: 155-156; pl. 8, figs. 1-7
v. 2002b Diadematidae indet. – Kroh: 12
v. 2003a Diadematidae indet. – Kroh: 160; pl. 2, figs. 1-5

mentioned as *Diadema desori* Reuss, 1860:

* 1860 ? *Diadema desori* m. n. sp. – Reuss: 222-223; pl. 3, figs. 3, 3a
1880 *Diadema desori* Rss. – Rzehak: 302
1892b *Diadema Desori* Rss. – Procházka: 342
1893 *Diadema desori* Reuss. – Toula: 289
1900 *Diadema Desori*, Rss. – Procházka: 21, 74
1900 ? *Diadema Desori*, Reuss. – Procházka: 146
1942 Stachelformen die *Diadema desorii* Reuss nahestehen – Toth: 525

mentioned as *Centrostephanus calarensis* Cotteau, 1905:

v. 1915 *Centrostephanus calarensis* Cott. Sp. – Vadász: 106; pl. 8 (2), fig. 11
1915 *Centrostephanus calariensis* Cott. sp. – Májer: 29, 82
1915 *Centrostephanus calariense* Cott. sp.– Májer: 35, 88
1969 *Centrostephanus calarensis* Cott. – Gábos & Ghiurca: 86-87; pl. 1, fig. 7 [undeterminable diadematid spine]
1977 *Centrostephanus calarensis* Cotteau, 1905 – Mączyńska: 195; pl. 1, figs. 8
1987 *Centrostephanus calarensis* Cotteau, 1905 – Mączyńska: 148
1988 *Centrostephanus calarensis* Cotteau, 1905 – Mączyńska: 60; pl. 1, fig. 4
1993 *Centrostephanus calarensis* Cotteau, 1905 – Mączyńska: 107; pl. 1, figs. 6-7

mentioned as *Centrostephanus rhodanicus* (Mayer-Eymar, 1910):

? 1987 *Centrostephanus rhodanicus* (Mayer-Eymar, 1910) – Mączyńska: 148

mentioned as *Centrostephanus airaghii* Lambert, 1907a:

v. 1915 *Centrostephanus Airaghii* Lamb. – Vadász: 106; pl. 8 (2), fig. 12
1915 *C.*[*entrostephanus*] *Airaghii* Lamk. – Májer: 35, 88
1928 *Centrostephanus Airaghii* Lamb. – Kutassy: 8
1969 *Centrostephanus airaghii* Lambert – Gábos & Ghiurca: 87; pl. 1, fig. 6 [undeterminable diadematid spine]

mentioned as *Centrostephanus* cf. *longispinus* Philippi, 1845:

1915 *Centrostephanus* cfr. *longispinus* Phil. sp.– Vadász: 106

mentioned as *Centrostephanus* sp.:

1955 *Centrostephanus* sp., regelmäßig skulpturiert – Tollmann: tab. 1
1955 *Centrostephanus* sp., unregelmäßig skulpturiert – Tollmann: tab. 1

misidentifications:

? 1977 *Cidaris* sp. div. – Mączyńska: 194; pl. 1, fig. 16

? 1987 *Plegiocidaris peroni* (Cotteau, 1877) – Mączyńska: 146, 148; pl. 1, figs. 2
? pp 1993 *Plegiocidaris peroni* (Cotteau, 1877) – Mączyńska: 106-107; pl. 6, fig. 1b

Remark: references from the outside the Paratethys are omitted.

Type-material:
Syntypes: 6 spine fragments (NHMW 1859.X.136); Naturhistorisches Museum Wien
Locus typicus: Rudoltické (= Rudelsdorf), Czech Republic
Stratum typicum: "Rudoltitzer Tegel"
Age: Badenian (Langhian-Early Serravallian), Middle Miocene

Material:
Late Eggenburgian (Early Burdigalian) – Eggenburg, NÖ, Austria
NHMW: 9 spine fragments (NHMW 2004z0110/0002, 0005-0007)
Late Eggenburgian (Early Burdigalian) – Grübern (Zogelsdorf Fm.), NÖ, Austria
NHMW: 225 spine fragments (NHMW 2003z0075/0001, 2003z0075/0004) and 9 interambulacral plates (NHMW 2003z0075/0010)
Late Eggenburgian (Early Burdigalian) – Limberg (Zogelsdorf Fm., Hengl quarry), NÖ, Austria
NHMW: 82 spine fragments (NHMW 2003z0002/0007)
Late Eggenburgian (Early Burdigalian) – Maissau (Zogelsdorf Fm.), NÖ, Austria
NHMW: 33 spine fragments (NHMW 1860.L.191b)
Late Eggenburgian (Early Burdigalian) – Unternalb (Retz Fm.), SE Retz, NÖ, Austria
NHMW: ~100 spine fragments and 5 coronal plates (NHMW 1999z0051/0019-22)
Ottnangian (Late Burdigalian) – Höbmannsbach, Taufkirchen Bay, ESE Schärding, OÖ, Austria
NHMW: 4 spine fragments (NHMW 1978/1966/12g, 12z)
Early Badenian (Langhian) – Bad Vöslau (?), NÖ, Austria
NHMW: 1 spine fragment (NHMW 1997z0178/1327)
Early Badenian (Langhian) – Eisenstadt (Hartl Fm.), Bgld, Austria
NHMW: 17 spine fragments (NHMW 1859.L.803), 4 spine fragments (NHMW 1869.L.803)
Early Badenian (Langhian) – Gainfarn, NÖ, Austria
NHMW: 1 interambulacral plate (NHMW 2004z0076/0021), 1 ambulacral plate (NHMW 2004z0076/0022), 5 spine fragments (NHMW 2004z0076/0023-26, ../0029)
Early Badenian (Langhian) – Niederleis, NÖ, Austria
NHMW: 3 interambulacral plates (NHMW 2002z0087/0021, 2002z0087/00023), 1 ambulacral plate (NHMW 2002z0089/0002), 12 spine fragments (NHMW 2002z0087/0018-20, 2002z0087/0022), 1 spine fragment (NHMW 2004z0001/0016b)
Early Badenian (Langhian) – Stotzing (sandpit Mayer), Bgld, Austria
NHMW: 2 spine fragments (NHMW 2004z0050/0003)
Badenian (Langhian-Early Serravallian) – Bruck an der Leitha, NÖ, Austria
NHMW: 26 spine fragments (NHMW 2004z0001/0021b)
Badenian (Langhian-Early Serravallian) – Enzesfeld, NÖ, Austria
NHMW: 1 spine fragment (NHMW 1981/56/7b)
Badenian (Langhian-Early Serravallian) – Grinzing, Vienna, Austria
NHMW: 6 spine fragments + 1 interambulacral plate (NHMW 1846.37.953b)
Badenian (Langhian-Early Serravallian) – old sandpit between Großhöflein and Kleinhöflein, near Eisenstadt, Bgld, Austria
NHMW: 57 spine fragments (NHMW 2003z0081/0001, ../0023-25), 1 epiphysis (NHMW 2003z0081/0038), and 11 test fragments (NHMW 2003z0081/0002)
Badenian (Langhian-Early Serravallian) – Mattersburg, Bgld, Austria
NHMW: 1 spine fragment (NHMW 1981/56/11b)
Badenian (Langhian-Early Serravallian) – Nussdorf, Wien, Austria
NHMW: 3 spine fragments (NHMW 2004z0001/0026)
Badenian (Langhian-Early Serravallian) – Oslip (sandpit E of the village), Bgld, Austria
NHMW: 1 spine fragment (NHMW 2003z0083/0001)
Badenian (Langhian-Early Serravallian) – Spielfeld, Styria, Austria
NHMW: 1 spine fragment (NHMW 2004z0001/0007)
Badenian (Langhian-Early Serravallian) – Steinebrunn (formerly Steinabrunn), NÖ, Austria
NHMW: 36 spine fragments (NHMW 1859.XLV.634), 23 spine fragments (NHMW 1865.I.612b), 33 spine fragments (NHMW 2004z0001/0024b)
Badenian (Langhian-Early Serravallian) –Teischl quarry, (? Hartl Fm., Eisenstadt, Bgld), Austria
NHMW: 1 interambulacral plate (NHMW 2004z0001/0008b)
Late Badenian (Early Serravallian) – Müllendorf (Mühlendorfer Kreide AG quarry), Bgld, Austria
NHMW: 2 spine fragment and 2 intermabulacral plates (NHMW 2003z0083/0001)

Foreign material:
Early Badenian (Langhian) – Coşteiu de Sus (= Kostej), Romania
NHMW: 2 spine fragments (NHMW 2004z0001/0003b)
Early Badenian (Langhian) – Kemence, Hungary
MAFI: *c.* 40 spine fragments [MAFI Ech 439 (material referred to as *Centrostephanus calarensis* Cotteau by Vadász, 1915)], 1 spine fragment [MAFI Ech 450 (material referred to as *Centrostephanus airaghii* Lambert by Vadász, 1915)]
Early Badenian (Langhian) – Lăpugiu des Sus (= Lapugy), Romania
NHMW: 2 spine fragments + 1 interambulacral plate (NHMW 2004z0001/0004b), 5 spine fragments (NHMW 1859.XLV.617B.b), 7 spine fragments (NHMW 2004z0001/0027b), 1 spine (NHMW 2004z0001/0028b)
Badenian (Langhian-Early Serravallian) – Nový Rybik (=Portzteich), near Sedlec, W Lednice, Czech Republic
NHMW: 1 ambulacral + 1 interambulacra plate (NHMW 1858.XLVII.78b)
Badenian (Langhian-Early Serravallian) – Rudoltické (= Rudelsdorf), Czech Republic
NHMW: 6 spine fragments [NHMW 1859.X.136 (**type material** of *Diadema desori* Reuss, 1860)]
Late Badenian (Early Serravallian) – Buituri (= Bujtur), Romania
NHMW: 1 spine fragment (NHMW 2004z0001/0005b), 20 spine fragments + 1 interambulacral plate (NHMW 1852.II.1603b)

Remarks: It is highly probable that several species/genera are present in the material considered here. The unified discussion under the heading "Diadematidae indet." does not imply that they are conspecific. The problems outlined below, however, precludes separation into homogenous units currently.

Description:
Ambulacral plates: Each plate bears one to two large perforate, crenulate marginal tubercles in the middle of the plate. Inner tubercles are usually absent. The plates are trigeminate and show diadematoid compounding.
Interambulacral plates: Most of the plates bear a single, large, perforate, strongly crenulate primary tubercle. Rarely two primary tubercles are developed. The remaining surface of the

plates is usually smooth and lacks morphological details. In some cases few, small secondary tubercles are developed at the margin.

Spines: The spines are very fragile and invariably preserved as fragments only. Spine diameter varies from 0.5 to 2 mm, the fragments are usually between 1 and 10 mm in length. In cross-section they show the typical diadematoid structure: wedge-shaped radial septa attached to a perforated tube with an empty central lumen (Pl. 8, Fig. 25). In some spines, however, the central lumen is crossed by trabeculae (Pl. 8, Fig. 24) [similar to the irregular stereom meshwork reprted from spines of extant diadematids (e.g. *Astropyga*)]. The surface ornamentation of the spines consists of spinous processes arranged in spirals, producing a verticillate pattern. The bases of the spines are distinctly separated from the shaft by a prominent, often oblique crenulate ring.

Discussion:

Spine fragments and coronal plates of the family Diadematidae can be easily identified by their typical verticillate ornamentation and characteristic cross-section (spines, Pl. 8, Figs. 21-25), their large, in most cases strongly crenulate, perforate tubercles on large plates lacking any other ornamentation (interambulacral plates, Pl. 8, Figs. 8, 11, 21) and diadematoid compounding (ambulacral plates, Pl. 8, Figs. 7, 10, 22).

A more refined identification of these disarticulated remains is difficult. Donovan et al. (2001: 3-4), however, claim that diadematoid spines can be identified to genus or even species level. Some authors (e.g. Kutscher, 1985) have even established new species based on disarticulated diadematoid ossicles. Comparison of spine morphology of extant genera (*Diadema*, *Centrostephanus* and *Echinothrix*; compare Fig. 12), however, showed that ornamentation in these three genera is very similar and individual variation along the spine and between spines is strong. Confident identification of disarticulated spines is therefore extremely difficult, if possible at all. In any case the disarticulated material would have to be very well preserved and features seen in cross-section would have to be considered too. Thus, specific and generic attribution might be possible in Pleistocene settings (where comparison can often be restricted to a smaller range of taxa living in that particular region today) but could not be realised for the Miocene of the Central Paratethys, where a large number of extant genera could potentially occur. Moreover, variation of external spine morphology observed in individual samples is large, suggesting either the presence of several diadematoid taxa, or more likely variation along the spines.

In the palaeontological literature several diadematoid species based on isolated spine fragments are recorded from the Paratethys and the Mediterranean [*Diadema desori* Reuss, 1860, *Centrostephanus airaghii* Lambert, 1907a, *C. calarensis* Cotteau, 1905 (The original paper of Cotteau could not be located. Moreover, Cotteau was already deceased in 1905. This taxon is obviously first mentioned by Lambert, 1907a), *C. rhodanicus* (Mayer-Eymar, 1910) (Correct authorship is Lambert, 1910a; the name *rhodanicus* Mayer is a collection name and thus not valid according to the ICZN), *C.* cf. *longispinus* (Philippi, 1845), *Centrostephanus* sp.]. Differential diagnoses of these taxa are, however, insufficient and it is impossible at present to confidently relate the Austrian material to any of these taxa.

Disarticulated diadematoid interambulacral plates were sometimes misidentified as cidaroids [e.g. by Mączyńska (1977: pl. 1, fig. 16) as *Cidaris* sp. and later (1987: pl. 1, fig. 2; 1993: pl. 6, fig. 1b) as *Plegiocidaris peroni*].

Occurrence:

Austria: Late Eggenburgian (Early Burdigalian), Ottnangian (Late Burdigalian), Early to Late Badenian (Langhian-Early Serravallian)

- Molasse Zone: Eggenburg, NÖ ([NHMW]); ? Gauderndorf, NÖ (Suess, 1866a); Grübern (Zogelsdorf Fm.), NÖ ([NHMW]); Höbmannsbach, ESE Schärding, OÖ ([NHMW]); Maissau (Zogelsdorf Fm.), NÖ ([NHMW]); Unternalb, near Retz, NÖ (Kroh & Harzhauser, 1999; [NHMW])
- Vienna Basin: ? Bad Vöslau, NÖ ([NHMW]); Baden, NÖ (Reuss, 1860); Bruck an der Leitha, NÖ ([NHMW]); Enzesfeld, NÖ ([NHMW]); Gainfarn, NÖ (Kroh, 2002b; [NHMW]); Grinzing, W (Reuss, 1860; [NHMW]); Müllendorf (Mühlendorfer Kreide AG quarry), Bgld ([NHMW]); Niederleis, NÖ (Kroh, 2003a; [NHMW]); Nussdorf, W ([NHMW]); Steinabrunn, NÖ (Reuss, 1860; [NHMW]); Stotzing (sandpit Mayer), Bgld ([NHMW])
- Gaaden Bay: roadcuts between Sittendorf-Sparbach-Weissenbach, NÖ (Toth, 1942)
- Eisenstadt-Sopron Basin: Eisenstadt, Bgld (Tollmann, 1955); Eisenstadt (Hartl Fm.), Bgld ([NHMW]); Großhöflein, Bgld (Tollmann, 1955); Mattersburg, Bgld ([NHMW]); Oslip, Bgld ([NHMW])
- Styrian Basin: Spielfeld, Styria ([NHMW])

Paratethys (non-Austrian occurrences): Ottnangian (Late Burdigalian) to Late Badenian (Early Serravallian)

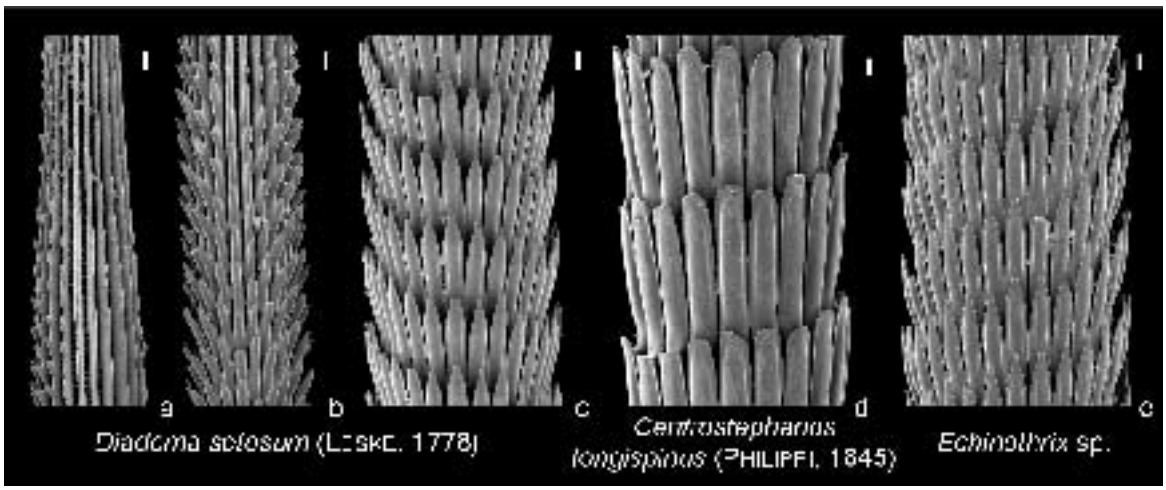

Figure 12: Spine ornamentation of extant Diadematidae [a-c: *Diadema setosum* (Leske, 1778), distal (a, b) and proximal part of the shaft (c); d: *Centrostephanus longispinus* (Philipi, 1845), proximal part; e: *Echinothrix* sp., proximal part]. Scale bars equal 100 µm.

Molasse Zone: Kralice nad Oslavou (= Kralitz), Czech Republic (Toula, 1893); Nový Rybik (= Portzteich), near Sedlec, W Lednice, Czech Republic ([NHMW]); Rudolticé (= Rudelsdorf), Czech Republic (Reuss, 1860; Procházka, 1900; [NHMW]); Židlochovice (= Groß-Seelowitz) (*Leda* beds), Moravia, Czech Republic (Rzehak, 1880)

Great Hungarian Basin (Pannonian Basin): Hont, Börzsöny, Hungary (Májer, 1915; Vadász, 1915); Kemence, Pest, Hungary (Májer, 1915; Vadász, 1915; [MAFI]); Királd, Borsod-Abaúj-Zemplén, Hungary (Kutassy, 1928)

Fore-Carpathian Basin: Kików, Central Poland (Mączyńska, 1993); Korytnica Clays, Korytnica, Poland (Mączyńska, 1977, 1987); Pińczów, Central Poland (Mączyńska, 1993); Rybnica, Southern Poland (Mączyńska, 1988); Skowronno, Central Poland (Mączyńska, 1993); Szczaworyż, Central Poland (Mączyńska, 1993); Wieliczka, Poland (Reuss, 1860); Żerniki, Central Poland (Mączyńska, 1993)

Transylvanian Basin: Berchezoaia, Maramureş, Romania (Gábos & Ghiurca, 1969); Buituri (= Bujtur), Hunedoara, Romania (Vadász, 1915; [NHMW]); Ciceu-Hăşmaş, Sălaj, Romania (Gábos & Ghiurca, 1969); Coştei de Sus (= Kostéj), Timiş, Romania (Gábos & Ghiurca, 1969; [NHMW]); Lăpugiu des Sus (= Lapugy), Hunedoara, Romania (Vadász, 1915; Gábos & Ghiurca, 1969; [NHMW]); Livezile-Aiud, Hunedoara, Romania (Gábos & Ghiurca, 1969); Valea Satului, Romania (Gábos & Ghiurca, 1969)

Cohort Echinacea Claus, 1876

Identification of small regular echinoids of the cohort Echinacea is notoriously difficult. Most outcrops surveyed during the present study yielded mainly poorly preserved, disarticulated material or surface details were obscured by syntaxial rim cement. Earlier workers used mainly size and the number of vertical rows of the interambulacra and ambulacra (e.g. Laube, 1871). The latter feature, however, is strongly size dependant, as the number of large, subequal tubercles increases during growth, as can be seen in growth series of e.g. extant *Sphaerechinus granularis* or *Tripneustes ventricosus*. Thus very small specimens were usually classified as *Arbacina*, those of medium size (~1.5 – 4 cm test diameter) as *Psammechinus* and larger ones as *Echinus*. Although, this method resulted in more or less reproducible determinations, it is highly artificial and does not result in natural groupings. Specific determinations of echinaceans in Laube (1871) are often very arbitrary and could not be reproduced in all instances, even in cases, where the original material could be located.

Owing to these difficulties a very different approach was followed during the present study. Scanning electron microscopic (SEM in the following) images of fossil material from Austria was compared with SEM images of (related) extant taxa (e.g. *Psammechinus microtuberculatus*, *P. miliaris*, *Sphaerechinus granularis*, *Paracentrotus lividus*, *Arbacia lixula*, *Echinometra mathaei*, *Tripneustes gratilla*, *T. ventricosus*, *Genocidaris maculata*, …) as well as fossil species from the Mediterranean region. Special emphasis was placed on the arrangement of the primary and secondary tubercles, the number and arrangement of the ambulacral pores and (if preserved) the nature of the apical disc.

Superorder Camarodonta Jackson, 1912
Order Temnopleuroida Mortensen, 19412
Family Temnopleuridae Agassiz, 1872
Genus *Arbacina* Pomel, 1869

Type-species: *Echinus monilis* Desmarest, 1816; by original designation (Pomel, 1869: XLI)
Diagnosis: Small hemispherical or subconical corona; no angular pits or pores; tubercles circular, imperforate; sutural depressions in the horizontal suture (see remarks); dense secondary tuberculation (modified from Mortensen, 1943a and Fell & Pawson, 1966)
Distribution: Early Miocene to Pliocene – circum-Mediterranean, Paratethys and western Africa
Remarks: One of the characteristic features of *Arbacina* according to Mortensen (1943a) are sutural depressions along the horizontal sutures of the interambulacra. The term "sutural depressions" is, however, somewhat misleading in this context. In fact these are not true depressions in the plate surface as in e.g. *Temnopleurus*. Instead these "sutural depressions" are areas along the horizontal sutures which are free of secondary tuberculation. Since the secondary tuberculation is very dense everywhere else, with the areoles of the tubercles often touching each other, these areas look like depressions, but in fact are not. This is especially evident in large specimens of *Arbacina* from the Pliocene of Rhodes Island, which has numerous subequal secondary tubercles.

Arbacina catenata (Desor in Agassiz & Desor, 1846)

(Pl. 11, Figs. 1-2)

*	1846	[*Echinus* (*Psammechinus*)] *catenatus* Desor. – Desor in Agassiz & Desor: 369, No. T 69
	1858	[*Psammechinus*] *catenatus* – Desor: 122
	1910a	*Arbacina catenata* Desor (*Psammechinus*), 1846. – Lambert: 27-28; pl. 1, figs. 52-58
	1910a	*Arbacina tenera* de Loriol, 1902 – Lambert: 28-29; pl. 1, figs. 59-62
#	1910a	*Arbacina Savini* Lambert. – Lambert: 30; pl. 1, figs. 71-73 [fide Philippe 1998]
? v	1915	*Arbacina tenera* Lor. – Vadász: 108-109
?	1930	*Arbacina tenera* Lor. – Vendl: 77
	1943a	*Arbacina catenata* (Desor) – Mortensen: 366; fig. 224a
?	1987	*Arbacina catenata* (Desor, 1847) – Mączyńska: 146, 148; pl. 2, figs. 3a-c
?	1993	*Arbacina catenata* (Desor, 1847) – Mączyńska: 108; pl. 2, fig. 1a-c
.	1998	*Arbacina catenata* (Desor, 1846) – Philippe: 55-58; pl. 7, figs. 1-8; pl. 8, figs. 1-2
v.	1999	*Arbacina* – Harzhauser & Kroh: 221
v.	1999	*Arbacina* sp. – Kroh & Harzhauser: 156-158; fig. 4; pl. 7, figs. 5-7
non	2003a	*Genocidaris catenata* (Desor, 1846) – Kroh: 161-162; figs. 2c-d; pl. 3, figs. 1-6 [misidentification]

Type-material:
Provenience and current whereabouts unknown. The only information available is found in Desor (1858: 122): "T. 69. (Original de l'espèce.) Tertiaire (Molasse?) du Midi. Très rare. Mus. d'Avignon.". Philippe (1998: 55), however, was not able to trace the type specimen in French collections. According to him it seems probable that the plaster cast T69 in the collection of Neuchâtel was made from a specimen coming from the Burdigalian of Avignon, France.

Material:
Late Eggenburgian (Early Burdigalian) – Gauderndorf (Himmelreich), NÖ, Austria
NHMW: 1 corona (NHMW 1869.III.41)
Late Eggenburgian (Early Burdigalian) – Limberg (Zogelsdorf Fm., Hengl quarry), near Maissau, NÖ, Austria
NHMW: 1 corona (NHMW 1998z0048/0048)
Late Eggenburgian (Early Burdigalian) – Roggendorf [Zogelsdorf Fm., Teufelslucke (cave)], NÖ, Austria
NHMW: 1 corona (NHMW 2004z0001/0018)
Late Eggenburgian (Early Burdigalian) – Unternalb (Retz Fm.), SE Retz, NÖ, Austria