Introduction

The present volume combines listings of literature records with new data, critical revisions, new descriptions and illustrations. The aim of this is to present to the reader a single volume including all data on Neogene echinoids of Austria combined with sufficient information to identify echinoids from Austria or neighbouring regions.

The CFA series necessitates the inclusion of poorly resolved references and/or material as it intends to document the occurrence of fossil taxa (of any level) as completely as possible (see Kühn in Flügel & Kropfitsch-Flügel, 1965). Therefore, fragmented and poorly preserved material, as well as records with unresolved taxonomy or records based on such material are also taken into account.

Descriptions and illustrations

All of the descriptions are based on Austrian material, except where explicitly stated otherwise. The material and its repositories, as well as short remarks (e.g. which part of the animal is preserved; if the material represents type or figured material of earlier papers) is listed under the section "Material" for each taxon. This section is followed by a section entitled "Foreign material for comparison" listing specimens which were used for direct comparison with the Austrian material. These are usually specimens from the Central Paratethys or (depending on availability) material from the type area of the species discussed. Likewise the specimens figured on the plates are of Austrian provenance, with very few exceptions. When foreign material is figured (usually in text-figures) it is explicitly labelled as such (by black numbers on white circles on the plates). Plate-drawings have been made with the aid of a *camera lucida* or by tracing plate outlines on greatly enlarged photographs and SEM photos. Where not readily visible, plate-contours could often be enhanced by wetting the specimens (with a mixture of water and glycerine), or in the case of some scutellid specimens by etching and/or grinding and polishing the oral surface until the micro-canal system was revealed. Stippled lines were used in cases in which contours were ambiguous. Cross-hatched areas indicate test surface damage. In clypeasteroids and spatangoids the interambulacra are usually shaded in grey.

Species concepts

In this time of increasing importance of genetics and DNA sequencing methods in systematics, it is necessary to comment on the species concepts employed in the present study. Although it has been shown that the echinoids can exhibit considerable morphological plasticity (e.g. Marcus, 1983; McNamara, 1995 for *Schizaster compactus*; ...) and morphology can be strongly linked to substrate and other environmental parameters (Ernst, 1973a, b; Stanton et al., 1979 for *Dendraster excentricus*) the basic premise in the present paper is that echinoid species can nevertheless be identified by a phenetic, or morphospecies approach. This is in fact a necessity in palaeontology as, of course, all other data (physiological, histological, genetic and in most cases also ontogenetic data, as well as any data on fertilisation success and reproductive isolation) are lost during fossilisation. Interestingly, a large number of systematic papers by neontologists [e.g. revisions of the extant Australian species of the family Schizasteridae by McNamara & Philip (1980b), of the Australian species of the genus *Pericosmus* by McNamara (1984), of the extant species of *Mellita* by Harold & Telford (1990), of the extant species of *Dendraster* by Mooi (1997)] relied on the same assumption.

Recent molecular studies on Indo-West Pacific members of the genus *Echinometra* (Matsuoka & Hatanaka, 1991; Palumbi et al., 1997), the genus *Eucidaris* (Lessios et al., 1999), the East Pacific and Atlantic species of *Echinometra* (McCartney et al., 2000) and the members of the genus *Diadema* from all over the world (Lessios et al., 2001b) shed new light on the suitability of phenetic (morphological) approaches in the systematics of "regular" echinoids (similar works on "irregular" echinoids such as the clypeasteroids or spatangoids are largely still lacking). Their results indicate a good agreement between prior classification on the basis of morphology and the groupings obtained by molecular analysis (i.e. most species defined on morphological grounds are monophyletic groupings in the trees obtained from genetic sequences). Individual molecular clades and sibling species, however, were often not recognised prior to the molecular analysis.

Studies linking genetic and morphological analyses are rare, notable exceptions are the papers on the *Echinocardium cordatum* complex by the working group around Bruno David and Jean-Pierre Féral (e.g. Laurin et al. 1994; but see also more recent papers by David & Laurin, 1996; Féral et al., 1998; David et al., 1999; Chenuli & Féral, 2003 and references therein). According to these studies both approaches (phenetic and molecular) have their merits, but results may differ.

As stated above, a phenetic approach was followed in the present study. Initial classification of the specimens was based on character analysis and spatial and temporal distribution. Whenever possible (depending on the availability of suitable numbers of specimens and their preservation) these classifications were subsequently tested by morphometric analyses. Classification prior to testing was favoured over "blind" analysis to avoid circular argument in subsequent testing of the classification. Potentially powerful multivariate analysis (e.g. principal component analysis, landmark methods, or canonical discriminant analysis) could not be employed due to the high number of missing values in the data sets. Instead, bivariate statistics, a method successfully applied in many studies before (e.g. Wörheide, 1995 for *Echinocardium cordatum*) was favoured.

The present study attempts to provide diagnostic characters for all species encountered in the study area (Austria) and, where possible, to differentiate them from all other species occurring in the Neogene of the Central Paratethys. The species accepted were the smallest morphologically diagnosable groups. During this process many previously established species turned out to form gradational series rather than distinct groups. Previously employed species concepts (e.g. by Vadász, 1915) led to the differentiation of closely related forms based on subtle differences in size and shape. This went so far as to recognize nearly each individual as a separate species (e.g. in the genus *Clypeaster*, where c. 80 species and subspecies were reported from the shallow sublittoral carbonate sediments of

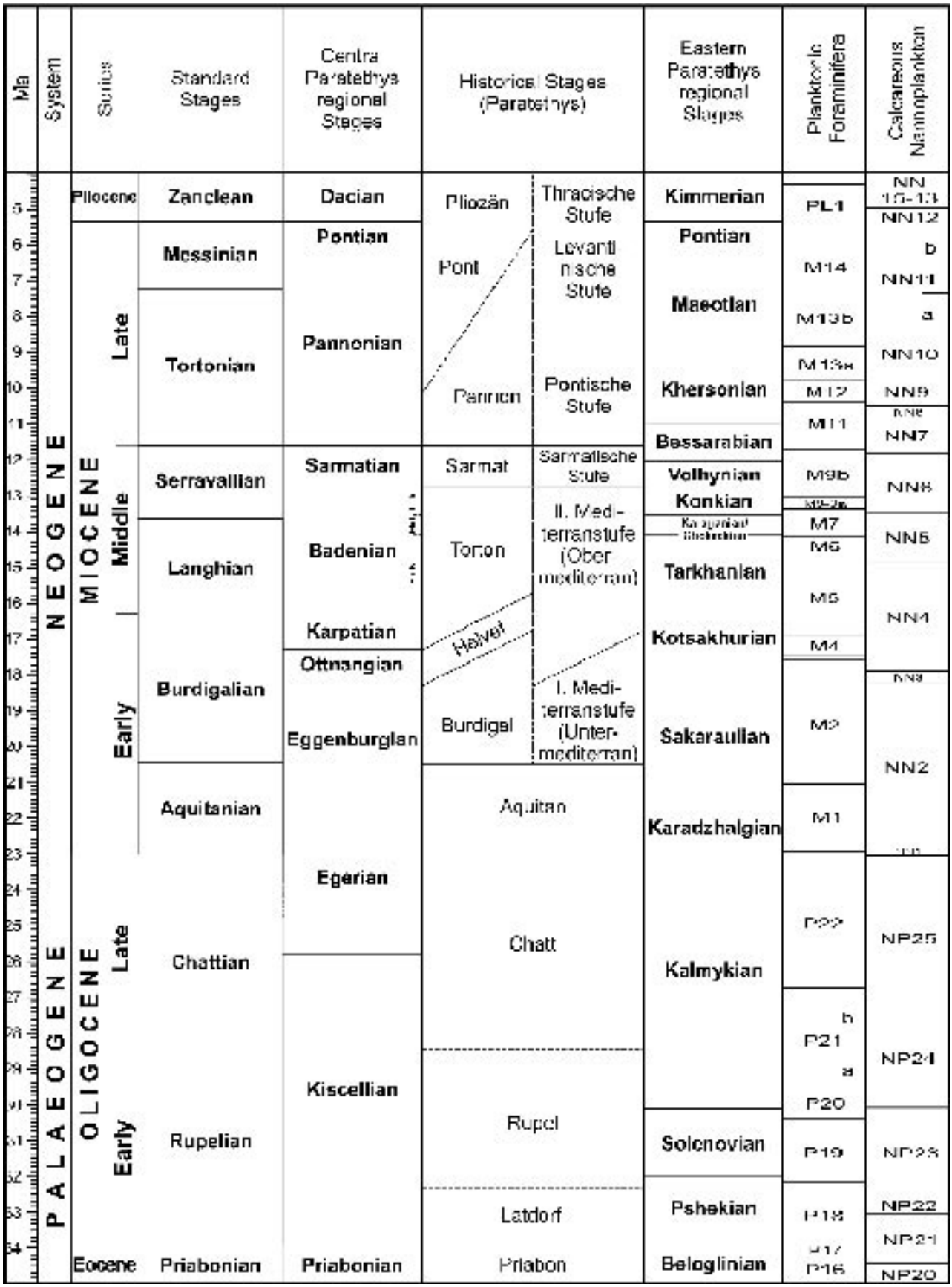


Table 1. Chronostratigraphic time scale for the interval Late Eocene to Early Pliocene. Modified from Schultz (2001: tab. 1), Rögl et al. (2002: tab. 4), and Harzhauser et al. (2003: fig. 2). Eastern Paratethys regional stages taken from Goncharova et al. (2001: 517, tab.). Absolute dates of stage boundavies modified according to Gradstein et. al. (2004).

the Badenian). The present approach, in contrast, is a kind of "minimum species approach" attempting to provide groupings that can be differentiated. Features that are used in the classification of related extant forms were also used here when possible.

Systematic treatment

The synonymy lists give the exact citation of the cited paper including spelling errors, punctuation and use of capitals. Clarifying remarks are added in square brackets. Spelling errors are underlined to indicate that they were present in the original publication. Critical symbols are used in the synonymy lists throughout this work. An asterisk (*) indicates references where a valid species was established; the double cross (#) indicates references where a junior synonym was established; a dot (.) indicates citations which are explicitly placed into the synonymy of the species under discussion, these are usually references accompanied by a figure and/or extensive description sufficient for revision; the letter "v" indicates that the material mentioned in the corresponding reference has been seen by the author; "pp" means than only part of the reference material of a citation belongs to the considered species; "non" means that a reference is explicitly excluded from the synonymy of the discussed species, the reasons for this are usually given in the discussion or in brackets at the end of the line; a question-mark (?) indicates that there are reasons to doubt that the reference belongs in the synonymy of the considered species; if there is no symbol the information found in the corresponding paper was insufficient to decide on the correctness of the determination but that there was also no evidence suggesting otherwise.

In the occurrence section the Austrian localities are listed first, followed by the Paratethyan ones and finally that of the Mediterranean. Within these sub-sections the localities are arranged according to their palaeogeographic position (e.g. the basins in which they are situated). The stratigraphic range of a given species in the respective areas (Austria, Paratethys and Mediterranean) is based on the references in the respective section corrected according to new stratigraphical data when available. References in this section consist of author and date only and the reader is referred to the synonymy lists to find the full citations.

Arrangement and use of higher level taxonomy follows Smith (1984a) and Smith & Wright (1989, 1990, 1993, 1996, 1999, 2000, 2003) respectively but is emended where necessary. The classification of the Clypeasteroida follows Mooi (1989), taking also into account the results of Mooi (1990c, d) and Mooi & Chen (1996). For the Cassiduloida the work of Kier (1962) forms the baseline, but new data based on morphology (Mooi, 1990a) and cladistic analyses (Suter, 1994a, b; Smith, 2001) are incorporated where necessary.

The descriptive terminology follows Melville & Durham (1966), Durham & Wagner (1966) and Smith (1984b) (see also glossary and explanatory illustrations on the inside of the frontside- and backside-cover). Ambulacral pore morphology follows Smith (1978, 1980c) with additional types from McNamara (1985b). Nomenclature for fasciole morphology follows Néraudeau et al. (1998b). Ambulacral compounding nomenclature follows Jensen (1982).

Open nomenclature is used where necessary. The use of the open nomenclature (cf., aff.) follows Bengtson (1988). Where the material was insufficient for determination to species or even generic rank, higher level taxa are used.

Descriptions are based on Austrian specimens only, reference to other material is given in the "Remarks" and "Discussion" sections respectively. All specimens referred to have been examined by the author personally, except where explicitly stated otherwise.

The results of the taxonomic revision are summarized at the end of the introduction. Table 2 shows the Central Paratethyan taxa currently considered as valid and their ranges within the Neogene of Austria, the Central Paratethys and the total known ranges. Doubtful records that could not be substantiated or rejected during the present work are summarised in Table 3. Taxa mentioned in earlier papers but rejected from the Austrian and/or Central Paratethyan echinoid faunas are listed in Tables 4 and 5, with short explanatory statements.

Geological Setting

The Austrian Neogene basins are part of the Paratethys, an epicontinental sea ranging from the Rhône Basin and western Switzerland (Lake Geneva) in the west to the Transcaspian area (Lake Aral) in the east (Laskarev, 1924). It developed in the Oligocene by separation from the Mediterranean through the newly formed land masses of the Alps, Dinarides, Hellenides and the Anatolian Massif (see Rögl & Steininger, 1983; Rögl, 1998). Its palaeogeography and connection to the Mediterranean is strongly linked to the Alpine orogenesis (Fig. 1).

The Paratethys may be subdivided into the Western, Central and Eastern Paratethys. The Western Paratethys comprises the French, Swiss and part of the Bavarian Molasse. The Central Paratethys includes the Eastern Bavarian, Upper Austrian and Lower Austrian Molasse, the Carpathian Foredeep, the Vienna Basin, the Styrian Basin, the Danube Basin, the Great Hungarian Basin, the Zala, Sáva and Dráva Basins, the Novohrad Basin, the Transcarpathian Basin and the Transylvanian Basin (ordered from west to east and north to south) (Fig. 2). The Eastern Paratethys extends from the Black Sea area to the Transcaspian area. At its largest extent the Paratethys extended for more than 55° longitude and 15° latitude (not considering the reduction due to alpine orogenesis), an area similar to or larger than the Mediterranean today. With continued raising and northwards movement of the alpine mountain chains, the connections between Mediterranean and Paratethys, as well as between Central and Eastern Paratethys became severed. At the Sarmatian-Badenian boundary most stenohaline organisms disappeared due to short-term changes of sea-water chemistry. Although normal to hypersaline conditions prevailed during most of the Sarmatian, only a few of these groups re-appeared due to restricted connections with the world ocean (Piller & Harzhauser, in press). By the time of the Pannonian (Tortonian, Late Miocene), marine sedimentation ceased in the Paratethys. Since that time the extent of the Paratethys shrank and fresh-water conditions and endemism prevailed. For further information the reader is referred to Rögl (1998; and references therein).

Stratigraphy

The history of stratigraphy in the Central Paratethys is complex. Although the faunal development of the Paratethys is closely linked to that of the Mediterranean, geodynamic processes connected with the Alpine orogenesis strongly influenced that development. Times of isolation and good connections alternated, resulting in a distinct faunal history. The similarities and differences led to the development of a regional chronostratigraphic subdivision that differs from that of the Mediterranean, but can be correlated with it in a rather straightforward way (see Tab. 1). To understand the older literature it is necessary to give a short overview of the different subdivisions previously employed for the Lower and Middle Miocene sediments of the Central Paratethys previously. Moreover, as in the international literature, Middle Miocene occurrences, species, and outcrops of the Central Paratethys are commonly attributed to the Late Miocene (e.g. Philippe, 1998). However, marine sedimentation in the Central Paratethys, however, ceased during the late Middle Miocene (see above).

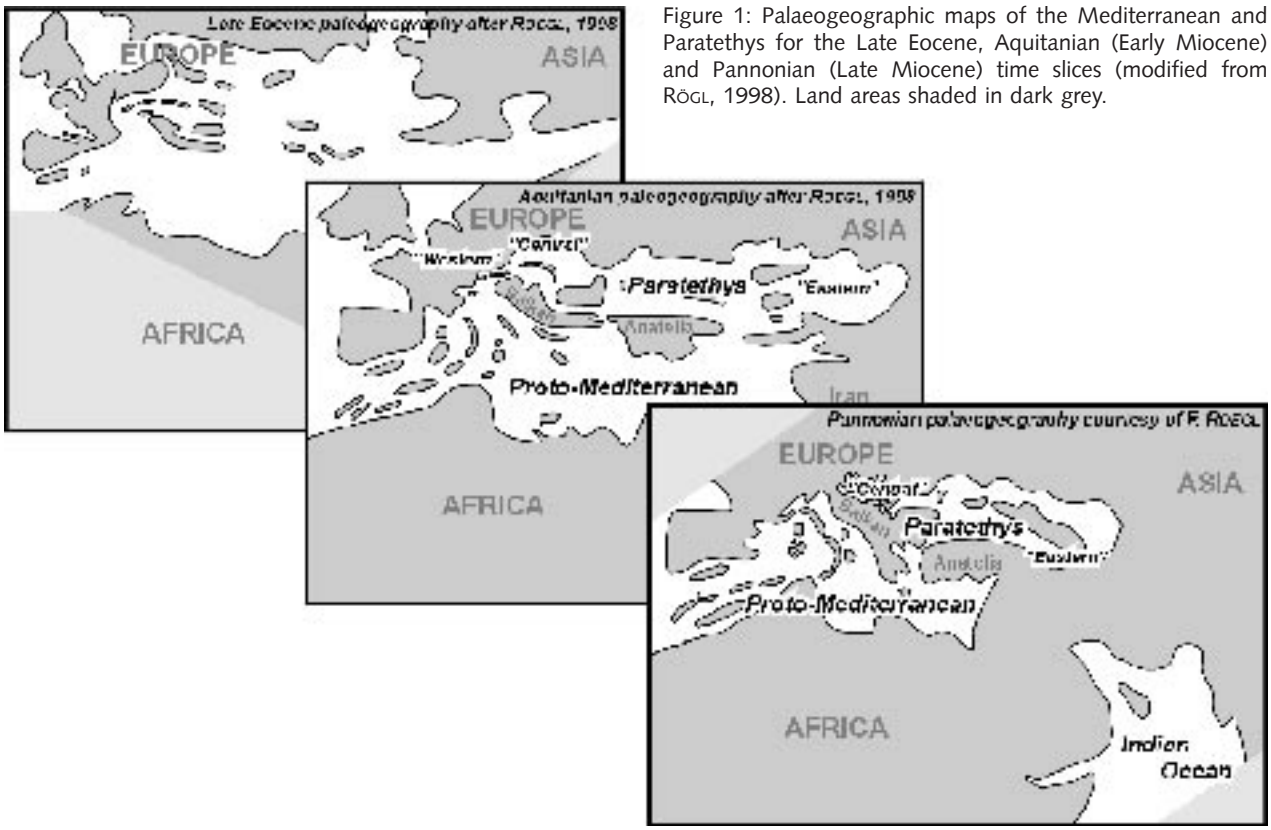


Figure 1: Palaeogeographic maps of the Mediterranean and Paratethys for the Late Eocene, Aquitanian (Early Miocene) and Pannonian (Late Miocene) time slices (modified from RÖGL, 1998). Land areas shaded in dark grey.

In the second half of the 19th and first decade of the 20th century a concept distinguishing between two stages, the "I. Mediterranstufe" or "Untermediterran" and the "II. Mediterranstufe" or "Obermediterran" was employed. The former was used mainly for Lower Miocene sediments and the latter for Middle Miocene ones. In the early 20th century this concept was replaced with a three-fold subdivision: "Burdigal – Helvet – Torton". While the "Burdigal" of this concept at least corresponds to what is known as Early Burdigalian today, the terms "Helvet" and "Torton" are misleading. "Helvet" was used for Middle Burdigalian as well as Langhian sediments. Most confusing, however, is the term "Torton" which was employed for Langhian to Lower Serravallian sediments based on an erroneous correlation with the Italian "Tortoniano" (Late Miocene) by SCHAFFER (1927b). This subdivision was in use as early as 1906 through *c.* 1975 by scientists working in the Central Paratethys, but is still present in the international literature (see PAPP et al., 1978a; and HARZHAUSER et al., 2003 for more information). The currently employed subdivision distinguishes four Early Miocene and two Middle Miocene stages (see Tab. 1). It was developed by a working group of the RCMNS around T. BALDI, I. CICHA, A. PAPP, F. RÖGL, J. SENEŠ, and F.F. STEININGER and published in the series "*Chronostratigraphie und Neostratotypen*" of the Slovak Academy of Sciences (later volumes were published by the Hungarian Academy of Sciences and Yugoslavian Academy of Sciences and Arts). This subdivision is constantly improved and substantiated by new results (e.g. BRZOBOHATÝ et al., 2003).

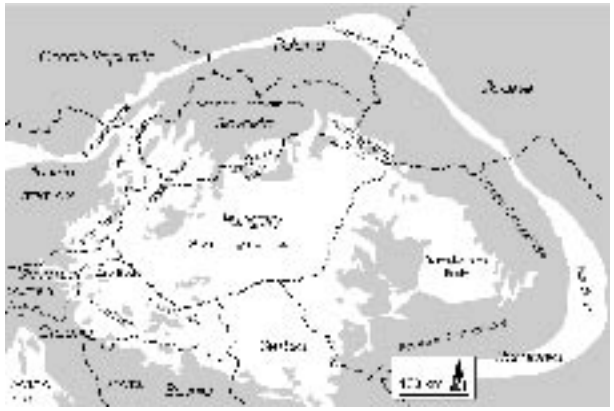
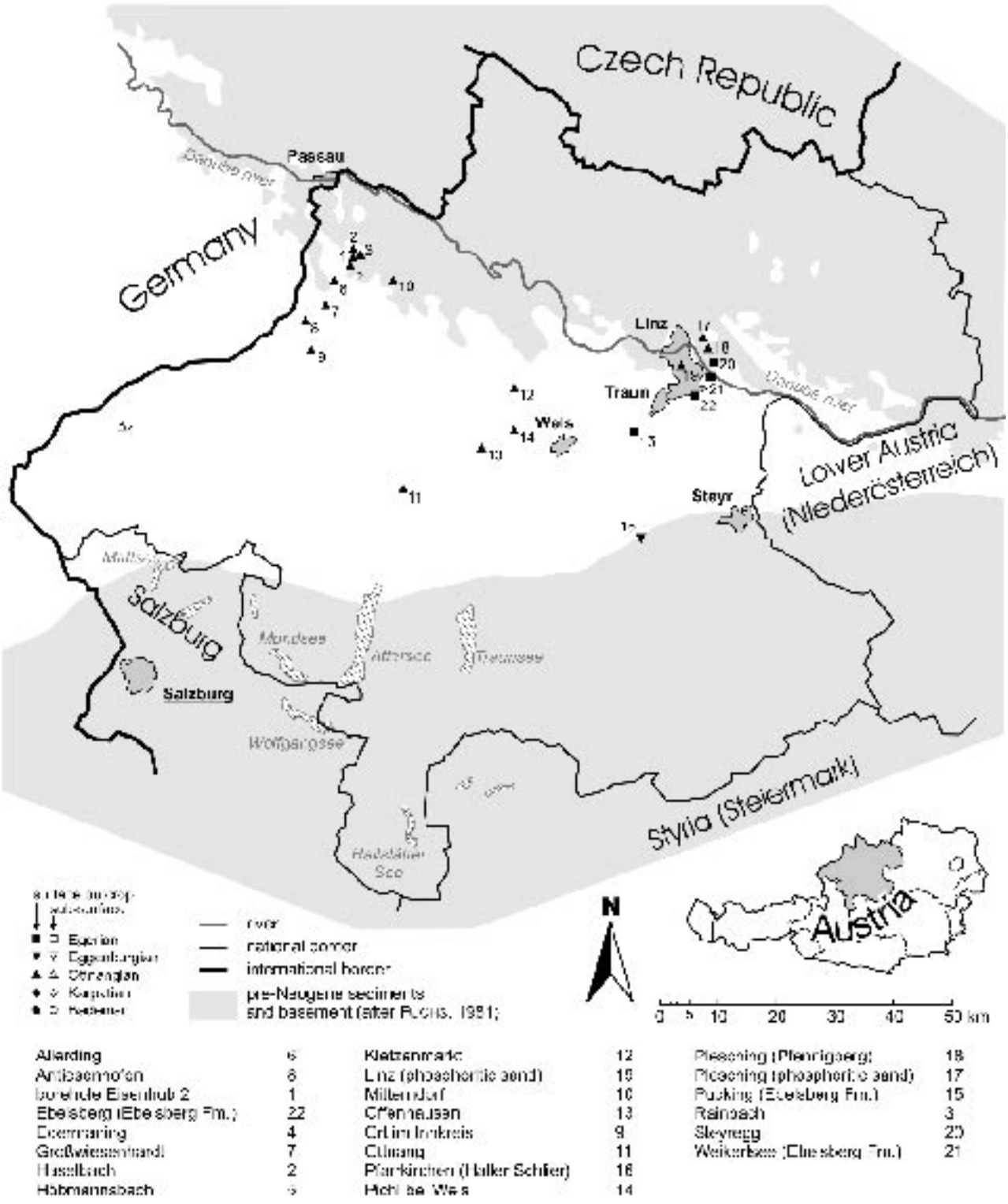


Figure 2: The Recent Carpathian-Pannonian Basin complex of the Central Paratethys showing the different sedimentary basins (modified from HARZHAUSER et al., 2003). Pre-Neogene sediments and basement shaded in grey.

Localities

At the end of the introduction the reader will find sketch maps showing the geographic position of the outcrops and historical localities mentioned in this work. The Austrian localities are shown on three maps: one for Oberösterreich (Upper Austria), one for Niederösterreich (Lower Austria), Wien (Vienna) and the northern half of Burgenland and one for Steiermark (Styria), the southern half of Burgenland and the easternmost part of Kärnten (Carinthia) (Figs. 3-5). In these maps, pre-Neogene sediments and basement are shaded in grey in these maps for easier orientation. In addition, smaller maps of other areas with Central Paratethyan sediments are provided to locate other Central Paratethyan localities (Figs. 6-9).

Note that many outcrops (mainly those in the Austrian-Czech, Austrian-Slovak, Austrian-Hungarian, and Hungarian-Romanian border regions) may be known by several different names in the geological literature. Wherever possible the currently used names are given in the "Occurrence" sections. The older names are mentioned in brackets (see also Tab. 6)



Allerding	6	Kletzenmarkt	12	Plesching (Plesrigberg)	18
Antiboemoten	8	Linz (phosphoritic sand)	19	Plesching (phosphoritic sand)	17
borehole Eisenhub 2	1	Mitterndorf	10	Pucking (Ebelsberg Fm.)	15
Ebelsberg (Ebelsberg Fm.)	22	Offenhausen	13	Rainbach	3
Doermaring	4	Ort im Innkreis	9	Steyregg	20
Großwiesenstandl	7	Ottnang	11	Weikersberg (Ebelsberg Fm.)	21
Haselbach	2	Pfarrkirchen (Haller Schlier)	16		
Habmannsbach	5	Hohlbe Weg	14		

Figure 3: Echinoid-bearing localities in Upper Austria (Oberösterreich) mentioned in this paper.

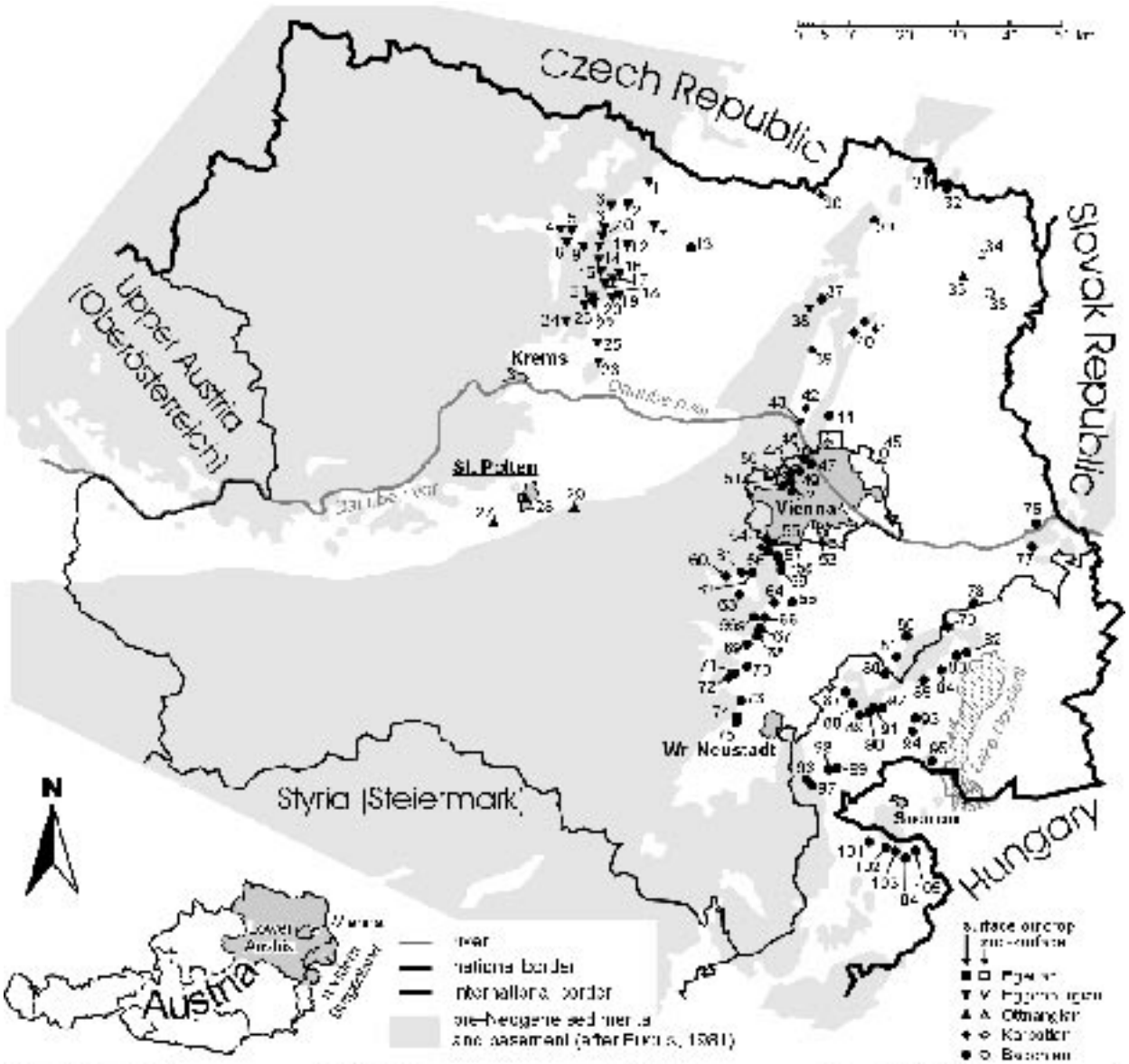
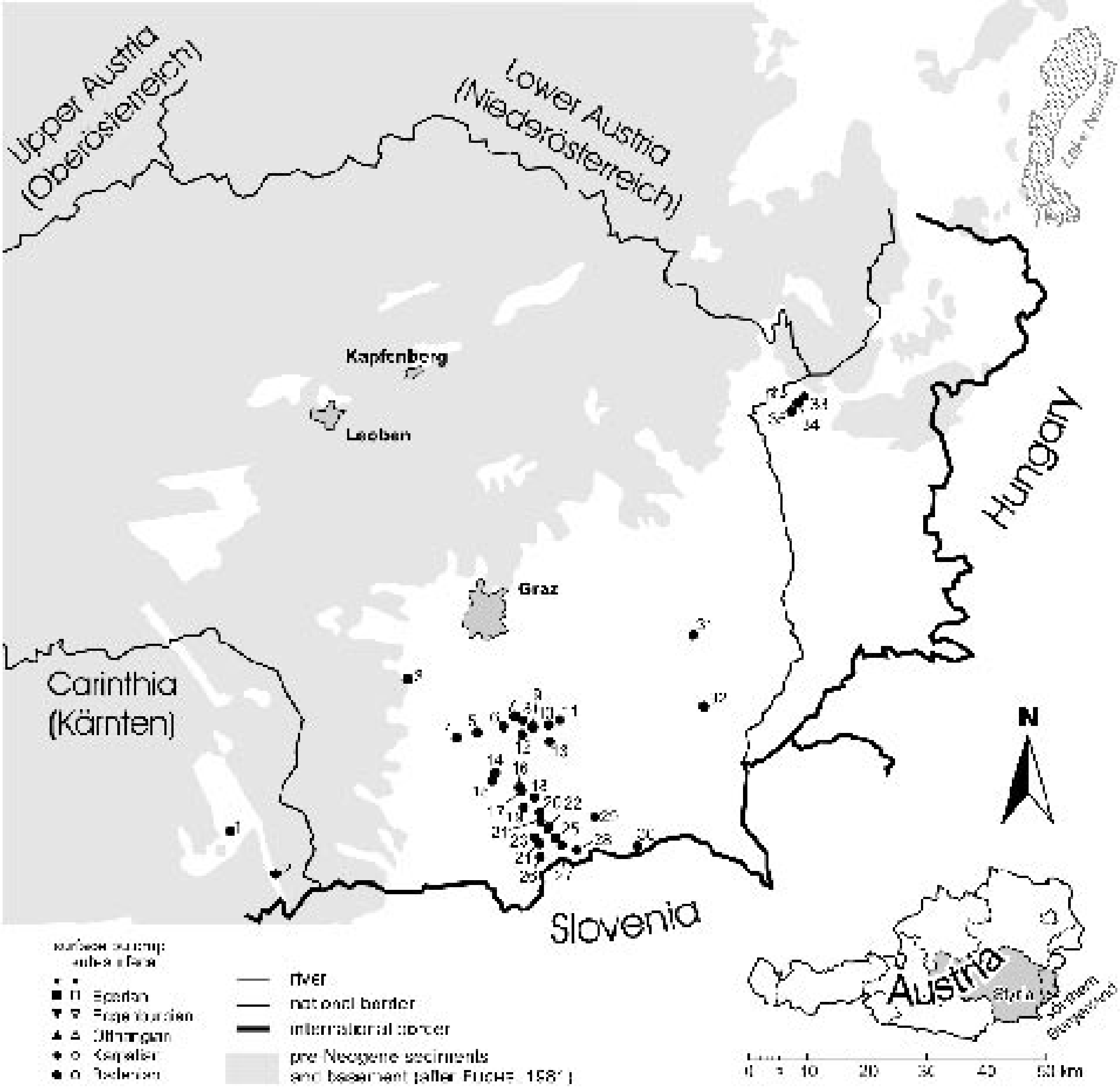


Figure 4: Echinoid-bearing localities in Lower Austria (Niederösterreich) and northern Burgenland mentioned in this paper.



Carinthia (Ktn)

Pfarrdorf im Lavanttal 2
Mühldorf im Lavanttal 1

Styria (Stmk)

Aflenz an der Sulm 21
Altenberg 16
Ehrenhausen 25
Ratsch 27
Gamlitz 24
Gamlitz (Eckberg) 26
Grubtal (Wenireiten) 23
Kainberg 17
Kollischberg 8
Leibnitz 18
Leibnitz (Seggauberg) 19
Muggenau 14
Neurath 31
Ober-Mureck 30
Perbersdorf 29
Pesendorf (Stiefingbach) 10
Petersdorf 32
Pichla 11
Pöls an der Wieserbahn 5
Retznei (Lafarge quarry) 22
Spielfeld 28
St. Georgen 13
St. Nikolai im Sausal 15
Sukdull 9
Wagna (brickyard) 20
Weißenegg 7
Weitendorf 6
Wetzelsdorf in der Weststeiermark 4
Wildon 12
Zirknitz 3

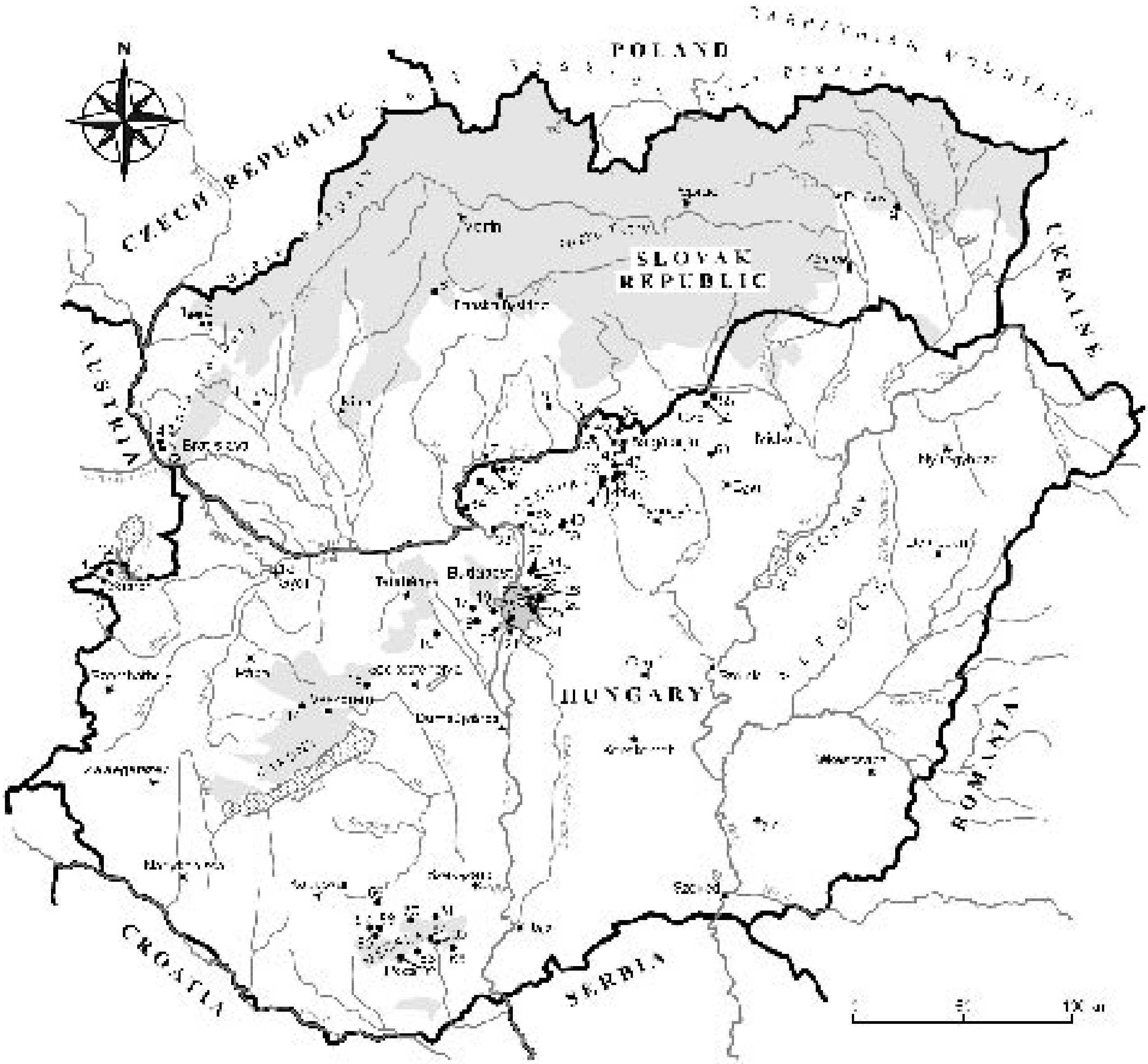
Burgenland (Bgld)

Pinkafeld 35
Schreibersdorf 33
Wiesfleck 34

Figure 5: Echinoid-bearing localities in Styria (Steiermark), Carinthia (Kärnten) and southern Burgenland mentioned in this paper.

Břeclav (= Bratelsbrunn)	10	Mikulov (= Nikolsburg)	11	Služín	7
Hrušovany nad Jevišovkou (= Grusbach)	9	Mušlov	12	Strachotín	19
Kelberk (= Kierberg)	18	Nový Rybník (= Perlsdorf)	13	Úvaly (= Garschner Joch)	14
Krumlov (= Krumau)	1	Orlová (= Orlau)	22	Veltlice (= Feldsberg)	15
Kralice nad Oslavou (= Kralitz)	3	Ostrava (= Ostrau)	21	Židlochovice (= Groß Seelowitz)	20
Květnice, near Lanmiesko	4	Pozořice	17	Znojmo (= Znaim)	2
Lednice (= Eisgrub)	16	Rudoltice (= Rudelsdorf)	6		
Lysice (= Liseitz)	5	Stalmky	8		

Figure 6: Czech localities mentioned in the text. Former German names used in the older literature are given in brackets.



Slovak Republic

Devínska Nová Ves (= Dévény Újfalu, = Neudorf an der March)	4
Devínska Kobyla (= Thebener Kogel)	5
Dubovce	1
Horné Strháre (= Felső Esztergály)	8
Hlinné	9
Šahy (= Ipolyság)	7
Creake	3
Radošovce	2
Veľká Čausa (borehole ČS-3)	6

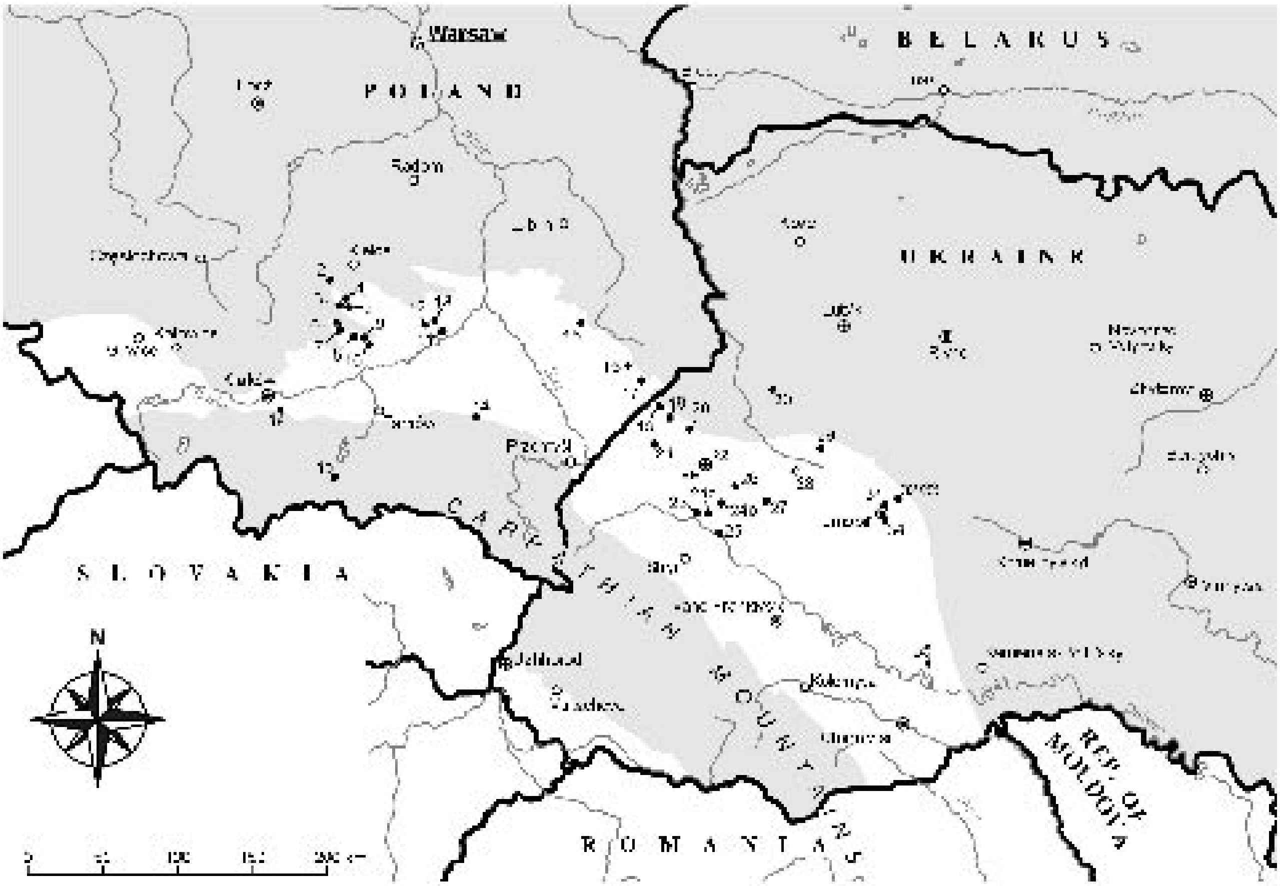
Hungary

Acsa	40
Alsóúklobos	16
Alsómold (= Alsó Tövel)	11
Bélapátfalva	53
Biatorbágy (= Bia)	17
Bocatyaher (= Egyházbér)	55
Bucsora	19
Budapest-Budafok	23
Budapest-Budatétény	22
Budapest-Rákoskeresztúr	26
Budapest-Kerepesi út	25
Budapest-Rákos	29
Budapest, XI. district	24
Budapest, XIV. district	27
Cinkota	28
Csomád	32
Drégelypalánk (= Drégely)	37
Érd	20
Érdliget	21
Ftes (= Fitea)	49
Felsőtold (= Felső-Told)	42
Fertőrákos (= Kroisbach)	12
Fót (= Fóth)	31
Garáb	43
Győr	13
Harka (= Harkau)	10
Herend-Márkó	14
Hidas (= Hidasd)	61
Hird	63
Hont	36
Karancslapujtő (= Lapujtő)	52
Kemence	35
Kozárd	55
Kisgeresd	38
Kishajmás (= Haromhaz)	57
Kovácsszénája (= Kovácséna, = Kovácsszénája)	58
Litkes	34
Magyaregregy	60
Márkháza	47
Mátraszőlős (= Mátraszőllős)	44
Mátraverebély	46
Mátyásföld	26
Mogyoród	30
Nagymaros	33
Nagypal	65
Nógrádszakál (= Szakali)	51
Öcsgárd	38
Pellérd	67
Pécs	62
Pécsvárad	64
Piliny	50
Püspökhatvan	39
Sajóvárkony	54
Sámsonháza	45
Sásd	56
Sopron (= Oedenburg)	11
Sopron-Rákos = Fertőrákos	12
Sóskút	18
Szalatna	57
Tétény = Budatétény	22
Tótmarokháza	47
Várpalota	15
Zagyvapálfalva (= Pálfalva)	48

Figure 7a: Slovak and Hungarian localities mentioned in the text. Former German and Hungarian names used in the older literature are given in brackets.

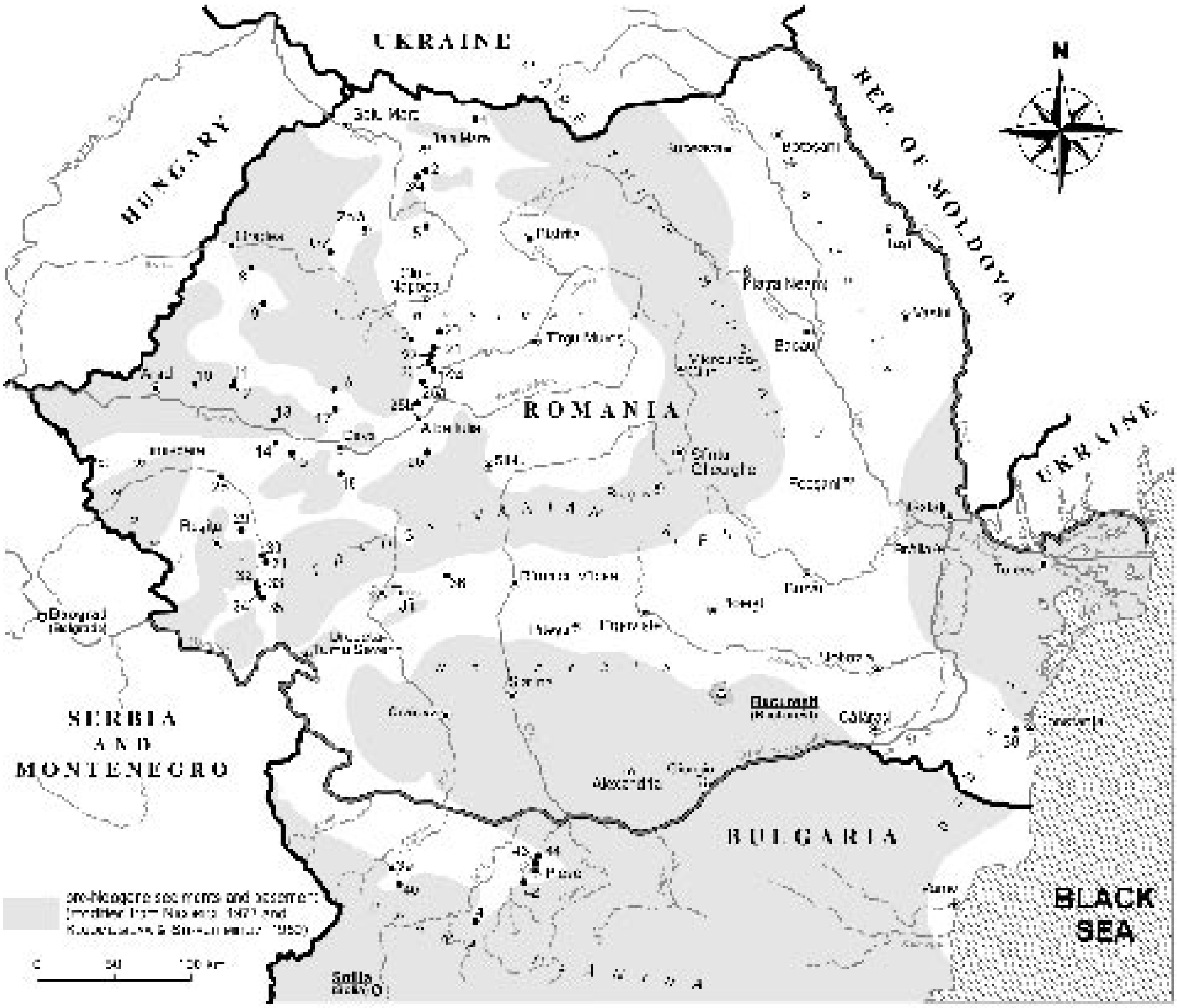

AUSTRIA
HUNGARY
ITALY
Ljubljana
SLOVENIA
Zagreb
CROATIA
ROMANIA
Beograd
BOSNIA AND
HERZEGOVINA
Sarajevo
SERBIA AND
MONTENEGRO
BULGARIA
Sofia
N
ADRIATIC SEA
Skopje
THE FORMER
YUGOSLAV REPUBLIC
OF MACEDONIA
Tirana
ALBANIA
GREECE
Slovenia
'Gallenegg', near Zagorje
ob Savi (= Sagor) 1
Laško (= Tüffer) 3
Trbovlje (= Trifail) 2
Croatia
Bačin Dol 21
Čučerje 9
Donja Voća 5
Gradina 23
Grahovljani 20
Croatia (cont.)
Kaznica Potok, near Seki Dakovački 25
Jelov Potok 22
Mesareki Brijeg, near Daruvar 19
Podsused 8
Popov Dol-Poljanica 7
Repušnica Potok 16
Zaprešić Breg 7
Zrinj 15
Bosnia-Herzegovina
Bosanska Kostajnica 15
Magajic-Poljane 30
Una river, Bosanski Novi
(= Bosnisch Novi) 17
Serbia & Montenegro
Golubec 38

Figure 7b: Neogene echinoderm localities in Bosnia & Herzegovina, Croatia, Serbia & Montenegro, and Slovenia. Former names used in the older literature are given in brackets.



Poland					
Busko	6	Świniary	11	Monastyrek (= Monastyrz)	19
Chomentów	4	Szczawnyca	9	Mykolaiv (= Mikołajów)	23
Huta Lubycka	17	Trzęsiny	15	Pidhirtsi (= Podhorce)	29
Huta Różaniecka	15	Wielkszka	16	Pidyarkiv (= Podjarków)	25
Karsy	3	Żerniki	2	Potelych (= Potylicz)	18
Kików	10	**Ukraine**		Radekhiv (= Radziechów)	30
Korytnica	5	Bilka	27	Szuszkowce	32
Nawodzice	13	Glebovychi (= Chłopowice)	24b	Velyki Birky (= Borki Wielkie)	34
Niechobrz	14	Grabnik	21	Vybranivka (= Wybranówka)	24a
Niskowa	16	Krekhiv (= Krechov, = Krechów)	20	Zalesce (= Zalesce)	25
Pińczów	7	Krzywcze Górne (= Krzywczyce)	35	Zbarazh (= Zbaraż)	31
Rybnica	12	Zolochiv district (for. [illegible])	26	Zhukiv (= Żuków, = Żukowce, = Żukowce, = Shukowze)	33
Skowronno	6	Lviv (= Lwów)	22		

Figure 8: Polish and Ukrainian localities mentioned in the text. Former Polish names used in the older literature are given in brackets.



Romania

Armeniş (= Örményes)	31
Bernecebaia	3
Brăteşti	9
Budurni	4
Bujturi (= Bujtur)	18
Cavovalerii (= Cavovei, = Kákovei)	19
Covăsinţ (= Kovaszi, = Kovaszinc)	10
Chechiş	2
Ciceu-Hăşmaş	5
Cioit	4
Coştei de Sus (=Kostéj)	14
Cricău (= Krakkó)	25b
Gârbova (= Szász-Orbó)	26
Gârbova de Sus (= Girbova de Sus, = Felső-Orbó)	25a
Globu Craiovei (= Globukrajova)	34
Iablaniţa (= Bélajablánc, = Jablanica)	35
Ilteu	13
Lăpugiu de Sus (= Felsőlapugy, = Lapugy)	15
Livezile (= Urháza, = Vladháza)	24
Lugoj	28
Luncaviţa (= Lunkavica)	32
Mănăstirea Polovragi (= Kloster Polowratsch)	36
Mehadica (= Mehadia, = Mehadika)	33
Mirşel (= Kresztamenes)	12
Mirşu de Sus (= Felménes)	11
Moldoveneşti (= Várfalva)	21
Murfatlar, Basarabi	38
Racniş (= Oláh-Rákos, = Oláhrákos)	23
Petnic (= Petnik)	s.w. 34 and 35
Pietroasa (= Csegez)	22
Ribicioara (= Ribice)	16
Ruci-Delineşti	29
Sălişte (= Szelistye)	13
Sânduleşti (= Szind)	20
Sîg (= Ság, = Sag)	6
Slatina-Timiş (= Temes-Szlatina)	30
Ţărăţel (= Cerecel, = Czerecel)	17
Ţaşad (= Tasad)	8
Tusa (= Tusza)	7
Valea Satului	3
Valeni	1

Bulgaria

Bivolare	44
Ochrid	39
Opanec	43
Palilula	41
Tamene	42
Urovene	40

Figure 9: Romanian and Bulgarian localities mentioned in the text. Former Hungarian names used in the older literature are given in brackets.

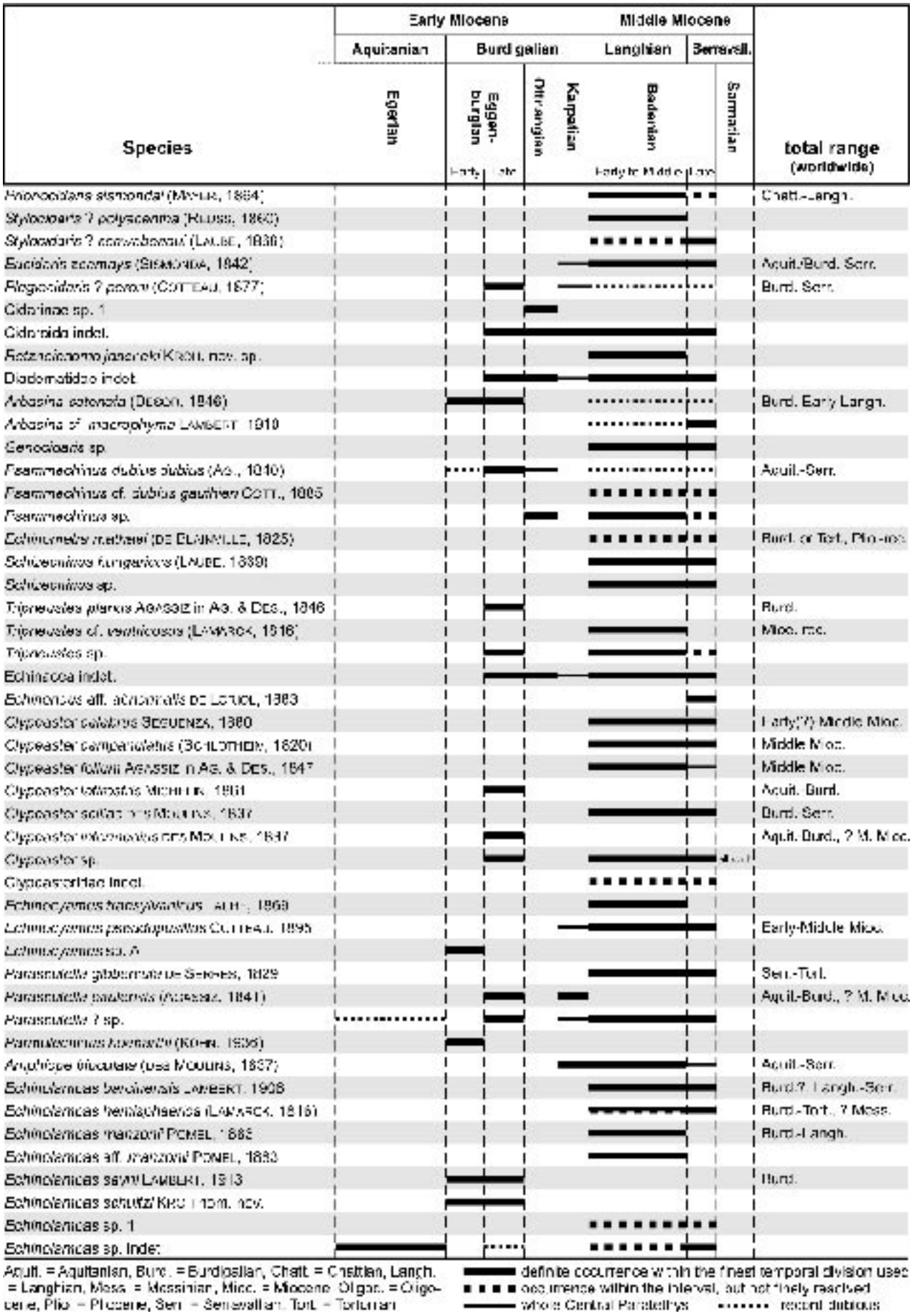


Table 2. List of accepted taxa and their ranges (arranged systematically).

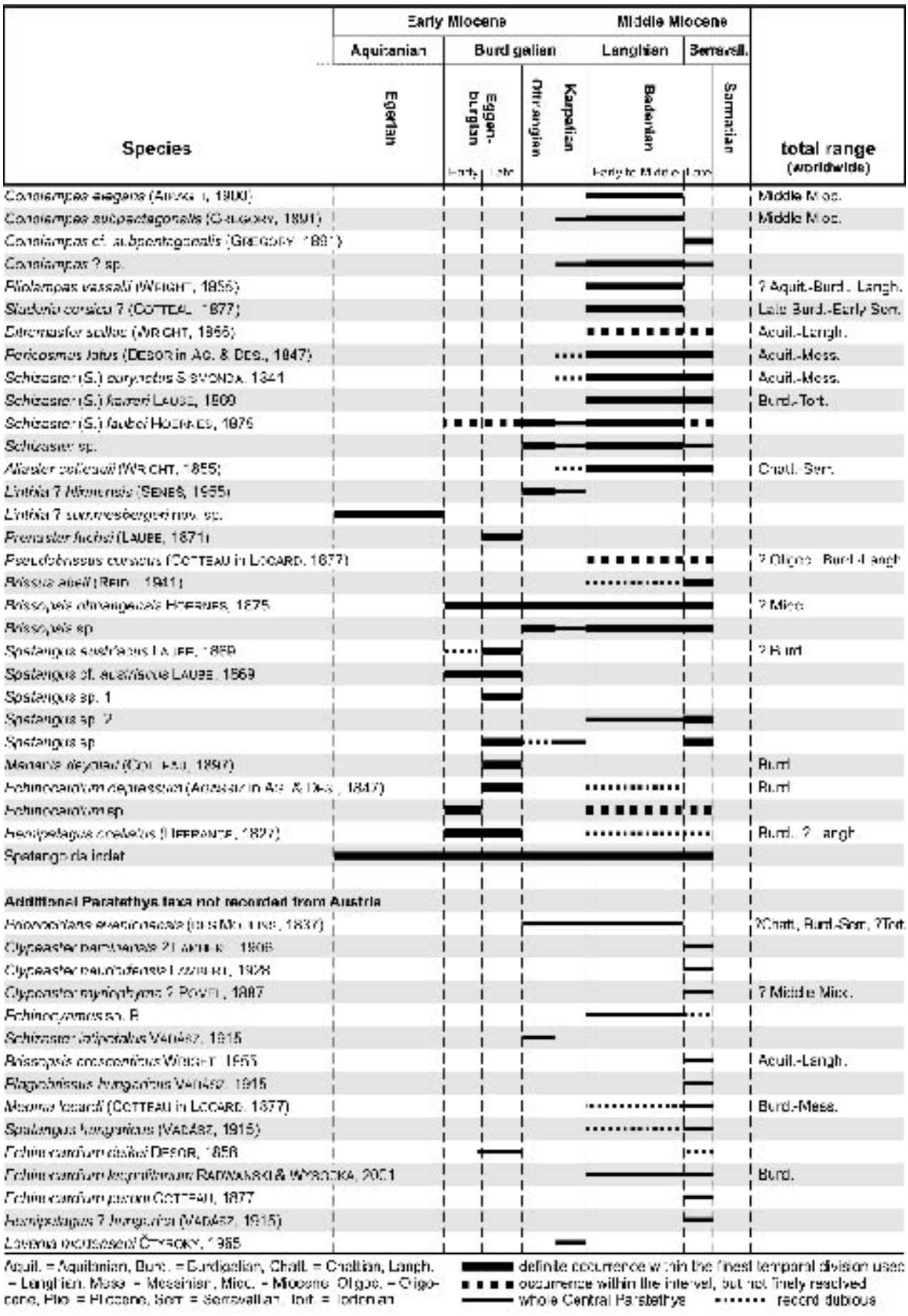


Table 2. List of accepted taxa and their ranges (arranged systematically) (continued).

species	first recorded by	remarks
Austria		
"Prionechinus" felmenesensis LAMBERT & THIÉRY, 1911	LÓCZY, 1877 (as *Echinus* cf. *dux*)	probably conspecific with *Arbacina* cf. *macrophyma*
"Prionechinus" loczyi LAMBERT & THIÉRY, 1911	LÓCZY, 1877 (as *Ps.* cf. *monilis*)	only known specimen is lost; description and illustration insufficient for revision
Echinocyamus calariensis (LAMBERT, 1908)	VADÁSZ, 1915	few specimens known, which are usually poorly preserved; needs to be substantiated
"Hemiaster" kalksburgensis LAUBE, 1869	LAUBE, 1869	type material lost; description and illustration insufficient for revision
Schizaster desori WRIGHT, 1955	LAUBE, 1869	reference material lost, illustration and description insufficient; not recorded for more than 120 year from the Central Paratethys
Central Paratethys		
"Fibularia" sandalina SZÖRÉNYI, 1953	SZÖRÉNYI, 1953	type specimen (only specimen known) not seen, illustration and description are poor; needs to be re-described
Clypeaster angustus POMEL, 1887	VADÁSZ, 1915	reference material not located, description insufficient, record doubtful
Clypeaster coronalis LAMBERT, 1913	VADÁSZ, 1915	reference material not located, record doubtful
Clypeaster martini DES MOULINS, 1837	MEZNERICS, 1941	sole record; needs to be confirmed
Clypeaster megastoma mediterraneus VADÁSZ, 1915	VADÁSZ, 1915	probably a misidentified *Clypeaster scillae*
Clypeaster cf. *latirostris laganoides* AGASSIZ	MEZNERICS, 1941	sole record; needs to be confirmed
Clypeaster cf. *parvituberculatus* POMEL, 1887	VADÁSZ, 1915	based on poorly preserved material, not illustrated, description insufficient for revision
Clypeaster cf. *petalodes* POMEL, 1887	VADÁSZ, 1915	reference material not located, description insufficient, record doubtful
"Scutella" eichwaldi SZÖRÉNYI, 1953	SZÖRÉNYI, 1953	probably conspecific with *Parascutella gibbercula*
"Scutella" cf. leoganensis LAMBERT, 1903	SZÖRÉNYI, 1953	illustration and description poor, might be conspecific with *Parascutella gibbercula*
Parascutella ? *guebhardi* (LAMBERT, 1915)	KÓKAY, 1988b	mentioned without description or illustration, needs to be confirmed
Parascutella ? *lusitanica* (DE LORIOL, 1896)	KÓKAY, 1988b	mentioned without description or illustration, needs to be confirmed
Echinolampas dacica VADÁSZ	VADÁSZ, 1915	no specimens seen, but species seems to be closely related, if not synonymous with *Echinolampas hemisphaerica*
Echinolampas dacica humilis VADÁSZ	VADÁSZ, 1915	see under *Echinolampas dacica*
Echinolampas dumasi COTTEAU, 1893	VADÁSZ, 1915	record based on a single specimen, variation unknown; might be a separate species or an abnormal *E. hemisphaerica*
Echinolampas italicus LAMBERT, 1906	VADÁSZ, 1915	material not seen, difficult to differentiate from flat specimens of *E. hemisphaerica*
Echinolampas percrassus MEZNERICS, 1941	MEZNERICS, 1941	needs to be re-described; could also be a very high *E. manzonii* or a juvenile *Conolampas*
Pliolampas gauthieri (COTTEAU, 1880)	SZÖRÉNYI, 1953	unconfirmed, reported to co-occur with eight other closely related species, each represented by a single specimen (revision necessary)
"Tristomanthus" angulosus (MAZZETTI, 1885)	SZÖRÉNYI, 1953	see under *Pliolampas gauthieri*
"Tristomanthus" aremoricus (BAZIN, 1884)	SZÖRÉNYI, 1953	see under *Pliolampas gauthieri*
"Tristomanthus" fischeuri (POMEL, 1887)	SZÖRÉNYI, 1953	see under *Pliolampas gauthieri*
"Tristomanthus" meslei (GAUTHIER, 1886)	SZÖRÉNYI, 1953	see under *Pliolampas gauthieri*
"Tristomanthus" podolicus SZÖRÉNYI, 1953	SZÖRÉNYI, 1953	see under *Pliolampas gauthieri*
"Tristomanthus" subcylindricus (AGASSIZ, 1846)	SZÖRÉNYI, 1953	see under *Pliolampas gauthieri*
Hemiaster sp.	HILBER, 1882	doubtful record without description or illustration
Pericosmus airaghii LAMBERT, 1909	SENEŠ, 1955	doubtful record without description or illustration
Schizaster cf. *scillae* DES MOULINS, 1837	VADÁSZ, 1915	specimens poorly preserved, identification doubtful
Schizaster cf. *parkinsoni* (DEFRANCE)	VADÁSZ, 1915	specimens poorly preserved, identification doubtful
"Macropneustes" compressus NEMES, 1888	NEMES, 1888a	description and illustration insufficient for revision, needs to be re-described
Spatangus delphinus DEFRANCE, 1827	VADÁSZ, 1915	reference material not located; description and illustration insufficient for revision
Spatangus desmaresti MÜNSTER in GOLDFUSS, 1829	EICHWALD, 1852	species from the Oligocene of Northern Germany; reported without sufficient description or illustration; needs to be confirmed
Spatangus fabianii ? (LAMBERT, 1924)	SZÖRÉNYI, 1953	material needs to be re-examined to confirm identification
Spatangus fothiensis (STRAUSZ, 1926)	STRAUSZ, 1926	type material lost; new material needed
Spatangus hungaricus buekkensis (KUTASSY, 1928)	KUTASSY, 1928	holotype (only specimen available) poorly preserved; needs to be re-described
Spatangus peroni COTTEAU in LOCARD, 1877	VADÁSZ, 1915	record based on single poorly preserved specimen; unconfirmed
Spatangus pustulosus WRIGTH, 1864	MEZNERICS, 1941	identification doubtful, needs to be confirmed
Spatangus cf. *delphinus* DEFRANCE, 1827	MĄCZYŃSKA, 1988	description and illustration insufficient for revision
Spatangus cf. *corsicus* COTTEAU, 1877	VADÁSZ, 1915	record based on poorly preserved material; unconfirmed
Spatangus sp. 3	MAJCEN et al., 1997	mentioned as *S. austriacus*, but clearly not conspecific with any known *Spatangus* species from the Central Paratethys; provenance unknown
Echinocardium intermedium LÓCZY, 1877	LÓCZY, 1877	RADWAŃSKI & WYSOCKA (2001) questioned the generic attribution; needs to be re-described

Table 3. Doubtful records of Neogene echinoids from Austria and the Central Paratethys (arranged systematically).

species	first recorded by	reason for rejection
acuminatus DESOR, *Clypeaster*	MICHELIN, 1861	jun. syn. of *Clypeaster campanulatus*
affinis LAUBE, *Pericosmus*	LAUBE, 1869	type material lost, tentatively placed into the synonymy of *Aliaster cotteauii*
airaghii LAMBERT, *Clypeaster*	SCHOUPPÉ, 1947	unconfirmed, likely to be a misidentification
alticostatus MICHELIN, *Clypeaster*	MICHELIN, 1861	jun. syn. of *Clypeaster campanulatus*
altus LAMARCK, *Clypeaster*	KARRER, 1868	misidentified *Clypeaster campanulatus*, respectively *C. scillae* (some of the later records)
altus conicus, *Clypeaster*	QUENSTEDT, 1874	misidentified *Clypeaster campanulatus*
angulare altum KLEIN, *Scutum* [*Clypeaster*]	KNORR / WALCH, 1771	*Clypeaster campanulatus*
angulatus oblonus VADÁSZ, *Clypeaster*	TOLLMANN, 1955	jun. syn. of *Clypeaster campanulatus*
angulata MÉRIAN, *Echinolampas*	VADÁSZ, 1915	misidentified *Echinolampas manzonii*
angustistellatus LAUBE, *Echinolampas*	LAUBE, 1869	nomen dubium (type material not unambiguously identified, probably hybrid species of *Echinolampas sayni* and *E. schultzi*)
catenata (DESOR), *Genocidaris*	KROH, 2003a	misidentified; material belongs to *Genocidaris* sp.
crassicostatus AGASSIZ, *Clypeaster*	ANDRAE, 1855	nomen nudum, misidentified *Clypeaster scillae*
cucurbites MERCATI, *Echinus*	STÜTZ, 1807	pre-Linnéan taxon, mentioned without description or illustration
desori REUSS, *Diadema*	REUSS, 1860	isolated spines of diadematids, undeterminable below family level
duciei WRIGHT, *Echinus, Psammechinus, Schize.*	LAUBE, 1869	misidentified *Schizechinus hungaricus*
dux LAUBE, *Echinus, Schizechinus*	LAUBE, 1869	junior synonym of *Schizechinus hungaricus*
elliptica DESOR, *Amphiope*	LAUBE, 1869	jun. syn. of *Amphiope bioculata*
euglyphus LAUBE, *Spatangus*	LAUBE, 1869	not conspecific with type material; referred to *Spatangus* aff. *austriacus* here
extraalpinus SCHAFFER, *Psammechinus*	SCHAFFER, 1912	junior synonym of *Psammechinus dubius dubius*
floridus MERCATI, *Echinus*	STÜTZ, 1807	pre-Linnéan taxon, mentioned without description or illustration
faujasii DEFRANCE, *Scutella*	FUCHS, 1869	misidentified *Parascutella gibbercula*
gibbosus DE SERRES, *Clypeaster*	MICHELIN, 1861	misidentified *Clypeaster campanulatus*
grandiflorus BRONN, *Clypeaster*	BRONN, 1837	jun. syn. of *Clypeaster scillae*
grateloupii SISMONDA, *Schizaster*	HOERNES, 1875a, b	misidentified *Linthia* ? *hlinnensis*
gregoryi LAMBERT, *Clypeaster*	SCHOUPPÉ, 1947	unconfirmed, likely to be a misidentification
hemisphaericus rhodensis LAUBE, *Echinolampas*	LAUBE, 1869	Paratethyal records belong to *Echinolampas hemisphaerica*, name restricted to material from the Pliocene of Rhodes island
hirta SISMONDA, *Cidaris*	PETERS, 1857	doubtful record, Pliocene species [jun. syn. of *Histocidaris rosaria* (BRONN)]; Paratethyal material are probably misidentified *Stylocidaris* ? *polyacantha* spines
hungaricus VADÁSZ, *Echinolampas*	TOLLMANN, 1955	jun. syn. of *Conolampas elegans*
kalksburgensis WIESBAUR, *Scutella*	WIESBAUR, 1874	jun. syn. of *Parascutella gibbercula*
kleinii GOLDFUSS, *Echinolampas*	FUCHS, 1868	misidentified *Echinolampas schultzi*
laubei LAMBERT, *Amphiope*	LAMBERT, 1912	jun. syn. of *Amphiope bioculata*
laurillardi AGASSIZ, *Echinolampas*	LAUBE, 1869	misidentified *Echinolampas schultzi* (Eggenburgian records) or *E. hemisphaerica* (Badenian records)
laurillardi acuminata SCHAFFER, *Echinolampas*	SCHAFFER, 1912	= *Echinolampas schultzi* nom. nov. (preoccupied by *E. acuminata* ABICH, 1882, after raising to species rank)
leithanus LAUBE, *Schizaster*	LAUBE, 1869	jun. syn. of *Schizaster* (*S.*) *eurynotus*
linkii GOLDFUSS, *Clypeaster, Echinolampas*	GOLDFUSS, 1829	jun. syn. of *Echinolampas hemisphaerica*; Eggenburgian specimens referred to this species by later authors belong to *E. schultzi*
marginatus ? LESKE, *Echinanthus* [*Clypeaster*]	SEDGWICK & MURCHISON, 1831	misidentified *Clypeaster* sp.
media SCHAFFER, *Scutella*	SCHAFFER, 1962	jun. syn. of *Parascutella paulensis*
michelotti AGASSIZ, *Clypeaster*	MICHELIN, 1861	misidentified *Clypeaster campanulatus*
miocaenicus SCHAFFER, *Brissus* (*Allobrissus*)	SCHAFFER, 1961	jun. syn. of *Brissus abeli*
mirabilis NICOLET, *Psammechinus*	LAUBE, 1869	misidentified *Psammechinus* cf. *dubius gauthieri* and/or *Schizechinus hungaricus*
monilis DESMAREST, *Echinus, Psammechinus*	LAUBE, 1869	misidentified *Psammechinus* cf. *dubius gauthieri*
multiconcava SCHAFFER, *Scutella*	SCHAFFER, 1962	jun. syn. of *Parascutella gibbercula*, robust morphotype
papillata LESKE, *Dorocidaris*	MANZONI, 1880	extant species [jun. syn. of *Cidaris cidaris* (LINNÉ), not conspecific with *Stylocidaris* ? *schwabenaui*]; later records are misidentified *S.* ? *schwabenaui* or *S.* ? *polyacantha* spines
parkinsoni DEFRANCE, *Schizaster*	LAUBE, 1869	misidentified *Schizaster* (*S.*) karreri
partschii MICHELIN, *Clypeaster*	MICHELIN, 1861	jun. syn. of *Clypeaster campanulatus*
perornatus SCHAFFER, *Spatangus, Maretia*	SCHAFFER, 1912	jun. syn. of *Hemipatagus ocellatus*
perspicillata AGASSIZ, *Amphiope*	LAUBE, 1869	misidentified *Amphiope bioculata*
plagiosomus AGASSIZ, *Conoclypus, Echinolampas*	LAUBE, 1869	= *Conolampas subpentagonalis* (not conspecific with type material of *C. plagiosomus*); some later records are misidentified *C. elegans*
portentosus MICHELIN, *Clypeaster*	MICHELIN, 1861	jun. syn. of *Clypeaster campanulatus*
pusillus MÜLLER, *Echinocyamus*	VINASSA de REGNY, 1897	extant species, not conspecific with *Echinocyamus transylvanicus*
pyramidalis MICHELIN, *Clypeaster*	MICHELIN, 1861	jun. syn. of *Clypeaster campanulatus*
rotundus LAUBE, *Hemiaster*	LAUBE, 1869	jun. syn. of *Ditremater scillae*
rosaceus, *Echinus* [*Clypeaster*]	STÜTZ, 1807	extant species (*Clypeaster rosaceus*, Caribbean), misidentified *Clypeaster* sp.
scillae DES MOULINS, *Schizaster*	LAUBE, 1869	misidentified *Schizaster* (*S.*) *eurynotus*
serresii DES MOULINS, *Echinus, Psammechinus*	LAUBE, 1869	misidentified *Schizechinus hungaricus*
styriaca HOERNES, *Amphiope*	HOERNES, 1883	jun. syn. of *Amphiope bioculata*, large morphotype
styriaca SCHAFFER, *Scutella*	SCHAFFER, 1962	jun. syn. of *Parascutella gibbercula*
subfolium POMEL, *Clypeaster*	KAZÁR, 2002	jun. syn. of *Clypeaster folium*
subpartschi SCHAFFER, *Clypeaster*	SCHAFFER, 1912	jun. syn. of *Clypeaster intermedius*
ventiencis vindobonensis LAMBERT, *Clypeaster*	LAMBERT, 1912	jun. syn. of *Clypeaster latirostris*
ventricosus austriacus TAUBER, *Tripneustes*	TAUBER, 1951	validity of ssp. remains to be shown; *Tripneustes* cf. *ventricosus* (LAMARCK, 1816)

Table 4. List of rejected Neogene echinoids from Austria (species arranged alphabetically).