

NHMW: 22 coronas and about one hundred test fragments (NHMW 1999z0051/0016 – 18)

Dimensions:

Largest whole specimen: diameter: 7.1 mm; height: 4.2 mm
estimate average diameter: 3.6 mm; estimate average height: 2.1 mm

Description:

Size and shape: The test is very small, hemispherical with circular outline. In profile the test is domed, with a tumid ambitus. The oral surface is flattened.

Apical system: The apical system is lacking in all specimens. The apical area is about one quarter of the test diameter wide.

Ambulacra: The ambulacra are about half to two third as wide as the interambulacra. The ambulacral plates are trigeminate and belong to the echinoid compound type. The pores are partitioned isopores (type P2 of SMITH, 1978), which are arranged in very slightly undulating vertical series. Each plate bears one large imperforate, noncrenulate (?) marginal tubercle with a distinct boss and a globular mamelon with undercut neck. The bases of the marginal tubercles are indented. Along the adapical and perradial border of each ambulacral plate, several imperforate, noncrenulate inner tubercles are found. Two to three of these situated at the edges of the plates are distinctly enlarged, the remaining ones are small.

Interambulacra: Each interambulacral plate bears one large imperforate, noncrenulate (?) primary tubercle with a distinct boss and a large globular mamelon with an undercut neck. The bases of the primary tubercles are indented. The primary tubercles lie approximately halfway along the adoral suture of each plate. Secondary tuberculation is very dense, leaving little or no space between the areoles of the secondary tubercles.

Peristome: Situated centrally on the ventral surface; circular in outline, with very shallow gill slits. The peristome is about half as wide as the test diameter in specimens of 3 to 6 mm TD.

Differential diagnosis:

According to PHILIPPE (1998: 58) *Arbacina piae* LOVISATO in COTTEAU, 1895 differs from *A. catenata* by its less globular shape, less homogenous secondary tuberculation and circular arrangement of secondary tubercles around the primary tubercles. Illustrations in COTTEAU (1895: pl. 3, figs. 1-6) are, however, rather poor and re-description/new illustration of *A. piae* are needed for comparison with *A. catenata*. Material from the Messinian Upper Coralline Limestone Formation of the Maltese Islands referred to *A. piae* by CHALLIS (1980) is a different species with differing tubercle arrangement.

A. mutellensis DE LORIO, 1896 differs by its more numerous and stronger projecting tubercles (PHILIPPE 1998).

A. jacquemeti LAMBERT, 1910a differs from *A. catenata* by its more numerous tubercles in ambital coronal plates and different tubercle arrangement (compare PHILIPPE, 1998: pl. 8, figs. 3-4).

Discussion:

The present material is highly similar to material attributed to *A. catenata* by PHILIPPE (1998). Only the weak crenulation of the marginal and primary tubercles seen in pl. 8, fig. 1b-c in PHILIPPE (1998) could not be observed in the Austrian material. This may, however, be related to the poor preservation of the Austrian specimens.

Sutural depressions along the horizontal sutures of the interambulacra, which MORTENSEN (1943a) regarded as critical feature of this genus, could not be observed. Nevertheless, the specimens are placed into the genus *Arbacina*. As PHILIPPE (1998: 57) showed recently, this feature is size-dependant and does not occur in smaller specimens. This could also be confirmed in Pliocene *Arbacina* specimens from Rhodes Island (Greece) in the collection of the NHMW, where the so called "sutural depressions" (see above under the remarks to the

genus *Arbacina*) are only developed in larger specimens (c. 10 mm test diameter). According to MORTENSEN (1943a) indentations in the margin of the primary and marginal spine bases are not present in *Arbacina*. Yet such indentations, albeit often faint, can be observed in the present specimens and in that of the Rhône Basin (compare PHILIPPE, 1998: pl. 8, figs. 1b-c, 2b-c). This suggests that this feature is not well suited as a sole distinction between these two genera.

In a recent revision of the echinoids of the Rhône Basin, PHILIPPE (1998) synonymised *Arbacina tenera* DE LORIO, 1902 and *A. savini* LAMBERT, 1910a with this species, *A. tenera* representing juvenile specimens and *A. savini* representing very large ones.

KROH (2003a: 161-162) referred this species to the genus *Genocidaris* based on disarticulated material from the Early Badenian of the northern Vienna Basin. This is, however, resulted from a misidentification of these specimens (see below under *Genocidaris* sp.). Additional material and comparison with supplementary fossil and extant material from various localities suggests that while the Niederleis material does belong to the genus *Genocidaris*, it is not conspecific with *A. catenata*.

Occurrence:

Although repeatedly reported in the literature no Badenian specimens of *A. catenata* could be located. It is thus unclear if this species is really present in the Badenian of the Paratethys or if these records are misidentifications (as e.g. the record of KROH, 2003a is).

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

Molasse Zone: Gauderndorf (Himmelreich), NÖ (NHMW); Limberg (Zogelsdorf Fm., Hengl quarry), near Maissau, NÖ (NHMW); Teufelslucke (Zogelsdorf Fm.), near Roggendorf, NÖ (NHMW); Unternalb (Retz Fm.), near Retz, NÖ (HARZHAUSER & KROH, 1999; KROH & HARZHAUSER, 1999)

Paratethys (non-Austrian occurrences): Eggenburgian (Early Burdigalian), ? Badenian (Langhian-Early Serravallian)

Eisenstadt-Sopron Basin: ? Fertőrákos, near Sopron, Győr-Monson-Sopron, Hungary (VENDL, 1930); Sopron-Rákos, Győr-Monson-Sopron, Hungary (VADÁSZ, 1915)

Great Hungarian Basin (Pannonian Basin): ? Budapest-Rákos, Pest, Hungary (VADÁSZ, 1915); ? Mátraverebély, Nógrád, Hungary (VADÁSZ, 1915); ? Sámsonháza, Nógrád, Hungary (VADÁSZ, 1915)

Fore-Carpathian Basin: ? Korytnica Clays, Korytnica, Poland (MACZYŃSKA, 1987); ? Pińczów, Central Poland (MACZYŃSKA, 1993)

Mediterranean: Burdigalian to Early Langhian

Western Mediterranean: **Vence, France:** Ste-Colombe and Gattières near Vence (LAMBERT, 1910a)

Rhône Basin: **Burdigalian:** Secteur des étangs (Fos-sur-Mer, Istres, Saint-Mitre-les-Remparts) (PHILIPPE, 1998), Littoral de Nerthe (Plan d'Arren) (LAMBERT, 1910a), Bassin de Mus-Sommières (Coustourelle, near Sommières) (PHILIPPE, 1998), Secteur de Montpellier (Juvignac) (PHILIPPE, 1998), Bassin d'Avignon (Les Angles, Avignon, Beaucaire, Vedène, Villeneuve-lès-Avignon) (LAMBERT, 1910a; PHILIPPE, 1998), Bassin d'Apt-Reillanne-Forcailquier (Bonnieux, Lacoste, Viens) (PHILIPPE, 1998), Bassin de Faucon-Mollans-Malaucaène (Vaison-la-Romaine) (PHILIPPE, 1998), Bassin de Valréas-Visan (Grignan, Montségur-sur-Lauzon, Nyons, Solérieux, Taulignan) (LAMBERT, 1910a; PHILIPPE, 1998), Dauphiné (Sainte-Marie-d'Alvey) (LAMBERT, 1910a; PHILIPPE, 1998), **Late Burdigalian (faciès "Marnes Bleues"):** Bassin de Faucon-Mollans-Malaucaène (Entrechaux) (PHILIPPE, 1998)

***Arbacina cf. macrophyma* LAMBERT, 1910**

(Pl. 11, Figs. 3-4; Pl. 12, Figs. 1-6)

- cf. 1910a *Arbacina macrophyma* LAMBERT. – LAMBERT: 31; pl. 2, figs. 2-5
? 1950 *Arbacina monilis* DESMANEST. – SZÖRÉNYI: 140; pl. 1, figs. 1, 1a-b

Material:

Late Badenian (Early Serravallian) – Müllendorf (Mühlendorfer Kreide AG quarry), Bgld, Austria
NHMW: 79 juvenile coronas (NHMW 2004z0006/0001-0003, 0005-0012, 0018-0020, 2004z0045/0004)
GBA: 82 coronas (GBA 2004/1/3)
Late Badenian (Early Serravallian) – Winden (old quarry, N of the Ludlloch (cave), N of the village), Bgld, Austria
NHMW: 1 corona (NHMW 2004z0001/0025b)

Dimensions:

Test diameter ranging from 4.2 to 8.3 mm, most common between 5.5 and 7.7 mm
Test height ranging from 2.1 to 3.9 mm, most common between 2.9 to 3.7 mm

Description:

Size and shape: The test rarely exceeds 7 mm in diameter and is hemispherical with circular outline. In profile the test is domed, with a tumid ambitus. The oral surface is slightly flattened.

Apical system: The apical system is dicyclic with the oculars widely exsert. The madreporite bears only few madreporic pores most of which are situated near the suture to ocular III and interambulacrum 2. The apical area is about one quarter of the test diameter wide. Each genital plate bears a single large tubercle, on the madreporite (genital plate 2) there may also be two. In one specimen (Pl. 11, Fig. 4a) the genital plates are ornamented by ridges.

Ambulacra: The ambulacra are about two third as wide as the interambulacra. The ambulacral plates are trigeminate and belong to the echinoid compound type. The pores are partitioned isopores (type P2 of SMITH, 1978), which are arranged in arcs of three. Each plate bears one large imperforate, noncrenulate marginal tubercle. The bases of the marginal tubercles are not indented. Secondary tuberculation moderately dense, consisting of rather large imperforate, noncrenulate inner tubercles.

Interambulacra: Each interambulacral plate bears one large imperforate, noncrenulate primary tubercle with a large globular mamelon with undercut neck. The bases of the primary tubercles are not indented. The primary tubercles lie approximately halfway along the adoral suture of each plate. Secondary tuberculation is moderately dense. Secondary tubercles along the adapical suture may be distinctly enlarged.

Peristome: The peristome is about half as wide as the test diameter, but ratio decreases as the animals grow. It has a circular outline. Gill slits are not discernible.

Discussion:

The studied specimens are tentatively assigned to *Arbacina macrophyma* LAMBERT, 1910a. Unfortunately, no re-description and new illustrations of this species exist. All subsequent authors simply refer to LAMBERT'S original description and illustrations. The present specimens from the Badenian of Müllendorf differ from *A. catenata* reported here from the Eggenburgian by its different tuberculation. In the Badenian species the primary tubercles are larger, show no indented bases and less dense secondary tuberculation (compare Pl. 11, Figs. 1d and 2 with Pl. 11, Fig. 3).

This species is easily confused with co-occurring juvenile *Schizechinus* sp. The latter may be recognised by its hemicyclic apical disc, less dense secondary tuberculation with large areas free of tubercles in the interambulacra. These areas are covered

by small granulae not present in *Arbacina* (compare Pl. 12, Fig. 7). Additionally the arrangement of the ambulacral pores in arcs of three is much more strongly developed in *Schizechinus* (compare Pl. 12, Fig. 7).

Occurrence:

Austria: Late Badenian (Early Serravallian)

Vienna Basin: Müllendorf (Mühlendorfer Kreide AG quarry), Bgld ([GBA]; [NHMW])

Danube Basin: Winden, Bgld ([NHMW])

Paratethys (non-Austrian occurrences): ? Badenian (Langhian-Early Serravallian)

Great Hungarian Basin (Pannonian Basin): ? Magyaregregy, Baranya, Hungary (SZÖRÉNYI, 1950)

Genus *Genocidaris* AGASSIZ, 1869

Type-species: *Genocidaris maculata* AGASSIZ, 1869; by original designation (AGASSIZ, 1869: 262).

Diagnosis: Small hemispherical corona; noncrenulate, imperforate primary tubercles with indented bases; radiating sculpture (ridges) around primary and marginal tubercles; apical disc dicyclic with widely exsert oculars; single plate covering periproct (modified from MORTENSEN, 1943a and FELL & PAWSON, 1966)

Distribution: Miocene to Recent – Caribbean Sea, North Atlantic Ocean, Mediterranean Sea, Central Paratethys

Ecology and biogeography: *G. maculata*, the only extant species of this genus, is found on sands with coralline algae and muddy sands with *Peyssonnelia* between 12 to 500 metres water depth in the Mediterranean (RIEDL, 1983). MORTENSEN (1943a: 263) found mainly bryozoan fragments in the intestines of this species.

***Genocidaris* sp.**

(Pl. 13, Figs. 1-12)

- v. 2001 *Brochopleurus* sp. – SCHMID et al.: 13 [misidentification]
v. 2003a *Genocidaris catenata* (DESOR, 1846) – KROH: 161-162; figs. 2c-d; pl. 3, figs. 1-6 [misidentification]

Material:

Early ? Badenian (Langhian) – Rauchstallbrunngraben (bryozoan marl), near Baden, NÖ, Austria

NHMW: 9 test fragments (NHMW 2004z0121/31-39)

Early Badenian (Langhian) – Niederleis, NÖ, Austria

NHMW: 6 test fragments (NHMW 2002z0087/0053, 2002z0089/0053, 2002z0090/0003-6)

Badenian (Langhian-Early Serravallian) – old sandpit between Großhöflein and Kleinhöflein, Bgld, Austria

NHMW: 2 test fragments (NHMW 2003z0081/0013-14)

Late Badenian (Early Serravallian) – St. Margarethen (Kummer quarry), Bgld, Austria

NHMW: 2 specimens (NHMW 1986/98, 1998/138/128)

Dimensions (in mm):

Inv. no.	test \varnothing	apic. area \varnothing	ps \varnothing
NHMW 1986/98	8.6	-	4.1
NHMW 1998/138/128	9.3	2.4	-

Description:

Size and shape: The test is very small, hemispherical with a circular outline. In profile, the test is domed, with a tumid ambitus.

Apical disc: Apical disc not preserved; diameter of apical area about 25 % of the test diameter.

Ambulacra: The ambulacra are about two-third to half the width of the interambulacra. The ambulacral plates are trigeminate with pores arranged in indistinct arcs of three and belong to the echinoid compound type. The pores are oblique P1 to P2 isopores (compare SMITH, 1978). Individual pore pairs are separated by granulated ridges. Each ambulacral plate bears one large, imperforate marginal tubercle, which lies slightly adorally of the centre of each plate. The bases of the marginal tubercles are distinctly indented (see Pl. 13, Fig. 1). Along the adapical and perradial border of each ambulacral plate, several imperforate, noncrenulate inner tubercles are seen, two to four of which are enlarged at the ambitus. The base of the marginal tubercles is connected to the bases of the inner tubercles by low ridges, producing a radiating pattern.

Interambulacra: Each interambulacral plate bears one large, imperforate primary tubercle. The bases of the primary tubercles are distinctly indented (see Pl. 13, Figs. 2, 5, 7). Similar to the ambulacra, the bases of the primary tubercles are connected to the bases of the secondary tubercles by low ridges, producing a radiating pattern. The secondary and miliary tuberculation is dense, consisting of small noncrenulate, imperforate tubercles.

Peristome: The peristome lies centrally on the oral side, is large, about 50 % of the test diameter, and circular. The gill slits are shallow and indistinct.

Discussion:

Apart from two whole specimens from the Kummer quarry in St. Margarethen only fragmented and/or disarticulated material is available. Despite this unfavourable preservation even individual plates are usually readily recognisable based on the radiating pattern produced by the low ridges connecting the primary/marginal tubercle with the secondary/inner tubercles. Based on this radiating pattern, the indented tubercles and the lack of sutural pits the material is placed into the genus *Genocidaris*. Species of the genus *Arbacina* may have a very similar tubercle arrangement but lack the distinct radiating pattern and the strong indentations in the bases of the primary respectively marginal tubercles (there may be faint indentations in *Arbacina*, contrary to the statement of MORTENSEN, 1943a). Two other extant genera show a similar ornamentation: *Lamprechinus* and *Trigonocidaris*. The latter, however, has crenulate tubercles (at least some). Judging from the illustrations in MORTENSEN (1943a) *Lamprechinus* has less secondary tubercles and longer ridges (no material of these two genera was available for SEM analysis).

In most specimens the primary and marginal tubercles are weakly crenulate. Some, however, are obviously noncrenulate (Pl. 13, Fig. 3b) and others show the crenulation very well (Pl. 13, Fig. 5b). A similar situation is present the Pliocene *Genocidaris maculata* from Northern Italy, which usually has noncrenulate tubercles, but commonly shows crenulation on some or all tubercles in some specimens (pers. comm. E. BORCHI, March 2004; see Fig. 13).

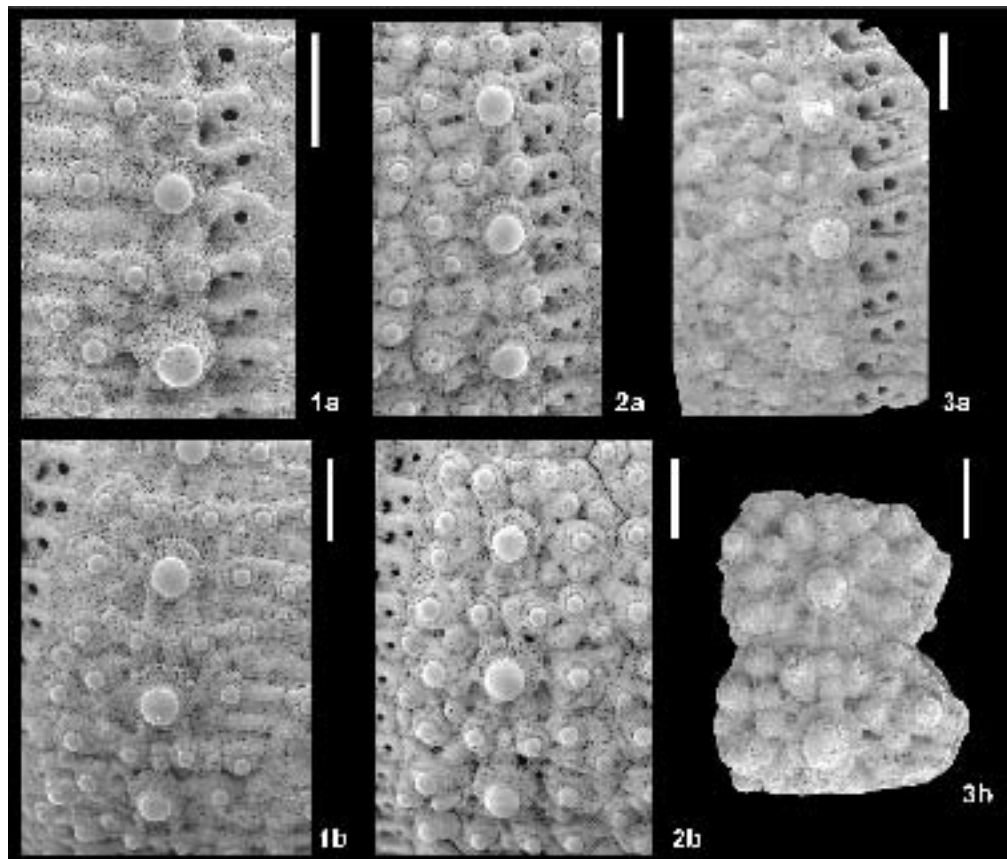


Figure 13: Comparison of the ornamentation in *Genocidaris maculata* (AGASSIZ, 1869) (1a-b; recent, off Florida Keys, Gulf of Mexico, USNM E12092), *Genocidaris maculata pliorecens* BORCHI, 1995 (2a-b; Pliocene of Castell'Arquato, Northern Italy; NHMW coll.), and *Genocidaris* sp. (3a-b; Badenian of Rauchstallbrunngraben, near Baden, NÖ; NHMW 2004z0121/0036 and ../0034). Figures "a" show the ambulacra, "b" the interambulacra; scale bars equal 0.5 mm.

KROH (2003a: 161-162) determined fragmented material of this species as *Arbacina catenata* (DESOR, 1846) and transferred that species the genus *Genocidaris*. This, however, was an error as subsequent investigations of new material from additional localities showed. While it was correct to place the specimens into the genus *Genocidaris*, they are not conspecific with the species of DESOR (1846).

Up to now this genus included a single extant species: *G. maculata* AGASSIZ, 1869, restricted to the Atlantic Ocean and the Mediterranean Sea. For fossil specimens from the Pliocene of Castell'Arquato, Italy the subspecies *G. maculata pliorecens* BORCHI, 1995 was established (BORCHI, 1995).

Occurrence:

Austria: Early to Late Badenian (Langhian-Early Serravallian)
Vienna Basin: Niederleis, NÖ (KROH, 2003a; [NHMW]);
Rauchstallbrunngraben, near Baden, NÖ ([NHMW])
Eisenstadt-Sopron Basin: between Großhöflein and
Kleinhöflein, near Eisenstadt, Bgld ([NHMW]); St. Margarethen
(Kummer quarry), Bgld (SCHMID et al., 2001; [NHMW])

Order Echinoida CLAUDIUS, 1876
Family Echinidae GRAY, 1825
Genus *Psammechinus* AGASSIZ & DESOR, 1846

Type-species: *Echinus miliaris* MÜLLER; by subsequent designation (LAMBERT & THIÉRY, 1910: 239)

Diagnosis: Ambitus is circular; ambulacral plates trigeminate with primary tubercles on each; buccal membrane densely plated, with contiguous or even imbricated plates; secondary spines numerous and smooth; apical disc dicyclic (FELL & PAWSON, 1966).

Distribution: Miocene to Recent – North Atlantic and Mediterranean

Ecology and biogeography: The two extant species of *Psammechinus* are restricted to the Mediterranean (*P. microtuberculatus*) and the eastern Atlantic Ocean (*P. miliaris*). They occur most commonly between 4 and 100 m water depth. *P. miliaris* may also inhabit intertidal settings and *P. microtuberculatus* is most common in the *Zostera* zone. Both feed on algae and small invertebrates (MORTENSEN, 1943b: 134-148).

Psammechinus dubius dubius (AGASSIZ, 1840)

(Pl. 14, Figs. 1-4)

- * 1840a *Echinus dubius* AG. – AGASSIZ: 84-85; pl. 22, figs. 4-6
1840b [*Echinometra*] *margaritifera* NIC. – AGASSIZ: 12 [fide LAMBERT & JEANNET, 1928: 147, 165-166]
1840b [*Echinus*] *dubius* AG. – AGASSIZ: 12
1875 *Psammechinus dubius*, AGASSIZ. – DE LORIO: 29-30; pl. 2, figs. 6, 6a-c, 7, 7a-b
- # 1912a *Psammechinus extraalpinus* SCHAFF. – SCHAFFER: 187; pl. 59, figs. 7-10
1913a *Psammechinus extraalpinus* SCHFF. –SCHAFFER: 10, 84-85, 154-155; pl. 10, figs. 7-8
- v pp 1915 *Psammechinus dubius* AG. – VADÁSZ: 110
1971a *Psammechinus* (?) *extraalpinus* SCHAFFER, 1912 – STEININGER: 593-594; pl. 1, figs. 3-4
1971b *Psammechinus* (?) *extraalpinus* SCHAFFER – STEININGER: 118
1998 *Psammechinus dubius* (AGASSIZ, 1840) – PHILIPPE: 65-67; pl. 8, figs. 5-8 [cum syn.]
2003b *Psammechinus dubius* (L. AGASSIZ, 1840) – KROH: 249

Type Material:

Echinus dubius AGASSIZ, 1840:

Syntypes: figured in AGASSIZ (1840a: pl. 22, figs. 4-6); current whereabouts unknown

Locus typicus: Chaux-de-Fonds, Switzerland

Stratum typicum: ? Upper marine Molasse (= Obere Meeresmolasse)

Age: Middle Burdigalian

Psammechinus extraalpinus SCHAFFER, 1912:

Syntypes: figured in SCHAFFER (1912a: 187; pl. 59, figs. 7-10);

Krahuletz Museum, Eggenburg, NÖ

Locus typicus: Reinprechtspölla, NÖ

Age: Late Eggenburgian (Early Burdigalian)

Material:

Late Eggenburgian (Early Burdigalian) – Reinprechtspölla, NÖ, Austria

NHMW: 16 specimens (NHMW 1997z0178/1832a-d, 1914.VII.55a-j, 2002z0181/0003)

IPUW: 3 specimens (no inventory no.)

KM: 4 specimens [KM22-24, 65 (syntypes of *Psammechinus extraalpinus* SCHAFFER, 1912a)]

Late Eggenburgian (Early Burdigalian) – Zogelsdorf (Zogelsdorf Fm., Johannisbruch), NÖ, Austria

NHMW: 1 specimen (NHMW 2002z0182/0001)

Foreign material for comparison:

Obere Meeresmolasse (Middle Burdigalian) – Hohburggraben, Belpberg, Switzerland

NMB: 16 specimens (NMBE 5011426-5011440, 5011442)

Obere Meeresmolasse (Middle Burdigalian) – between Seitenberg and Studweidholz, N Bütschelegg, Switzerland

NMB: 1 specimen (NMBE 5011444)

Obere Meeresmolasse (Middle Burdigalian) – Seitenberg, near Niedermuhlern, Switzerland

NMB: 1 specimen (NMBE 5011443)

Karpatian (Late Burdigalian) – Drégely, Nógrád, Hungary

MAFI: 2 specimens (MAFI Ech 447)

Dimensions:

Inv. No.	test ø	TH
NHMW 1997z0178/1832a	28.9	18.2
NHMW 1997z0178/1832b	22.5	13.5
NHMW 1997z0178/1832c	~21.0	13.8
NHMW 1997z0178/1832d	20.5	10.4
NHMW 1914.VII.55a	21.6	12.3
NHMW 1914.VII.55b	26.3	14.7
NHMW 1914.VII.55c	19.1	9.8
NHMW 1914.VII.55d	18.0	9.6
NHMW 1914.VII.55e	24.9	-
NHMW 1914.VII.55f	20.0	9.7
NHMW 1914.VII.55g	26.5	15.8
NHMW 1914.VII.55h	24.6	~13.6
NHMW 1914.VII.55i	18.3	-
NHMW 1914.VII.55j	26.6	~ 15

Description:

Size and shape: Test of small to medium size, the test diameter ranging from 18.0 to 28.9 mm in the investigated specimens. The outline of the corona is circular. The aboral surface is domed, the oral surface flattened and depressed around the peristome. The ambitus is tumid.

Apical disc: The apical disc is not preserved in any specimen. The apical area is small, occupying no more than 20 % of the test diameter.

Ambulacra: The ambulacra consist of trigeminate plates of the echinoid compound type. The pores are partitioned isopores of the P2 type and are arranged in arcs of three. Each plate bears one large noncrenulate, imperforate marginal tubercle and several smaller inner tubercles. The most perradial inner tu-

bercle is distinctly enlarged. The interporiferous zone of a single ambulacral column is about one and a half to two times as wide as the poriferous zone at the ambitus.

Interambulacra: The interambulacra are about one and a half times as wide as the ambulacra at the ambitus. Each plate bears one noncrenulate, imperforate primary tubercle, which lies slightly below the centre of the plate. The secondary tuberculation is dense. Two to four (at the ambitus) secondary tubercles are distinctly enlarged on each side of the primary tubercle. These enlarged secondary tubercles and the primary tubercle are arranged in a more or less horizontal row. Along the interradial suture of the interambulacra a narrow "naked zone" is present in some specimens.

Peristome: The peristome is large, about 40-45 % of the test diameter and has a circular outline. The gill slits are very shallow.

Periproct: not preserved.

Primary spines: The primary spines have a smooth base with a granulated ring. The acetabulum has a noncrenulate margin and the shaft is striated longitudinally.

Discussion:

The studied specimens clearly belong to *Psammechinus dubius dubius* (AGASSIZ, 1840a). All features correspond well to the original description (AGASSIZ, 1840a) and the re-description of PHILIPPE (1998). A throughout revision and complete synonymy of closely related taxa was recently published by PHILIPPE (1998) and the reader is referred to that paper.

The type material of *Psammechinus extraalpinus* SCHAFFER, 1912a is indistinguishable from the material referred to *P. dubius dubius* and is therefore placed into the synonymy of the latter.

FELL & PAWSON (1966: U433) stated that the placement of Miocene species referred to *Psammechinus* is not supported by evidence of buccal plates, a feature they regarded as critical for this genus. It is true that no buccal plates are preserved in any specimen known from a Miocene *Psammechinus* species. Nevertheless, placement of *P. dubius* and its subspecies into this genus is well supported by other features. Comparison with extant *P. microtuberculatus* and *P. miliaris* from the Mediterranean and the North Atlantic respectively, reveals high similarities in tuberculation patterns, ambulacral pores structure and arrangement, overall shape and type of apical disc [dicyclic with clearly exsert ocular plates; AGASSIZ (1840a) and pers. observ. on Swiss Material (specimen NMBE 5011427)].

VADÁSZ (1915) recorded this species from several localities in Hungary. Only the material from the Karpatian of Drégely, Nógrád (MAFI Ech 447), however, can be identified to species level. The remaining specimens [MAFI Ech 300 (Fót, Pest), MAFI Ech 453 (Piliny, Nógrád)] are indeterminable internal casts or strongly abraded coronas.

Although this (sub-)species was reported in several papers from Badenian deposits of the Central Paratethys (e.g. MAČZYŃSKA, 1979, 1987, 1988; KAZÁR, 2002) this could not be substantiated (see below under *Psammechinus dubius* ?). Most records from the Badenian of Austria and all specimens examined belong to the subspecies discussed below.

Occurrence:

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

Molasse Zone: Achberg, near Maria Dreieichen (Scutellensande), NÖ (STEININGER, 1971a, b); Fels am Wagram, NÖ {STEININGER, 1971a [record questionable; in an earlier, extensive monograph on this locality (STEININGER, 1963), this species is not mentioned]}; Maissau, NÖ (SCHAFFER, 1912a); Reinprechtspölla, NÖ (SCHAFFER, 1912a, 1913a; STEININGER, 1971a); Zogelsdorf (Johannisbruch), NÖ ([NHMW])

Paratethys (non-Austrian occurrences): "Obere Meeres-molasse" (Middle Burdigalian) to Karpatian (Late Burdigalian)

Swiss Molasse: Belpberg, Switzerland ([NMB]); Chaux-de-Fonds, Switzerland (AGASSIZ, 1840a, b; DE LORIOI, 1875); between Seitenberg and Studweidholz, N Bütschegg, Switzerland ([NMB]); Sidenberg, near Niedermuhlern, Switzerland ([NMB]); Ste-Croix, Vaud, Switzerland (DE LORIOI, 1875); Verrières, Neuchâtel, Switzerland (DE LORIOI, 1875)

Great Hungarian Basin (Pannonian Basin): Drégely, Nógrád, Hungary (VADÁSZ, 1915; MIHÁLY, 1985; KRÖH, 2003b [MAFI])

Mediterranean: Aquitanian to Serravallian

Rhône Basin: numerous localities (see PHILIPPE, 1998: 65)

Psammechinus cf. *dubius gauthieri* COTTEAU, 1885

(Figs. 14-15; Pl. 15, Figs. 1-3)

- v pp 1869a *Psammechinus mirabilis* NICOLET sp. – LAUBE: 182
v 1869a *Psammechinus monilis* DESMAR. sp. – LAUBE: 182
v pp 1870 *Psammechinus mirabilis* NIC. – LAUBE: 314
v 1870 *Psammechinus monilis* DERM. – LAUBE: 314
v pp 1871 *Psammechinus mirabilis* NICOLET sp. – LAUBE: 59
v pp 1871 *Psammechinus monilis* DESMAREST sp. – LAUBE: 59
? 1958a *Psammechinus dubius* AG. – SIEBER: 152

Material:

Badenian (Langhian-Early Serravallian) – Steinebrunn (formerly Steinabrunn), NÖ, Austria

NHWM: 1 corona (NHMW 1846.37.954a), 2 coronas [NHMW 9023; These specimens are most probably the reference specimens of LAUBE (1869a, 1870, 1871)], 3 coronas on a slab (NHMW 2004z0001/0029a-c), 1 corona with partially preserved apical disc (NHMW 2004z0001/0030)

Foreign material for comparison:

Badenian (Langhian-Early Serravallian) – Úvaly (= Garschen-thal or Garschönthal), near Valtice (= Feldsberg), Czech Republic

NHMW: 9 coronas (NHMW 1859.XLV.630), 6 coronas + 1 fragment (NHMW 1859.XLV.633, 633a), 1 corona with preserved apical disc (NHMW 1872.V.42a), 1 corona (NHMW 1872.V.42b), 3 partially fragmented coronas (NHMW 1875.XXV.44), 4 coronas (NHMW 1904.VIII.93)

Dimensions (in mm):

Inv. No.	test ø	TH	ps ø	pc ø
NHMW 9023a	18.5	13.3	7.9	-
NHMW 9023b	16.7	11.8	6.9	2.0
NHMW 1859.XLV.633a	13.0	7.5	5.5	-
NHMW 1859.XLV.633b	15.5	9.9	6.3	-
NHMW 1859.XLV.633c	15.6	9.3	-	-
NHMW 1859.XLV.633d	16.6	10.3	7.2	-
NHMW 1859.XLV.633e	17.1	9.9	7.3	-
NHMW 1859.XLV.633f	18.3	11.1	-	-

Description:

Size and shape: Test small, with circular outline rarely exceeding 20 mm test diameter. In profile the test is high, with a tumid ambitus.

Apical disc: Apical disc dicyclic with oculars widely exsert (Fig. 14). Both genital and ocular plates densely tuberculated. Genital plate 2, the madreporite, strongly inflated and covered by numerous moderately large madreporic pores. All 5 gonopores opened. In a single specimen (NHMW 9023b, Fig. 14.B) a

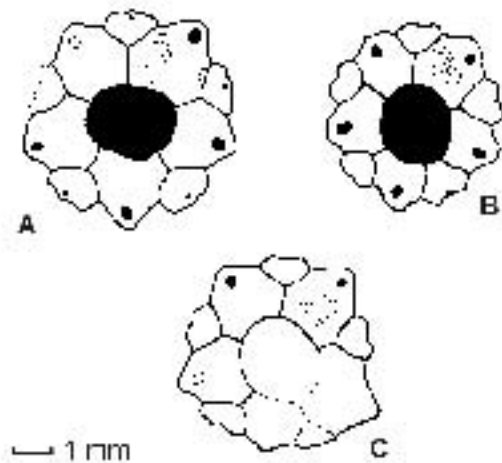


Figure 14: *Psammechinus* cf. *dubius gauthieri* COTTEAU, 1885: apical disc [A: NHMW 1872.V.42 from Úvaly (= Garschenthal), Czech Republic; B: NHMW 8023b and C: NHMW 2004z0001/0030 from Steinebrunn, NÖ].

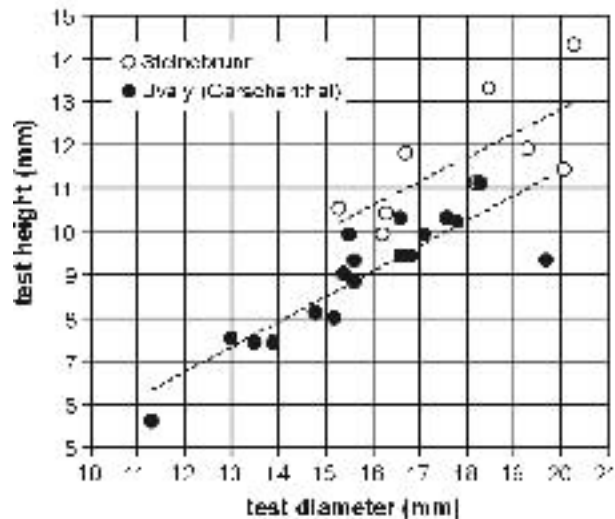


Figure 15: *Psammechinus* cf. *dubius gauthieri* COTTEAU, 1885: variation of test height (plotted against test diameter) in material from Steinabrunn (NÖ, Austria) and Úvaly (Czech Republic).

hemicyclic apical disc with ocular I insert and ocular II exsert was observed. As all other features are identical with the remaining material this specimen is considered as freak.

Ambulacra: The ambulacra consist of trigeminate plates of the echinoid compound type. The pores are partitioned isopores of the P2 type and are arranged in arcs of three. Each plate bears one large noncrenulate, imperforate marginal tubercle and several smaller inner tubercles. In ambital plates the most peripherally situated of the inner tubercles is distinctly enlarged. The ambulacra are up to two third as wide as the interambulacra at the ambitus.

Interambulacra: Each interambulacral plate bears one moderately large noncrenulate, imperforate primary tubercle, which lies halfway along the adoral margin of the plate. The secondary tuberculation is dense. Ambitally there are 1-2 distinctly enlarged secondary tubercles on each side of the primary tubercle. Together with the latter they form a more or less horizontal row on each plate.

Peristome: The peristome is large, about 43 % of the test diameter and has a subcircular outline. Gill slits are present, but developed as faint notches.

Periproct: The periproct is small, about 12 % of TD in diameter and lies centrally within the apical disc. It is very slightly oval, elongated along the I-3 axis.

Discussion:

The specimens come from a biotretic packstone to grainstone consisting mainly of fragmented corallinaceans, bryozoans and echinoderm debris. Most outcrops are situated at the Austria-Czech border on a small hill called Veitsberg, which lies approximately halfway between Steinebrunn and the former Garschenthal (today called Úvaly). In Steinebrunn a second outcrop was situated, which yielded a high-diversity mollusc fauna and (among else) disarticulated echinoderm material from a pelitic sand facies. This locality is sometimes referred to as "Steinabrunn-Milchhaus" and is not to be confused with the limestone-facies locality discussed here.

Apart from the hemicyclic apical disc in a single specimen all features are typical for the genus *Psammechinus*. Especially tuberculation pattern and ambulacral pore structure and arrangement are very similar to *P. microtuberculatus* or *P. dubius dubius*. *Arbacina* specimens of comparable test diameter have

a much smaller peristome with only c. 33 % TD in diameter. *Schizechinus* specimens of similar size have distinct, already well developed gill slits and differ strongly in tuberculation patterns.

The specimens differ only slightly from typical *P. dubius dubius*. The major differences are their more numerous (in specimens of comparable size) and more tightly arranged secondary tubercles. Moreover, some of the specimens are rather high (with test height ranging up to c. 70 %), compared to *P. dubius dubius* (height ranging from 48.5.6 to 63.0 % diameter, with a mean of 55.5 %). Similar specimens occur in the Burdigalian and Langhian of the Rhône Basin. There they are attributed to *Psammechinus gauthieri* COTTEAU, 1885 (COTTEAU, 1885: 65-66; pl. 8, figs. 15-17; no. 45), which is currently considered as subspecies of *P. dubius* (PHILIPPE, 1998: 72-73; pl. 9, figs. 7-9) (The arrangement of the ambulacral pore in COTTEAU's figure is incorrectly illustrated. In echinoid-type compound plates it is always the middle pore pair on each plate the lies most adradially, not the lowermost).

Similarly strong variation in test height as observed in this species was documented for several extant echinaceans in the Mediterranean (ERNST, 1973a). Especially apparent is that different populations from (slightly) different environments show strong differences in coronal height. This is paralleled by the "populations" from the two outcrops Steinebrunn and Úvaly (= Garschenthal) (Fig. 15) which are located very close to each other (several 100 meters). ERNST (1973a) related such differences in coronal height to differences in wave exposure and food availability.

Occurrence:

Austria: Badenian (Langhian-Early Serravallian)

Vienna Basin: Nussdorf, W (LAUBE, 1869a, 1871); Steinebrunn (formerly Steinabrunn), NÖ (LAUBE, 1869a, 1871; SIEBER, 1958a; [NHMW])

Paratethys (non-Austrian occurrences): Badenian (Langhian-Early Serravallian)

Vienna Basin: Úvaly (= Garschenthal or Garschönthal), near Valtice (= Feldsberg), Czech Republic (LAUBE, 1869a, 1871; [NHMW])

Psammechinus dubius ? (AGASSIZ, 1840)

- ? 1882 *Psammechinus monilis* DESM. – HILBER: 236
? v pp 1915 *Psammechinus dubius* AG. – VADÁSZ: 110
[indeterminable echinaceans]
1938 *Psammechinus extraalpinus* SCHAEFFER 1912 –
POLJAK: 174-175; pl. 2, figs. 2, 2a
? 1953 *Psammechinus dubius* (AGASSIZ), 1840. –
SZÖRÉNYI: 11, 58
? 1969 *Psammechinus dubius* (AGASSIZ) – GÁBOS &
GHIURCA: 88; pl. 2, fig. 2 [illustration &
description not sufficient for revision]
1970 schizechinid (?) echinoids – RADWAŃSKI: 382
1973 *Psammechinus* sp. – RADWAŃSKI: pl. 7
? 1979 *Psammechinus dubius* (AGASSIZ, 1846) –
MAĆZYŃSKA: 31, pl. 1, figs. 1-2 [very small
coronas, poorly preserved, probably better
referred to as Echinacea indet.]
? 1981 *Psammechinus dubius* AG. – HALMAI: 106
? 1984 *Psammechinus dubius* (AG.) – KÓKAY et al.: 290
? 1985 *Psammechinus dubius* (AGASSIZ, 1846) – MIHÁLY:
238; pl. 1, figs. 3-5 [indeterminable juvenile
Echinacean]
? 1987 *Psammechinus dubius* (L. AGASSIZ, 1840) –
MAĆZYŃSKA: 146, 148; pl. 2, figs. 6-7; pl. 3, figs.
1-7 [juvenile echinaceans, precise determination
difficult]
1988 *Psammechinus dubius* (AGASSIZ, 1840) –
MAĆZYŃSKA: 61; pl. 1, figs. 7-9; pl. 3, fig. 11;
pl. 5, fig. 4; pl. 6, fig. 1
? 1988 *Psammechinus dubius laqueatus* LAMBERT –
MAĆZYŃSKA: pl. 3, figs. 1-7 [juvenile echinaceans,
precise determination difficult]
? 1993 *Psammechinus dubius* (L. AGASSIZ, 1840) –
MAĆZYŃSKA: 108-109; pl. 2, figs. 4-5 [small
juveniles, identification doubtful]
1996 *Psammechinus dubius* – MACHALSKI: 26;
unnumbered fig. on p. 25 (small specimens)
? 2002 *Psammechinus dubius* – KAZÁR: 153; fig. 1
2004 *Psammechinus dubius* (L. AGASSIZ, 1840) –
RADWAŃSKI & WYSOCKA: 384, 385-386; pl. 2,
figs. 3, 3a; pl. 3, figs. 1-2; pl. 4-5; pl. 6, figs. 2b
(small specimens)

Discussion:

Most of the records of *Psammechinus dubius* from the Badenian of the Central Paratethys are based on either poorly preserved or juvenile specimens (often both). These specimens would probably be better referred to as Echinacea indet. More convincing specimens of this species have been reported from the Early Badenian of the Carpathian Foredeep (MAĆZYŃSKA, 1988; MACHALSKI, 1996; RADWAŃSKI & WYSOCKA, 2004). They come from a mass occurrences at Świniary in Southern Poland, which have been interpreted as tempestites (RADWAŃSKI & WYSOCKA, 2004). As most specimens from these mass-occurrences retain at least parts of their spine cover or are obscured by syntaxial rim cement or adhering sediment their determination is difficult. Only a single illustration of their tuberculation pattern is available in the literature (MAĆZYŃSKA, 1988: pl. 5, fig. 4). Unfortunately this is from the adapical region of the corona and therefore poorly suited for interspecific comparison. Convincing evidence for the attribution to *Psammechinus dubius* has yet to be published. Based on the available information the attribution can only be regarded as tentative at best.

Occurrence:

Austria: ? Early Badenian (Langhian)

Vienna Basin: ? Stotzing (sandpit Mayer), Bgld, Austria (KAZÁR, 2002)

Paratethys (non-Austrian occurrences): Karpatian (Late Burdigalian) Eggenburgian (Early Burdigalian) to Early Badenian (Langhian)

Great Hungarian Basin (Pannonian Basin): ? Budafolk, Hungary (VADÁSZ, 1915); ? Budapest, Hungary (KÓKAY et al., 1984; MIHÁLY, 1985); ? Fót, Hungary (VADÁSZ, 1915; HALMAI, 1981); ? Piliny, Hungary (VADÁSZ, 1915)

Fore-Carpathian Basin: Huta Różaniecka, southeastern Poland (MAĆZYŃSKA, 1979); ? Korytnica Clays, Korytnica, Poland (MAĆZYŃSKA, 1987); ? Mikołajów, S of Lwów, western Ukraine (HILBER, 1882; SZÖRÉNYI, 1953); Nawodzice, Southern Poland (MAĆZYŃSKA, 1988); ? Rybnice, southern Poland (MAĆZYŃSKA, 1988); ? Pińczów, Central Poland (MAĆZYŃSKA, 1993); Świniary, southern Poland (MAĆZYŃSKA, 1988)

Transylvanian Basin: Berchezoaia, Bucium, Ciolt, and Valea Satului, Romania (GÁBOS & GHIURCA, 1969)

Zala, Sáva and Dráva Basins: Jelav Potok, near Lončice, Croatia (POLJAK, 1938)

Psammechinus sp.

(Fig. 16; Pl. 15, Figs. 4-7)

- ? 1882 *Psammechinus* sp. – HILBER: 236
? 1893 *Psammechinus* sp. – TOULA: 289
? 1958b *Psammechinus* – SIEBER: 297
? 1961 *Psammechinus* – SCHAEFFER: 149
? 1987 *Psammechinus* sp. – MAĆZYŃSKA: 146; pl. 2, figs. 5a-c
v. 2002b *Psammechinus* sp. – KROH: 12

Material:

Ottngangian (Late Burdigalian) – Allerding, OÖ

NHMW: 3 test fragments (NHMW 2004z0005/0002)

DANNINGER coll.: 2 specimens (no reference no.; a cast of the figured specimen is stored at the NHMW under 2004z0005/0001), 3 test fragments (NHMW 2004z0005/0002)

Early Badenian (Langhian) – Gainfarn, NÖ, Austria

NHMW: 3 test fragments (NHMW 2004z0076/0001-3)

Badenian (Langhian-Early Serravallian) – Oslip, Bgld, Austria

Fürnkranz coll.: 1 corona (no inventory no.)

Dimensions (in mm):

Inv. No.	test ø	TH
DANNINGER coll. spec. 1	11.8	~ 5
DANNINGER coll. spec. 2	20.8	-

Description:

Size and shape: Test small, with circular outline. The aboral surface is arched; ambitus tumid.

Apical disc: not preserved

Ambulacra: The ambulacra consist of trigeminate plates of the echinoid compound type. The pores are partitioned isopores of the P2 type and are arranged in arcs of three. Each plate bears one large noncrenulate, imperforate marginal tubercle and few smaller inner tubercles. The ambulacra are about two third as wide as the interambulacra at the ambitus.

Interambulacra: Each interambulacral plate bears one moderately large noncrenulate, imperforate primary tubercle, which lies halfway along the adoral margin of the plate. The secondary tuberculation is dense, several secondary tubercles are distinctly enlarge, especially those adradially of the primary tubercle. No "naked zone" along the interradial suture.

Peristome: The peristome is large, about 45 % of the test diameter and has a circular outline. Shallow gill slits are present.

Discussion:

The investigated material, 2 subadult specimens and some disarticulated coronal plates from the Ottngangian, can be at-