

Type-material:*Hemiaster cotteaii* WRIGHT, 1855:

Holotype: BMNH E1584 (figured by WRIGHT, 1855: pl. 7, fig. 2a-d); British Museum of Natural History, London

Locus typicus: Malta

Stratum typicum: *Globigerina* Limestone

Age: Aquitanian-Langhian, Early to Middle Miocene

Remarks: According to ROSE (1974b, 1975) and CHALLIS (1980) the occurrence is restricted to the Lower *Globigerina* Limestone.

Opissaster lovisatoi COTTEAU, 1895:

Syntypes: private collection of LOVISATO and collection of COTTEAU (not seen)

Type-area: Sardinia, Italy [two localities are mentioned by COTTEAU (1895): Mont San Michele, near Cagliari and Cadreas, Bonorva]

? *Opissaster mariae* COTTEAU, 1895:

Holotype: the specimen figured by COTTEAU (1895: pl. 5, figs. 4-5); private collection of LOVISATO (not seen)

Locus typicus: Cagliari, Sardinia

Stratum typicum: "Calcaire compact (tramezzario)"

Age: Early or Middle Miocene

? *Pericosmus affinis* LAUBE, 1869:

Holotype: a single specimen [figured by LAUBE (1871: pl. 17, fig. 2)] from the collection of the "k. k. geol. Reichsanstalt" (Geological Survey of Austria); specimen lost

Locus typicus: Sievering, Vienna

Stratum typicum: Leitha limestone

Age: Badenian (Langhian-Early Serravallian)

Remarks: The holotype of this species could not be located in the collections of the Geological Survey of Austria. According to Franz STOJASPAL (former head of the palaeontological collection, pers. comm. 2003) part of the collection was destroyed during the Second World War, among it also part of the type-collection. The holotype of *P. affinis* is thus considered lost.

Material:

Early Badenian (Langhian) – Stotzing (sandpit Mayer), Bgld, Austria

NHMW: 1 specimen (NHMW 2004z0093/0018)

WANZENBÖCK coll.: 2 specimens (W20, W21)

Late Badenian (Early Serravallian) – Müllendorf (Mühlendorfer Kreide AG quarry), Bgld, Austria

NEITZ coll.: 1 specimen (no inv. no.)

Foreign material for comparison:

Late Badenian (Early Serravallian) – Gârbova de Sus (= Felsö-Orbó), Romania

MAFI: 1 specimen [MAFI Ech 245 (figured as *T. cotteaii* by VADÁSZ, 1915)]

Dimensions (in mm):

Inv. No.	TL	TW	TH
W20	56.1	62.2	40.4
W21	67.5	66.5	-

Description:

Size and shape: Test large, subcircular to slightly heart shaped. Anterior margin rounded with very shallow frontal sinus. Posterior margin rounded to slightly bluntly pointed. The maximum width lies slightly posterior of the centre, coinciding with the apical disc. In profile the test is high, arched to slightly wedge shaped with tumid ambitus and obliquely truncated posterior end. The maximum height lies slightly posterior of the centre, around the apical disc.

Apical disc: The apical disc is situated slightly posterior of the centre. It is ethmolytic with four large genital pores. The ocular

pores are small and have a circular outline. The anterior gonopores are slightly smaller than the posterior ones (Fig. 69.B).

Ambulacra: Ambulacrum III deeply sunken with undercut walls adapically. On the aboral surface it is straight and closes slightly outside the peripetalous fasciole. Towards the ambitus it becomes distinctly shallower, forming only a very shallow frontal sinus. The pores are oblique partitioned anisopores with laterally positioned neural canal (compare SMITH, 1980c) and are arranged in two straight rows. The interporiferous zone is broad with dense secondary tuberculation. Outside the peripetalous fasciole the pores are minute constricted unipores (compare SMITH, 1980c). Adorally ambulacrum III forms a slightly depressed phyllode consisting of three unipores with extensive periporal area.

The paired ambulacra are petaloid and deeply sunken. The anterior pair forms an angle of around 105°, the posterior pair an angle of about 60 to 70°. The distal ends of the anterior paired petals flex slightly laterally. The posterior petals are about half as long as the anterior pair. The pores are conjugated anisopores and separated from each other by low ridges. The interporiferous zone is narrow and smaller than the single poriferous zone. The pores are smaller and more rounded at the distal ends of the petals.

Adorally, ambulacra II and IV form distinct, large phyllodes, which lack primary and bear few secondary tubercles. Each bears up to nine constricted unipores with extensive periporal areas. The pores are slit-like, broadest at their adoral end, where a shallow but distinct neural canal is found. Ambulacra I and V form sparsely tuberculated peri-plastronal areas on the oral surface. Adorally they form small, slightly depressed phyllodes similar to those of ambulacra II and IV.

Interambulacra: On the aboral surface, the interambulacra are highly inflated around the apical disc and along the petals. They all form high, arched keels, except in interambulacrum 5. The tuberculation is dense and homogeneous. Small perforate, crenulate primary tubercles with inclined areoles forming a confluent pattern are present. Secondary tubercles are sparse. The primary tubercle slowly become larger towards the petals and the margin of the test. The largest tubercles are found at the border of ambulacrum III.

The primary tubercles are larger and more widely spaced on the oral surface, with simple secondary tubercles spread among them. The primary tubercles have a rounded perforate mameleon with undercut neck, distinct crenulate platforms and flat to slightly concave, inclined areoles. The largest tubercles are found on the anterior half of the margin of the oral side and near the peristome.

The plastron is mesamphisternous, broad, with a rounded anterior end. Its tuberculation is denser than on the remaining oral surface. Only primary tubercles, forming a fan-shaped pattern, radiating from the posterior end are present; they increase in size from the posterior to the anterior end.

Peristome: A large peristome is situated near the anterior margin of the oral side (about 20 % of TL from anterior margin). It is kidney-shaped and has a large protuberant rounded labrum with a distinct rim.

Periproct: The periproct is large, marginally situated and overhung by a small rostrum. It is oval in shape and vertically elongated.

Fascioles: The peripetalous fasciole band is very broad, especially at the distal ends of the petals and in ambulacrum III. The fasciole is deeply indented between the anterior and posterior paired petals; somewhat lesser between the anterior paired petals and the frontal petal and only slightly between the posterior petals (Fig. 69.A). No lateral or subanal fascioles are present.

Differential diagnosis:

Aliaster ? almerai LAMBERT, 1906 from the Miocene of Vence in France can be distinguished from the species considered here by its spherical form (length, width and height are all sub-

equal); proportionally higher interambulacral plates on the ambitus, a shallower ambulacrum III, which is relatively wide at the ambitus; a very shallow frontal sinus; a more acute angle between the anterior paired petals; shorter posterior paired petals and the presence of only two gonopores in the apical disc (compare LAMBERT, 1906a, 1906b, 1909). Sardinian material attributed to *Aliaster almerai* (LAMBERT, 1909) (under the genus name *Opissaster*) belongs to *A. lovisatoi* (COTTEAU, 1895) according to LAMBERT (1915a: 158-159; under the name *Trachyaster*), a species considered synonymous to *A. cotteauui* (WRIGHT, 1855) here. LAMBERT caused also considerable confusion by figuring Sardinian material of *A. cotteauui* under the name "*Opissaster almerai*" in his monograph on the echinoids of the Province Barcelona, Spain (LAMBERT, 1906a). The specimens figured on pl. 9, fig. 4-6 in that work (LAMBERT, 1906a), originate from Sardinia and belong to *A. cotteauui*, whereas the specimen figured on pl. 7, fig. 5 in LAMBERT (1906a) originates from Spain and is conspecific with *A. ? almerai* (see LAMBERT, 1915a: 157-159).

Aliaster insignis (POMEL, 1887), and its junior synonym *A. jourdyi* (PÉRON & GAUTHIER in COTTEAU et al., 1891) (according to LACHKHEM & ROMAN, 1995: 11) from the Messinian of Algeria and Morocco are very similar to *A. cotteauui*, and indeed LAMBERT (1909: 80) synonymised *A. jourdyi* with *A. cotteauui*. LACHKHEM & ROMAN (1995), however, list that species as *A. insignis*. The information available to the present author is insufficient to decide if both *A. jourdyi* and *A. insignis*, one of them or non are synonymous to *A. cotteauui*. Fact is that they differ by their slightly smaller petaloid area, lower test height and narrower frontal petal.

Another species attributed to the genus *Aliaster* by VALDINUCCI (1974a) is *Opissaster cotteri* DE LORIO, 1896, which is known only from a single poorly preserved specimen. Based on DE LORIO's description this species seems to differ by its longer, laterally flexed posterior petals and more strongly indented peripetalous fasciole from *A. cotteauui*.

Aliaster aichinoi (CHECCHIA-RISPOLI, 1927) from the Middle Miocene of Cyrenaica, Libya differs by its strongly flexed anterior petals, more elongated test, and less diverging paired petals.

Another species somewhat similar to *A. cotteauui* considered here is *Gregoryaster coranguinum* (GREGORY, 1891), which co-occurs with *A. cotteauui* in Malta. *G. coranguinum* differs by its highly arched profile, long paired petals, which are subequal in length; two distinct protuberances on the posterior end of the plastron; an ethmophract apical disc which is situated centrally or slightly anterior of the centre and the not indented anterior part of the peripetalous fasciole (compare GREGORY, 1891 and CHALLIS, 1980).

Discussion:

The Austrian material is clearly conspecific with material from the Lower to Middle Miocene *Globigerina* Limestone of Malta described as *Hemiaster cotteauui* WRIGHT, 1855. The generic placement of this species has been subject to some discussion. First it was transferred to the genus *Opissaster* by LAMBERT (1909: 80), later to the genus *Trachyaster* by CHALLIS (1980: 190). Recently it was transferred back to *Opissaster* by NÉRAUDEAU (1994: 329, tab. 4). KROH & NEBELSICK (2003) placed it tentatively into the genus *Trachyaster*. This is supported by the presence of relatively short petals, only a peripetalous fasciole, the shallow frontal sinus, the posteriorly eccentric, ethmolytic apical disc and the short posterior paired petals, which are about half as long as the anterior paired petals. Other features, however, contradict this generic placement (e.g. the peripetalous fasciole is hardly indented between the paired petals in the type species of *Trachyaster*, *T. globosus* POMEL, 1869, whereas it is deeply embayed in *H. cotteauui*). The genus *Opissaster* can be ruled out because it is characterised among others by an ovoid outline and a deep frontal sinus (FISCHER, 1966). Moreover, most authors (e.g. LAMBERT, 1915a; LAMBERT &

THIÉRY, 1924) included only forms with 2 to 3 gonopores. These features cannot be found in the species considered here. Since neither the placement in *Trachyaster* nor in *Opissaster* seemed to be feasible and other genera were not available, VALDINUCCI (1974a) established the genus *Aliaster* for the species which seem to fall "in between" *Opissaster* and *Trachyaster*. Although, SMITH ("The Echinoid Directory", state 25.05.2003) regards *Aliaster* as junior synonym of *Opissaster*, the present author does not share this opinion based on the very different shape and other features discussed above (under the remarks to the genus).

COTTEAU (1913a) placed *A. jourdyi* (PÉRON & GAUTHIER) and *A. mariae* (LOVISATO) in the synonymy of *A. cotteauui* (referred to as *Opissaster cotteauui* in COTTEAU, 1913a).

CHALLIS (1980: 193) opinion that *Hemiaster vadosus* GREGORY, 1891 from the *Globigerina* Limestone of Malta represents juveniles of *A. cotteauui* cannot be accepted here. *H. vadosus* has an ethmophract apical disc and a distinctly different test shape (GREGORY, 1891 and pers. obs.), whereas *A. cotteauui* has an ethmolytic apical disc.

Pericosmus affinis LAUBE, 1869 a species based on a single specimen from Sievering (now lost) is possibly a junior synonym of *Aliaster cotteauui*. Although LAUBE (1869a, 1871) placed the species in the genus *Pericosmus* and compared it with *P. latus* (a species here shown to occur in Austria too) his description and illustration reveal many discrepancies. In particular the extremely shallow frontal notch (well developed in *Pericosmus*), the adapically deeply sunken, narrow ambulacrum III (shallow adapically and moderately deep and rather broad ambitally in *Pericosmus*), the shape of the peripetalous fasciole, the posteriorly eccentric maximum height and the short posterior paired petals do not fit with the genus *Pericosmus*. These discrepancies were also pointed out by STEFANINI (1909: 20), who remarked that *P. affinis* could probably be a *Trachyaster*. The only feature in LAUBE's description which does not fit with *Aliaster cotteauui* is the presence of a thin marginal fasciole, the course of which is, unfortunately, not mentioned in the description and not visible in the illustration. Without a re-examination of the type it is currently impossible to settle this question. Since the type is lost *P. affinis* LAUBE, 1869 is tentatively placed in the synonymy of *A. cotteauui* based on the description of LAUBE (1871).

In most papers this species is referred to as *cotteauui*, in contrast to the original spelling *cotteauui* by WRIGHT (1855). According to the ICZN (4th ed., Articles 33.4. and 33.5.) the original spelling is to be used and *cotteauui* has to be regarded as "incorrect subsequent spelling" (not as emendation) regardless whether the change from -ii to -i was intentional or not.

Occurrence:

Austria: Early to Late Badenian (Langhian-Early Serravallian)
Vienna Basin: Müllendorf (Mühlendorfer Kreide AG quarry), Bgld ([NEITZ coll.]); ? Sievering, Vienna (LAUBE, 1869a, 1871); Stotzing (sandpit Mayer), Bgld (KAZÁR, 2002; [WANZENBÖCK coll.])

Paratethys (non-Austrian occurrences): ? Karpatian (Late Burdigalian) – Late Badenian (Early Serravallian)

Transcarpathian Basin: ? Hlinné, eastern Slovakia (SENEŠ, 1955; CÍCHA et al., 1967)

Transylvanian Basin: Gârbova de Sus (= Felső-Orbó), Romania (VADÁSZ, 1915; [MAFI])

Mediterranean: Chattian to Serravallian

Western Mediterranean: **Algeria:** Prov. of Oran, (COTTEAU, 1913a); **France:** Vence, Alpes-Maritimes (LAMBERT, 1915a); **Italy, mainland:** Emilia (COTTEAU, 1913a), ? Montese (MAZZETTI, 1882a), ? Salto, Emilia (STEFANINI, 1909), ? Rocca Malatina, Emilia (STEFANINI, 1909), Serra die Guidoni, Emilia (STEFANINI, 1909); **MOROCCO** (NÉRAUDEAU, 1994); **Sar-**

dinia, Italy: (COTTREAU, 1913a; VALDINUCCI, 1974a; NÉRAUDEAU, 1994): Bosa, Planargia (LAMBERT, 1909), Cadreas, Bonorva (COTTEAU, 1895; LAMBERT, 1909), Cagliari (? COTTEAU, 1895; LAMBERT, 1909), Cap Sant'Elia (LAMBERT, 1909), Modulo, Planargia (LAMBERT, 1909), Mont San Michele, near Cagliari (COTTEAU, 1895), Monte Alvu, near Bosa (LAMBERT, 1909), Planargia (LAMBERT, 1906a), Portotorres (CHECCHIA-RISPOLI, 1927a), Sant Michele (LAMBERT, 1909), Tresnuraghes, Cagliari (LAMBERT, 1909);

Central Mediterranean: Maltese Islands (DESOR, 1858; COTTREAU, 1913a; NÉRAUDEAU, 1994): Lower Coralline Lst. (WRIGHT, 1864), *Globigerina* Lst. undifferentiated (WRIGHT, 1855, 1864; GREGORY, 1891; BOGGILD & ROSE, 1984); Lower *Globigerina* Lst. (ROSE, 1974b, 1975; CHALLIS, 1980)

Eastern Mediterranean: Attique, Greece (COTTREAU, 1913a); Gebel Gharra, Eastern Desert, Egypt (KROH & NEBESICK, 2003)

Genus *Linthia* DESOR, 1853

Type-species: *Linthia insignis* DESOR, 1853; by original designation.

Diagnosis: Test usually small, heart-shaped, anterior ambulacrum not petaloid, depressed with groove at the margin; apical disc ethmolytic with four gonopores; posterior paired petals only slightly shorter than anterior ones; peripetalous fasciole sharply indented between the petals; latero-anal fasciole present or absent (modified from KIER, 1984; and McNAMARA, 1985a).

Distribution: Late Cretaceous to Pliocene – cosmopolitan (FISCHER, 1966)

Remarks: FISCHER (1966: U576) distinguished two subgenera within the genus *Linthia*: *Linthia* (*L.*) and *Linthia* (*Lutetiaster*) (Type-species: *Spatangus subglobosus* LAMARCK, 1816; by original designation). This distinction was based mainly on periproct shape (vertically or transversely elongated) and position of the apical disc (central to anteriorly or central to posteriorly). Few workers followed this classification, as it proved to be very difficult to apply.

Linthia ? hlinnensis (SENEŠ, 1955)

(Fig. 70; Pl. 68, Figs. 1a-b)

- v. 1875a *Schizaster Grateloupii* SISM. – HOERNES: 385, 389
- v. 1875b *Schizaster Grateloupii* SISM. – HOERNES: 211
- v. 1877 *Schizaster Grateloupi* SISM. – FUCHS: 663
- * 1955 *Trachyaster hlinnensis* nov. sp. – SENEŠ: 6, 26-27; pl. 1, fig. 3
- 1956 *Schizaster grateloupi* SISM. – SIEBER: 317
- 1967 *Trachyaster hlinnensis* SENEŠ – ČIČHA et al.: 93
- 1978 *T.[trachyaster] hlinnensis* SENEŠ, 1955 – KIER & LAWSON: 100
- 1991 *Schizaster grateloupi* SISMONDA – RUPP et al.: 40
- 1994 *H. (Trachyaster) hlinnensis* – NÉRAUDEAU: 329, tab. 4
- 2003b *Linthia ? hlinnensis* (SENEŠ, 1955) – KROH: 251

Type-material:

Trachyaster hlinnensis SENEŠ, 1955:

Holotype: the specimen figured by SENEŠ (1955: pl. 1, fig. 3); housed in the collection of coal exploration at Turč Teplice (SENEŠ, 1955: 26) (not seen)

Locus typicus: Hlinné, Eastern Slovakia

Age: "Helvetian" [Karpatian (Late Burdigalian), Early Miocene, pers. com. I. ČIČHA, 11.04.2003]

Material:

Ottangian (Late Burdigalian) – Ottang, OÖ, Austria

GBA: 1 natural internal cast (steinkern) (GBA 1875/01/77, reference specimen of HOERNES, 1975a, b)

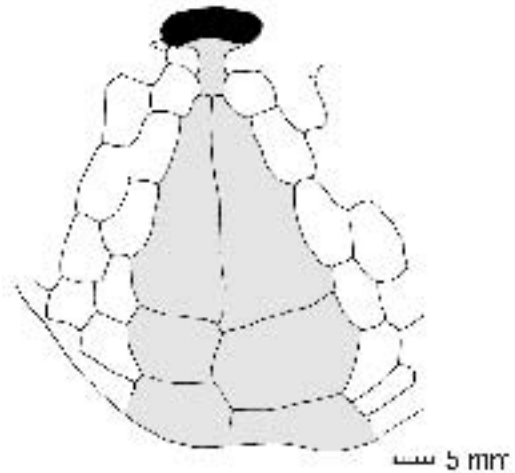


Figure 70: *Linthia ? hlinnensis* (SENEŠ, 1955): plastron structure (Ottang, OÖ, GBA 1875/01/77).

Dimensions (in mm):

Inv. No.	TL	TW	TH
GBA 1875/01/77	75.7	68.9	-

Description:

Size and shape: Test of large size with elongated, broadly heart-shaped outline. The anterior margin is rounded with a moderately deep frontal sinus. The posterior margin is transversely truncated. The maximum width lies slightly anterior of the centre. In profile the test might have been low arched or slightly wedge shaped, sedimentary compaction, however, obliterated any detailed information.

Apical disc: The structure of the apical disc is unclear. Four gonopores can be observed nevertheless. The apical disc lies slightly posterior of the centre, about 55 % of TL from the anterior margin.

Ambulacra: Adapically the ambulacra form broad, sunken petals. Ambulacrum III is slightly shallower than the paired petals and forms a very moderately deep frontal sinus. The pores of ambulacrum III are arranged in two straight rows, adapically they are closely spaced.

The paired petals are moderately long, straight and extend about 65 to 70 % of the corresponding test radius. The posterior paired petals are shorter than the anterior ones, being about 80 % their length. The anterior paired petals form an obtuse angle of nearly 100°, while the posterior petals form an acute angle of about 65°. The poriferous zones of the paired petals consist closely spaced elongate isopores. The interporiferous zones are very narrow.

Interambulacra: All interambulacra except interambulacrum 5 are distinctly inflated adapically, forming keels along the sunken petals. The plastron is moderately large and mesamphisternous (Fig. 70). The labrum is about twice as long as wide, extends to the second ambulacral plate and projects only slightly over the peristome. Adorally it bears a distinct rim.

Peristome: The peristome lies close to the anterior margin at the oral side of the test, about 20 % TL from it. It is facing downwards and is transversely elongated, kidney-shaped, measuring 13.4 x 5 mm in the present specimen.

Periproct: The periproct is poorly preserved in the specimen examined. It lies high on the vertically truncated posterior end of the test.

Fascioles: not preserved

Differential diagnosis:

Apart from outer shape and gross morphology this species differs from the co-occurring *Schizaster laubei* HOERNES, 1875a by

its transversely truncated margin, straight and more diverging anterior paired petals, longer posterior paired petals and its longer and differently shaped labrum. Albeit the two taxa are easily distinguished in whole specimens, partial internal casts may be more difficult to distinguish.

Discussion:

The only specimen available is a natural internal mould (steinkern) from the Ottnangian (Late Burdigalian) of Ottnang, OÖ. This specimen was originally referred to *Schizaster grate-loupi* SISMONDA, 1841 by HOERNES (1875a: 385, 389). It differs, however, from the latter species by its more elongated outline and different angles between the paired petals. LAMBERT & THIÉRY (1924: 504) placed the latter species in the "section" (subgenus) *Hemiaster* (*Gregoryaster*). Subsequent authors followed HOERNES' determination uncritically. In 1955 SENEŠ (1955: 26) established the species *Trachyaster hlinnensis* for specimens from a similar sedimentary environment of Karpatian (Late Burdigalian) age. The specimen from Ottnang considered here is clearly conspecific with *T. hlinnensis* on base of overall test morphology and shape of the petals. The generic attribution of this species is, however, much more difficult since only internal moulds are known. The genus *Trachyaster*, in which this species was originally placed, is characterised (among other features) by an ethmolytic apical disc, short posterior petals and a subcircular, wedge-shaped test. The morphology of the petalodium of *hlinnensis* alone excludes an inclusion in the genus *Trachyaster*. Without information on the fascioles and tuberculation it is very difficult to confidently refer this species to a particular genus. Within the Spatangoida the families Hemiasteridae, Pericosmidae and Schizasteridae would be possible (on base of plastron architecture). The Pericosmidae, however, can be excluded, since *Lambertona* and *Victoraster* have a very different morphology and *Pericosmus* has a different structure of the adapical ambulacrum III (there are fewer, higher ambulacral plates). Despite the overall similarity with some species of *Brissopsis*, brissids can be excluded because they have an ultramphisternous plastron (with near-symmetric sternal and episternal plates), whereas the species considered here has a mesamphisternous plastron (with biserially offset episternals).

The species considered here is tentatively referred to the subgenus *Linthia* based on the similarity in petal morphology,

plastron structure and gross morphology. It has to be pointed out, that this has to be tested with better preserved material because fasciole morphology and apical disc structure are crucial in hemiasterids and schizasterids.

Occurrence:

Austria: Ottnangian (Late Burdigalian)

Molasse Zone: Ottnang, OÖ (HOERNES, 1875a, b; FUCHS, 1877; SIEBER, 1956; RUPP et al., 1991; [NHMW])

Paratethys (non-Austrian occurrences): Karpatian (Late Burdigalian)

Transcarpathian Basin: Hlinné, eastern Slovakia (SENEŠ, 1955; CÍCHA et al., 1967; KROH, 2003b)

***Linthia ? summesbergeri* nov. sp.**

(Fig. 71; Pl. 68, Figs. 2-7)

Type-material:

Holotype (Pl. 68, Fig. 2): specimen NHMW 2003z0026/1187a (cast of the aboral side on a slab together with 3 other specimens, two of which are designated as paratypes)

Paratypes: NHMW 2003z0026/1178, 1187b (cast of the aboral side), 1187c (cast of the oral side), 1190 (cast of the aboral side), 1212 (cast of the oral side; 1213 is the corresponding mould), 1226 (cast of the oral side)

Locus typicus: Weikerlsee, in the eastern part of Linz, OÖ, Austria

Stratum typicum: grey shales of the Ebelsberg Formation
Age: Egerian (Chattian to Aquitanian), Late Oligocene to Early Miocene

Remarks: HOCHULI (1978: 31) dated the Ebelsberg Fm. at Ebelsberg as belonging into the late Pollen biozone Ng. Z I., which can be correlated with the calcareous Nannoplankton biozone NP25, respectively Foraminifera biozone P22 (Late Oligocene, Chattian; HOCHULI, 1978: 4, 31; STEININGER et al., 1989). The upper part of the Ebelsberg Fm. at section Ebelsberg (unpublished data, pers. comm. F. RÖGL, 26.11.2003) and Asten (RÖGL et al., 1979: 1047), however, yielded Early Miocene nannofossils. Similarly, at section Hinzenbach (near Eferding, Upper Austria) the upper parts of the Ebelsberg Fm. yielded a pollen flora in-

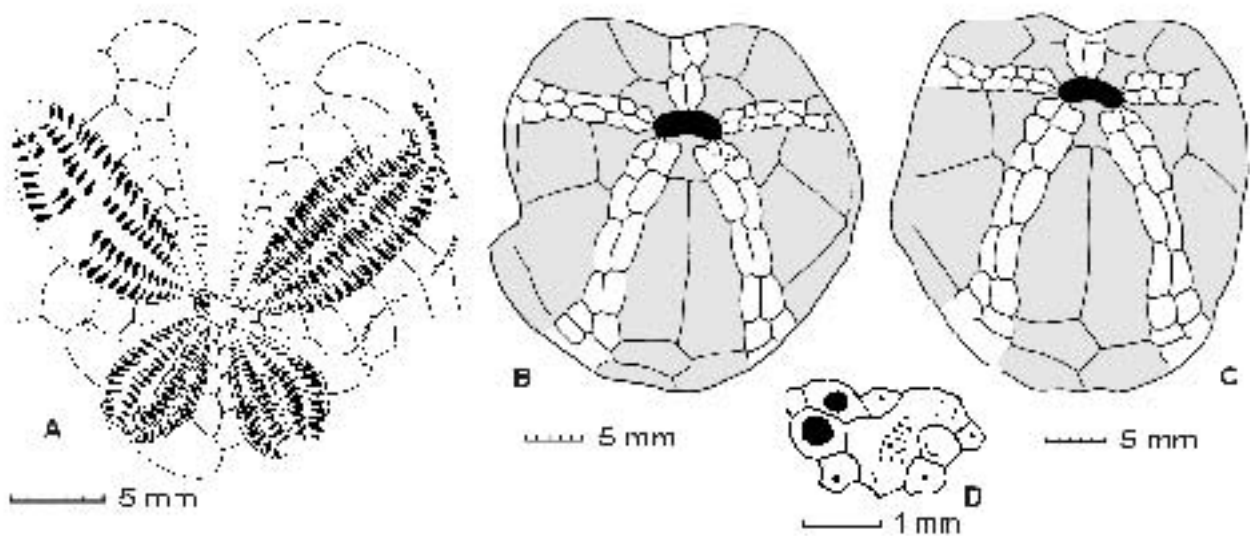


Figure 71: *Linthia ? summesbergeri* nov. sp.: petal structure and fasciole outline (dotted) (A: holotype, NHMW 2003z0026/1187a), oral plating (B: NHMW 2003z0026/1212, C: NHMW 2003z0026/1226), and apical disc (D: holotype, NHMW 2003z0026/1187a). All specimens from the Egerian Ebelsberg Fm. at Weikerlsee, Linz E, OÖ; all drawn from natural casts of the surface (internal view) and are presented mirrored here for easier comparison (corresponding to external view).

dicative of Pollen biozone Ng. Z. II (HOCHULI, 1978: 32), which correlates with the Late Egerian to Early Eggenburgian (HOCHULI, 1978; STEININGER et al., 1989). The geographic situation, the flora and additional data to the sections Ebelsberg, Weikerlsee, Asten and Pucking can be found in KOVAR (1982: 9-11).

Dervatio nominis: Named after my colleague Herbert SUMMESBERGER.

Diagnosis:

Small, cordate schizasterid with broad petals, the anterior paired petals nearly reaching the ambitus, ethmolytic apical disc, mesamphisternous plastron, broad, arrowhead-shaped labrum, and moderately deep frontal sinus.

Material:

Egerian (Chattian – Aquitanian) – Weikerlsee (Ebelsberg Fm.), Linz, OÖ, Austria

NHMW: 95 moulds and internal casts (NHMW 2003z0026/1169-1188, 1190-1218, 1220-1224, 1226-1228, 1231-1233)

Egerian (Chattian – Aquitanian) – Ebelsberg Fm., Pucking or Ebelsberg or Weikerlsee or Asten, OÖ, Austria

NHMW: 1 specimen (NHMW 2003z0026/1394)

Dimensions (in mm):

Inv. No.	TL	TW	TH*
NHMW 2003z0026/1178	38.0	35.6	-
NHMW 2003z0026/1187a	20.8	20.1	-
NHMW 2003z0026/1190	15.5	15.0	-
NHMW 2003z0026/1196	>27	~32	-
NHMW 2003z0026/1212	33.7	31.8	-
NHMW 2003z0026/1226	31.4	30.5	-

*as all specimens are preserved either as moulds or casts and are strongly flattened no height measurements were possible

Description:

Size and shape: Test of small to medium size, usually between 20 and 40 mm in length. Outline cordate, antero-posteriorly elongated. A shallow but distinct frontal notch is developed. Test profile unknown, all specimens flattened due to sediment compaction.

Apical disc: Apical disc subcentrally, ethmolytic, with 4 (?; preservation poor, unclear if there are genital pores in genital plates G1 and G2) circular gonopores, the anterior ones of which are smaller. The madreporite separates both genitals 1 and 4, as well as oculars I and V (Fig. 71.D). (Based on specimen NHMW 2003z0026/1187a in which some gonopores and madreporic pores are preserved as casts).

Ambulacra: Paired ambulacra petaloid with closely spaced elongate isopores. Petals very broad, slightly sunken, with laterally flexed tips (Fig. 71.A). Anterior paired petals nearly reach the ambitus and diverge at an obtuse angle between 100 and 120°. Posterior paired petals about 60 % of anterior ones in length, diverging at about 60 to 70°. Ambulacrum III nonpetaloid, strongly widening towards the anterior margin, but becoming smaller again just before reaching the ambitus. Pores in ambulacrum III are closely spaced partitioned isopores.

Adorally phyllodes are developed, nature and number of pores, however, unclear due to unfavourable preservation. Ambulacra I and V form moderately wide naked peri-plastral areas adorally.

Interambulacra: Aborally the interambulacra 2 and 3 form well developed keels, whereas only weak keels are developed in interambulacra 1, 4 and 5. Plastron mesamphisternous with T-shaped labrum, unequal sternal plates and biserially offset episternals (Figs. 71.B-C). Contact between labrum and sternum broad, giving the posterior part of the labrum an arrowhead-shaped (triangular) appearance. Labrum extending to

the second ambulacral plate, although sometimes barely so (e.g. Fig. 71.B).

Aboral tuberculation largely unknown. Orally the interambulacra bear moderately large tubercles, which are largest at the plastron, where they are arranged in a fan-shaped pattern.

Peristome: The peristome is transversely elongated, kidney-shaped with a slightly projecting labrum. It measures 6.1 vs. 2.4 mm in a 33.7 mm TL specimen and lies c. 27-30 % from the anterior margin.

Periproct: Due to its position on the ambitus the periproct is poorly preserved in all available specimens.

Fascioles: The holotype shows traces of a narrow fasciole band in interambulacrum 1 and ambulacrum 2 (Fig. 71.A). Thus the presence of a peripetalous fasciole seems to be highly probable. Other fascioles not ascertained.

Differential diagnosis:

Linthia burdigalensis (TOURNOUER, 1869), from the Calcaire a Astérides near Bordeaux, France, differs by its shorter and differently shaped petals.

L. calabra (SEGUENZA, 1880) from the Oligocene of Calabria, Southern Italy differs strongly by its narrow and short petals.

L. montecchiana OPPENHEIM, 1902 from the Lower Oligocene of Northern Italy differs by its much smaller, globular shape, lack of a frontal notch and short petals.

L. peolae BOTTO-MICCA, 1896 from Monte Castello, Piemonte, Italy, a species similar in appearance to *L. insignis* DESOR, 1853, differs from the present species by its elongate outline and narrow petals.

L. ? lorioli AIRAGHI, 1899 from the Oligocene of Italy differs strongly by its large size, deep frontal notch and narrow, elongated petals (this species actually might belong to *Pericosmus*, based on the description and photographs provided by AIRAGHI, 1899).

L. cevensis BOTTO-MICCA, 1896 from the Miocene of Ceva, Piemonte, Italy differs by its shorter and narrower petals (see BOTTO-MICCA, 1896; and AIRAGHI, 1901).

This form can easily be differentiated from *Brissopsis ottnangensis*, which occurs in a similar facies of the Ottnangian by its mesamphisternous plastron with biserially offset episternals and asymmetric sternals. Incomplete specimens of these two taxa can be extremely similar when preserved as external or internal casts.

Discussion:

Lacking any information on the fascioles generic and family placement of this taxon is difficult. The mesamphisternous plastron indicates that it is a member of the suborder Hemiasterina. While palaeostomatids have an ethmophract apical disc and pericosmids and aeropsids can be ruled out based on overall test morphology, hemiasterids and schizasterids are possible candidates. Fortunately, known hemiasterids with ethmolytic apical disc are sufficiently different. Within the Schizasteridae the material seems to be most closely related with *Linthia* based on the subcentral, ethmolytic apical disc, the long petals, mesamphisternous plastron and strong divergence of anterior petals. There is also a marked similarity to the marsupiate genera *Abatus* and *Tripylus*, which differ from *Linthia* mainly by the loss of the latero-anal fasciole band in adults and the presence of just three (rarely two) gonopores (no gonopores in genital plate G2). Especially the broad petals are reminiscent of these genera. Both are, however, restricted to the Antarctic and sub-Antarctic region today. Fossil representatives are known from the Paleocene of Madagascar (LAMBERT, 1933) and the Eocene of Seymour Island, Antarctic Peninsula (MCKINNEY et al., 1988). Since there is only incomplete information on the fascioles and since it is unclear if all 4 gonopores are developed, the present material is tentatively referred to *Linthia*.

This species is clearly distinct from all known Oligocene and Miocene species of *Linthia*. LAMBERT & THIÉRY (1925: 518-521)

list 8 species from this interval and none have been described since that time (KIER & LAWSON, 1978; Zoological Record). Differential diagnoses to these taxa are given above.

Occurrence:

Austria: Egerian (Chattian-Aquitainian)

Molasse Zone: Weikerlsee (Ebelsberg Fm.), Linz, OÖ (NHMW)

Genus *Prenaster* DESOR, 1853

Type-species: *Prenaster alpinus* DESOR, 1853; by original designation

Diagnosis: Test oval (antero-posteriorly elongated) without frontal notch; posterior end truncated; ethmolytic apical disc, situated strongly eccentric anteriorly; ambulacrum III non-petaloid, narrow, flush with test aborally, with minute pores; paired ambulacra petaloid, weakly sunken; anterior petals strongly divergent, up to 180°; plastron mesamphisternous, with short but wide labrum and large, symmetrical sternal plates; peristome strongly eccentric anteriorly; periproct high on posterior face; peripetalous and latero-anal fascioles present; fascioles meet behind the anterior petals and pass sub-ambitally around the anterior margin; peripetalous fasciole may be indented or straight behind anterior petals and passes ambulacra about 3 to 4 plates below the end of the petals (modified from FISCHER 1966 and SMITH "The Echinoid Directory", 02.11.2003).

Distribution: Eocene to Recent – Europe, Northern Africa, Madagascar, Australia (SMITH "The Echinoid Directory", 02.11.2003)

Remarks: FISCHER (1966: U576) regarded *Savinaster* LAMBERT, 1911 and *Protenaster* POMEL, 1883 as subgenera of *Prenaster*. Based on a careful revision of extant and fossil species of *Protenaster*, McNAMARA (1985b:312-313) rejected the placement of this taxon as subgenus of *Prenaster*. He showed that *Protenaster* is a morphologically very conservative genus and has a fossil record from the Late Eocene onwards. According to him *Protenaster* can be distinguished from *Prenaster* by its possession of deeper petals; a deeper ambulacrum III, in which well developed pore pairs occur; an anterior notch; and a peripetalous fasciole which is indented between the anterior and posterior petals, and which does not extend below the ambitus anteriorly (McNAMARA, 1985b: 313). SMITH ("The Echinoid Directory", 02.11.2003) placed *Parabrissus* BITTNER, 1880, *Savinaster* LAMBERT, 1911, and *Waurmia* McNAMARA & PHILIP, 1984 into the synonymy of *Prenaster*.

Ecology and biogeography: *Prenaster enodatus* (CHESHER, 1968), the only extant species of *Prenaster*, was dredged south of the Grand Bahama Island from a mud bottom in 366 metres depth (CHESHER, 1968).

Prenaster fuchsi (LAUBE, 1871) is morphologically very similar to the australasian species *Protenaster australis* (GRAY, 1851). That genus differs mainly by its sunken petals, presence of a frontal notch, different position of its periproct and supra-ambital passing peripetalous fasciole. *P. australis* burrows up to 10 cm deep in near-shore, calcareous sand bottoms or coarse shell grit in shallow depth between 0 and 20 metres water depth. Many specimens are recorded as having been collected from reef platforms or from beaches off which limestone reefs occur. They live buried up to 10 cm deep in fine calcareous sand (74.5 % of the sediment in the grain size fraction between 0.125 and 0.25 mm, 17.5 % between 0.25 and 0.5 mm) (McNAMARA & BRYCE, 1983; McNAMARA, 1985b; MISKELLY, 2002).

***Prenaster fuchsi* (LAUBE, 1871)**

(Figs. 72-73; Pl. 69, Figs. 1-2)

- v. 1869a *Brissomorpha Fuchsi* LAUBE. – LAUBE: 184 [*nomen nudum*]
- v. 1870 *Brissomorpha Fuchsi* LBE. – LAUBE: 314
- v.* 1871 *Brissomorpha Fuchsi* LAUBE. – LAUBE: 73; pl. 19, fig. 1
- v. 1875 *Brissomorpha Fuchsi* LAUBE – QUENSTEDT: 678
- 1877 *Brissomorpha* – FUCHS: 662
- 1900 *Brissomorpha Fuchsi* LAUBE – HESSE: 259-260; fig. 6
- v. 1912a *Brissomorpha Fuchsi* LAUBE. – SCHAFFER: 192; text-fig. 4; pl. 58, figs. 20-21
- 1924 *Brissomorpha Fuchsi* LAUBE – LAMBERT & THIÉRY: 442
- v. 1966 *Brissomorpha fuchsi* – FISCHER: U616; fig. 504-2a-b

Type-material:

Lectotype (Pl. 69, Figs. 1a-d): NHMW 1866.XX.18 (LAUBE, 1871: 73; pl. 19, fig. 1)

Paralectotype (Pl. 69, Figs. 2a-c): NHMW 1866.XX.19

Locus typicus: Gauderndorf, NÖ

Stratum typicum: Gauderndorf Fm.

Age: Late Eggenburgian (Early Burdigalian), Early Miocene

Remarks: Both specimens mentioned in the paper of LAUBE (1871: 73) could be traced in the collection Naturhistorisches Museum Wien (previously k. k. Hof-Mineralienkabinet). The better preserved one is chosen as lectotype.

Material:

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

NHMW: 2 specimens (NHMW 1866.XX.18 – 19)

Dimensions (in mm):

Inv. No.	TL	TW	TH
NHMW 1866.XX.18	84.3	75.9	48.3
NHMW 1866.XX.19	71.1	60.0	42.1

Description:

Size and Shape: Test large, ranging from 71.1 to 84.3 mm in the studied material. The outline of the test is oval, antero-posteriorly elongated. The anterior margin is rounded, without frontal notch, the posterior margin bluntly pointed. In profile the test is rhomboidal and rather high. The maximum width lies about halfway along the length. The test width is about 85-90 % of TL, the height 57-59 % of TL.

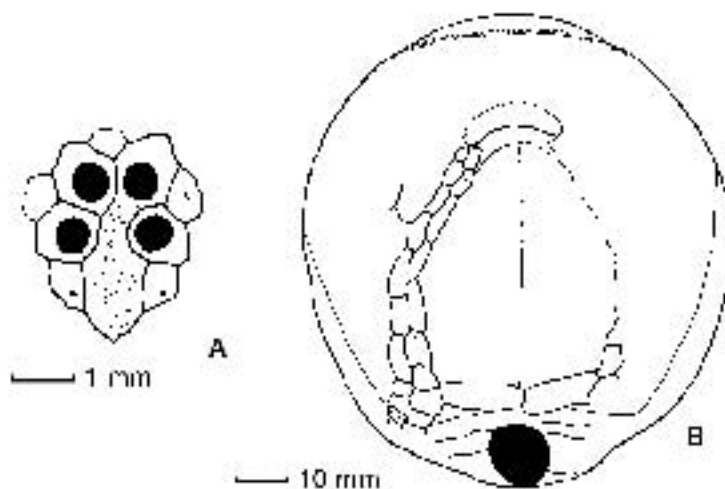


Figure 72: *Prenaster fuchsi* (LAUBE, 1871): apical disc (A) and plastron structure (B) (Eggenburgian, Gauderndorf, NÖ, lectotype, NHMW 1866.XX.18).

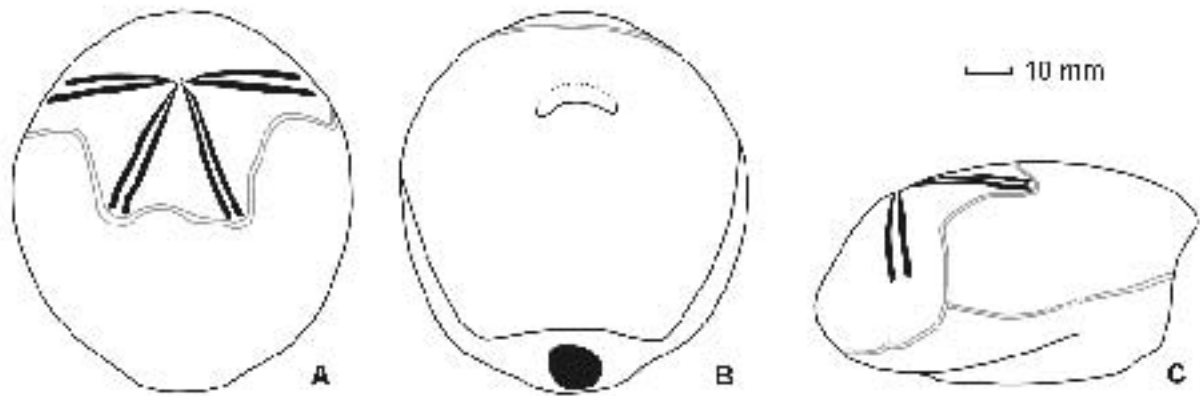


Figure 73: *Prenaster fuchsi* (LAUBE, 1871): fasciole outlines (A: aboral, B: oral, and C: left lateral view; Eggenburgian, Gauderndorf, NÖ, lectotype, NHMW 1866.XX.18).

Apical disc: The apical disc is situated strongly anteriorly, about 20 % TL of the anterior margin. It is ethmolytic with four large, circular gonopores (Fig. 72.A).

Ambulacra: Frontal ambulacrum nonpetaloid, bearing numerous small, oblique, partitioned isopores. A frontal sinus is not developed. The paired ambulacra are petaloid. The pores within the petals are conjugated iso- to anisopores (outer pore oval to teardrop-shaped in distal pore pairs). The uppermost 15 to 20 pore pairs of the anterior poriferous zones of the anterior paired petals are very small. Except in the phyllodes, where large unipores with extended periporal area can be observed, only minute pores (? unipores) are present outside the petals. The poriferous zones are slightly depressed within the petals. The interporiferous zones are narrow and covered by small tubercles similar to those of the interambulacra. The anterior paired petals diverge at about 180° and extend nearly to the ambitus, the posterior paired petals are shorter (about 80 % of the APP), extending only about halfway towards the ambitus and form an acute angle of about 50°. On the oral side ambulacra I and V from narrow naked peri-plastral areas.

Interambulacra: The interambulacra are covered with small perforate, crenulate primary tubercles to which relatively short, spatulate spines are attached. On the aboral surface the tuberculation is relatively homogenous, whereas it is differentiated on the oral surface. There larger tubercles are found along the anterior-lateral margin and on the plastron where they form a radiating pattern. Interambulacrum 5 forms a rounded, raised keel on the aboral side, which overhangs the posterior end of the test forming a prominent beak. The plastron is mesamphisternous (Fig. 72.B) and very broad. The labrum is also broad, but short and projects slightly over the peristome.

Peristome: The peristome is kidney shaped and moderately large, measuring 13.4 vs. ~7 mm in the smaller specimen. It lies strongly anteriorly, about 21 % TL from the anterior margin.

Periproct: The periproct is large, measuring 18.7 vs. 11.7 mm in the larger specimen and has an oval, dorso-ventrally elongated outline. It is situated below the beak formed by the aboral interambulacrum 5. The distinctly obliqueness of the periproct observed in both specimens available, does not seem to be related to post-sedimentary compression.

Fascioles: Both, peripetalous and latero-anal fascioles are present. The fasciole band of both is moderately wide and corresponds to the orthofasciole type (*sensu* NÉRAUDEAU et al., 1998b). The peripetalous fasciole is indented between anterior and posterior paired petals and runs down towards the ambitus along the anterior paired petals. It crosses ambulacrum III, interambulacra 2 and 3 just below the ambitus (see Figs. 73.A-C). The latero-anal fasciole is not well visible in both specimens since it is partly covered by spines still attached to the test. It branches off from the peripetalous fasciole just behind the posterior petals and forms a V below the periproct.

Spines: The spine microstructure of this species was described by HESSE (1900: 260, fig. 6) based on spines detached from the type specimens. According to him the spines show a hollow central lumen and 23 to 30 radial septa.

Differential diagnosis:

Prenaster nelsoni (MCCOY, 1882) from the Late Oligocene Waurn Ponds Limestone of Australia (McNAMARA & PHILIP, 1984) differs by its more widely spaced pore pairs, possession of large double pores beyond the peripetalous fasciole and lack of a hood overhanging the periproct. Otherwise the two species are remarkably similar.

Prenaster enodatus (CHESHER, 1968), an extant species from the Caribbean Sea differs by its less well developed and smaller petals, more reduced anterior poriferous zone of the anterior paired petals, extremely thin peripetalous fasciole, which is not indented between the anterior and posterior paired petals (CHESHER, 1968).

Prenaster excentricus (WRIGHT, 1855) from the Messinian Upper Coralline Limestone of the Maltese Islands differs by its lower profile, slightly more sunken petals, shorter and more closed posterior petals, lack of a hood overhanging the periproct and its horizontally elongated periproct (compare WRIGHT, 1864; CHALLIS, 1980).

Pseudobrissus corsicus (COTTEAU, 1877) from the Miocene of Corsica and the Burdigalian of the Rhône Basin differs by its strongly sunken petals and presence of a slight frontal notch. It shares the presence of peripetalous and latero-anal fascioles, their course and a hood-like projection above the periproct (compare COTTEAU, 1877; PHILIPPE, 1998).

Prenaster jeanneti PUPERS, 1933 from the Late Eocene of Bonaire differs by its even more anteriorly displaced apical disc, backwards flexed anterior paired petals, more posterior peristome, and lack of a rostrum or hood (compare KIER, 1984).

Prenaster parvus PALMER in SÁNCHEZ ROIG, 1949 from the Late Eocene of Cuba differs by its stronger divergence of the anterior paired petals (flexed backwards), more deeply sunken, well developed petals, lack of a rostrum or hood, and the presence of well developed pore pairs in aboral ambulacrum III (compare KIER, 1984).

Brissus ? cabrerai (SÁNCHEZ ROIG, 1953) from the Late Eocene of Cuba differs by its more elongate outline, less diverging posterior paired petals, more backwards flexed anterior paired petals and lack of a rostrum or hood. KIER (1984: 82-83) placed this species in the genus *Brissus*, based on a "short track of subanal fasciole present forming lobe below periproct" on the otherwise very weathered test. As all other features are reminiscent of *Prenaster*, the present author is of the opinion that this "short track" might as well have been part of the subanal portion of a latero-anal fasciole.