

Sharks and guitarfishes (Elasmobranchii) from the Late Jurassic of Europe

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Abstract

Fossil elasmobranchs are exceptionally well preserved in the Late Jurassic Plattenkalk Fossillagerstätten of S Germany (Eichstätt/Solnhofen-, Nusplingen-area) and SE France (Cerin). Fossil collections in the Bayerische Staats-sammlung für Paläontologie und Geologie, München, Bürgermeister-Müller-Museum, Solnhofen, Jura-Museum Eichstätt, Musée des Confluences, Lyon, Natural History Museum, London, Paläontologische Forschungs-, Lehr- und Schausammlung, Institut für Geowissenschaften der Universität Tübingen, Paläontologisches Institut und Museum der Universität Zürich, Staatliches Museum für Naturkunde, Stuttgart, and Université Catholique, Lyon document the presence of all major groups of elasmobranchs (hybodonts, squalomorphs, squatinimorphs, galeomorphs and batomorphs) in the Plattenkalk ichthyofauna. Of this material 48 articulated and identified specimens of Plattenkalk sharks and guitarfishes were sampled for dermal denticles and oral teeth. Sampled taxa comprise *Hyodus fraasi* BROWN, 1900, *Notidanoides muensteri* (AGASSIZ, 1843), *Protospinax annectans* WOODWARD, 1919, *Pseudorhina alifera* (MÜNSTER, 1842), *Pseudorhina acanthoderma* (FRAAS, 1854), *Pseudorhina* sp., *Paracestracion falcifer* (WAGNER, 1857), *Heterodontus zitteli* (EASTMAN, 1911), *Phorcynis catulina* THIOLLIÈRE, 1852, *Phorcynis* sp., *Palaeocarcharias stromeri* DE BEAUMONT, 1960, *Bavariscyllum tischlingeri* THIES, 2005, *Palaeoscyllium formosum* WAGNER, 1857, *Palaeoscyllium* ? sp., *Corysodon cirinensis* SAINT-SEINE, 1949, *Synechodus* sp., *Paraorthacodus jurensis* (SCHWEIZER, 1964), *Paraorthacodus* sp., *Sphenodus macer* (QUENSTEDT, 1851), *Sphenodus nitidus* WAGNER, 1862, *Asterodermus platypterus* AGASSIZ, 1843, *Asterodermus* sp., *Belemnobatis sismondae* THIOLLIÈRE, 1852, and *Spathobatis bugesiacus* THIOLLIÈRE, 1852. The extracted denticles and teeth were studied and photographed with a SEM in order to reveal the inter- and intraspecific morphological variation of these hard parts. The morphological data are compiled in a catalogue of 100 plates which will serve for a better identification of isolated dermal denticles and teeth of Late Jurassic and other fossil elasmobranchs (found, for example, in washing residues) as well as a database for the study of elasmobranch evolution.

Keywords: Chondrichthyes, Hybodontiformes, Neoselachii, Late Jurassic, lithographic limestones, Germany, France.

Zusammenfassung

Aus den oberjurazeitlichen Plattenkalke von S-Deutschland (Eichstätt/Solnhofen, Nusplingen) und SE-Frankreich (Cerin) kennt man hervorragend erhaltene, artikulierte Skelette von Elasmobranchiern. Die Sammlungen der Bayerischen Staatssammlung für Paläontologie und Geologie, München, des Bürgermeister-Müller-Museums, Solnhofen, des Jura-Museums Eichstätt, des Musée des Confluences, Lyon, des Natural History Museum, London, der Paläontologischen Forschungs-, Lehr- und Schausammlung des Instituts für Geowissenschaften der Universität Tübingen, des Paläontologischen Instituts und Museums der Universität Zürich, des Staatlichen Museums für Naturkunde, Stuttgart und der Université Catholique, Lyon, belegen das Vorkommen aller Großgruppen der Elasmobranchier (Hybodontiformes, Squalomorphii, Squatinimorphii, Galeomorphii, Batomorphii) in der Plattenkalk-Ichthyofauna. Aus diesem Material wurden 48 systematisch zugeordneten Skeletten von Haien und Geigenrochen Haut- und Kieferzähne entnommen. Die Zähnchen wurden mit dem Rasterelektronenmikroskop untersucht und fotografiert, um das Spektrum der zwischen- und innerartlichen morphologischen Variabilität dieser Hartteile offen zu legen und zu dokumentieren. Die für die Untersuchung ausgewählten Skelette gehören zu folgenden Taxa: *Hyodus fraasi* BROWN, 1900, *Notidanoides muensteri* (AGASSIZ, 1843), *Protospinax annectans* WOODWARD, 1919, *Pseudorhina alifera* (MÜNSTER, 1842), *Pseudorhina acanthoderma* (FRAAS, 1854), *Pseudorhina* sp., *Paracestracion falcifer* (WAGNER, 1857), *Heterodontus zitteli* (EASTMAN, 1911), *Phorcynis catulina* THIOLLIÈRE, 1852, *Phorcynis* sp., *Palaeocarcharias stromeri* DE BEAUMONT, 1960, *Bavariscyllum tischlingeri* THIES, 2005, *Palaeoscyllium formosum* WAGNER, 1857, *Palaeoscyllium* ? sp., *Corysodon cirinensis* SAINT-SEINE, 1949, *Synechodus* sp., *Paraorthacodus jurensis* (SCHWEIZER, 1964), *Paraorthacodus* sp., *Sphenodus macer* (QUENSTEDT, 1851), *Sphenodus nitidus* WAGNER, 1862, *Asterodermus platypterus* AGASSIZ, 1843, *Asterodermus* sp., *Belemnobatis sismondae* THIOLLIÈRE, 1852 und *Spathobatis bugesiacus* THIOLLIÈRE, 1852. Die so gewonnenen morphologischen Daten wurden in einem Katalog mit 100 Tafelabbildungen zusammengestellt. Der Katalog stellt eine Grundlage für die systematischen Zuordnung isoliert aufgefunderner Haut- und Kieferzähne oberjurazeitlicher und anderer Haie und Rochen (z. B. aus Schlammrückständen) sowie eine Datenbank für evolutive Betrachtungen der Elasmobranchier dar.

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1. Introduction

The evolutionary history of the neoselachians is traced back to the Early Mesozoic on the basis of tooth enameloid structure (THIES 1982), or even into the Palaeozoic on the basis of overall dental morphology (DUFFIN & WARD 1983; DUFFIN et al. 1996; TURNER & YOUNG 1987). Most of the neoselachian fossil record is confined to isolated oral teeth and dermal denticles. They are considered as microvertebrate remains together with isolated embedded teeth, scales and otoliths of bony fishes.

Exceptions are provided by the articulated fossil sharks and rays discovered in e.g., the Lower Jurassic deposits of Lyme Regis in England, the Lower Jurassic *Posidonia* Shale of Southern Germany, and the Upper Jurassic lithographic limestones (Plattenkalke) of Southern Germany and France. The Plattenkalke in particular have yielded numerous well preserved articulated skeletons of neoselachians.

The scientific study of these fishes started with the use of the Plattenkalke for lithographic purposes soon after the invention of the lithographic printing technique by A. SENEFFELDER in 1798. The works of AGASSIZ (1843) and MÜNSTER (1842), for example, give evidence of early findings of Plattenkalk selachians in Southern Germany. A little later, THIOLLIÈRE (1849) became interested in the fossil sharks and rays from the French Plattenkalke.

The French material is dominated by fossil guitarfishes (genera *Spathobatis* THIOLLIÈRE, 1849 and *Belemnobatis* THIOLLIÈRE, 1852) described in detail by SAINT-SEINE (1949) and revised by CAVIN et al. (1995) with respect to the guitarfishes. The German Upper Jurassic Plattenkalk material includes more specimens of sharks by far than of batoids, and a number of neoselachian species have been described (EASTMAN 1911; FRAAS 1854; MEYER 1859; MÜNSTER 1842; SCHWEIZER 1964; WAGNER 1857, 1862; WOODWARD 1889, 1898, 1918). These descriptions are now outdated and insufficient and do not match modern

taxonomic demands. Excepting SCHWEIZER, the authors lacked modern optical equipment and so could not consider dental morphology in any detail. However, tooth morphology has turned out since then to be the most important criterion in the taxonomy of extinct neoselachians because oral teeth form the most frequent fossil remains of these fishes. More recently, *Squatina* DUMÉRIL, 1806, *Synechodus* WOODWARD, 1889, *Paraorthacodus* GLICKMAN, 1957, *Sphenodus* AGASSIZ, 1843, and *Macrourogaleus* FOWLER, 1947 from the Plattenkalke were restudied by DUFFIN (1993a, b), BÖTTCHER & DUFFIN (2000), CARVALHO et al. (2008), KLUG (2008, 2009, 2010), and KLUG et al. (2009). To this, THIES (2005) and KRIWET (2008a, b) added the descriptions of three new galeomorph shark species. The remainder of the neoselachian taxa of the Southern German lithographic limestones is, however, still in urgent need of revision as shown by LEIDNER & THIES (1999) and KRIWET & KLUG (2004). In most of these taxa the morphology of the oral teeth and dermal denticles is only little known or even unknown. The shape and position of the fins are often obscured by post mortem and taphonomic processes. Specimens may have lost whole or part fins after death and/or were embedded in the sediment in such a way that some of their fins are only partially observable or even not discernable at all in the fossil. Fin structure is therefore of only limited value as a taxonomic criterion in many cases.

Thus, in the extensive absence of published data on the morphologies of oral teeth and dermal denticles the identification of neoselachians other than *Pseudorhina* JAEKEL, 1898 from the lithographic limestones is often impossible. The same is true of isolated microremains of these fishes found in different facies outside the Plattenkalk depositional areas. Most specimens of Plattenkalk neoselachians housed in museum or university (or private) collections are therefore misidentified or not identified at all, even though the dentition is preserved in many. In order to improve the taxonomic state of Late Jurassic neoselachians, we started

some time ago to study the dentitions and scales of a number of neoselachian specimens from the Plattenkalke of Germany and France and to collect data on their morphologies. The results of these studies are presented in this catalogue.

Acronyms of repositories

BMMS	Bürgermeister-Müller-Museum Solnhofen, Germany
BSPHG	Bayerische Staatssammlung für Paläontologie und Geologie München (formerly Bayerische Staatsammlung für Paläontologie und Historische Geologie), Germany
FCL	Université Catholique Lyon (formerly Faculté Catholique), France
GPIT	Paläontologische Forschungs-, Lehr- und Schau-sammlung, Institut für Geowissenschaften der Universität Tübingen, Germany
JME (SOS)	Jura-Museum Eichstätt, Germany
MHNL	Musée des Confluences, Lyon (formerly Museum d'Histoire Naturelle), France
NHML	Natural History Museum London, England
PIMUZ	Paläontologisches Institut und Museum der Universität Zürich, Switzerland
SMNS	Staatliches Museum für Naturkunde Stuttgart, Germany

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2. Europe in Late Jurassic times

During Late Jurassic times (~161–145 Ma) the continent today called Europe was situated between 30° and 50° northern latitude neighboured by the landmasses of Laurasia in the west, Eurasia in the East and Gondwana in the South. Most of the area was covered by a shallow epicontinental sea spreading between smaller and larger islands and landmasses (Fig. 1). In Kimmeridgian and Tithonian times southern central Europe consisted of an archipelago comprising amongst others the Ringkøbing-Fyn-High, the Pompeckj Swell, the London-Brabant-Massif, the Rhenish Massif, the Bohemian Massif, and

Amorica (Fig. 1). Within this palaeogeographical setting the famous Fossilagerstätten of Brunn, Eichstätt, Solnhofen and Nusplingen in Southern Germany and Cerin in France formed which have yielded all the fossil selachian material brought together in this publication.

Numerous studies have dealt with various aspects of the Southern German Kimmeridgian/Tithonian Fossilagerstätten. For example, MEYER & SCHMIDT-KALER (1990) summarized the palaeogeography and the evolution of sponge reefs of the Southern German Upper Jurassic. The sedimentology, taphonomy and palaeoecology of the Southern German Kimmeridgian/Tithonian Plattenkalk facies were studied by FÜRSICH et al. (2007) and MUNNECKE et al. (2008). In a beautifully illustrated atlas, FRICKINGER (1994) tried to give an overview of the fossils from the Solnhofen/Eichstätt area he found in public and private collections. In a series of publications RÖPER & ROTHGAENGER (1998a, b), RÖPER et al. (1999), and RÖPER et al. (1996, 2000) documented the fossil fauna and flora of well-known lithographic limestone occurrences in Bavaria (Southern Germany). The most outstanding fossil yielded by the Southern German lithographic limestones is certainly the *Archaeopteryx* which has drawn the attention of many prominent researchers all around the world for a long time now. In a comprehensive book on *Archaeopteryx* WELLNHOFER (2008) also presented reconstructions of the palaeoenvironment, palaeoecology and palaeoclimatology of the Solnhofen/Eichstätt Plattenkalk occurrences. DIETL & SCHWEIGERT (2001) put their focus on the Nusplinger Plattenkalke in Baden-Württemberg (Southern Germany). They briefly outlined the history of research carried out at this locality, described the depositional environment and the fossil content of the Nusplinger Plattenkalke and reconstructed the ancient biotop. SCHWEIGERT (2007) emphasized the different biostratigraphical ages of the various Southern German lithographic limestone occurrences based on ammonite faunal associations. Concerning fishes KRIWET & KLUG (2004, 2008) have reviewed the diversity and biogeography of Late Jurassic European Plattenkalk chondrichthyans.

The quarries near Cerin (Département Ain) are the most prominent Late Jurassic lithographic limestone occurrences in France and represent the French counterpart of the Southern German Fossilagerstätten in the Eichstätt-Solnhofen-Nusplingen area with respect to richness and quality of preservation of Late Jurassic faunas and floras of central Europe. Like the German localities the Plattenkalke of Cerin mirror the biotope and ecosystem of an ancient lagoon in a tropical marine environment. Collecting fossils from the Cerin Plattenkalke has started in the early 19th century and has then culminated in the activities of VICTOR THIOLLIÈRE (e. g., 1849, 1852, 1854). Modern digging campaigns and their results are summarized by PHILIPPE et al. (2004). Their book on Cerin fossils contains

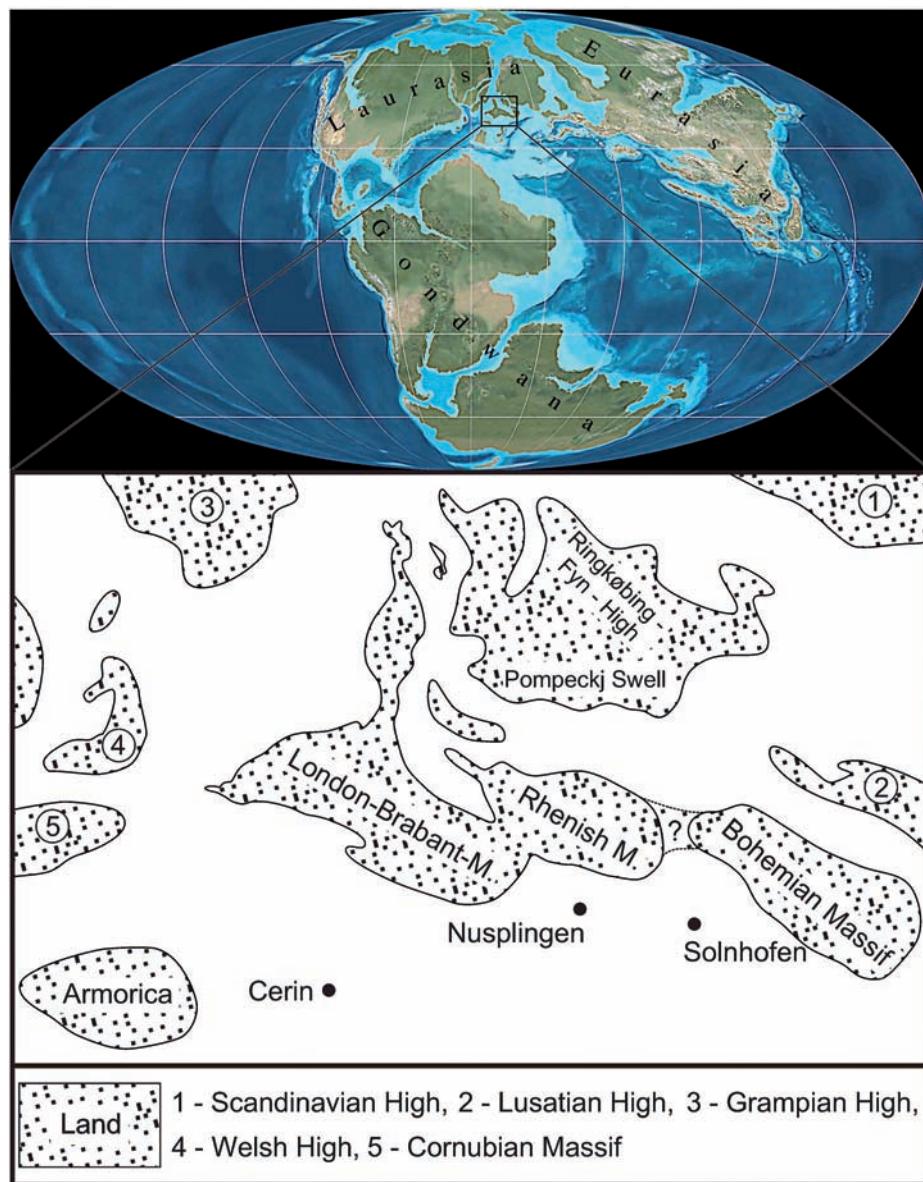


Fig. 1. Late Jurassic palaeogeography. The global map above is a generalized mollewide view of the palaeogeographical situation in the Late Jurassic 150 My BP. The detailed enlargement below shows the palaeogeography of central Europe at Late Jurassic times (Oxfordian/Tithonian) (after BLKEY 2008 and ZIEGLER 1990).

a beautiful colour reconstruction of the ancient lagoonal habitat. The biostratigraphical age of the Cerin Plattenkalke is more difficult to determine than those of the Southern German occurrences. Rare findings of ammonites indicate a Latest Kimmeridgian age or an age at the Kimmeridgian/Tithonian boundary (ENAY et al. 1994). With regard to their biostratigraphical age the Plattenkalke of Cerin are therefore comparable to the Nusplinger Plattenkalke more than to the lithographic limestones of the Eichstätt/Solnhofen occurrences.

3. Material and methods

The material consists of 48 articulated skeletons and skeletal remains of selachians collected from Late Jurassic Plattenkalk localities in Southern Germany and Southeast France and which are deposited in European palaeontological museums. With one exception (*Hybodus fraasi*) the entire material represents neoselachian sharks and guitarfishes (Tab. 1).

When the authors inspected museum collections in the nineties of the last century for Late Jurassic elasmobranch specimens being suited for the study of dermal denticles and oral teeth associated with the skeletal remains, they found that almost all of the specimens in question apart from type material were either misidentified or not identified at all. The space on the labels for notes indicating specimen identity were either left open or yielded confusion or provided wrong information. This was mainly caused by the fact that the systematics of fossil elasmobranchs is mostly based on dental morphology. Fossil articulated specimens in museum collections, however, often do not display oral teeth. In many cases the teeth were not prepared and sometimes they were not preserved at all. Fossil selachians from the Plattenkalke are of considerable economical value, and it was therefore very difficult in earlier times to convince museum curators that additional preparation was necessary on many specimens to reveal their tooth morphology in order to enable systematical identification. Preparation of the dentition often means partial (even though minor) destruction of the skull of the specimen concerned and curators were therefore very skeptical against such ideas leaving specimens of fossil articulated elasmobranchs in museum collections in their care mostly mis- or unidentified.

The situation improved in the nineties of the last century when museum curators began to understand that specimens of Plattenkalk selachians are of only minor scientific value without a proper systematic identification. We therefore got permission to extract dermal denticles and oral teeth of selected specimens of selachians from the German and French Plattenkalke in order to prepare this catalogue. Since then the works of KLUG (2008, 2009, 2010), KLUG et al. (2009), KRIWET (2008a, b), KRIWET & KLUG (2004), LEIDNER & THIES (1999), and THIES (2005) have considerably improved the systematics of neoselachian sharks from the lithographic limestones. With respect to Late Jurassic neoselachian rays the situation is, however, still very unsatisfying. The genera *Asterodermus*, *Belemnobatis*, and *Spathobatis* are in an urgent need of revision.

The extraction of isolated oral teeth and dermal denticles from articulated specimens was done by acid preparation which can preferably be applied on phosphatic fossils such as denticles and teeth in a carbonate matrix. For sampling of denticles and teeth selected areas of the skin and jaws, repectively, of a specimen concerned were covered and protected by an acetone-soluble lacqueur. In the centre of this lacqueur-covering a little spot was left uncovered and unprotected. A circular wall of plasticine was then built around this spot, and the little tray formed this way was filled up with a 5 to 10 % acetic acid, which was buffered with calcium phosphate. The acid dissolves the carbonate matrix at the unprotected bottom of the little tray and unhinges enclosed phosphatic remains. In most

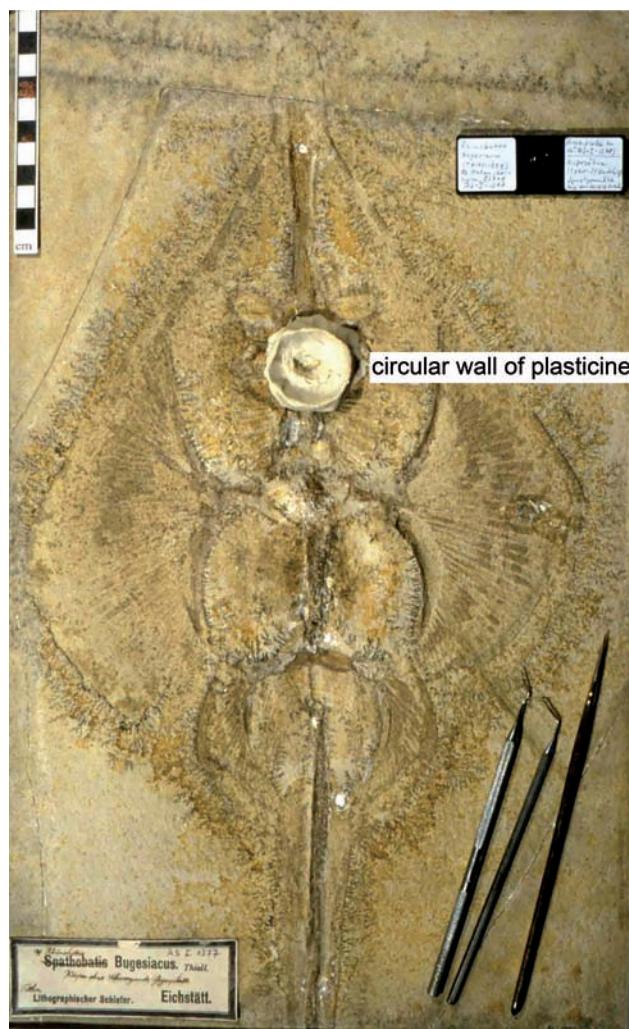


Fig. 2. A specimen of Late Jurassic guitarfish (*Asterodermus* sp., BSPHG AS-I-1377) is sampled for oral teeth. The sampling area is covered with a protective lacqueur apart from a little spot in the middle right above the dentition near the symphysis which is left uncovered. Around this spot a circular wall of plasticine is built in order to form a little tray lacking the bottom. The tray is filled with acetic acid. Unhinged teeth are collected with a brush and retained in a plastic container (upper right corner).

cases application of acid had to be repeated several times. After acid treatment was finished the exhausted acid solution was removed with a pipette, the spot was washed with water and loose parts – dermal denticles, teeth – were collected with a brush and kept in little plastic containers. The sampling procedure is illustrated by Fig. 2. Sampling usually left bright spots on the specimens because the acid removed dirt covering the surface of the specimen and some matrix, of course. These conspicuous bright spots were dyed with watercolour after sampling so that they did not stand out anymore and give the specimen an undamaged aged appearance.

4. The localities

The elasmobranch remains originate from the localities listed below. The localities are arranged according to their age.

4.1. Southern Germany

The administrative district of Eichstätt in Bavaria (S Germany) comprises numerous small fossiliferous Plattenkalk sites including the area around Solnhofen. Many of the historic sites have never been described properly, with their exact locations being obscure today. The localities mentioned on the labels of the specimens studied are mostly (abandoned) Plattenkalk quarries at or near small villages which are nowadays districts of larger communities. The city of Eichstätt (geographical position: 48° 54' N, 11° 11' E) situated in the centre of Bavaria approximately half way between Munich and Nuremberg is well suited as a reference point for finding the other localities listed below on actual maps. (Also, the geographical position of most of the localities mentioned can easily be traced on the internet web site of "google maps".)

Formerly, the age of the Southern German Plattenkalk localities were commonly given as "Tithonian" or "Kimmeridgian". The localities were, however, long suspected to vary in age. In recent years SCHWEIGERT & GARASSINO (2003) and SCHWEIGERT (2007) have succeeded in determining exact biostratigraphical ages of the Plattenkalk localities by studying ammonite faunal associations. According to these authors Plattenkalk occurrences in the Solnhofen area in general belong into the Early Tithonian whereas the occurrences in the Eichstätt area are slightly older being Earliest Tithonian in age. The Nusplingen Plattenkalk is even older and is placed into the Late Kimmeridgian. The biostratigraphical ages indicated for the localities in the list below and in Table 1 are taken from SCHWEIGERT & GARASSINO (2003) and SCHWEIGERT (2007).

Solnhofen

Geographic position: Quarries around the city of Solnhofen, 13 km west of Eichstätt.

Age: Late Jurassic, Early Tithonian, Hybonotum Zone, Ruepellianus Subzone, *rueppellianus* horizon. In the earlier literature (WOODWARD 1889; MAISEY 1976) fossil elasmobranchs from the Solnhofen Plattenkalke housed in the Natural History Museum in London were erroneously described as being "Kimmeridgian" or even "Lower Kimmeridgian" in age.

Langenaltheim

Geographic position: Abandoned quarries at the community of Langenaltheim 5 km west of Solnhofen, 18 km west of Eichstätt.

Age: Late Jurassic, Early Tithonian, Hybonotum Zone, Ruepellianus Subzone, *rueppellianus* horizon.

Kelheim or Kehlheim

Geographic position: Quarries near the city of Kelheim, 40 km east of Eichstätt and 20 km southwest of Regensburg.

Age: Late Jurassic, Early Tithonian, Hybonotum Zone, Ruepellianus Subzone, *riedlingensis* horizon.

Eichstätt

Geographic position: Abandoned quarries at the city of Eichstätt in the centre of Bavaria, half way between Munich and Nuremberg.

Age: Late Jurassic, Early Tithonian, Hybonotum Zone, Riedense Subzone (upper part), horizon still unnamed. Like fossil fishes from Solnhofen specimens coming from the Plattenkalke of Eichstätt were also erroneously described as being "Kimmeridgian" or "Lower Kimmeridgian" in age in the earlier literature (WOODWARD 1889; MAISEY 1982; DUFFIN 1988).

Birkhof

Geographic position: Abandoned quarry at Birkhof, district of the community of Schernfeld, 2.5 km northwest of Eichstätt.

Age: Late Jurassic, Early Tithonian, Hybonotum Zone, Riedense Subzone (upper part), horizon still unnamed.

Blumenberg

Geographic position: Abandoned quarry at Blumenberg, district of the city of Eichstätt, 1.5 km northwest of the centre of the city.

Age: Late Jurassic, Early Tithonian, Hybonotum Zone, Riedense Subzone (upper part), horizon still unnamed.

Wintershof-Ost

Geographic position: Abandoned quarry at Wintershof-Ost, district of the city of Eichstätt, 2 km north of the centre of the city.

Age: Late Jurassic, Early Tithonian, Hybonotum Zone, Riedense Subzone (upper part), horizon still unnamed.

Zandt

Geographic position: Abandoned quarry at Zandt, district of the community of Denkendorf, 15 km east of Eichstätt.

Age: Late Jurassic, Early Tithonian, Hybonotum Zone, Riedense Subzone (lower part), *eigeltingense* horizon.

Nusplingen

Geographic position: Abandoned quarry on the Westerberg southwest of the community of Nusplingen, 60 km south of Stuttgart.

Age: Late Jurassic, Late Kimmeridgian, Beckeri Zone, Ulmense Subzone, *hoelderi* horizon.

Egesheim

Geographic position: Abandoned quarry on the Westerberg northeast of the community of Egesheim, 60 km south of Stuttgart.

Age: Late Jurassic, Late Kimmeridgian, Beckeri Zone, Ulmense Subzone, *hoelderi* horizon.

Brunn

Geographic position: Quarry north of the village of Brunn, 15 km northwest of Regensburg, 50 km east of Eichstätt.

Age: Late Jurassic, Late Kimmeridgian, Beckeri Zone, Subeumela Subzone, *kiderleni* horizon.

4.2. Southern France

Cerin

Geographic position: Quarry at the village of Cerin (community of Marchamp, Département de l'Ain) approximately 80 km east of the city of Lyon in southeast France.

Age: The biostratigraphical age of the Cerin Fossillagerstätte is still uncertain due to the rareness and poor preservation of ammonites among the fossil invertebrates. ENAY et al. (1994) supposed an age at the Kimmeridgian/Tithonian boundary or even an Earliest Tithonian age for the Cerin Plattenkalke based on the only three specimens of the ammonite fauna which could be identified on the species level. PHILIPPE et al. (2004) advocated a Late Kimmeridgian age for the Cerin Plattenkalk occurrence.

Tab. 1. Sampled specimens, their localities and ages. Age after SCHWEIGERT & GARASSINO (2003), SCHWEIGERT (2007), and ENAY et al. (1994).

Specimen	Collection/ Cat. No.	Locality	Age		Plate
<i>Hybodus fraasi</i> BROWN, 1900	BSPHG 1899-I-2	Solnhofen	Early Tithonian	Hybonotum Zone Rueppellianus Subzone <i>rueppellianus</i> horizon	1
<i>Notidanoides muensteri</i> (AGASSIZ, 1843)	GPIT Pi 1210-3	Nusplingen	Late Kimmeridgian	Beckeri Zone Ulmense Subzone <i>hoelderi</i> horizon	2
<i>Protospinax annectans</i> WOODWARD, 1918,	NHML P8775 holotype	Solnhofen	Early Tithonian	Hybonotum Zone Rueppellianus Subzone <i>rueppellianus</i> horizon	3
<i>Squalogaleus woodwardi</i> MAISEY, 1976 (= <i>Protospinax annectans</i> WOODWARD, 1918)	NHML P37014 holotype	Solnhofen	Early Tithonian	Hybonotum Zone Rueppellianus Subzone <i>rueppellianus</i> horizon	4–5
<i>Pseudorhina alifera</i> (MUENSTER, 1842)	SOS 438	Wintershof-Ost	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	6–8
<i>Pseudorhina alifera</i> (MUENSTER, 1842)	SOS 2210	Langenaltheim	Early Tithonian	Hybonotum Zone Rueppellianus Subzone <i>rueppellianus</i> horizon	9–11
<i>Pseudorhina speciosa</i> (VON MEYER, 1856) (= <i>Pseudorhina alifera</i> (MUENSTER, 1842))	BSPHG AS-I-1368	Eichstätt	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	12–13
<i>Pseudorhina speciosa</i> (VON MEYER, 1856) (= <i>Pseudorhina alifera</i> (MUENSTER, 1842))	NHML P37013	Solnhofen	Early Tithonian	Hybonotum Zone Rueppellianus Subzone <i>rueppellianus</i> horizon	14
<i>Pseudorhina acanthoderma</i> (FRAAS, 1854)	SMNS 5735	Nusplingen	Late Kimmeridgian	Beckeri Zone Ulmense Subzone <i>hoelderi</i> horizon	15–16
<i>Pseudorhina acanthoderma</i> (FRAAS, 1854)	SMNS 3695/27	Nusplingen	Late Kimmeridgian	Beckeri Zone Ulmense Subzone <i>hoelderi</i> horizon	17–18
<i>Pseudorhina acanthoderma</i> (FRAAS, 1854)	GPIT B-161	Nusplingen	Late Kimmeridgian	Beckeri Zone Ulmense Subzone <i>hoelderi</i> horizon	19
<i>Pseudorhina</i> sp.	PIMUZ A/I 3050	Eichstätt	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	20–23
<i>Paracestracion falcifer</i> (WAGNER, 1857)	SMNS 11150	Nusplingen	Late Kimmeridgian	Beckeri Zone Ulmense Subzone <i>hoelderi</i> horizon	24
<i>Paracestracion falcifer</i> (WAGNER, 1857)	SOS 2215	unknown	uncertain (Solnhofen Formation)		25–26

Tab. 1 (continued)

Specimen	Collection/ Cat. No.	Locality	Age		Plate
<i>Paracestracion falcifer</i> (WAGNER, 1857)	NHML P8657	Eichstätt	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	27
<i>Heterodontus zitteli</i> (EASTMAN, 1911)	NHML P6938 counterpart of holotype	Eichstätt	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	28
<i>Phorcynis catulina</i> THIOLLIÈRE, 1852	MHNL 15.293 holotype	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian		29
<i>Phorcynis catulina</i> THIOLLIÈRE, 1852	BSPHG AS-I-1364	Eichstätt	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	30–32
<i>Crossorhinus jurassicus</i> WOODWARD, 1918 (= <i>Phorcynis catulina</i> THIOLLIÈRE, 1852)	NHML P11211 holotype	Eichstätt	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	33–34
<i>Palaeoscyllium minus</i> WOODWARD, 1889 (= <i>Phorcynis catulina</i> THIOLLIÈRE, 1852)	NHML P5541 holotype	Eichstätt	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	35
<i>Phorcynis catulina</i> THIOLLIÈRE, 1852	MHNL 15.294	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian		36
<i>Phorcynis</i> sp.	BSPHG 1960-XVIII-55	Zandt near Denkendorf, Reitzer quarry	Early Tithonian	Hybonotum Zone Riedense Subzone (lower part) <i>eigeltingense</i> horizon	37–40
<i>Palaeocarcharias stromeri</i> DE BEAUMONT, 1960	SOS 2216 (JME-22-1)	Blumberg	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	41–43
<i>Bavariscyllum tischlingeri</i> THIES, 2005	SOS 4124 holotype	Eichstätt (exact locality unknown)	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed (Malm zeta 2b, pers. com. H. TISCHLINGER)	44–45
<i>Palaeoscyllium formosum</i> WAGNER, 1857	BSPHG AS-I-1365 holotype	Solnhofen	Early Tithonian	Hybonotum Zone Rueppellianus Subzone <i>rueppellianus</i> horizon	46
<i>Palaeoscyllium formosum</i> WAGNER, 1857	BSPHG AS-I-589	Solnhofen	Early Tithonian	Hybonotum Zone Rueppellianus Subzone <i>rueppellianus</i> horizon	47–51
<i>Palaeoscyllium</i> ? sp.	BMMS BSP1993-XVIII	Brünn	Late Kimmeridgian Beckeri Zone Subeumela Subzone <i>kiderleni</i> horizon (horizon no. 7 in the Brünn section, RÖPER et al. 1996, pers. com. M. RÖPER)		52
<i>Corysodon cirinensis</i> SAINT-SEINE, 1949	MHNL 15.297 holotype	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian		53
<i>Corysodon cirinensis</i> SAINT-SEINE, 1949	FCL paratype	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian		54–56
<i>Corysodon cirinensis</i> SAINT-SEINE, 1949	MHNL 15.388	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian		57–58
<i>Synechodus</i> sp.	SOS 3152	Birkhof	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	59–64

Tab. 1 (continued)

Specimen	Collection/ Cat. No.	Locality	Age	Plate	
<i>Paraorthacodus jurensis</i> (SCHWEIZER, 1964)	GPIT Pi: 1210/1	Nusplingen	Late Kimmeridgian Beckeri Zone Ulmense Subzone <i>hoelderi</i> horizon	65	
<i>Paraorthacodus</i> sp.	BSPHG 1894-X-5 (labelled as <i>Pristiurus</i> cf. <i>hassei</i> WOODWARD)	Eichstätt	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	66
<i>Spenodus macer</i> (QUENSTEDT, 1852)	SMNS 80142/44	Egesheim	Late Kimmeridgian Beckeri Zone Ulmense Subzone <i>hoelderi</i> horizon	67–68	
<i>Sphenodus nitidus</i> WAGNER, 1862	BSPHG AS-VIII-647 holotype	Solnhofen	Early Tithonian	Hybonotum Zone Rueppellianus Subzone <i>rueppellianus</i> horizon	69
<i>Asterodermus</i> <i>platypterus</i> AGASSIZ, 1843	NHML P12067 holotype	Kelheim	Early Tithonian	Hybonotum Zone Rueppellianus Subzone <i>riedlingensis</i> horizon	70
<i>Asterodermus</i> <i>platypterus</i> AGASSIZ, 1843	SOS 2212	Blumberg	Early Tithonian	Hybonotum Zone Riedense Subzone (upper part) horizon unnamed	71
<i>Asterodermus</i> sp.	BSPHG 1960-XVIII-56	Zandt near Denkendorf	Early Tithonian	Hybonotum Zone Riedense Subzone (lower part) <i>eigeltingense</i> horizon	72–79
<i>Asterodermus</i> sp.	BSPHG AS-I-1377	Kelheim (old label: Eichstätt)	Early Tithonian	Hybonotum Zone Rueppellianus Subzone <i>riedlingensis</i> horizon	80–83
<i>Asterodermus</i> sp.	BSPHG 1964-XXIII-577	Zandt near Denkendorf	Early Tithonian	Hybonotum Zone Riedense Subzone (lower part) <i>eigeltingense</i> horizon	84–86
<i>Belemnobatis sismondae</i> THIOLLIÈRE, 1852	MHNL 15.263	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian	87–88	
<i>Belemnobatis sismondae</i> THIOLLIÈRE, 1852	MHNL 15.264	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian	89–90	
<i>Belemnobatis sismondae</i> THIOLLIÈRE, 1852	MHNL 15.753	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian	91	
<i>Belemnobatis sismondae</i> THIOLLIÈRE, 1852	MHNL 15.262	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian	92	
<i>Belemnobatis sismondae</i> THIOLLIÈRE, 1852	MHNL 15.304 (labelled as <i>Spathobatis bugesiacus</i> THIOLLIÈRE, 1852)	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian	93	
<i>Spathobatis bugesiacus</i> THIOLLIÈRE, 1852	MHNL 15.307 holotype	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian	94–95	
<i>Spathobatis bugesiacus</i> THIOLLIÈRE, 1852	MHNL 15.308 (labelled as <i>Aster-</i> <i>odermus</i> sp.)	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian	96–98	
<i>Spathobatis bugesiacus</i> THIOLLIÈRE, 1852	NHML P10934	Cerin	Kimmeridgian/Tithonian boundary or Earliest Tithonian	99–100	

5. Scales and teeth of Late Jurassic sharks and rays from Europe

5.1. Explanation of descriptive terms

The morphologies of dermal denticles and oral teeth will not be described in detail in 5.2. Instead, morphologies typical for the taxon concerned will be briefly characterised. Morphological terms applied on dermal denticles follow REIF (1985), DUFFIN & WARD (1993), and THIES (1995) (Fig. 3). CAPPETTA (1987) compiled and explained morphological terms for oral teeth.

5.2. Systematic palaeontology

Class Chondrichthyes HUXLEY, 1880
 Subclass Elasmobranchii BONAPARTE, 1838
 Cohort Euselachii HAY, 1902
 Family Hybodontidae OWEN, 1846
 Genus *Hybodus* AGASSIZ, 1837

Hybodus fraasi BROWN, 1900
 Pl. 1

Material: BSPHG 1899-I-2.
 Locality: Solnhofen.

Literature: BROWN (1900), MAISEY (1978, 1986a, 1987), LEIDNER & THIES (1999), KRIWET & KLUG (2004), REES & UNDERWOOD (2008).

Description. – Dermal denticles: Base wider than crown and without neck, crown laterally compressed and hook-like, with numerous vertical folds which continue onto the base, folds sometimes bifurcating basally.

Oral teeth: Only little known (see MAISEY 1986a, fig. 8).

Remarks. – MAISEY (1987) tentatively assigned *H. fraasi* to the genus *Egertonodus* MAISEY, 1987.

Subcohort Neoselachii COMPAGNO, 1977
 Order Hexanchiformes BUEN, 1926
 Family Hexanchidae GRAY, 1851
 Genus *Notidanoides* MAISEY, 1986

Notidanoides muensteri (AGASSIZ, 1843)
 Pl. 2

Material: GPIT Pi 1210-3.
 Locality: Nusplingen.
 Literature: AGASSIZ (1843), SCHWEIZER (1964), MAISEY & WOLFRAM (1984), MAISEY (1986b), LEIDNER & THIES (1999), KRIWET & KLUG (2004).

Description. – Dermal denticles: Two different types of dermal denticles known:

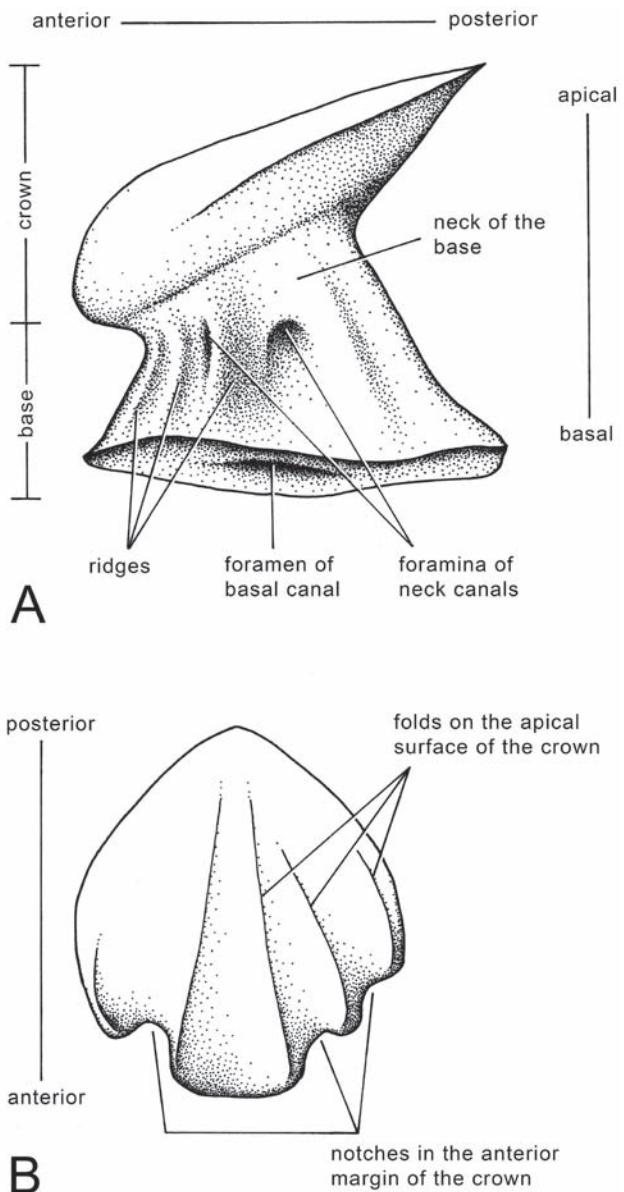


Fig. 3. Explanation of morphological terms applied on dermal denticles (from THIES 1995, partly based on DUFFIN & WARD 1993 and REIF 1985). – A. Lateral view. B. Apical view.

- little differentiated denticles with a sheet-like and cordiform crown in apical aspect, apical surface of crown anteriorly with a short and delicate median keel and one or two pairs of diverging folds laterally, anterior margin with two shallow notches and a sharp, transverse, undulating fold, posterior margin smooth, base smaller than crown and with a neck (e.g., Pl. 2, Figs. C, J);
 - denticles almost identical morphologically with the foregoing type apart from the posterior margin of the crown which is denticulate (e.g., Pl. 2, Fig. G).
- Oral teeth: See SCHWEIZER (1964, pl. 9, fig. 29–35).

Order inc. sed.

Family Protospinacidae WOODWARD, 1918
Genus *Protospinax* WOODWARD, 1918

Protospinax annectans WOODWARD, 1918
Pls. 3–5

M a t e r i a l: NHML P8775, holotype; NHML P37014, paratype; holotype of *Squalogaleus woodwardi* MAISEY, 1976.

L o c a l i t y: Solnhofen.

L i t e r a t u r e: WOODWARD (1918), MAISEY (1976), THIES (1983), DUFFIN (1993a), CARVALHO & MAISEY (1996), UNDERWOOD (2002), KRIWET (2003), KRIWET & KLUG (2004).

D e s c r i p t i o n. – **D e r m a l d e n t i c l e s** (holotype, Pl. 3): Three different types of dermal denticles known:

- undifferentiated denticles with a flat, smooth and knob-like crown (e.g., Pl. 3, Figs. K, L);
- well differentiated denticles showing a crown of arrowhead-like aspect in apical view, with a prominent median keel, keel bulging and with sharp lateral edges anteriorly (e.g., Pl. 3, Figs. B, H; Pl. 4, Fig. B);
- large thorn-like denticles with a wide, circular base and a thick, smooth and acuminate crown (e.g., Pl. 3, Fig. Q).

O r a l t e e t h (paratype, Pl. 5): Root only poorly preserved, crown mesiodistally expanded, smooth labially and lingually, central cusp rudimentary, no apron, uvula narrow and small, mesiodistal cutting edge extending over entire crown.

R e m a r k s. – MAISEY (1976) considered the holotype of *P. annectans* WOODWARD, 1918 (NHML P8775) to represent a species of *Belemnobatis* THIOLLIÈRE, 1852: *B. annectans* (WOODWARD, 1918). Also, he transferred the paratype of *P. annectans* (NHML P37014) to a new genus and species: *Squalogaleus woodwardi* MAISEY, 1976. However, subsequent workers including CARVALHO & MAISEY (1996), UNDERWOOD (2002), and KRIWET & KLUG (2004) did not agree with this view for reasons of skeletal and dental morphology. They retained *Protospinax* WOODWARD, 1918 and synonymized *Squalogaleus* MAISEY, 1976 with it.

Order Squatiniformes BUEN, 1926

Family Squatinidae BONAPARTE, 1838
Genus *Pseudorhina* JAEKEL, 1898

Pseudorhina alifera (MÜNSTER, 1842)
Pls. 6–14

M a t e r i a l: SOS 438, SOS 2210, BSPHG AS-I-1368, NHML P37013.

L o c a l i t i e s: Wintershof-Ost, Langenaltheim, Eichstätt, Solnhofen.

L i t e r a t u r e: MÜNSTER (1842), DINKEL (1921), LEIDNER & THIES (1999), UNDERWOOD (2002), KRIWET & KLUG (2004), CARVALHO et al. (2008).

D e s c r i p t i o n. – **D e r m a l d e n t i c l e s:** Two different types of dermal denticles and ontogenetic variation known:

- undifferentiated denticles with a flat, smooth and knob-like crown in adult (e.g., Pl. 7), semiadult (e.g., Pl. 9, Fig. B) and juvenile specimens (e.g., Pl. 12, Fig. G);
- well differentiated denticles showing a crown of arrowhead-like aspect in apical view, with a prominent median keel, keel bulging and having sharp lateral edges anteriorly, base of stellate shape in basal view. The crown of this type is laterally expanded in adults (e.g., Pl. 6, Fig. D), narrower in semiadults (e.g., Pl. 9, Figs. C, H) and even spike-like in juveniles (e.g., Pl. 12, Figs. M, N).

O r a l t e e t h (with strong ontogenetic heterodonty):

Specimen SOS 438, adult (Pl. 8, lower part, Figs. A–C): Teeth mesiodistally expanded, with a high and erect central cusp, lateral cusps missing or very rudimentary, apron wide and basally flat, uvula well developed, mesiodistal cutting edge extending over central cusp and crown base, crown surface smooth, root hemiaulacorhize.

Specimen SOS 2210, semiadult, anterior or lateral teeth (Pl. 10, Fig. I; Pl. 11): Crown less expanded mesiodistally, central cusp erect and stout, one pair of small lateral cusplets, apron broad and basally flat, uvula strongly developed, mesiodistal cutting edge extending over central cusp and lateral cusplets, crown smooth on both faces, root hemiaulacorhize.

Specimen BSPHG AS-I-1368, juvenile, anterior to posterior teeth (Pl. 13): Crown expanded mesiodistally, with a central cusp and one pair of well developed lateral cusplets, apron semicircular in outline and not or only a little distinguished from the base of the crown, uvula well developed, mesiodistal cutting edge extending over central cusp and lateral cusplets, labial and lingual surface of crown smooth, root only poorly preserved.

R e m a r k s. – DINKEL (1921), LEIDNER & THIES (1999), UNDERWOOD (2002), and CARVALHO et al. (2008) recognized *Pseudorhina speciosa* (VON MEYER, 1856) as juvenile specimens of *Pseudorhina alifera* (MÜNSTER, 1842) by congruence of dermal denticle and oral tooth morphologies.

Pseudorhina acanthoderma (FRAAS, 1854)

Pls. 15–19

M a t e r i a l: SMNS 5735, SMNS 3695/27, GPIT B-161.

L o c a l i t y: Nusplingen.

L i t e r a t u r e: FRAAS (1854), DINKEL (1921), SCHWEIZER (1964), LEIDNER & THIES (1999), UNDERWOOD (2002), KRIWET & KLUG (2004), CARVALHO et al. (2008).

D e s c r i p t i o n. – **D e r m a l d e n t i c l e s:** Same types and morphologies as in *P. alifera*, additionally: much enlarged and thickened denticles of spine- or hook-like appearance (e.g., Pl. 15, Fig. F; Pl. 16, Fig. B).

Oral teeth: The dental morphology of *P. acanthoderma* was described and figured by CARVALHO et al. (2008).

Pseudorhina sp.
Pls. 20–23

Material: PIMUZ A/I 3050.

Locality: Eichstätt.

Literature: LEIDNER & THIES (1999), CARVALHO et al. (2008).

Description. – **Dermal denticles:** Same types and morphologies as in *P. alifera*, additionally: small denticles in which the crown is thickened and consisting of a system of branching ridges (e.g., Pl. 20, Figs. B, C) (and which were presumably derived from denticles with an arrowhead-shaped crown having a strong median keel and strong lateral folds on their apical surfaces as in the denticles of *P. alifera* in Pl. 20, Figs. D, E; Pl. 22, Fig. C or Pl. 6, Fig. C).

Oral teeth (Pl. 23): Mesiodistally expanded, crown with a high and erect central cusp, no lateral cusplets, apron broad and basally rounded, uvula well developed, mesiodistal cutting edge extending over central cusp and crown base, crown surface smooth, root hemiaulacorhizate.

Remarks. – CARVALHO et al. (2008) identified the specimen PIMUZ A/I 3050 as belonging to *Pseudorhina alifera* (MÜNSTER, 1842). This specimen differs, however, in oral tooth morphology from *P. alifera*. In size the teeth of PIMUZ A/I 3050 fall in between the teeth of semiadult and adult specimens of *P. alifera*. Whereas the teeth of semiadults and adults of *P. alifera* have lateral cusplets or, at least, vestigial remains thereof the teeth of PIMUZ A/I 3050 are completely devoid of lateral cusplets. Also, in *P. alifera* the apron is flat basally but rounded in PIMUZ A/I 3050. Rudimentary lateral cusplets are also present in the teeth of adult *P. acanthoderma* (FRAAS, 1854). Moreover, in the teeth of *P. acanthoderma* the apron is narrower and deeper than in the teeth of *P. alifera* and PIMUZ A/I 3050. All this indicates together with the occurrence of an additional morphotype of dermal denticles that PIMUZ A/I 3050 may represent a new, still undescribed species of *Pseudorhina*.

Order Heterodontiformes BERG, 1937

Family Heterodontidae GRAY, 1851

Genus *Paracestracion* KOKEN in ZITTEL, 1911

Paracestracion falcifer (WAGNER, 1857)
Pls. 24–27

Material: SMNS 11150, SOS 2215, NHML P8657.

Localities: Nusplingen, Eichstätt.

Literature: WAGNER (1857), SCHWEIZER (1964), REIF (1973; 1974a, b; 1976), REIF & GOTO (1979), LEIDNER & THIES

(1999), MAISEY (1982), UNDERWOOD (2002), KRIWET & KLUG (2004), KRIWET (2008b).

Description. – **Dermal denticles:** Three different types of dermal denticles known:

- undifferentiated denticles with a flat crown of knob-like appearance in apical view, apical crown surface smooth or with short delicate folds at the anterior margin, anterior notches small and inconspicuous or missing (e.g., Pl. 26, Figs. B, C, D);
- differentiated denticles with a crown of leaf-like shape in apical view, apical surface with an anteriorly bulging median keel with sharp apicolateral edges, lateral folds present, posterior margin of crown denticulated, anterior margin with lateral notches (e.g., Pl. 24, Figs. B–E);
- differentiated denticles with an arrowhead-shaped crown in apical aspect, median keel reduced to a strongly bulging anterior protuberance with sharp apicolateral edges, distinct notches in the anterior margin of crown, apical surface of crown with short folds anteriorly (e.g., Pl. 25, Figs. C, I, J; Pl. 27, Figs. B, C).

Oral teeth: See SCHWEIZER (1964, text-fig. 3; pl. 8, figs. 2–4), KRIWET & KLUG (2004, figs. 11b, c, 12c, d) and KRIWET (2008b, fig. 3). The description and figures in SCHWEIZER (1964) demonstrate the strong ontogenetic and monognathic heterodonty present in the dentition of *P. falcifer*.

Remarks. – The ontogenetic development of dermal denticles of *H. falcifer* was previously studied by REIF (1973, 1974a) who identified the same denticle morphotypes as described and figured in this catalogue. He also documented their distribution over the body of *H. falcifer*. In different studies REIF (1974b, 1976) investigated the morphogeneses, pattern formations and functions of the dermal skeleton and dentition in the Recent species of *Heterodontus* BLAINVILLE, 1816.

Paracestracion viohli KRIWET, 2008

The dermal denticles and oral teeth of *P. viohli* were described and figured by KRIWET (2008b).

Genus *Heterodontus* BLAINVILLE, 1816

Heterodontus zitteli (EASTMAN, 1911)
Pl. 28

Material: NHML P6938, counterpart of holotype.

Localities: Eichstätt.

Literature: EASTMAN (1911, 1914), SCHWEIZER (1964), MAISEY (1982), UNDERWOOD (2002), KRIWET & KLUG (2004).

Description. – Dermal denticles: Differentiated denticles with a crown of lanceolate shape in apical view, apical surface with a prominent median keel with sharp apicolateral edges, keel bulging anteriorly and reaching almost to the posterior tip of crown. The denticles are intermediate morphologically between the two types of differentiated denticles of *Paracestracion falcifer*.

Oral teeth: Unknown (see EASTMAN 1914).

Remarks. – SCHWEIZER (1964) discussed the systematic position of *Heterodontus zitteli* (EASTMAN, 1911) and regarded it as a younger synonym of *P. falcifer*. MAISEY (1982) rejected this view on reasons of different relative fin positions and fin spine vascularization of *P. falcifer* and *H. zitteli*. According to MAISEY (1982) both taxa are considered as different here.

Order Orectolobiformes APPLEGATE, 1972

Family inc. sed.

Genus *Palaeorectolobus* KRIWET, 2008

Palaeorectolobus agomphius KRIWET, 2008

Dermal denticles and oral teeth of *P. agomphius* were described and figured by KRIWET (2008a).

Order Orectolobiformes APPLEGATE, 1972 ?

Family inc. sed.

Genus *Phorcygnis* THIOLLIÈRE, 1852

Phorcygnis catulina THIOLLIÈRE, 1852

Pls. 29–36

Material: MHNL 15.293, holotype; BSPHG AS-I-1364; NHML P11211, holotype of *Crossorhinus jurassicus* WOODWARD, 1918; NHML P5541, holotype of *Palaeoscyllium minus* WOODWARD, 1889; MHNL 15.294.

Localities: Cerin, Eichstätt.

Literature: THIOLLIÈRE (1852), SAINT-SEINE (1949), DESROCHES (1972), CAPPETTA (1987), LEIDNER & THIES (1999), KRIWET & KLUG (2004).

Description. – Dermal denticles: Two different types of dermal denticles known:

- undifferentiated denticles with a flat crown of cordiform shape in apical view, apical crown surface smooth or with short delicate folds at the anterior margin (e. g., Pl. 30, Figs. B–E, G–I; Pl. 31);
- differentiated denticles with a narrow and slender crown of arrowhead-like aspect in apical view, crown with a prominent median keel reaching from the anterior margin nearly to the posterior extremity of the crown, one pair of shorter lateral folds present running parallel to the median keel (e. g., Pl. 30, Figs. J, O, P).

Oral teeth (specimen BSPHG AS-I-1364, semi-adult, Pl. 32): Basal part of tooth crown expanded mesiodistally, cusp straight and inclined distally, lateral cusplets rudimentary, missing on the mesial side of the crown in anterior teeth, apron wide, flat and with a convex basal margin, only little distinguished from the basal part of the crown, uvula wide and short, mesiodistal cutting edge well developed on central cusp and crown base, ornament of short longitudinal ridges near the basal margin of the labial crown surface present only in posterolateral and posterior teeth, root hemiaulacorhize.

Remarks. – DESROCHES (1972) allocated the specimen MHNL 15.294 (Pl. 40) to *Corysodon cirinensis* SAINT-SEINE, 1949 without explaining his opinion. Here MHNL 15.294 and the specimens BSPHG AS-I-1364, NHML P11211 (Pl. 33–34), and NHML P5541 (Pl. 35) from Southern Germany are identified as belonging to the species *P. catulina* for reasons of dermal denticle morphology.

CAPPETTA (1987) synonymized already *Crossorhinus jurassicus* WOODWARD, 1918 and *Palaeoscyllium minus* WOODWARD, 1889 with *Phorcygnis catulina* THIOLLIÈRE, 1852. Morphologies of dermal denticles and oral teeth found in the holotypes of *C. jurassicus* and *P. minus* (Pls. 33–35) confirm CAPPETTA's view.

Phorcygnis sp.

Pls. 37–40

Material: BSPHG 1960-XVIII-55.

Locality: Zandt.

Description. – Dermal denticles (Pls. 37, 38): Same types and morphologies as in *P. catulina*.

Oral teeth (Pls. 39, 40): Agreeing in general morphology with the teeth of the 20 cm long specimen BSPHG AS-I-1364 of *P. catulina* (Pl. 32), apart from the lateral cusplets which are developed more concisely than in the teeth of specimen BSPHG AS-I-1364. Whereas the teeth of BSPHG AS-I-1364 have only rudimentary lateral cusplets these are much more distinct in BSPHG 1960-XVIII-55. Also, the teeth of BSPHG 1960-XVIII-55 sometimes have two cusplets on either side of the central cusp (Pl. 39, Figs. C, D).

Remarks. – Even though the dermal denticles of specimen BSPHG 1960-XVIII-55 agree with those of *Phorcygnis catulina* there are some differences in oral tooth morphology between BSPHG 1960-XVIII-55 and the specimen BSPHG AS-I-1364 of *P. catulina*. Specimen BSPHG 1960-XVIII-55 may therefore represent a different species of *Phorcygnis* THIOLLIÈRE, 1852 and is listed here in open nomenclature.

Order Lamniformes BERG, 1958?

Family inc. sed

Genus *Palaeocarcharias* DE BEAUMONT, 1960*Palaeocarcharias stromeri* DE BEAUMONT, 1960

Pls. 41–43

Material: SOS 2216 (JME 22-1).

Locality: Blumenberg.

Literature: DE BEAUMONT (1960), DUFFIN (1988), LEIDNER & THIES (1999), KRIWET & KLUG (2004).

Description. – Dermal denticles: Two different types of dermal denticles known:

- undifferentiated denticles with a flat crown of leaf-shaped appearance in apical view, apical crown surface smooth or with short delicate folds at the anterior margin, anterior notches small and inconspicuous or missing (e.g., Pl. 42, Figs. B, C, F);
- differentiated denticles with a stout and arrowhead-shaped or cordiform crown, distinct notches in the anterior margin of crown, apical surface of crown with posteriorly converging folds (e.g., Pl. 41, Figs. B, C, F).

Oral teeth (Pl. 43): Of lamniform appearance, central cusp of crown high and erect, no lateral cusplets, mesial and distal crown tongues nearly reaching the basal extremities of the root lobes, mesiodistal cutting edge extending over cusp and crown tongues, labial and lingual surface of crown smooth, root V-shaped and with a nutritive groove, lingual protuberance of the root oval in outline in basal view.

Order Carcharhiniformes COMPAGNO, 1973

Family Scyliorhinidae GILL, 1862

Genus *Bavariscyllum* THIES, 2005*Bavariscyllum tischlingeri* THIES, 2005

Pls. 44–45

Material: SOS 4124, holotype.

Locality: Eichstätt (exact locality unknown).

Literature: THIES (2005).

Description. – Dermal denticles: Only poorly preserved, crown leaf-shaped in apical view, no median keel, apical surface of crown with a few delicate folds, lateral folds longer than median fold, not reaching the posterior margin of the crown, notches in anterior margin of crown inconspicuous (Pl. 44, Figs. B–F).**Oral teeth** (Pl. 45): Tooth crowns widened mesiodistally at the base, central cusp of crown high and erect, rudimentary cusplets on lateral heels, mesial and distal crown tongues well developed, no apron, no uvula, distinct neck present, basal margin of crown concave on the labial side, mesiodistal cutting edge present on central

cusp and lateral heels, two prominent ridges on the labial surface of the crown extending over the crown tongues and mediobasal part of the crown and converging apically, root only partly preserved, with a bulky lingual protuberance.

Order Carcharhiniformes COMPAGNO, 1973

Family inc. sed.

Genus *Palaeoscyllium* WAGNER, 1857 (non MARCK, 1863)*Palaeoscyllium formosum* WAGNER, 1857

Pls. 46–51

Material: BSPHG AS-I-1365, holotype; BSPHG AS-I-589.

Locality: Solnhofen.

Literature: WAGNER (1857), LEIDNER & THIES (1999), UNDERWOOD (2002), KRIWET & KLUG (2004), SWEETMAN & UNDERWOOD (2006).

Description. – Dermal denticles: Three different types of dermal denticles known:

- undifferentiated denticles with a knob-like, thick crown of cordiform shape in apical view, apical crown surface smooth or with short delicate folds at the anterior margin, anterior notches shallow and inconspicuous (e.g., Pl. 49, Figs. D, E);
- differentiated denticles with an arrowhead-shaped crown, crown with a thick and anteriorly bulging median keel and curved, posteriorly converging lateral folds, keel with two lateral ridges, distinct notches in the anterior margin of crown (e.g., Pl. 46, Fig. O; Pl. 47, Fig. C);
- differentiated denticles similar to the foregoing type, but with a much enlarged and elevated median keel, keel bulky anteriorly (Pl. 49, Fig. H).

Oral teeth (Pls. 50, 51): Tooth crowns with a high and erect central cusp and one (in anterior teeth) or two (in lateral teeth) lateral cusplets, no apron, no uvula, distinct neck present, basal margin of tooth crown concave medially and overhanging the root on the labial side, no crown tongues, labial and lingual surface of crown covered by longitudinal ridges, mesiodistal cutting edge well developed only on the apical parts of central cusp and lateral cusplets, root with a bulky lingual protuberance and expanded lobes.**Remarks.** – Oral teeth are not preserved in the holotype of *P. formosum* (BSPHG AS-I-1365) but in the specimen BSPHG AS-I-589 which agrees with the holotype in fin positions and dermal denticle morphology. LEIDNER & THIES (1999) synonymized *Parasymbolus* CANDONI, 1993 from the Kimmeridgian of Northern France (CANDONI 1993, 1994) with *Palaeoscyllium* WAGNER, 1857 on the basis of dental morphology.

Palaeoscyllium ? sp.
Pl. 52

Material: BMMS BSP1993-XVIII.
Locality: Brunn.

Description. – Dermal denticles: Similar in their morphology to the differentiated denticle types of *Palaeoscyllium formosum* WAGNER, 1857. This refers in particular to the denticle in Pl. 52, Fig. D which agrees with the denticles with a much enlarged and bulky median keel of *P. formosum* shown in Pl. 49, Fig. H.

Oral teeth: Unknown.

Remarks. – Regarding dermal denticle morphology there is some agreement between this specimen and *Palaeoscyllium formosum* WAGNER, 1857. Differences occur, however, in the shape and size of the caudal fin and in the shape, size and relative positions of the other fins (Pl. 46, Fig. A; Pl. 47, Fig. A; Pl. 52, Fig. A). In the absence of oral teeth the specimen is therefore only tentatively assigned to the genus *Palaeoscyllium* WAGNER, 1857.

Order Carcharhiniformes COMPAGNO, 1973 ?
Family inc. sed.

Genus *Corysodon* SAINT-SEINE, 1949

Corysodon cirinensis SAINT-SEINE, 1949
Pls. 53–58

Material: MHNL 15.297, holotype; FCL, paratype; MHNL 15.388.

Locality: Cerin.

Literature: SAINT-SEINE (1949), DESROCHES (1972), CAPPETTA (1987), THIES & CANDONI (1998), LEIDNER & THIES (1999), KRIWET & KLUG (2004).

Description. – Dermal denticles: Three different types of dermal denticles known:

- undifferentiated denticles with a knob-like, thick crown of irregular shape in apical view, apical crown surface smooth or with short delicate folds at the anterior margin, anterior notches small and inconspicuous (e. g., Pl. 53, Figs. C–F),
- differentiated denticles with a laterally expanded crown, posterior margin of crown rounded, anterior margin with deep notches and a large, anteriorly protruding peg in between, apical surface of crown with coarse, nearly parallel running folds beginning at the anterior margin and fading before reaching the posterior margin (e. g., Pl. 55, Figs. A, B, D),
- crown with a thick, elevated and anteriorly bulging median keel and a pair of coarse, curved lateral folds, keel with two lateral ridges and a pair of coarse anterior folds in between, distinct notches in the anterior margin of crown (e. g., Pl. 55, Fig. C).

Oral teeth (of *Corysodon* sp.): See THIES & CANDONI (1998, pl. 2).

Remarks. – The drawing of the oral teeth of *C. cirinensis* in SAINT-SEINE (1949) is inaccurate. Isolated teeth of *Corysodon* sp. from the Kimmeridgian of Northern France and Northern Germany (THIES & CANDONI 1998) demonstrate the dental morphology of *Corysodon*. These teeth show also that *Corysodon* SAINT-SEINE, 1949 is not synonymous with *Palaeoscyllium* WAGNER, 1857 as suggested by CAPPETTA (1987).

Order Synechodontiformes DUFFIN & WARD, 1993

Family Palaeospinacidae REGAN, 1906
Genus *Synechodus* WOODWARD, 1888

Synechodus sp.
Pls. 59–64

Material: SOS 3152.

Locality: Birkhof.

Literature: LEIDNER & THIES (1999), KLUG (2009, 2010).

Description. – Dermal denticles: Similar morphological types as described for *Notidanoides muensteri* (AGASSIZ, 1843), only the median keel on the apical surface of the crown is more pronounced and prominent, has sharp lateral edges and reaches to the posterior tip of the crown. Additionally: denticles with a crown of furcate appearance in apical view, crown surface mostly reduced to the median keel and the lateral folds, median keel bulging anteriorly and with a sharp apical edge, anterior margin of crown deeply notched and with a transverse undulating fold, base smaller than crown and with a high and slender neck (e. g., Pl. 60, Figs. C–F; Pl. 62, Fig. D; Pl. 63, Fig. H).

Oral teeth (with strong gradient monognathic heterodonty, Pl. 64): Tooth crowns multicuspied with a central cusp and up to three pairs of lateral cusplets, one pair of lateral cusplets in anterior teeth (Pl. 64, Fig. 1), three pairs in lateral and posterior teeth (Pl. 64, Figs. C, D), mesiodistal cutting edge running over central cusp and lateral cusplets, labial and lingual surface of crown ornamented with longitudinal ridges, ridges anastomosing basally on labial side, labial face of crown not overhanging root, root polyhemialucorhize.

Remarks. – KLUG (2009) considered the specimen SOS 3152 as belonging to the species *Synechodus ungeri* KLUG, 2009. Comparison of dental morphologies shows, however, differences. The holotype of *S. ungeri* has teeth with a higher number of lateral cusplets and more widely spaced central cusp and lateral cusplets. In general, in the holotype of *S. ungeri* the tooth cusps are more gracile, relatively more slender and higher and more clearly separated from each other than in the teeth of specimen SOS 3152 (KLUG 2009, figs. 3, 4). Because the specimen SOS

3152 is a little smaller than the holotype of *S. ungeri* and reaches only 75 % of its length the differences in dental morphology might reflect ontogenetic heterodonty. However, SOS 3152 is also younger in terms of stratigraphy. It comes from the Earliest Tithonian (see Tab. 1) whereas the holotype of *S. ungeri* dates into the Latest Kimmeridgian. It can therefore not be excluded that SOS 3152 represents a species of *Synechodus* different from *S. ungeri*. For these reasons the specimen is listed here in open nomenclature as *Synechodus* sp.

Genus Paraorthacodus GLICKMAN, 1957

Paraorthacodus jurensis (SCHWEIZER, 1964)
Pl. 65

M a t e r i a l: GPIT Pi 1210/1, holotype.

L o c a l i t y: Nusplingen.

L i t e r a t u r e: SCHWEIZER (1964), REIF (1973), DUFFIN (1993b), KLUG et al. (2009), KLUG (2010).

D e s c r i p t i o n. – **D e r m a l d e n t i c l e s:** With a cordiform crown in apical aspect, apical surface of crown with a more or less pronounced median keel with sharp lateral edges and one or more pairs of coarse, curved or straight converging lateral folds, anterior margin with two or more distinct notches and a sharp transverse, undulating fold (Pl. 65, Fig. E), posterior margin smooth, base smaller than crown and with a short neck.

O r a l t e e t h: See SCHWEIZER (1964, text-fig. 1, pl. 7, figs. 3, 5, 6), DUFFIN (1993b, text-figs. 3, 4, pl. 2), KLUG et al. (2009, figs. 6, 7).

R e m a r k s. – The scales in Pl. 65, Figs. B–E were extracted from the holotype of *P. jurensis* (specimen GPIT Pi 1210/1) and photographed with an SEM by the late Prof. Dr. W.-E. REIF (University of Tübingen). They were previously published by REIF (1973) and DUFFIN (1993b).

Paraorthacodus sp.
Pl. 66

M a t e r i a l: BSPHG 1894-X-5.

L o c a l i t y: Eichstätt.

L i t e r a t u r e: KRIWET & KLUG (2004), KLUG (2008, 2010).

D e s c r i p t i o n. – **D e r m a l d e n t i c l e s:** Two different types of dermal denticles known:

- little differentiated denticles with a leaf-like crown of lanceolate appearance in apical view and an anterior peduncle, apical surface of crown with three delicate longitudinal folds starting at the anterior margin, median fold short and straight, lateral folds longer, curved and diverging, lateral folds anteriorly continuous with a sharp transverse fold along the anterior margin, transverse fold with a short median

spine continuing basally as a median fold on the anterior side of the peduncle, no notches in anterior margin of crown, posterior margin of crown smooth (e. g., Pl. 66, Fig. C);

- denticles identical morphologically with the foregoing type apart from the posterior margin of the crown which is denticulate (e. g., Pl. 66, Figs. B, D).

O r a l t e e t h: Unknown from specimen BSPHG 1894-X-5.

R e m a r k s. – BSPHG 1894-X-5 is a juvenile specimen. It was originally labelled as *Pristiurus* cf. *hassei* WOODWARD. KRIWET & KLUG (2004) recognized this specimen together with specimen BSPHG 1996-I-31 (not figured here) as a juvenile of an unknown species of *Paraorthacodus* GLICKMAN, 1957 by development and position of fins and dental morphology (observable in BSPHG 1996-I-31 only).

Order Synechodontiformes DUFFIN & WARD, 1993

Family Orthacodontidae GLICKMAN, 1957
Genus Sphenodus AGASSIZ, 1843

Sphenodus macer (QUENSTEDT, 1851)
Pls. 67–68

M a t e r i a l: SMNS 80142/44.

L o c a l i t y: Egesheim.

L i t e r a t u r e: QUENSTEDT (1851), LEIDNER & THIES (1999), BÖTTCHER & DUFFIN (2000), KRIWET & KLUG (2004), KLUG (2010).

D e s c r i p t i o n. – **D e r m a l d e n t i c l e s:** Three different types of dermal denticles known:

- undifferentiated denticles with a knob-like crown of rounded or rhomboidal shape in apical view, apical surface of crown smooth, margins entire or only slightly notched and with rudimentary folds anteriorly (e. g., Pl. 68, Figs. D, F, I);
- little differentiated denticles (e. g., Pl. 67, Figs. B, C) with a crown very similar to those of *Notidanoides muensteri* in Pl. 2, Figs. C and J apart from the median keel of the apical surface of the crown, which is less delicate and much broader anteriorly in the corresponding denticles of *S. macer*. Resemblance also exists with the denticles of *Synechodus* sp. in Pl. 59, Figs. D and E apart from the extension of the median keel on the apical crown surface which reaches to the posterior tip of the crown in those scales;
- differentiated denticles (e. g., Pl. 67, Figs. D, F, H; Pl. 68, Fig. E) with a crown corresponding well with those of *Paraorthacodus jurensis* in Pl. 65, Figs. D, E and H; differences are discernable in the orientation of the lateral folds which converge in the denticles of *P. jurensis* but run parallel or even diverge in *S. macer*.

Oral teeth: See BÖTTCHER & DUFFIN (2000) and KRIWET & KLUG (2004).

Remarks. – The dermal denticles in Pl. 67, Fig. F and Pl. 68, Figs. C, E, H and I were already figured by BÖTTCHER & DUFFIN (2000, fig. 10).

Sphenodus nitidus WAGNER, 1862
Pl. 69

Material: BSPHG AS-VIII-647, holotype.

Locality: Solnhofen.

Literature: WAGNER (1862), BÖTTCHER & DUFFIN (2000), KRIWET & KLUG (2004), KLUG (2010).

Description. – **Dermal denticles:** Three different types of dermal denticles known:

- undifferentiated denticles like those of *Sphenodus macer* in Pl. 68, Fig. I with a knob-like crown of rounded shape in apical view, apical surface of crown smooth, anterior margin slightly notched and with rudimentary folds (Pl. 69, Fig. D);
- little differentiated denticles with a crown very similar to those of *Notidanoides muensteri* in Pl. 2, Figs. C, H and J including a delicate median keel and an undulating transverse fold at the anterior margin (e.g., Pl. 69, Figs. C, F);
- differentiated denticles like those of *Protospinax annectans* figured in Pl. 3, Figs. B, D and E showing an arrowhead-shaped crown in apical view and a prominent median keel which bulges anteriorly and has sharp lateral edges (e.g., Pl. 69, Figs. B, H).

Oral teeth: See BÖTTCHER & DUFFIN (2000) and KRIWET & KLUG (2004).

Order Rajiformes BERG, 1940

Family Rhinobatidae MUELLER & HENLE, 1838
Genus *Asterodermus* AGASSIZ, 1843

Asterodermus platypterus AGASSIZ, 1843
Pls. 70–71

Material: NHML P2067, holotype; SOS 2212.

Localities: Kelheim, Blumenberg.

Literature: AGASSIZ (1843), LEIDNER & THIES (1999), KRIWET & KLUG (2004).

Description. – **Dermal denticles:** Two different types of dermal denticles known:

- undifferentiated denticles with a flat, smooth and knob-like crown (e.g., Pl. 71, Fig. K, P);
- little differentiated thorns (Pl. 70, Figs. B, C; Pl. 71, Figs. B–H, J, L–O) showing crowns with some variation in coronal shape ranging from small and knob-like (e.g., Pl. 71, Figs. C, G) to elongated anteroposteriorly and arrow-shaped in apical view

(e.g., Pl. 71, Figs. E, F), posterior end of crown more elevated than anterior end, posterior part of crown laterally expanded to a varying extend, anteroposteriorly elongated crowns with a constriction between anterior and posterior end of crown (e.g., Pl. 71, Fig. J), anterior and posterior ends of crown rounded, marginal band of numerous small tubercles around the crown present (e.g., Pl. 70, Figs. B, C), sometimes reduced to the anterior part of crown, base much larger than crown and also showing some morphological variation ranging from flat and stellate in basal view (e.g., Pl. 70, Figs. B, C) to cushion-like and rounded (e.g., Pl. 71, Fig. O), neck reduced in height and carrying radiating ridges with nutritional foramina in between.

Oral teeth: Unknown.

Remarks. – The teeth of *Asterodermus platypterus* are unknown since the holotype lacks the skull. It remains therefore doubtfull whether the specimen SOS 2212 labelled as *Asterodermus platypterus* really belongs to this species.

Asterodermus sp.
Fig. 2, Pls. 72–86

Material: BSPHG 1960-XVIII-56, BSPHG AS-I-1377, BSPHG 1964-XXIII-577.

Localities: Zandt, Kelheim.

Literature: LEIDNER & THIES (1999).

Description. – **Dermal denticles:** Same morphological types as described for *A. platypterus*, additionally: more differentiated thorns apparently being derived from the little differentiated thorns of *P. platypterus* and showing crowns of irregular outline in apical view, crowns still with a median transverse constriction, posterior end widened laterally and deeply notched to produce lobe-like coronal appendages, anterior end also notched, but to a lesser extent, crown marginally tuberculated to a varying extent, base exceeding crown considerably in anteroposterior diameter and width, cushion-like, neck reduced and carrying ridges, basal surface convex (e.g., Pl. 72, Figs. F, G; Pl. 73, Figs. A, B; Pl. 74, Figs. A, B; Pl. 76, Figs. D, H; Pl. 77, Figs. B, C, D).

Oral teeth:

Specimen BSPHG 1960-XVIII-56 (part), adult:

– Upper jaw, anterolateral teeth (Pl. 78): Teeth mesiodistally expanded, labial face approximately two times as wide as high, with a rudimentary central cusp, apron broad and curved basally, only vaguely detached from the crown or continuous with the basal margin of the crown, uvula well developed and bulbous apically, labial and lingual surfaces of crown smooth and separated by a mesiodistal ridge extending over the entire crown, root holaulacorhize.

– Lower jaw (with gradient monognathic heterodonty), anterior teeth near the symphysis (Pl. 79): Mesiodistal width of crown increasing from 1.5 to 2.5 times equalling height of labial face of crown, otherwise teeth identical with those from the upper jaw.

Specimen BSPHG AS-I-1377, semiadult:

– Upper or lower jaw, anterior teeth from near the symphysis (Pl. 82): Teeth very similar to the anterolateral teeth from the upper jaw of specimen BSPHG 1960-XVIII-56 (part) (Pl. 78) but a little smaller and proportionally wider, labial face of crown between 2.5 and 3 times as wide as high, root hemiaulacorhize.

– Upper or lower jaw, posterior teeth from the angle of the jaw (Pl. 83): Teeth smaller than anterior teeth, only approximately half as wide, crowns and roots formed irregularly but still showing the same morphological elements as the anterior teeth on Pl. 82.

Specimen BSPHG 1964-XXIII-577, semiadult:

Lateral teeth, presumably coming from the upper and lower jaw (Pl. 86): Teeth nearly identical in size and proportions with those from the anterior part of the upper or lower jaw of specimen BSPHG AS-I-1377 (Pl. 82), root hemi- and holaulacorhize.

Genus *Belemnobatis* THIOLLIÈRE, 1852

Belemnobatis sismondae THIOLLIÈRE, 1852

Pls. 87–93

Material: MHNL 15.263, MHNL 15.264, MHNL 15.753, MHNL 15.262, MHNL 15.304.

Locality: Cerin.

Literature: THIOLLIÈRE (1852), SAINT-SEINE (1949), DESROCHES (1972), MAISEY (1976), CAVIN et al. (1995), LEIDNER & THIES (1999), UNDERWOOD & WARD (2004).

Description. – Dermal denticles: Same morphological types as described for *Asterodermus*, additionally:

- denticles with simple, thickened and smooth crowns, anterior part of crown slightly expanded with a convex anterior margin without notches, posterior part elongated, pointed and elevated, base larger than crown, neck expanded basoapically and with longitudinal ridges, basal surface flat and stellate in basal view (e.g., Pl. 91, Figs. H–L; Pl. 92, Figs. C, D);
- large spike-like thorns obviously being derived from the forgoing morphological type, crowns nearly upright and larger but otherwise showing the same morphology as in the forgoing type, base also of the same morphology but with an extremely elongated neck (e.g., Pl. 91, Figs. C, D; Pl. 92, Fig. F).

Oral teeth: Specimen MHNL 15.264, adult; upper jaw, left side, lateral teeth (Pl. 90, lower part): Teeth very similar in size and morphology to the anterolateral upper

jaw teeth of *Asterodermus* sp. (specimen BSPHG 1960-XVIII-56, Pl. 78), but mesiodistally a little wider proportionally with the labial face of crown being approximately 2.5 times as wide as high.

Remarks. – CAVIN et al. (1995, pl. 3) previously published teeth of *B. sismondae* coming also from the specimen MHNL 15.264. These show a wider range of crown width/height-ratios ranging from 1.5 in anterior teeth to 2.6 and 3.1 in lateral teeth. The specimen MHNL 15.304 in the Musée des Confluences, Lyon, is labelled as *Spathobatis bugesiacus* THIOLLIÈRE, 1852 but was identified by SAINT-SEINE (1949), DESROCHES (1972) and CAVIN et al. (1995) as *Belemnobatis sismondae* THIOLLIÈRE, 1852.

Genus *Spathobatis* THIOLLIÈRE, 1849

Spathobatis bugesiacus THIOLLIÈRE, 1852

Pls. 94–100

Material: MHNL 15.307, holotype; MHNL 15.308; NHML P10934.

Locality: Cerin.

Literature: THIOLLIÈRE (1852), SAINT-SEINE (1949), DESROCHES (1972), MAISEY (1976), CAVIN et al. (1995), LEIDNER & THIES (1999), UNDERWOOD et al. (1999), UNDERWOOD (2002), UNDERWOOD & WARD (2004).

Description. – Dermal denticles: Same morphological types as described for *Asterodermus platypterus*, additionally: thorns with large, anteroposteriorly elongated crowns of arrow-like shape, posterior end of crown arrowhead-shaped with a more or less pointed and elevated posterior tip and two “barb”-like appendages (e.g., Pl. 94, Fig. B; Pl. 98, Fig. A), anterior end of crown shaft-like (e.g., Pl. 98, Fig. A; Pl. 99, Fig. F) or laterally expanded, lobate and notched anteriorly (e.g., Pl. 94, Fig. B; Pl. 98, Fig. A), base exceeding crown in size, cushion-like (e.g., Pl. 94, Fig. B) or with a flat, stellate basal surface (e.g., Pl. 97, Fig. A), neck with ridges and foramina in between.

Oral teeth (of unknown position from the specimen NHML P10934, Pl. 100, lower part): Teeth very similar in size and morphology to the teeth of *Asterodermus* and *Belemnobatis* but with a distinct and peg-like apron, labial face of crown being approximately 2.5 times as wide as high, root holaulacorhize.

Remarks. – The specimen MHNL 15.308 in the Musée des Confluences, Lyon, is labelled as *Asterodermus* sp. SAINT-SEINE (1949, pl. II), DESROCHES (1972) and CAVIN et al. (1995) identified this specimen as *Spathobatis bugesiacus* THIOLLIÈRE, 1852. CAVIN et al. (1995, pl. 2) also figured anterior and lateral oral teeth of this specimen and of the specimen NHML P2099. These also show a distinct apron but are relatively narrower than the teeth of specimen NHML P10934, showing a crown width/height-ratio of less than 2.5.

6. References

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Plates, explanation of lettering

- A, B, C ... – the capital letter at the beginning of each lettering refers to a specimen of articulated skeleton, scale or tooth shown in the figure concerned.
- 1, 2, 3, ... – the large cipher following the capital letter indicates different aspects of the same scale or tooth specimen.
- a, b, c – the small letter following the capital letter or the large cipher refers to the same letter shown on the figure of the articulated skeleton concerned and which indicates the position on the skeleton a scale specimen was sampled from.
- 1, 2, 3 – a smaller cipher sometimes following the small letter indicates neighbouring sample positions in the same sampling area on the articulated skeleton.

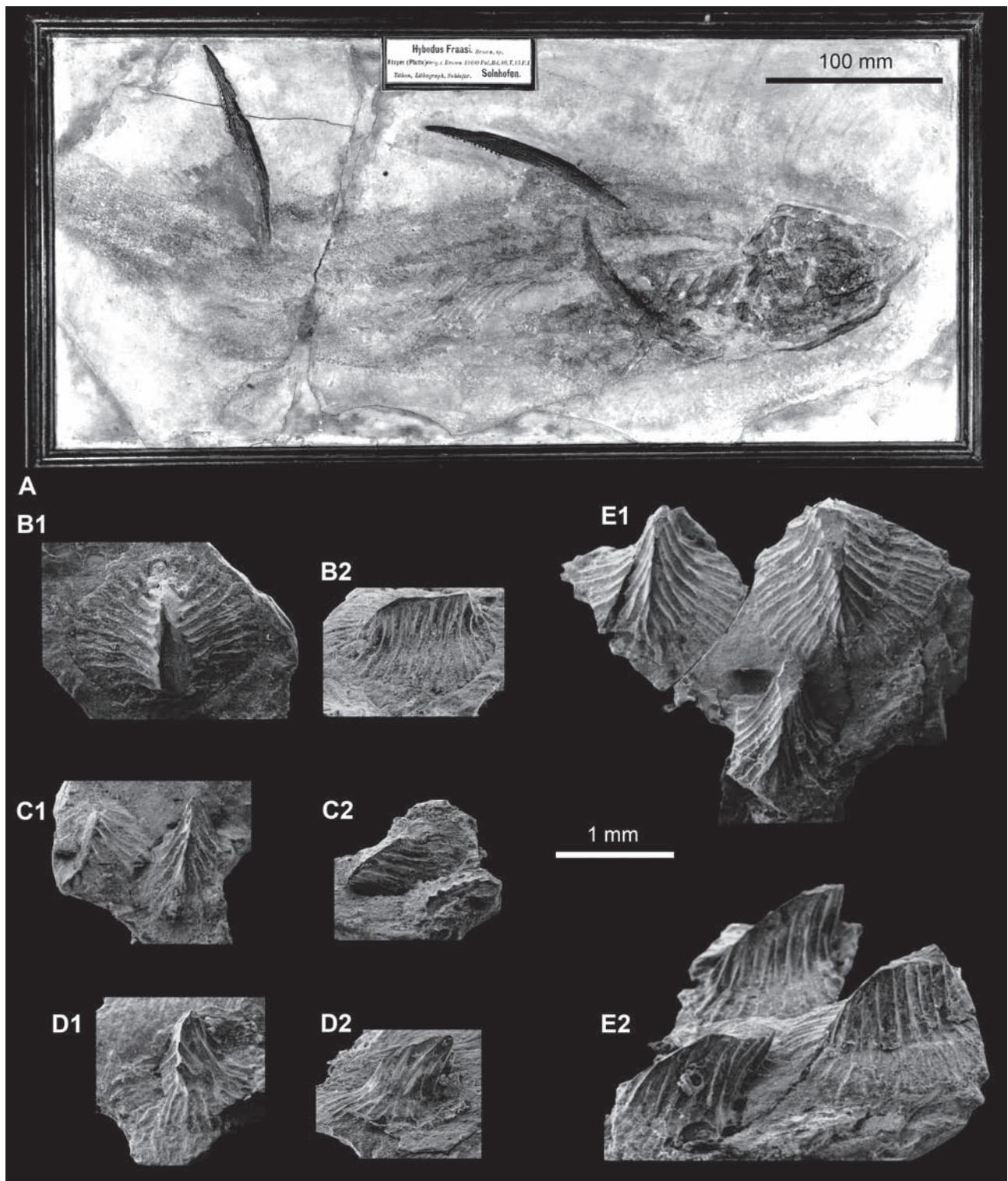


Plate 1. *Hybodus fraasi* BROWN, 1900 (BSPHG 1899-I-2, holotype), Solnhofen

Fig. A. Overview of the specimen. **Figs. B–E.** Isolated scales. – **B.** Scale of unknown position; 1 – apical, 2 – lateral view. **C.** Associated scales from the middle trunk region behind the base of the pelvic fin; 1 – apical, 2 – lateral view. **D.** Scale from caudal peduncle; 1 – apical, 2 – lateral view. **E.** Associated scales from the ventro-lateral middle trunk region; 1 – apical, 2 – lateral view. The scale samples were taken and described by MAISEY (1986).

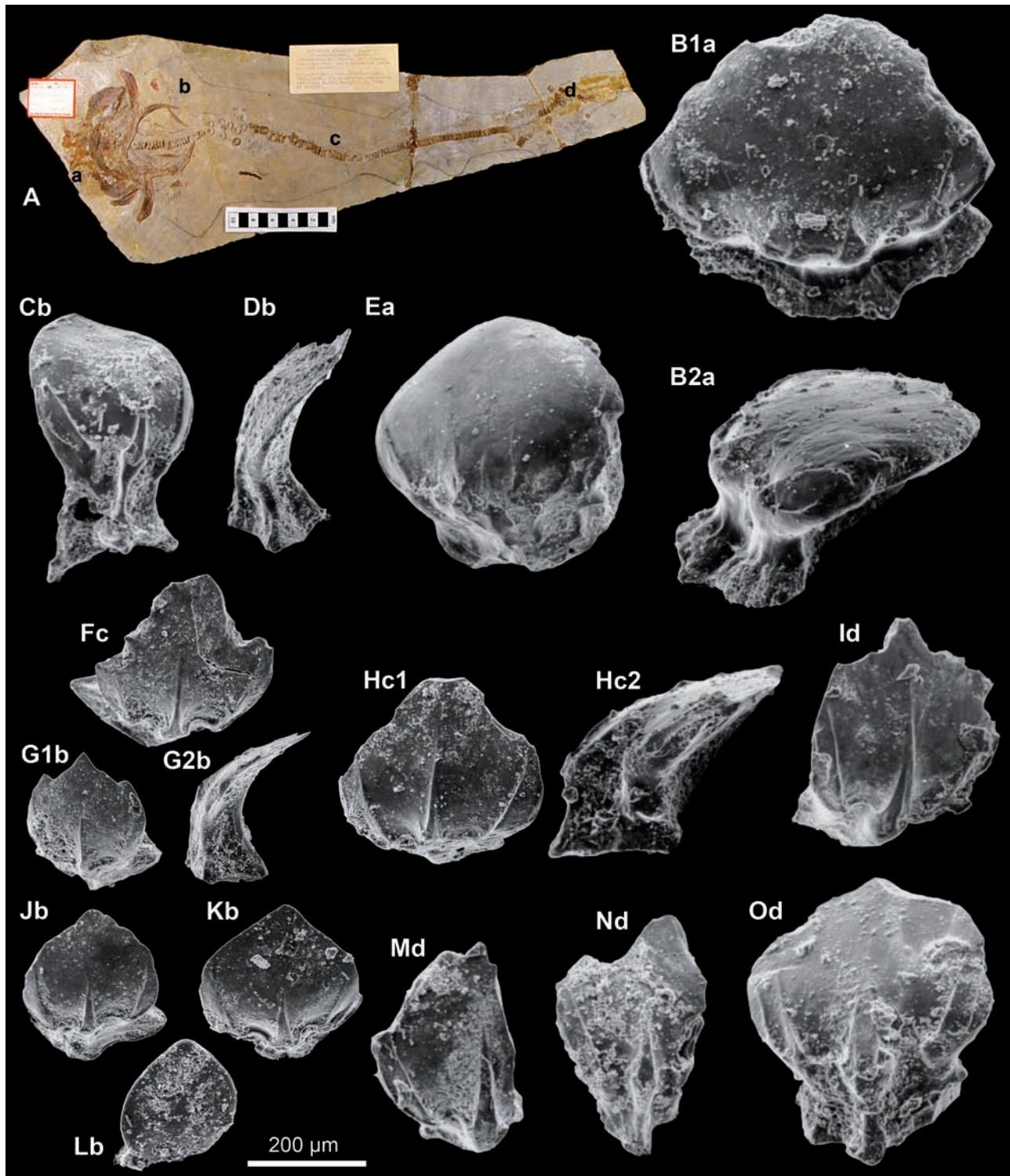


Plate 2. *Notidanoides muensteri* (AGASSIZ, 1843) (GPII T 1210-3, holotype), Nusplingen

Fig. A. Overview of the specimen. **Figs. B–O.** Isolated scales. – **B1a, B2a.** Scale from the cranial region; 1 – apical, 2 – lateral view. **Cb.** Scale from the pectoral fin, anterior view. **Db.** Scale from the dorsal lobe of the caudal fin, lateral view. **Ea.** Scale from the cranial region, apical view. **Fc.** Scale from the dorsal side of the trunk in front of the dorsal fin, apical view. **G1b, G2b.** Scale from the pectoral fin; 1 – apical, 2 – lateral view. **Hc1, Hc2.** Scale from the trunk in front of the dorsal fin; 1 – apical, 2 – lateral view. **Id, Md,** **Nd, Od.** Scales from the dorsal lobe of the caudal fin, apical view. **Jb, Kb, Lb.** Scales from the pectoral fin, apical view.

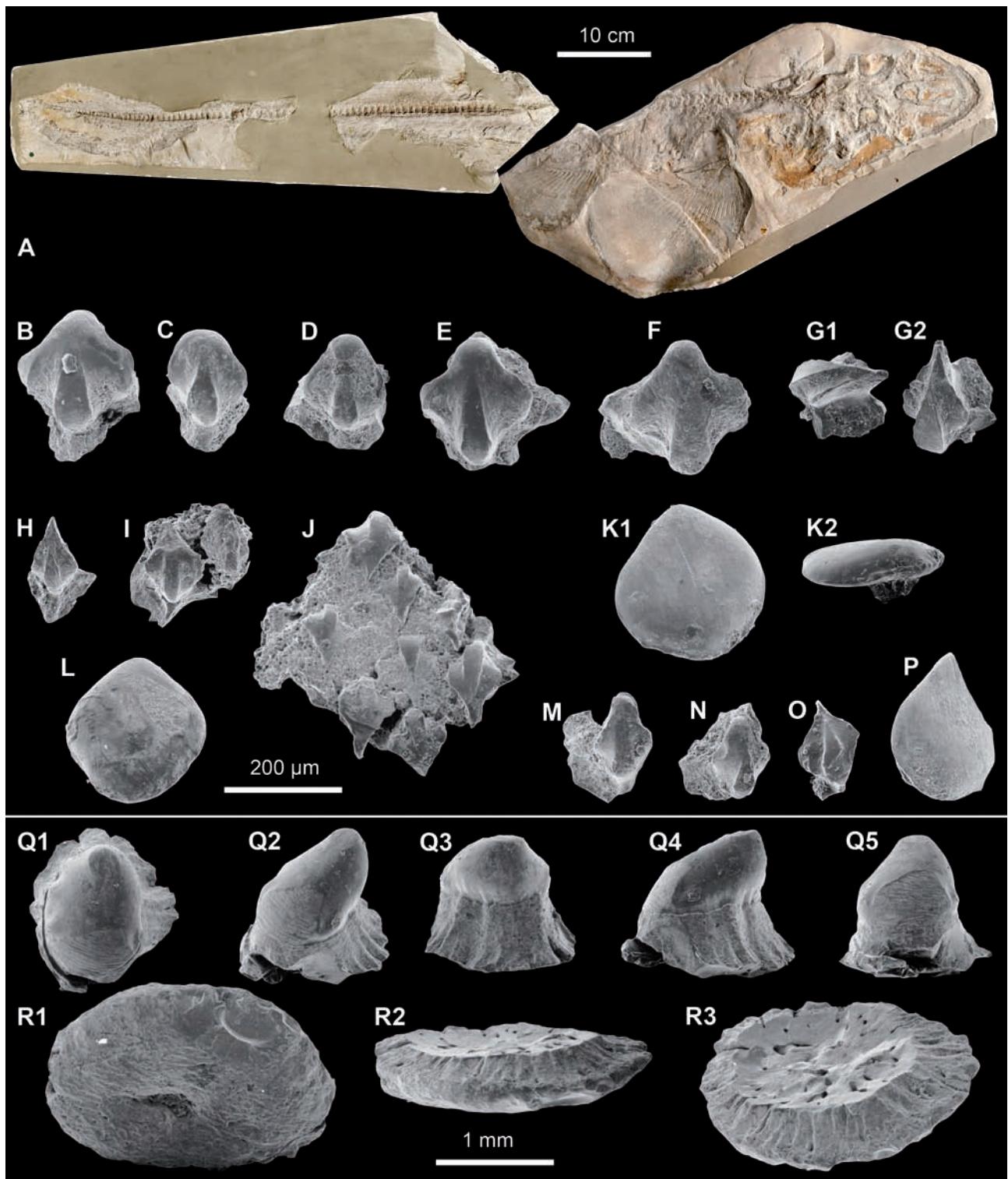


Plate 3. *Protospinax annectans* WOODWARD, 1919 (NHML P8775, holotype), Solnhofen

Fig. A. Overview of the specimen. **Figs. B–Q.** Isolated scales and thorns. – **B–F, H, I, L–P.** Scales of unknown position, apical view. **G.** Scale of unknown position; 1 – lateral, 2 – apical view. **J.** Associated scales of unknown position, apical view. **K.** Scale of unknown position; 1 – apical, 2 – lateral view. **Q.** Thorn from above the left orbit; 1 – apical, 2 – antero-lateral, 3 – posterior, 4 – postero-lateral, 5 – anterior view. **R.** Base broken off the thorn in Fig. Q during preparation; 1 – basal, 2, 3 – lateral view.

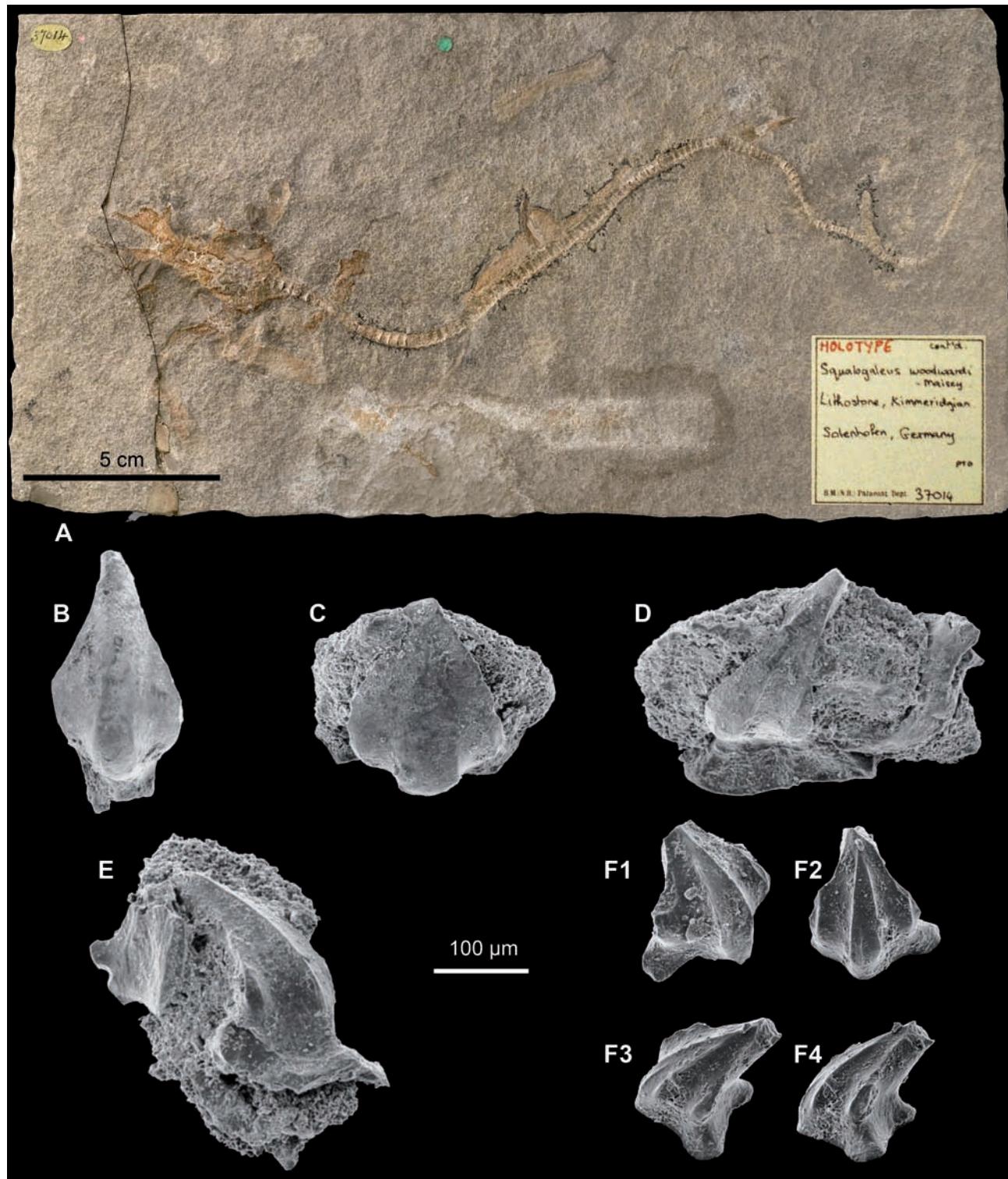


Plate 4. *Squalogaleus woodwardi* MAISEY, 1976 (NHML P37014, holotype) (= *Protospinax annectans* WOODWARD, 1919), Solnhofen Fig. A. Overview of the specimen. Figs. B–F. Isolated scales. – B–D. Scales of unknown position, apical view. E. Scale of unknown position, latero-anterior view. F1, F2, F3, F4. Scale of unknown position; 1 – latero-anterior, 2 – apical, 3, 4 – lateral view.

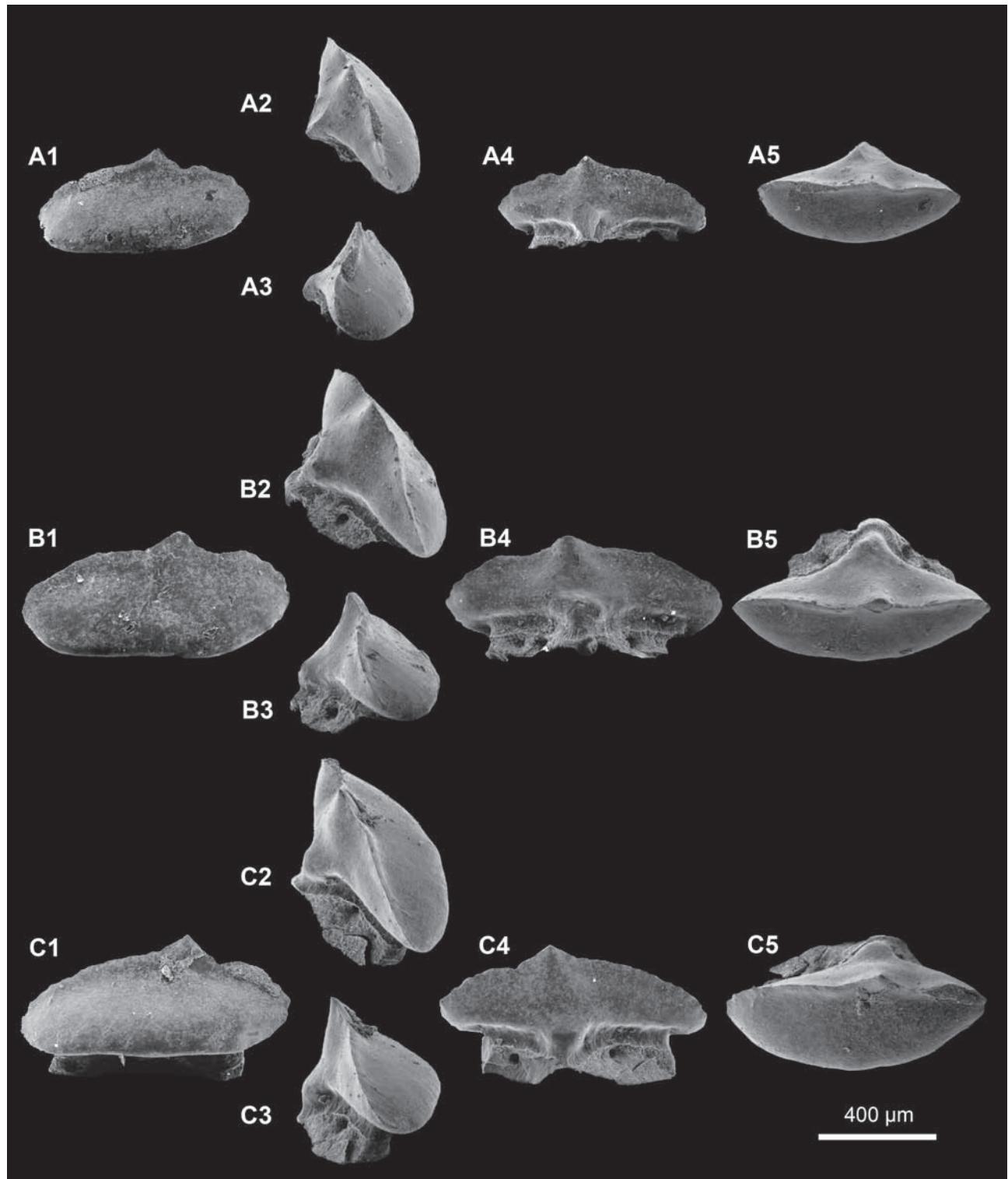


Plate 5. *Squalogaleus woodwardi* MAISEY, 1976 (NHML P37014, holotype) (= *Protospinax annectans* WOODWARD, 1919), Solnhofen
Figs. A–C. Oral teeth; 1 – labial, 2, 3 – lateral, 4 – lingual, 5 – apical view.

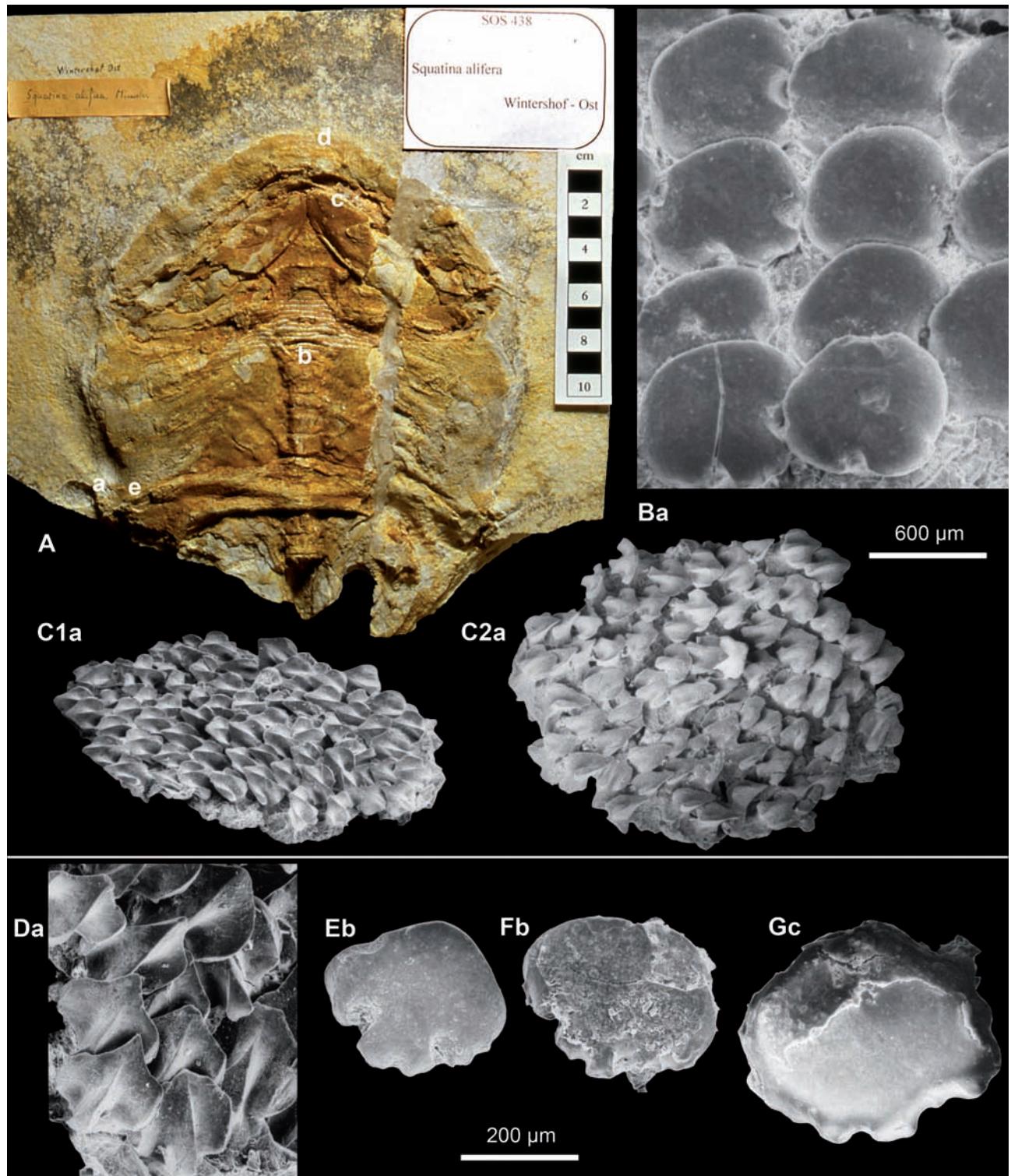


Plate 6. *Pseudorhina alifera* (MÜNSTER, 1842) (SOS 438), Wintershof-Ost

Fig. A. Overview of the specimen. **Figs. B–G.** Isolated scales. – **Ba.** Associated scales from the neck region, apical view. **C1a, C2a.** Associated scales from the neck region; 1 – apical, 2 – lateral view. **Da.** Associated scales from the neck region, apical view. **Eb, Fb.** Scales from the gular region, apical view. **Gc.** Scale from the lower jaw, apical view.

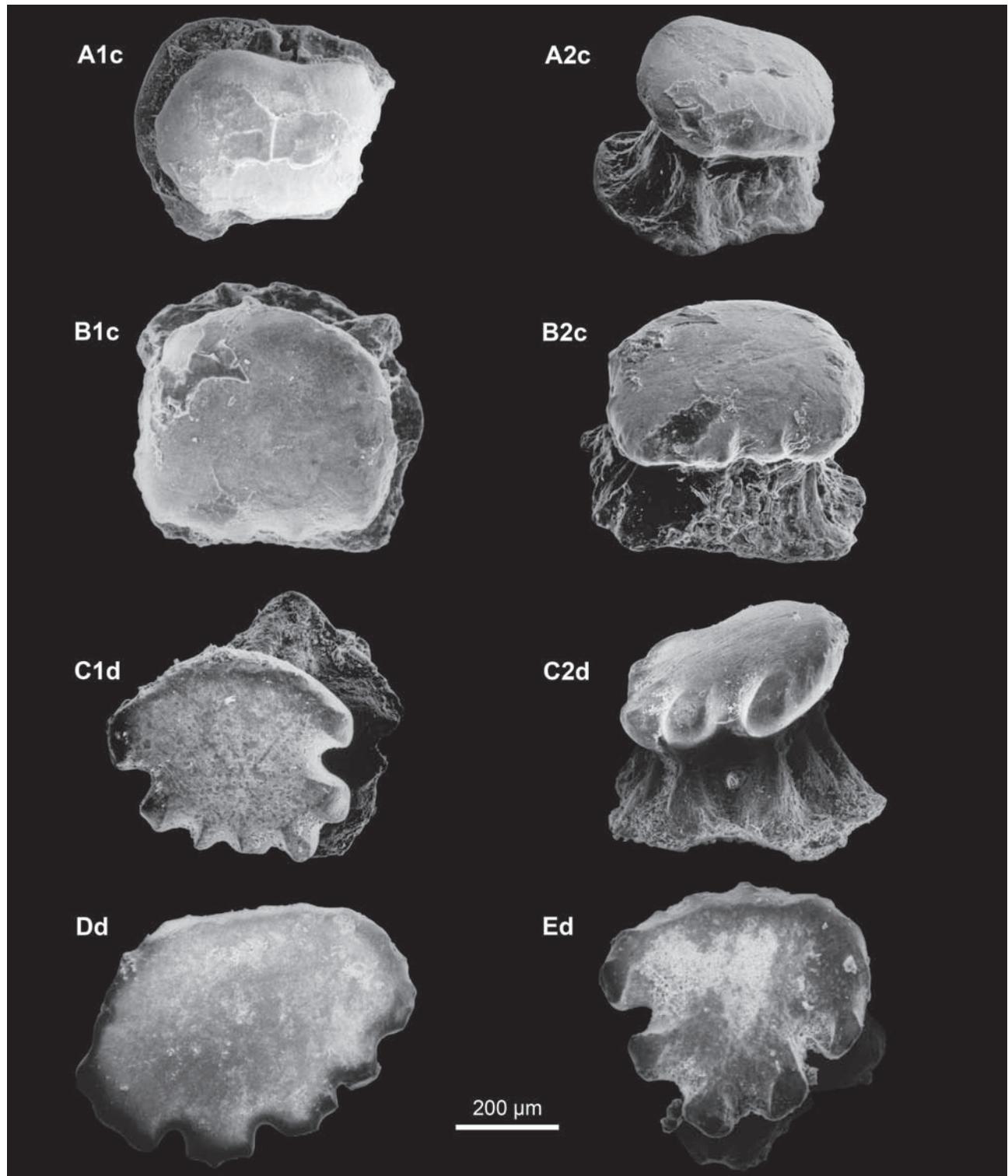


Plate 7. *Pseudorhina alifera* (MÜNSTER, 1842) (SOS 438), Wintershof-Ost

Figs. A–E. Isolated scales. – **A1c, A2c, B1c, B2c.** Scales from the lower jaw; 1 – apical, 2 – lateral view. **C1c, C2d.** Scale from the rostral region; 1 – apical, 2 – lateral view. **Dd, Ed.** Scales from the rostral region, apical view.

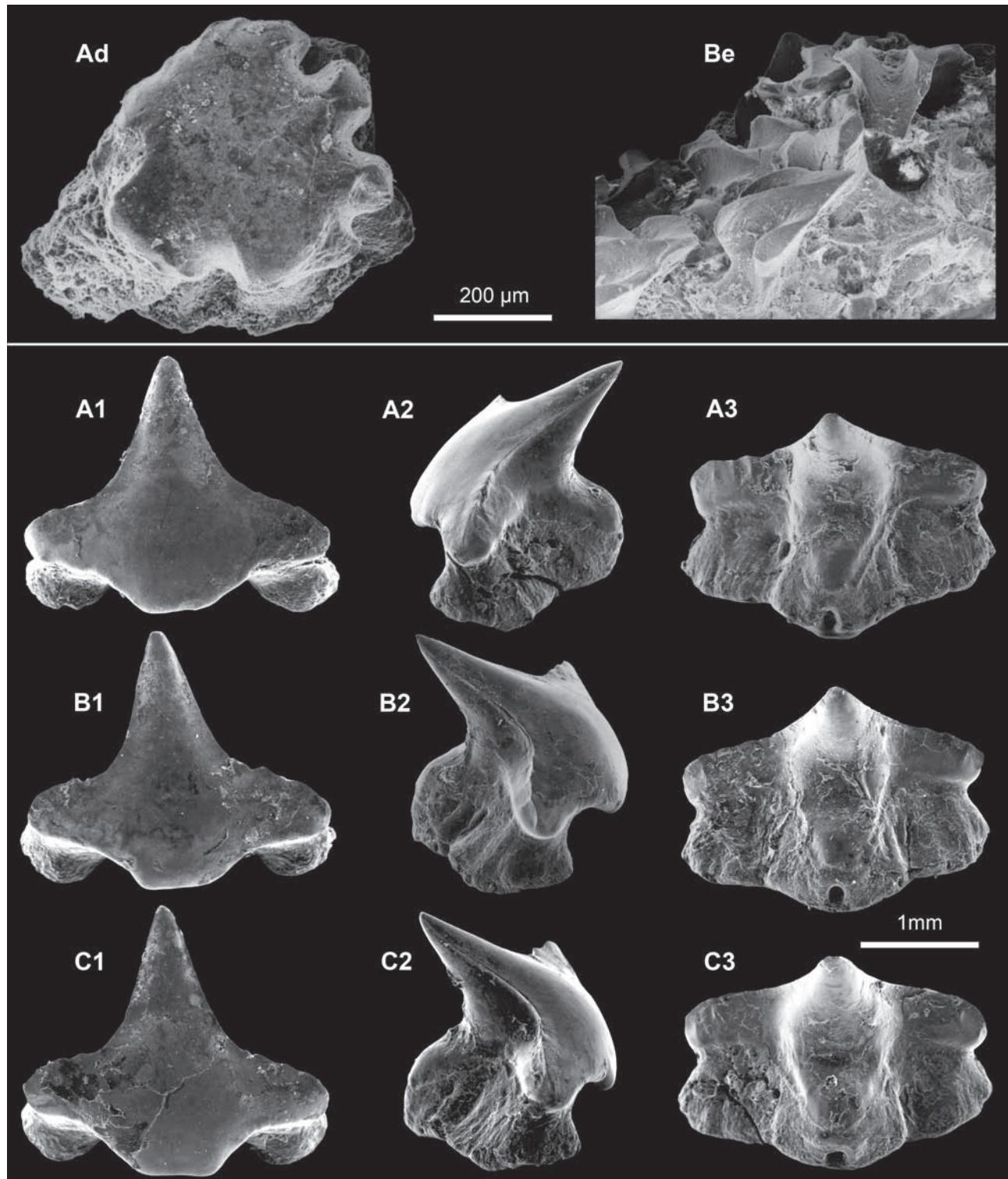


Plate 8. *Pseudorhina alifera* (MÜNSTER, 1842) (SOS 438), Wintershof-Ost

Upper part

Figs. A–B. Isolated scales. – **Ad.** Scale from the rostral region, apical view. **Be.** Associated scales from the neck region, lateral view.

Lower part

Figs. A–C. Oral teeth; 1 – labial, 2 – lateral, 3 – lingual view.

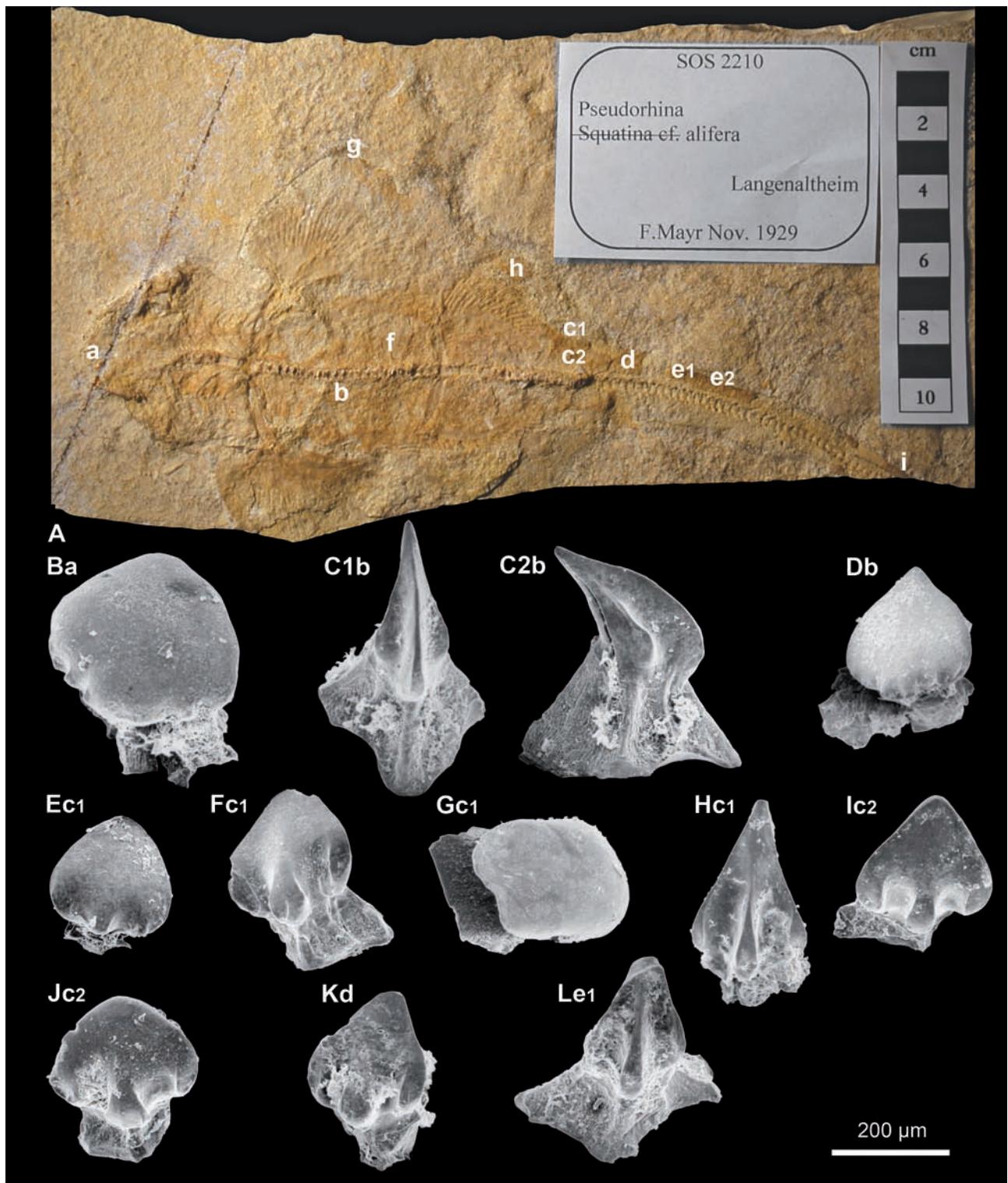


Plate 9. *Pseudorhina alifera* (MÜNSTER, 1842) (SOS 2210), Langenaltheim

Fig. A. Overview of the specimen. **Figs. B–L.** Isolated scales. – **Ba.** Scale from the rostral region, apical view. **C1b, C2b.** Scale from middle trunk region; 1 – apical, 2 – lateral view. **Db.** Scale from middle trunk region, apical view. **Ec1, Fc1, Gc1, Hc1, Ic2, Jc2.** Scales from the posterior trunk region, apical view. **Kd, Le1.** Scales from anterior tail region, apical view.

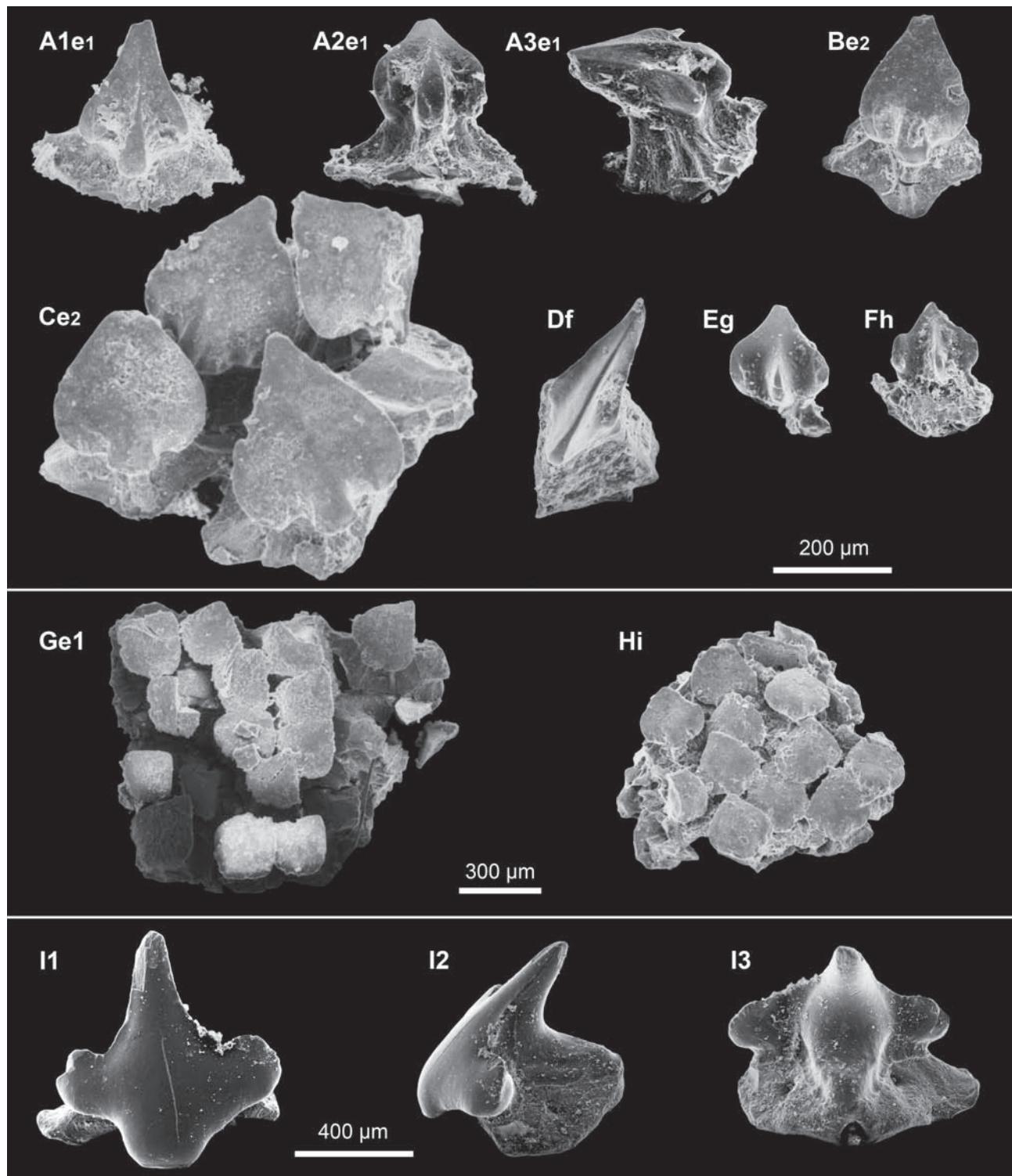


Plate 10. *Pseudorhina alifera* (MÜNSTER, 1842) (SOS 2210), Langenaltheim

Figs. A–H. Isolated scales. – **A1e1, A2e1, A3e1.** Scale from the anterior tail region; 1 – apical, 2 – anterior, 3 – lateral view. **Be2.** Scale from the anterior tail region, apical view. **Ce2.** Associated scales from the anterior tail region, apical view. **Df.** Scale from middle trunk region, apical view. **Eg.** Scale from the pectoral fin, apical view. **Fh.** Scale from the pelvic fin, apical view. **Ge1.** Associated scales from the anterior tail region, apical view. **Hi.** Associated scales from the posterior tail or caudal fin, apical view. **Fig. I.** Anterior or lateral oral tooth; 1 – labial, 2 – lateral, 3 – lingual view.

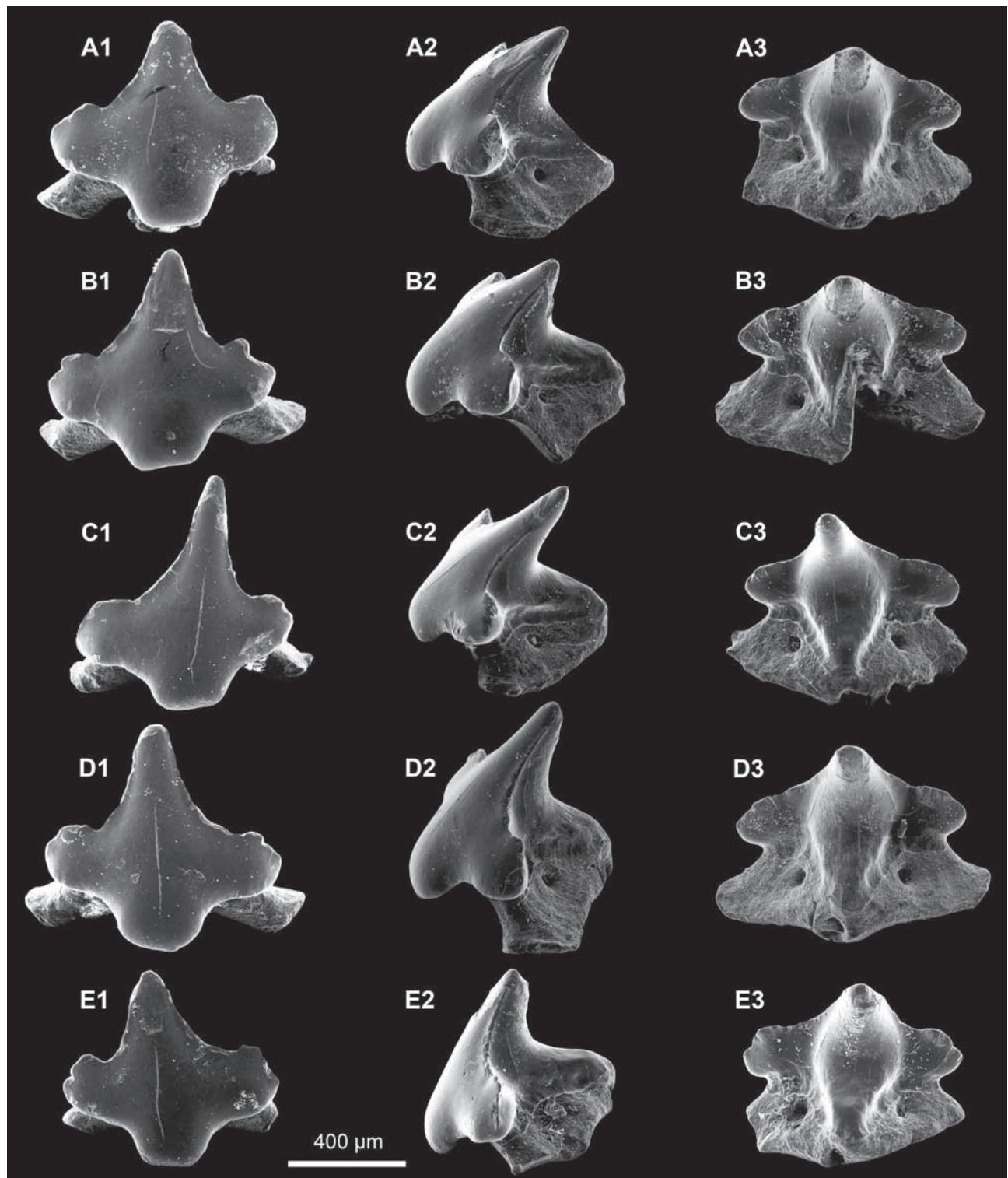


Plate 11. *Pseudorhina alifera* (MÜNSTER, 1842) (SOS 2210), Langenaltheim

Figs. A–E. Anterior or lateral oral teeth; 1 – labial, 2 – lateral, 3 – lingual view.

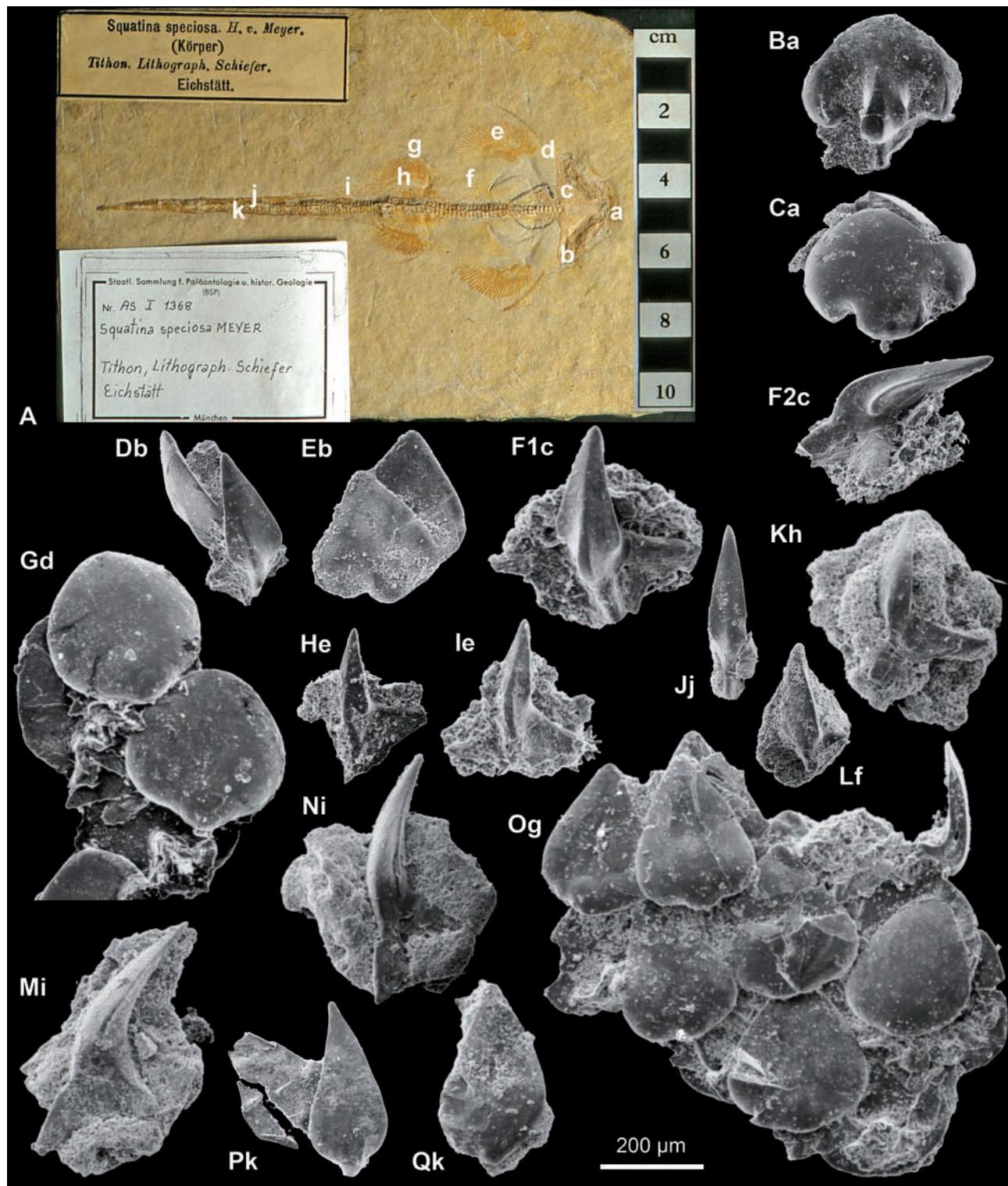


Plate 12. *Pseudorhina speciosa* (VON MEYER, 1856) (BSPHG AS-I-1368) (= *Pseudorhina alifera* (MÜNSTER, 1842)), Eichstätt

Fig. A. Overview of the specimen. **Figs. B–Q.** Isolated scales. – **Ba, Ca.** Scales from the rostral region, apical view. **Db, Eb.** Associated scales from the lateral cranial region, apical view. **F1c, F2c.** Scale from the cranial region; 1 – apical, 2 – lateral view. **Gd.** Associated scales from the anterior edge of the pectoral fin, apical view. **He, Ie.** Scales from the pectoral fin, apical view. **Jj.** Scale from the tail, apical view. **Kh.** Scale from the pelvic girdle region, anterior view. **Lf.** Scale from the middle trunk region, apical view. **Mi, Ni.** Scales from the anterior tail region, apical view. **Og.** Associated scales from the pelvic fin, apical view. **Pk, Qk.** Scales from the tail, apical view.

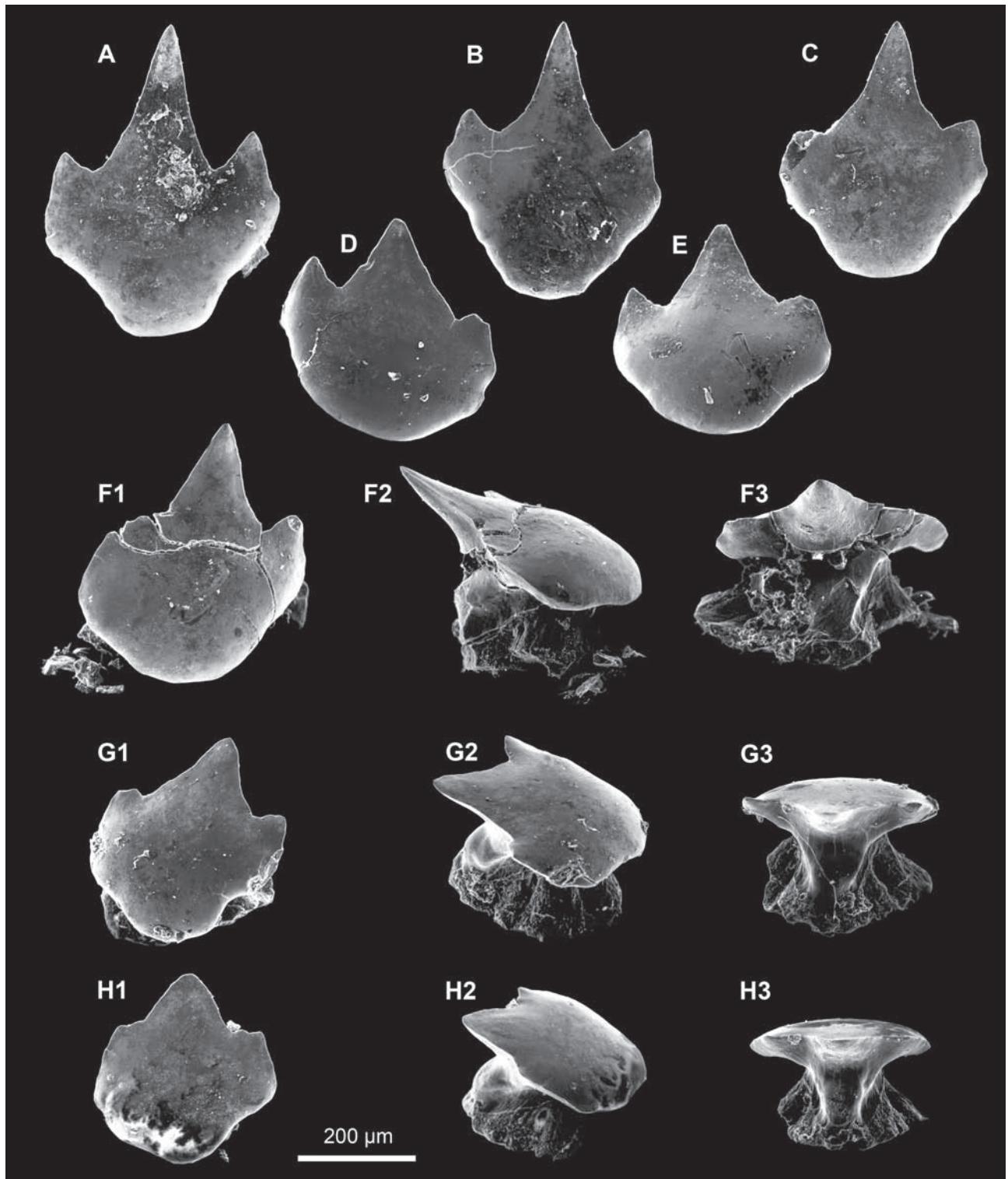


Plate 13. *Pseudorhina speciosa* (VON MEYER, 1856) (BSPHG AS-I-1368) (= *Pseudorhina alifera* (MÜNSTER, 1842)), Eichstätt

Figs. A–H. Oral teeth. – A–C. Anterior or antero-lateral teeth, labial view. D–E. Lateral or latero-posterior teeth, labial view. F–H. Lateral to posterior teeth; 1 – labial, 2 – lateral, 3 – lingual view.

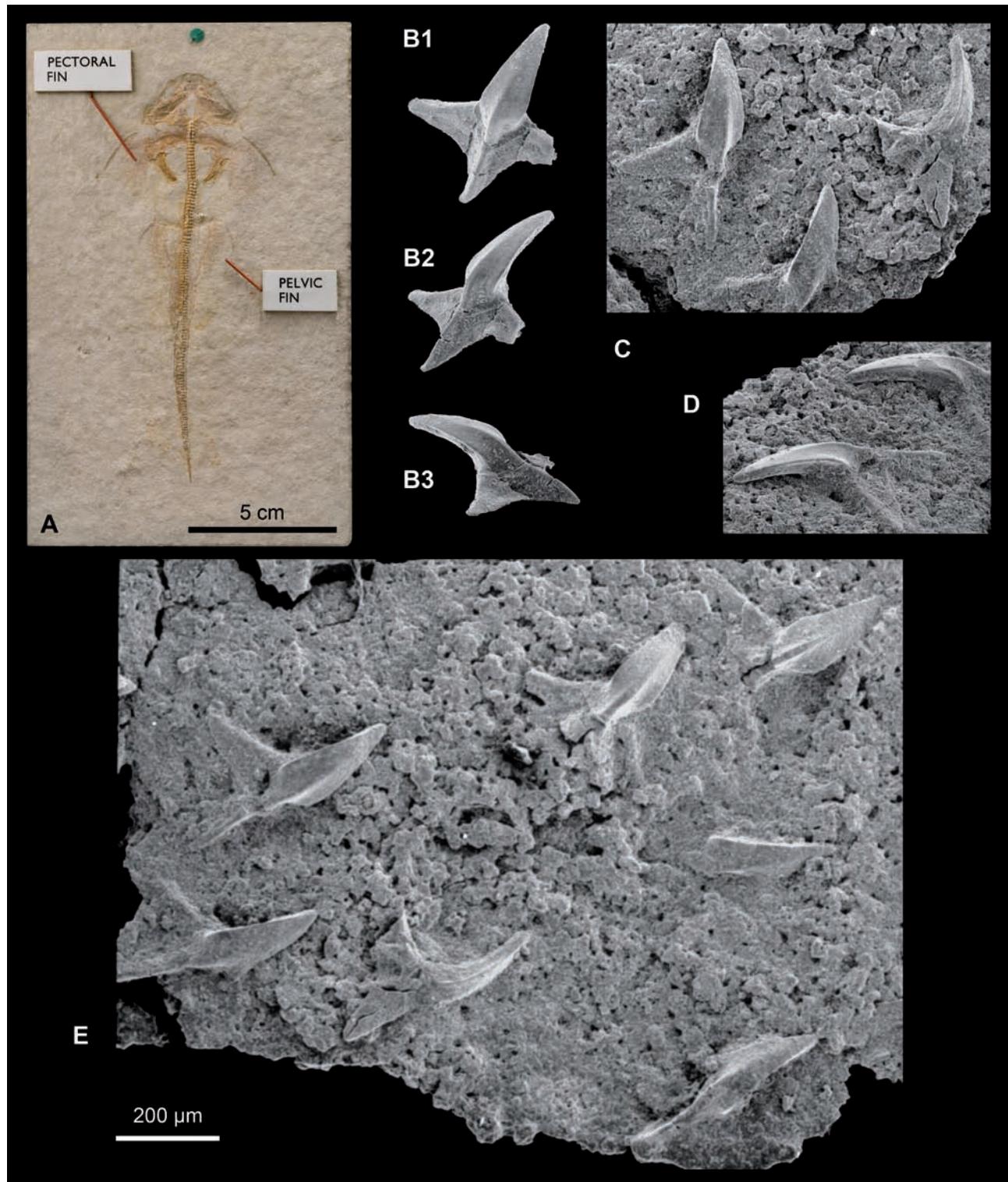


Plate 14. *Pseudorhina speciosa* (VON MEYER, 1856) (NHML P37013) (= *Pseudorhina alifera* (MÜNSTER, 1842)), Solnhofen

Fig. A. Overview of the specimen. **Figs. B–E.** Isolated scales. – **B.** Scale of unknown position; 1 – apical, 2 – antero-lateral, 3 – lateral view. **C–E.** Associated scales of unknown positions, apical view.

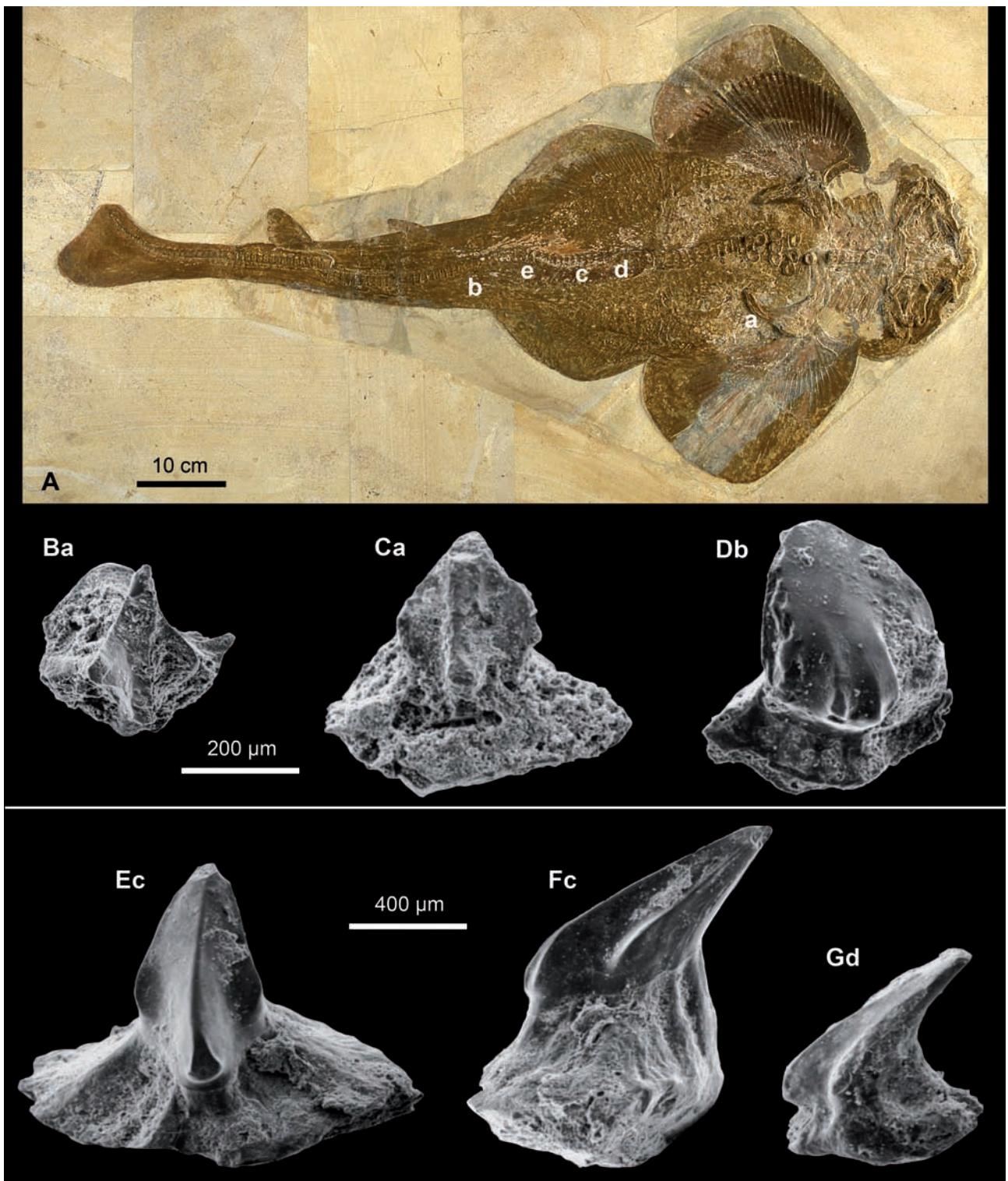


Plate 15. *Pseudorhina acanthoderma* (FRAAS, 1854) (SMNS 5735), Nusplingen

Fig. A. Overview of the specimen. **Figs. B–G.** Isolated scales. – **Ba, Ca.** Scales from the anterior trunk region, apical view. **Db.** Scale from the anterior tail region, apical view. **Ec.** Scale from the posterior trunk region, apical view. **Fc.** Scale from the posterior trunk region, lateral view. **Gd.** Scale from the middle trunk region, lateral view.

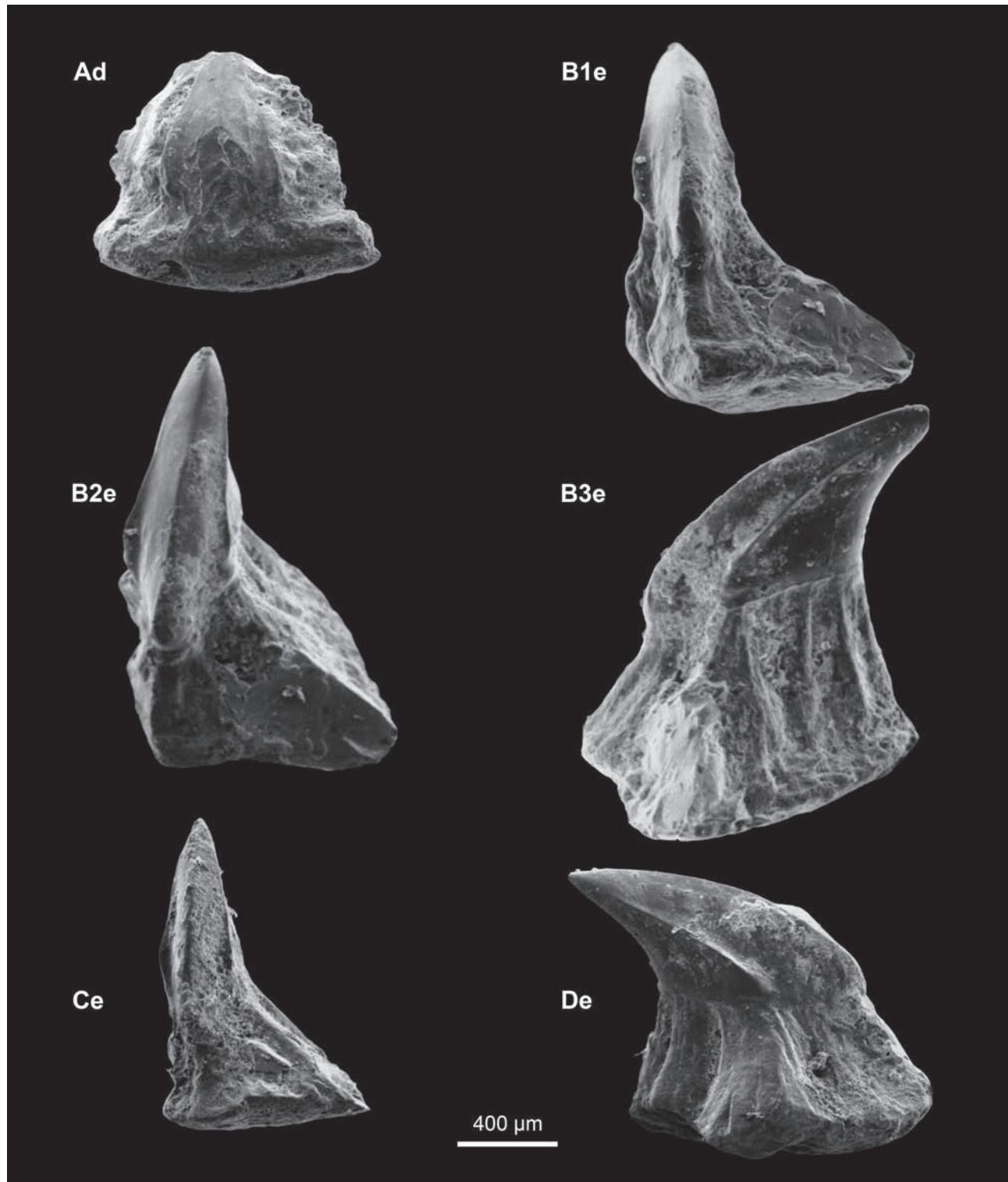


Plate 16. *Pseudorhina acanthoderma* (FRAAS, 1854) (SMNS 5735), Nusplingen

Figs. A–D. Isolated scales. – **Ad.** Scale from the middle trunk region, anterior view. **B1e**, **B2e**, **B3e**. Scale from the posterior trunk region; 1 – anterior, 2 – apical, 3 – lateral view. **Ce**. Scale from the posterior trunk region, apical view. **De**. Scale from the posterior trunk region, lateral view.



Plate 17. *Pseudorhina acanthoderma* (FRAAS, 1854) (SMNS 3695/27, original of SCHWEIZER (1964), specimen number 19), Nusplingen
Fig. A. Overview of the specimen. Figs. B–F. Isolated scales from the pelvic region; 1 – apical, 2 – lateral view.

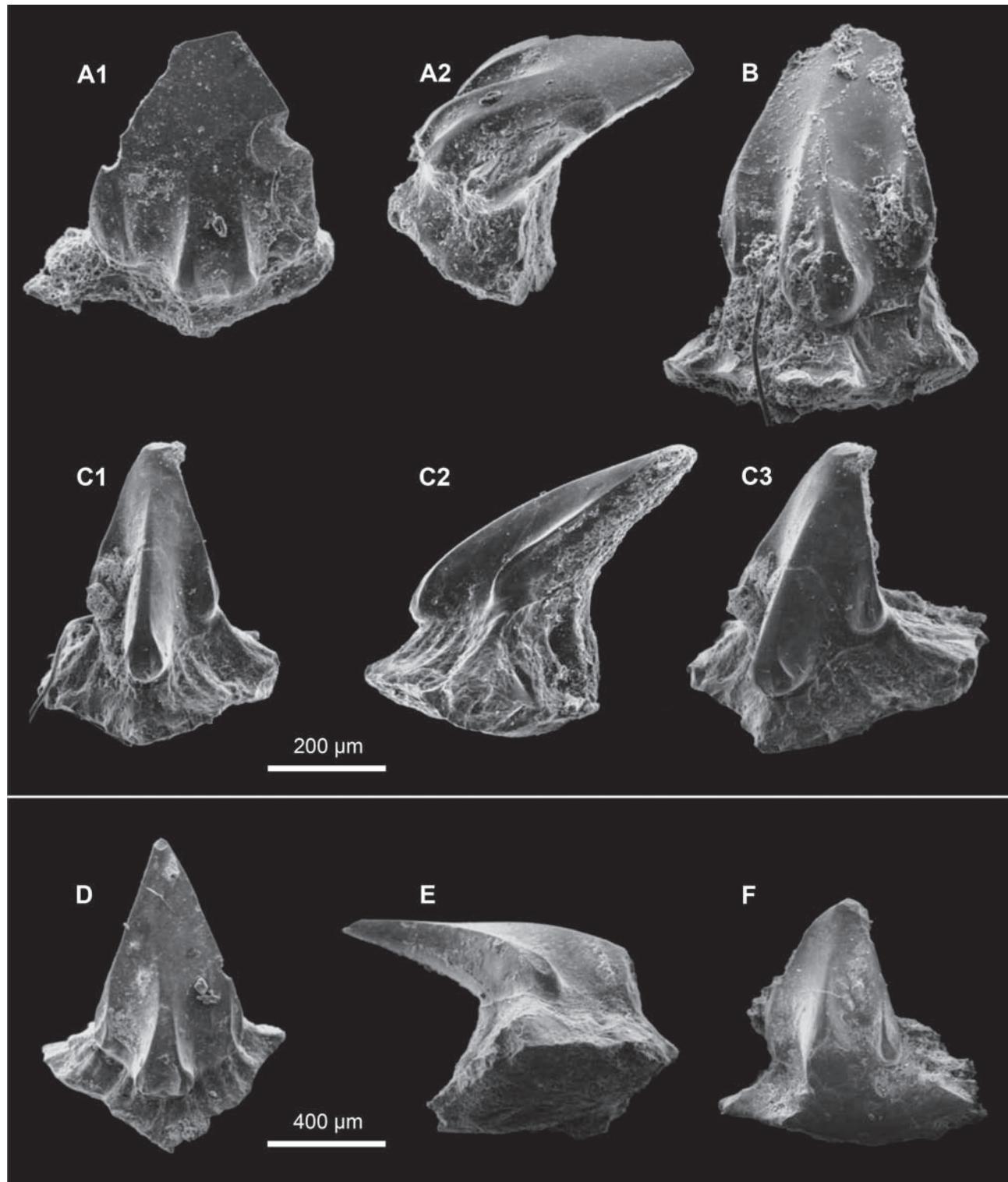


Plate 18. *Pseudorhina acanthoderma* (FRAAS, 1854) (SMNS 3695/27, original of SCHWEIZER (1964), specimen number 19), Nusplingen
Figs. A–F. Isolated scales from the pelvic region in different views; 1 – apical, 2 – lateral, 3 – anterior view.

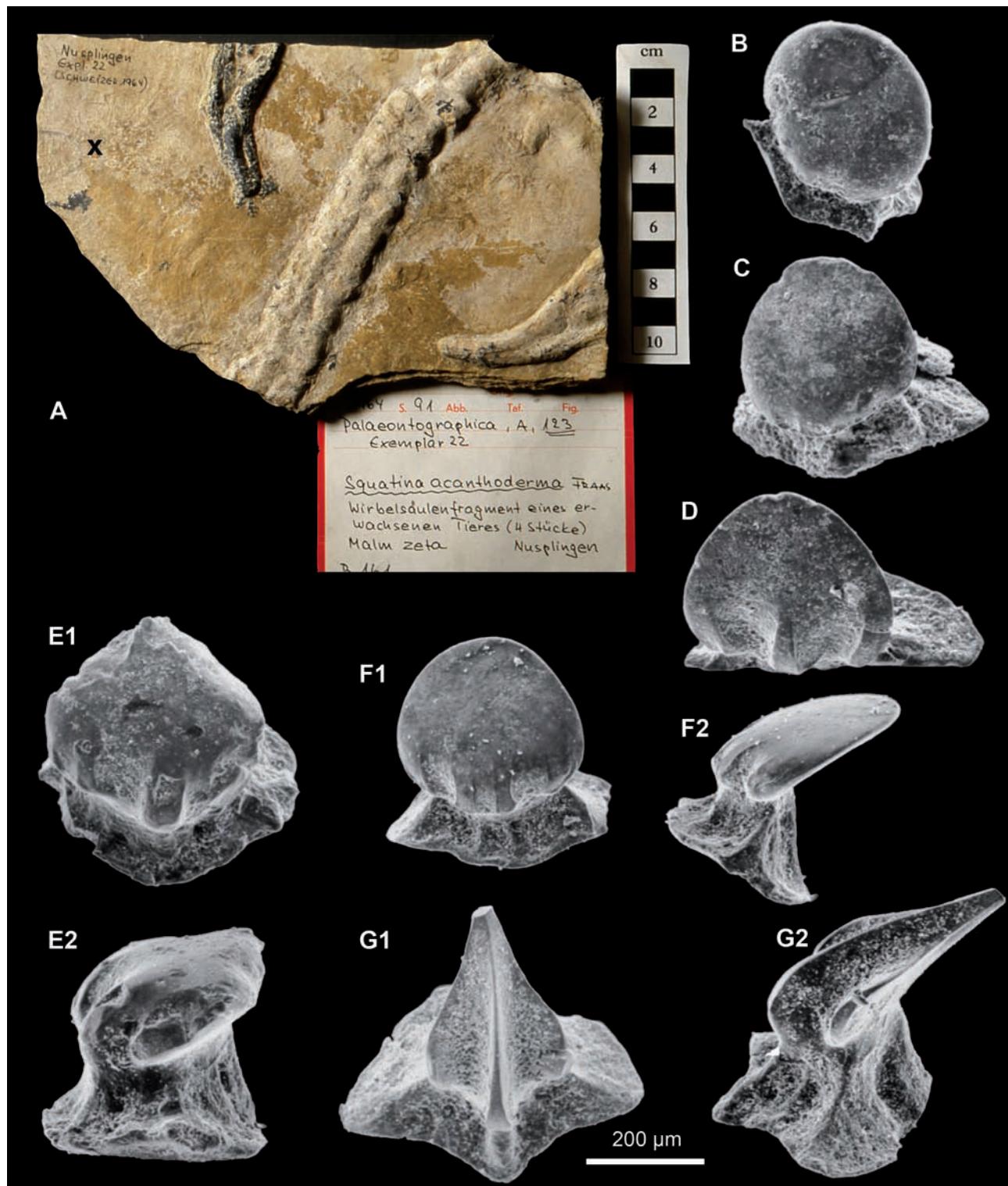


Plate 19. *Pseudorhina acanthoderma* (Fraas, 1854) (GPIT B-161, original of SCHWEIZER (1964), specimen number 22), Nusplingen
Fig. A. Overview of the specimen. **Figs. B–G.** Isolated scales from the pectoral girdle region in different views; 1 – apical, 2 – lateral view.

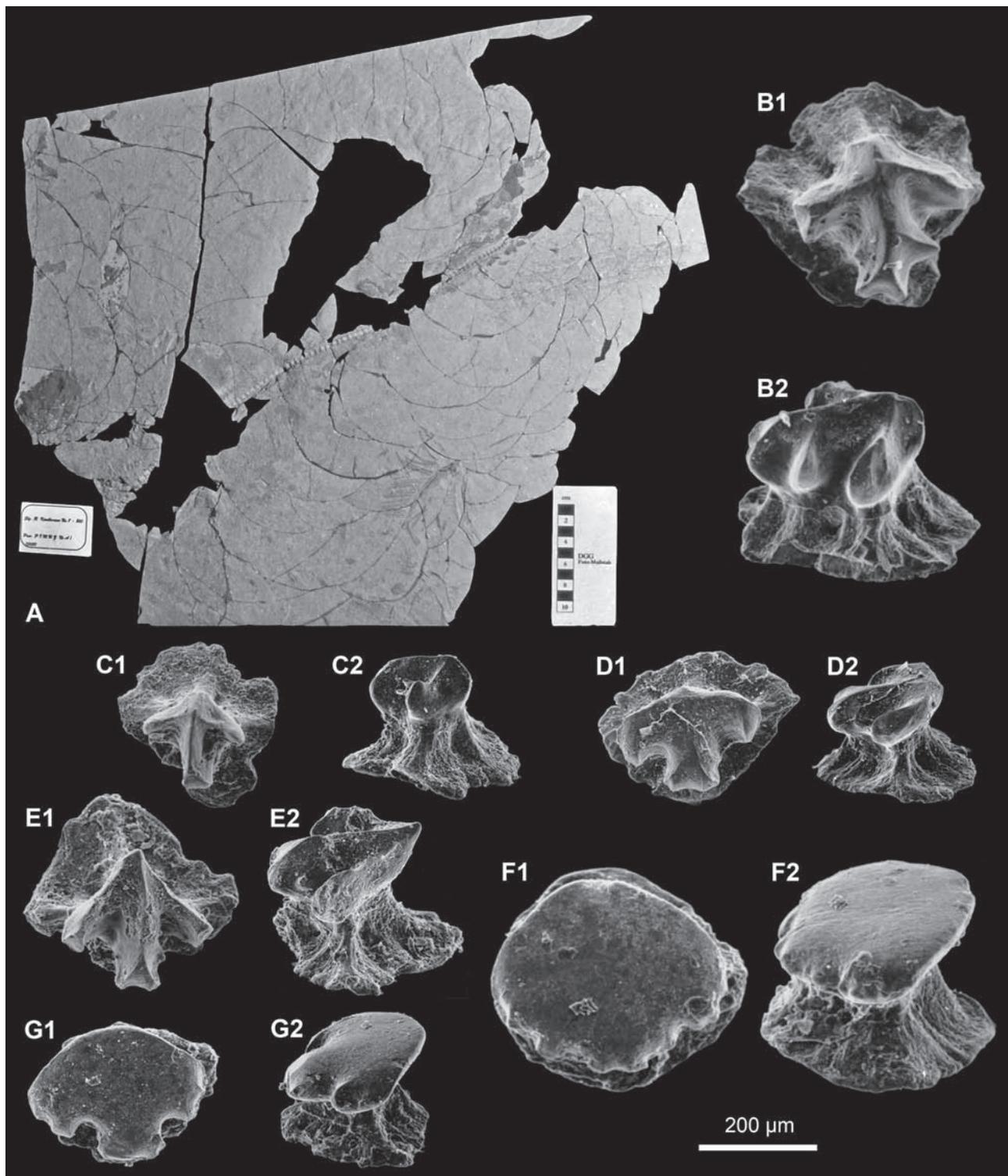


Plate 20. *Pseudorhina* sp. (PIMUZ A/I 3050), Eichstätt

Fig. A. Overview of the specimen. The limestone plate containing the specimen is broken into numerous isolated pieces. For photography the pieces were reassembled as far as possible in order to reconstruct the original fossil plate. The figured scales come from a small limestone piece which was left over and which position within the plate could not be traced. This piece of unknown position was dissolved in acetic acid, and the scales were collected from the residue. A small piece of limestone from the jaw region was also dissolved and yielded oral teeth. **Figs. B–G.** Isolated scales; 1 – apical, 2 – lateral view.

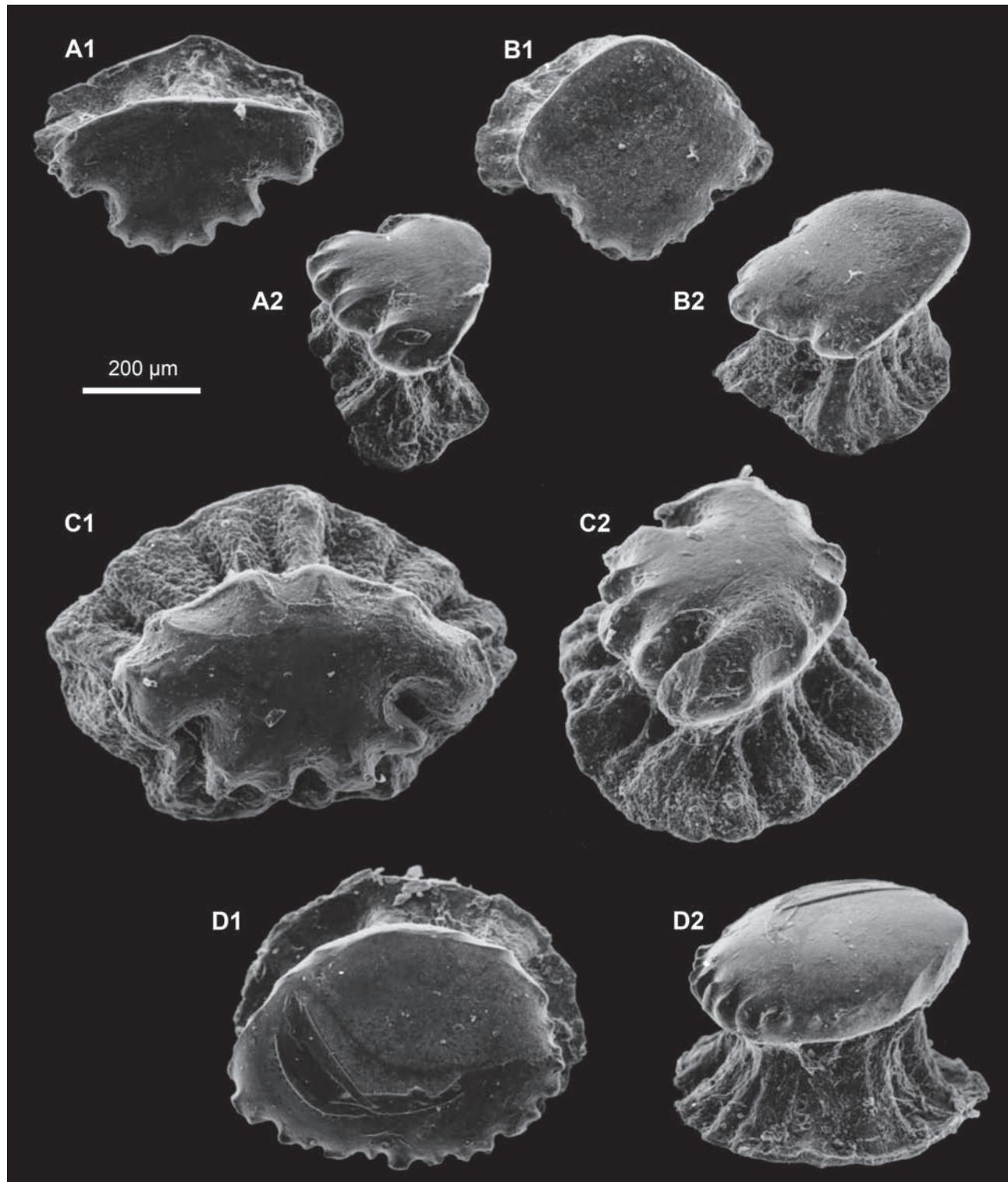


Plate 21. *Pseudorhina* sp. (PIMUZ A/I 3050), Eichstätt

Figs. A–D. Isolated scales; 1 – apical, 2 – lateral view.

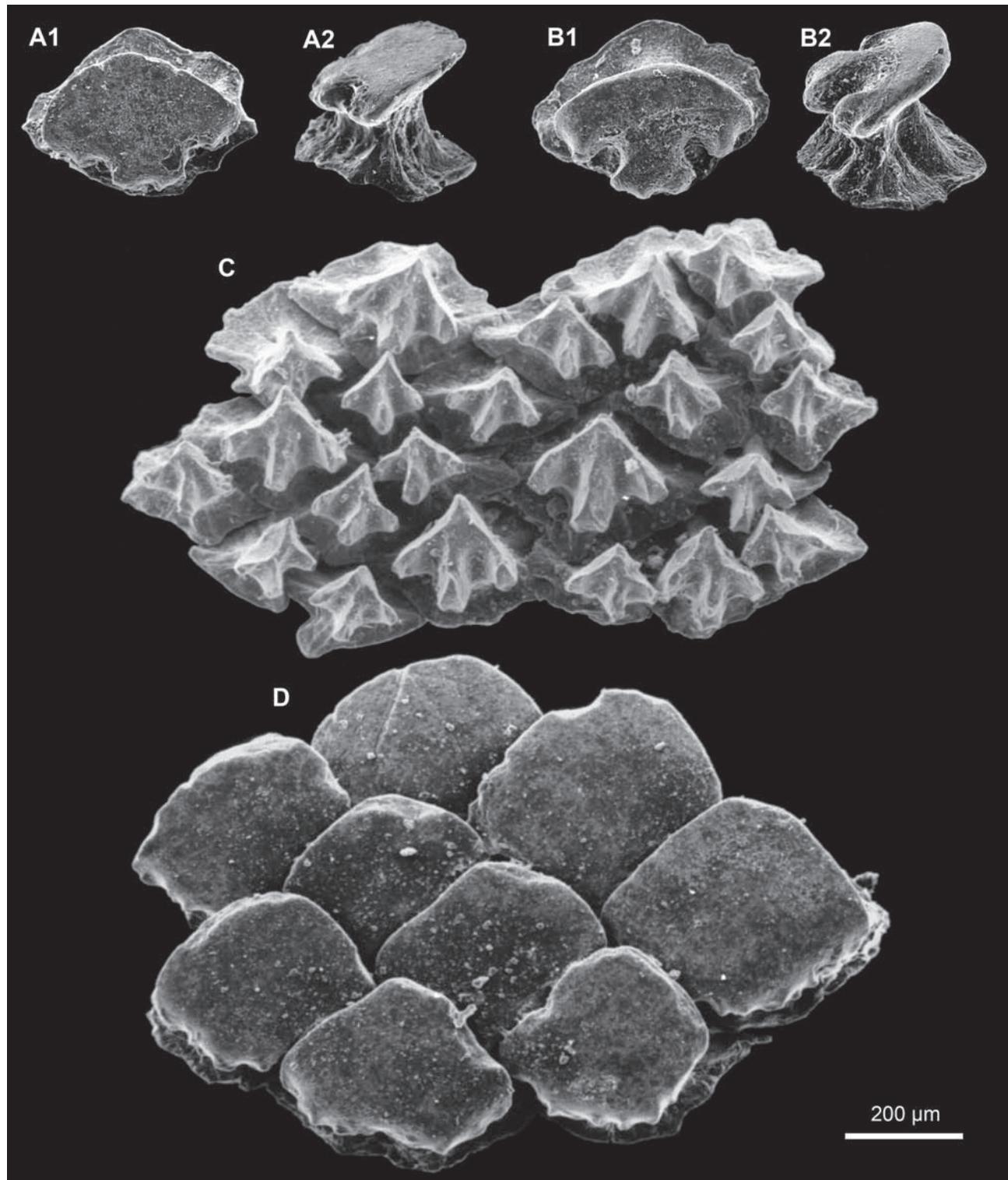


Plate 22. *Pseudorhina* sp. (PIMUZ A/I 3050), Eichstätt

Figs. A, B. Isolated scales; 1 – apical, 2 – lateral view. Figs. C, D. Associated scales of unknown position, apical view.

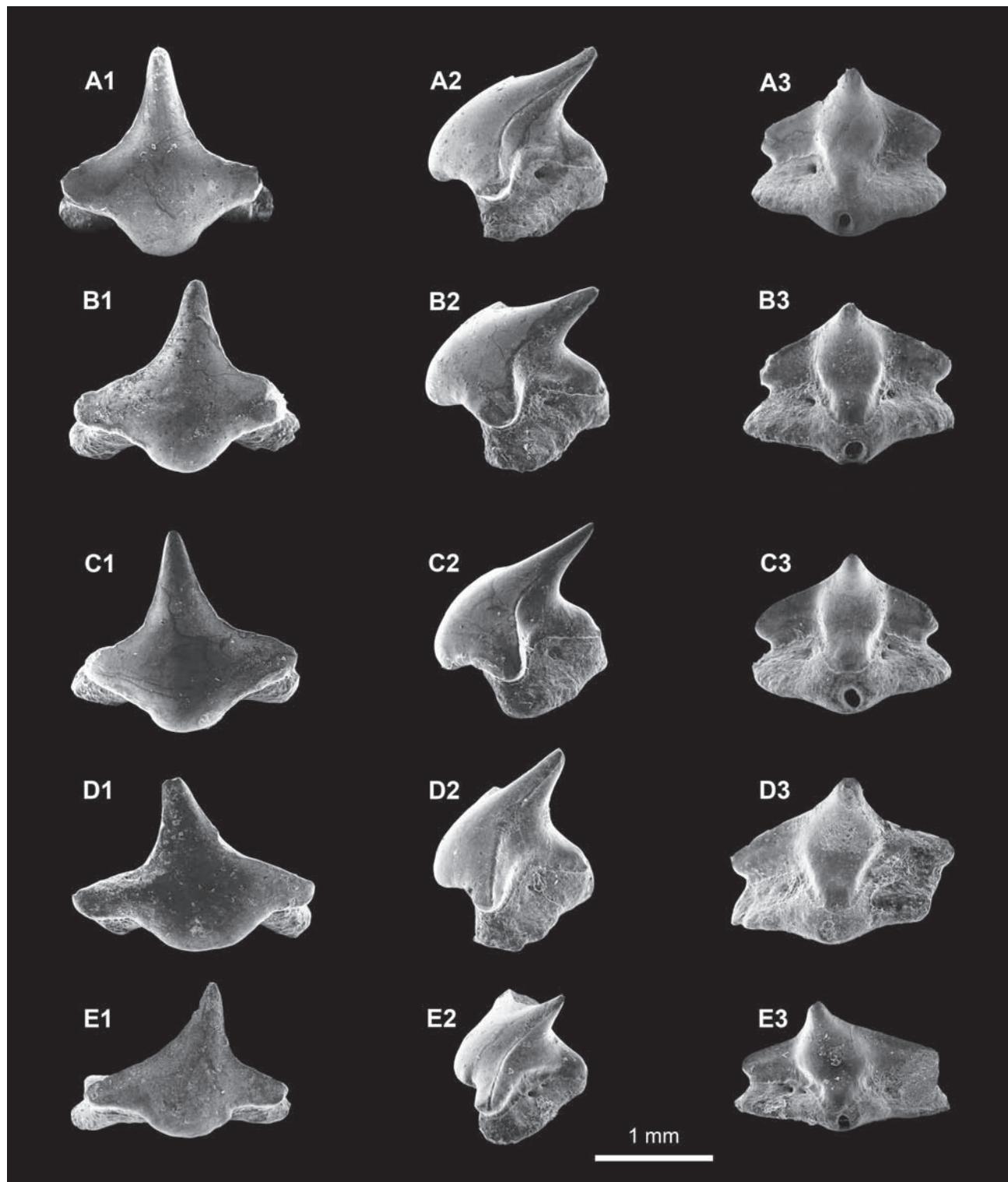


Plate 23. *Pseudorhina* sp. (PIMUZ A/I 3050), Eichstätt

Figs. A–E. Oral teeth. – A–C. Anterior teeth. D–E. Lateral teeth. 1 – labial, 2 – lateral, 3 – lingual view.

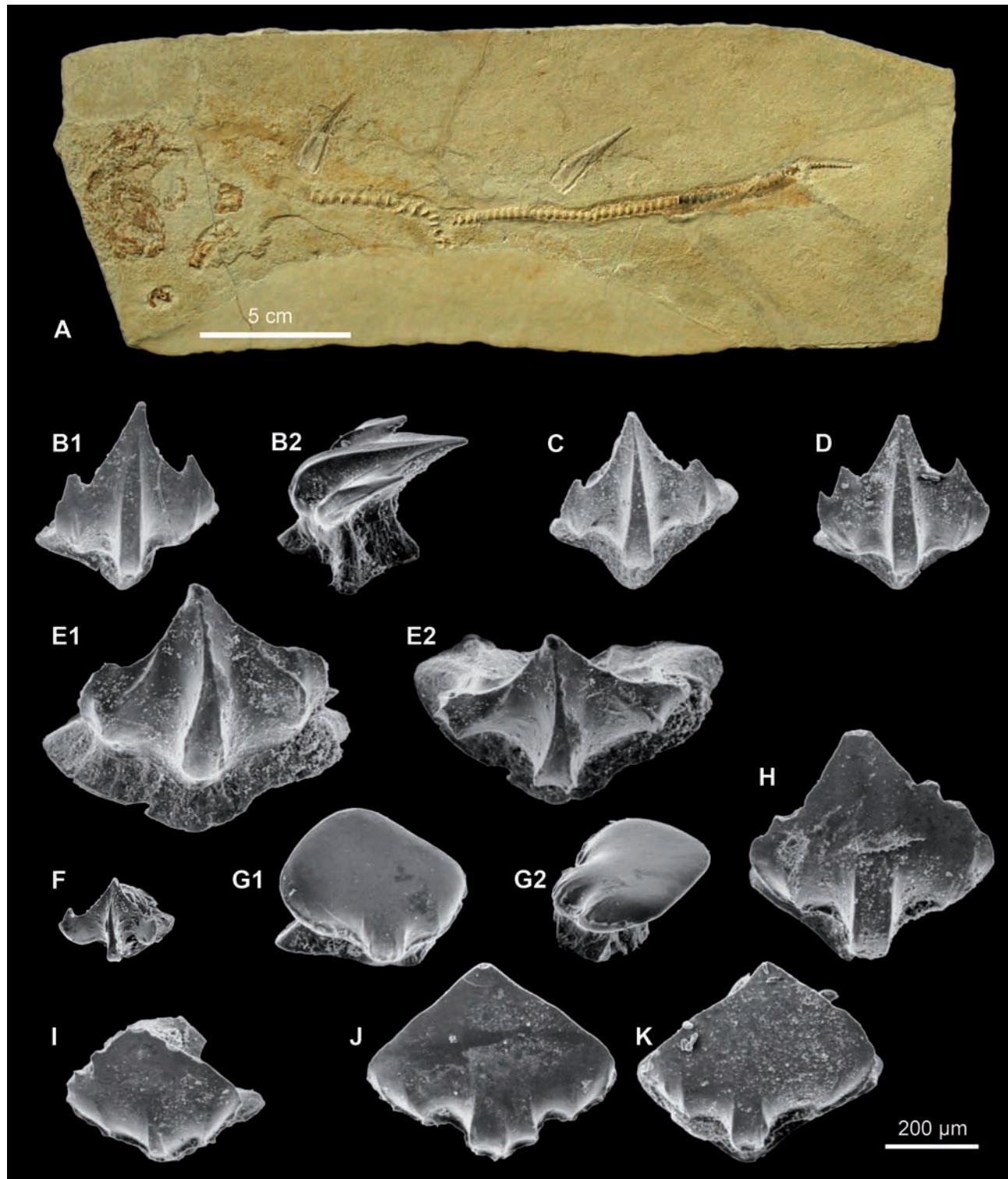


Plate 24. *Paracestracion falcifer* (WAGNER, 1857) (SMNS 11150, “Exemplar II” of SCHWEIZER (1964)), Nusplingen

Fig. A. Overview of the specimen. **Figs. B–K.** Isolated scales. The figured scales were collected from an acetic acid dissolution residue of a small piece of limestone broken off the specimen. Their exact position on the fossil is unknown. – **B1, B2, G1, G2.** Isolated scales; 1 – apical, 2 – lateral view. **C, D, E, F, H, I, J, K.** Isolated scales, apical view.



Plate 25. *Paracestracion falcifer* (WAGNER, 1857) (SOS 2215)

Fig. A. Overview of the specimen. **Figs. B–K.** Isolated scales. – **Ba.** Scale from the pelvic fin, apical view. **Cc.** Scale from the middle tail region, apical view. **Dd.** Scale from caudal peduncle, apical view. **Eg, Ig.** Scales from the pectoral girdle region, apical view. **Ff.** Scale from the dorsal side of the middle trunk region, apical view. **G1b, G2b.** Scale from the anterior tail region; 1 – apical, 2 – lateral view. **Hh2.** Scale from the distal part of pectoral fin, apical view. **J1g, J2g.** Scales from the pectoral girdle region; 1 – apical, 2 – lateral view. **Ke.** Associated scales from second dorsal fin, apical view.

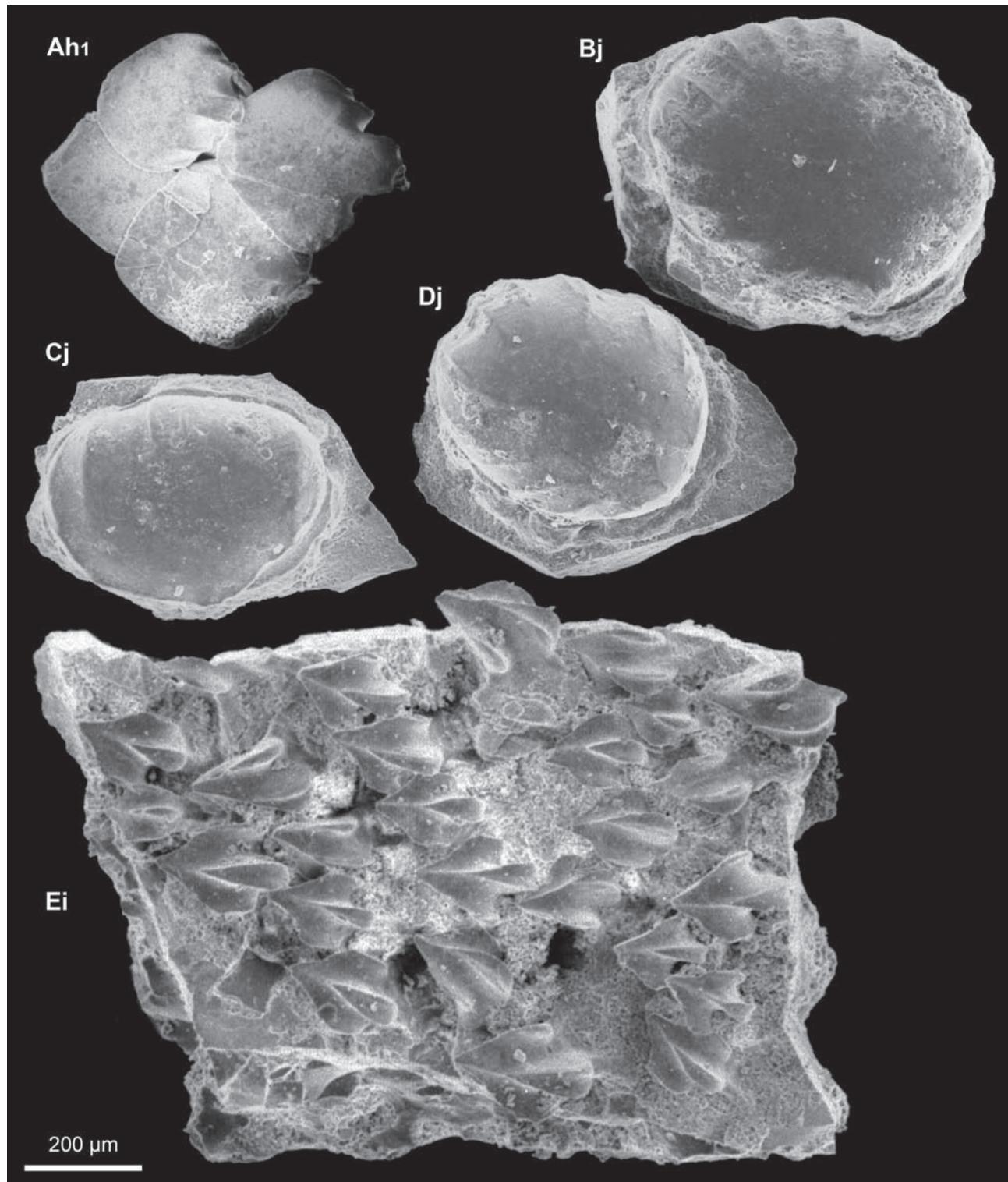


Plate 26. *Paracestracion falcifer* (WAGNER, 1857) (SOS 2215)

Figs. A–E. Isolated scales and tubercles. – **Ah1.** Associated scales from the proximal part of pectoral fin, apical view. **Bj, Cj, Dj.** Tubercles from the second dorsal fin spine, apical view. **Ei.** Associated scales from the proximal region of second dorsal fin, apical view.

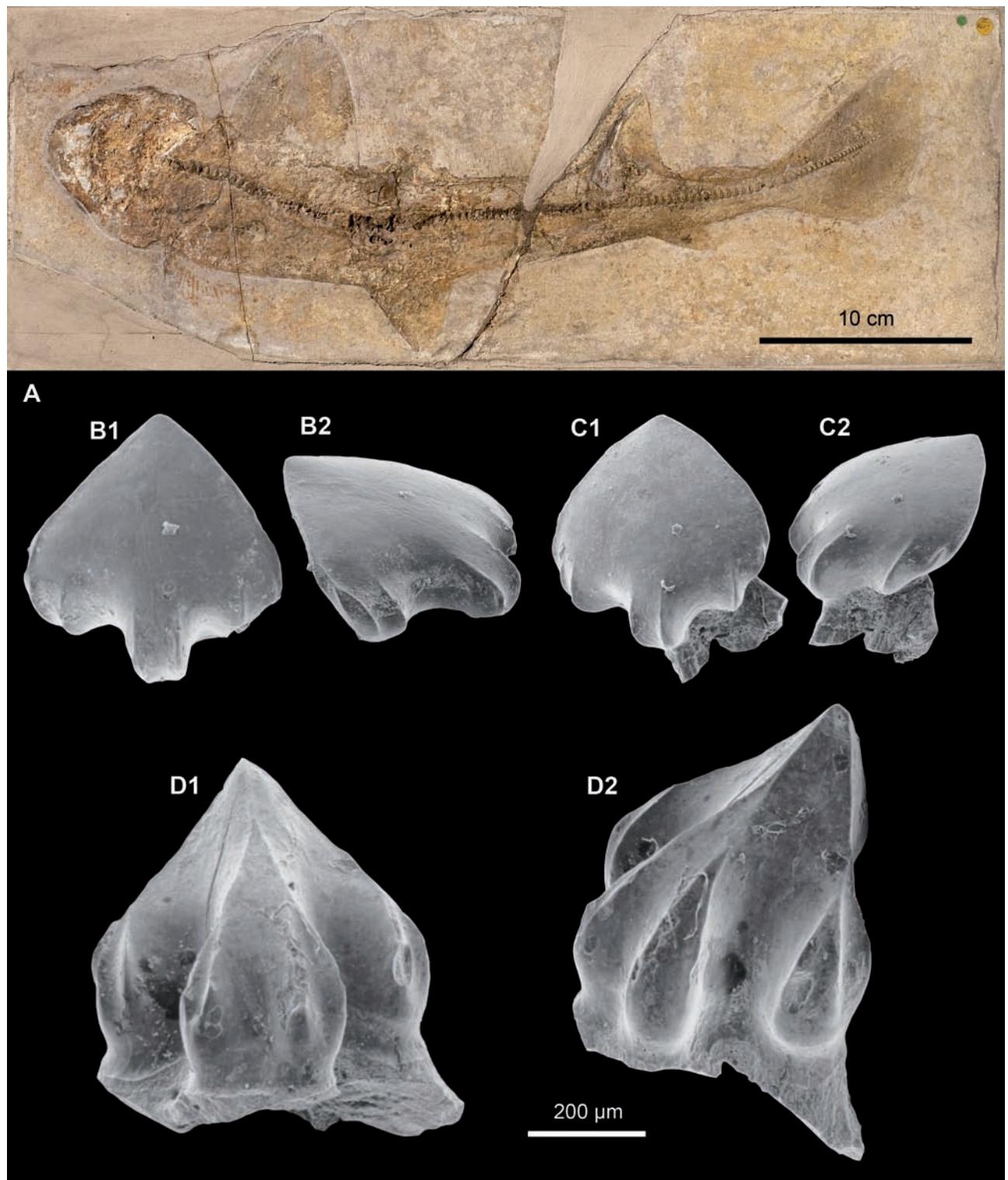


Plate 27. *Paracestracion falcifer* (WAGNER, 1857) (NHML P8657), Eichstätt

Fig. A. Overview of the specimen. Figs. B–D. Isolated scales of unknown position; 1 – apical, 2 – antero-lateral view.

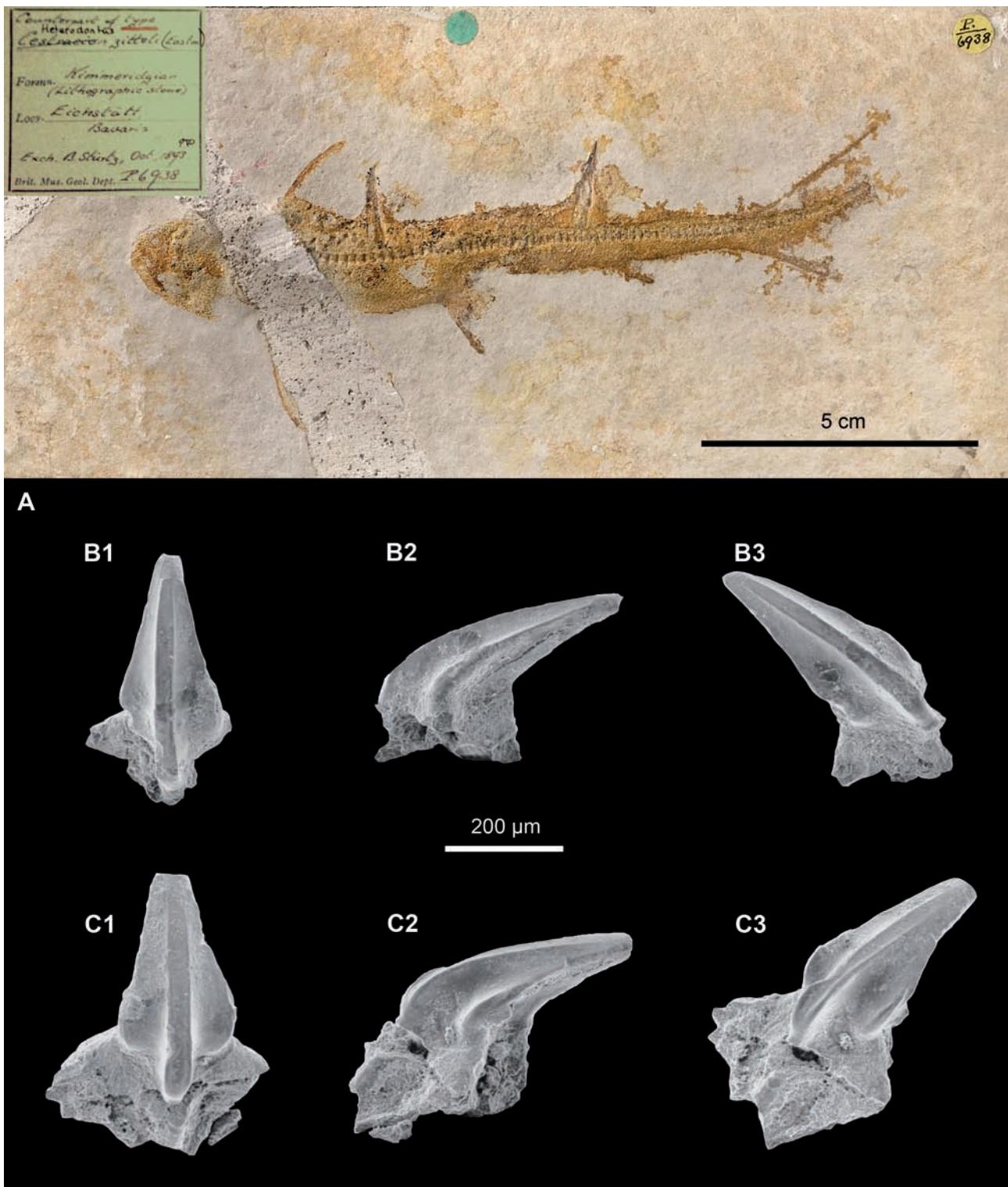


Plate 28. *Heterodontus zitteli* (EASTMAN, 1911) (NHML P6938, counterpart of the holotype), Eichstätt

Fig. A. Overview of the specimen. Figs. B, C. Isolated scales of unknown position; 1 – apical, 2 – lateral, 3 – antero-lateral view.

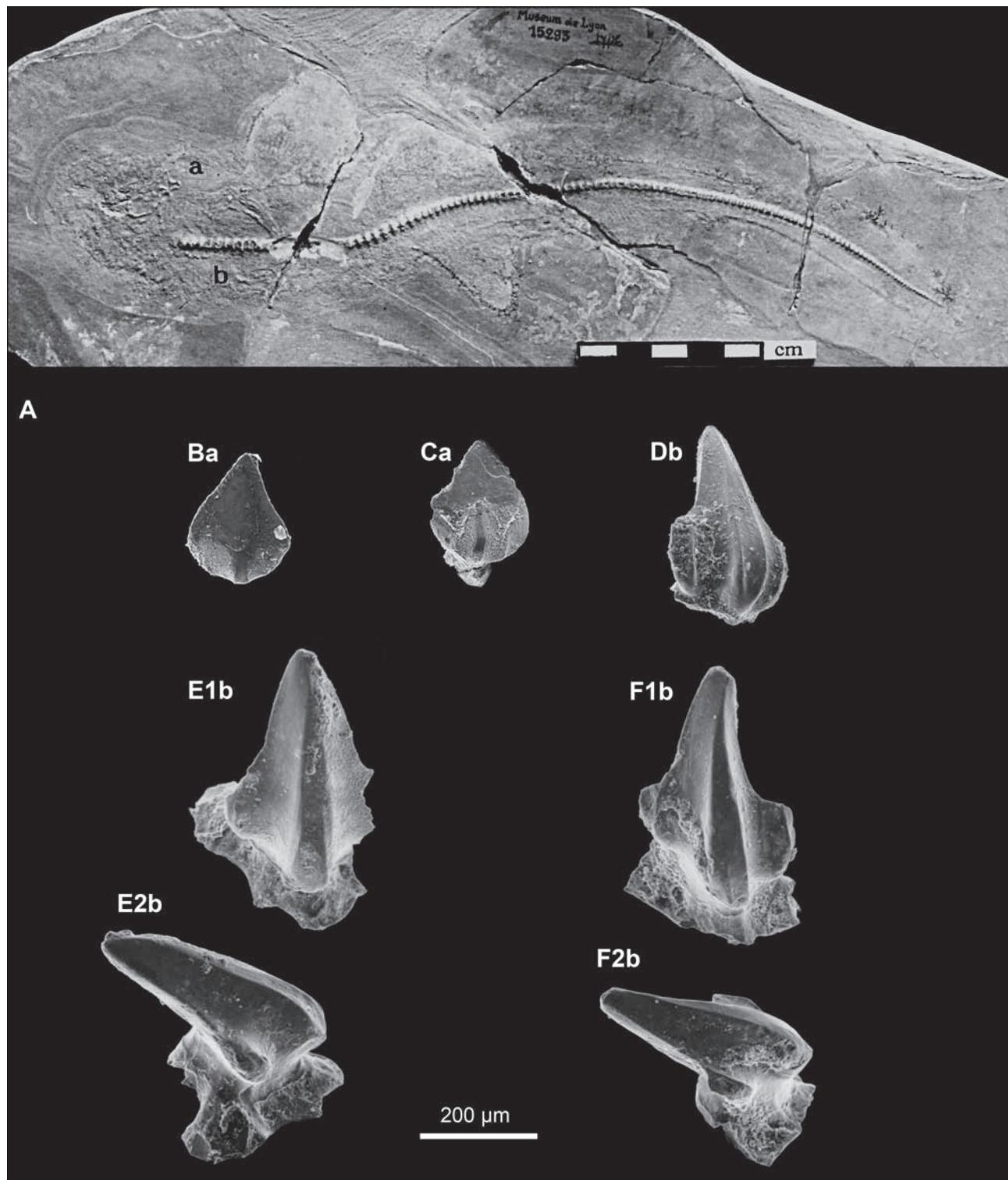


Plate 29. *Phorcynis catulina* THIOLLIÈRE, 1852 (MHNL 15.293, holotype), Cerin

Fig. A. Overview of the specimen. Figs. B–F. Isolated scales. – **Ba**, **Ca**. Scales from the cranial region, apical view. **Db**. Scale from the posterior cranial region, apical view. **E1b**, **E2b**, **F1b**, **F2b**. Scales from the posterior cranial region; 1 – apical, 2 – lateral view.

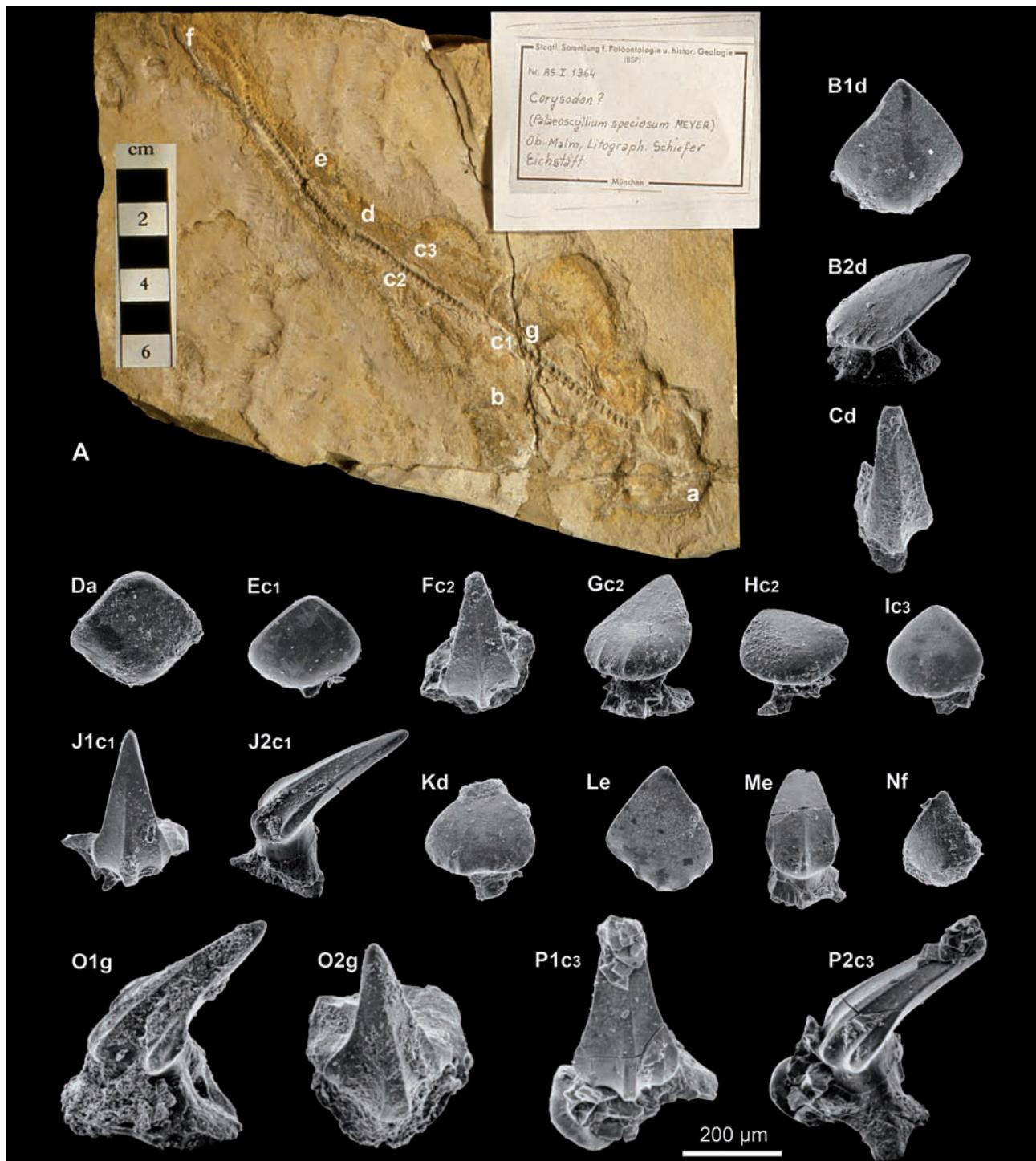


Plate 30. *Phorcynis catulina* THIOLLIÈRE, 1852 (BSPHG AS-I-1364), Eichstätt

Fig. A. Overview of the specimen. **Figs. B–P.** Isolated scales. – **B1d, B2d.** Scale from the anterior tail region; 1 – apical, 2 – lateral view. **Cd.** Scale from the anterior tail region, apical view. **Da.** Scale from the rostral region, apical view. **Ec1.** Scale from the middle trunk region, apical view. **Fc2.** Scale from the posterior trunk region, apical view. **Gc2, Hc2.** Scales from the posterior trunk region, anterior view. **Ic3.** Scale from the posterior trunk region, apical views. **J1c1, J2c1.** Scale from middle trunk region; 1 – apical, 2 – lateral view. **Kd.** Scale from the anterior tail region, apical view. **Le, Me.** Scales from the middle tail region, apical view. **Nf.** Scale from the caudal fin, apical view. **O1g, O2g.** Scale from the middle trunk region; 1 – apical, 2 – lateral view. **P1c3, P2c3.** Scale from posterior trunk region; 1 – apical, 2 – lateral view.

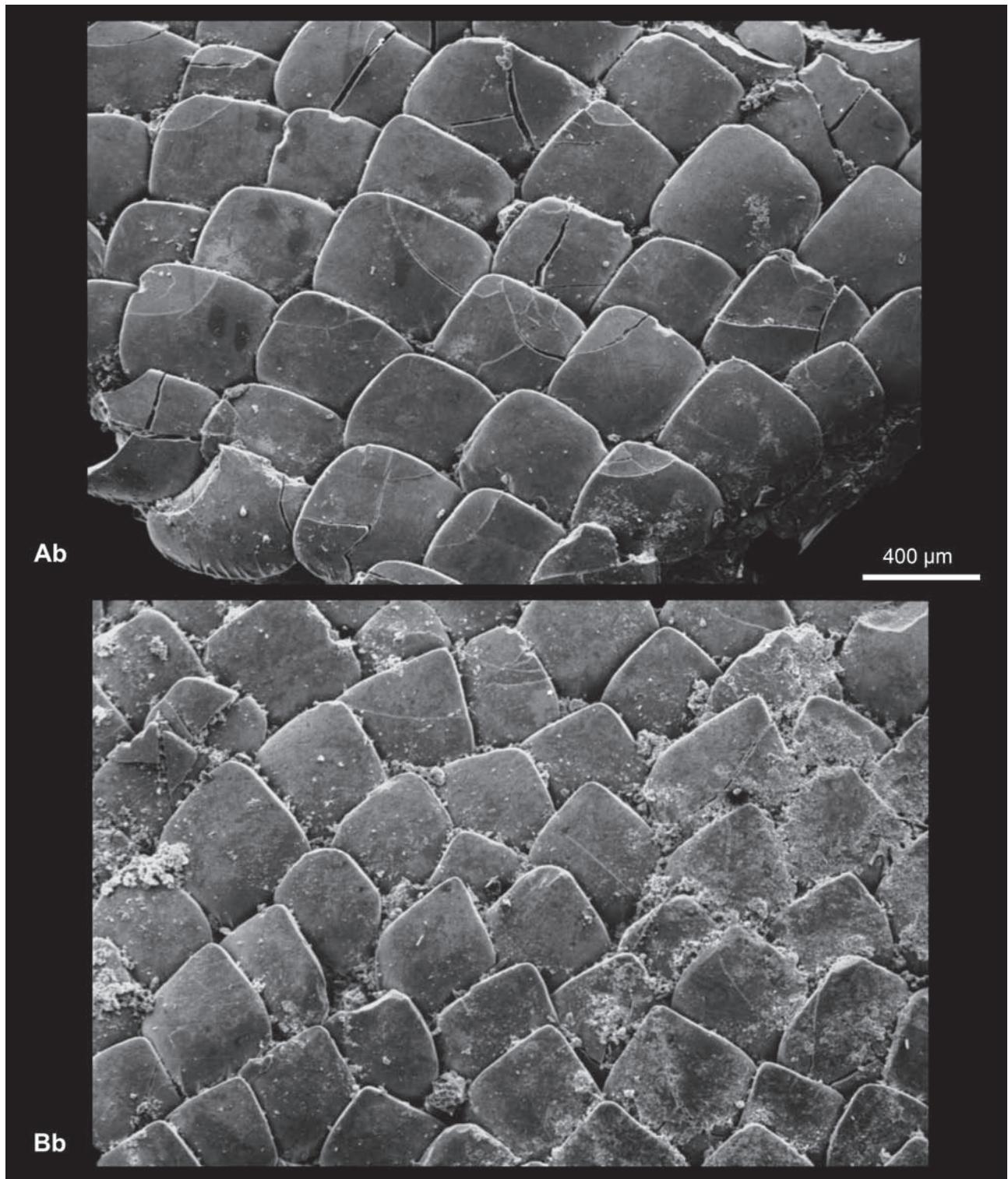


Plate 31. *Phorcynis catulina* THIOLLIÈRE, 1852 (BSPHG AS-I-1364), Eichstätt

Figs. A_b, B_b. Associated scales from the dorsal (?) surface of the pectoral fin, apical view.

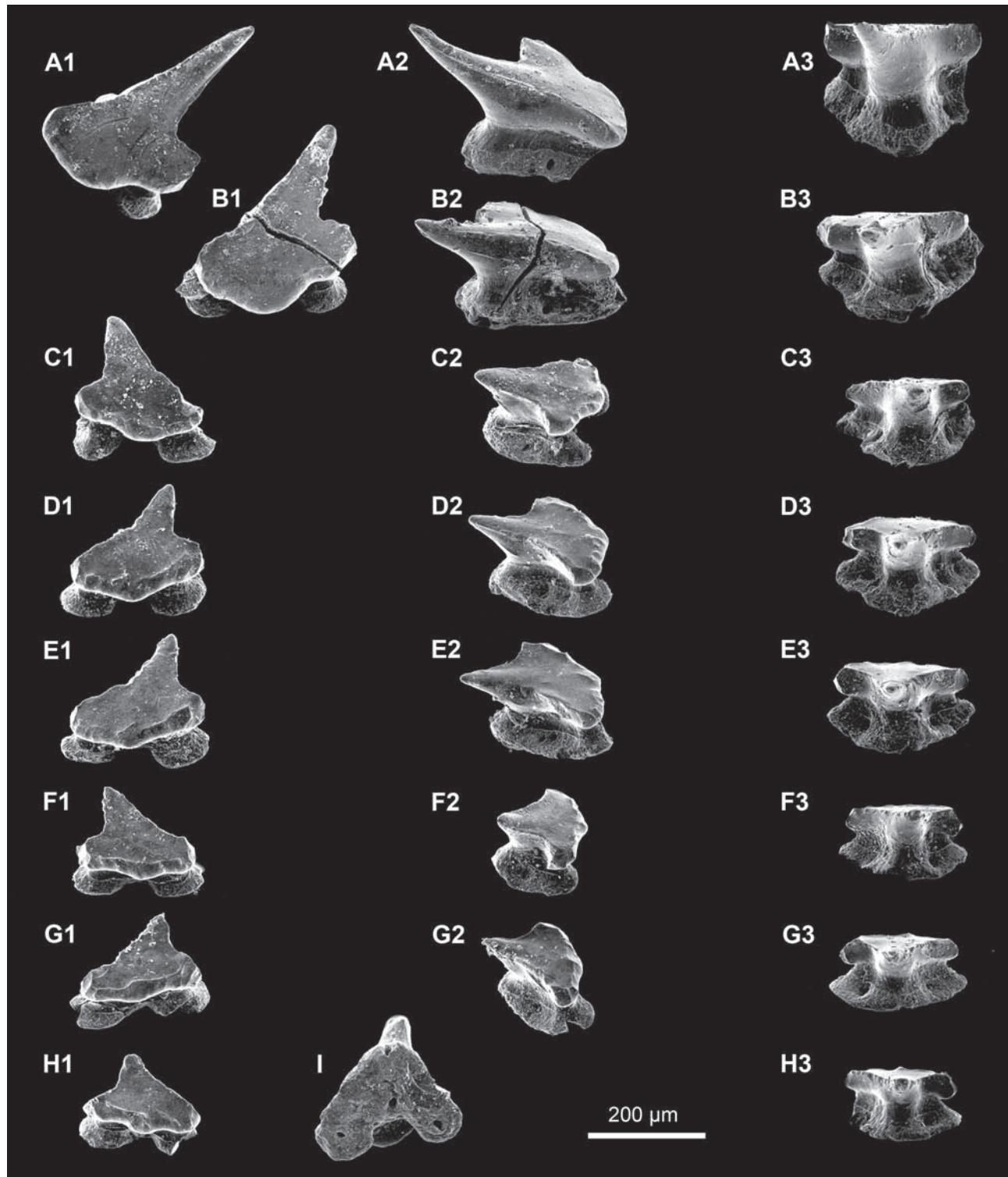


Plate 32. *Phorcynis catulina* THIOLLIÈRE, 1852 (BSPHG AS-I-1364), Eichstätt

Figs. A–I. Oral teeth. – A, B. Anterior or antero-lateral teeth. C–E. Lateral teeth. F. Latero-posterior tooth. G, H. Posterior teeth. I. Tooth root in basal view. 1 – labial, 2 – lateral, 3 – lingual view.

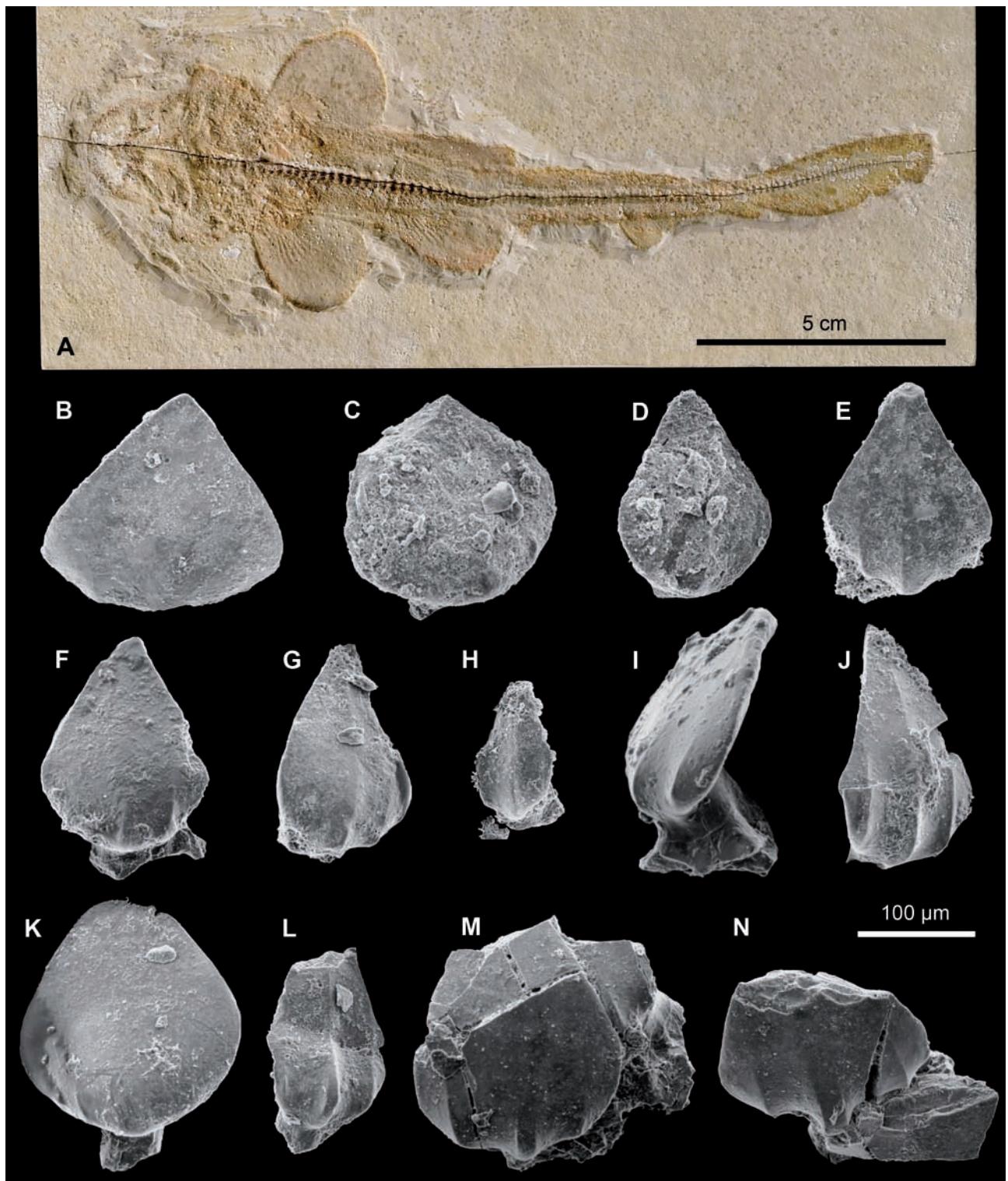


Plate 33. *Crossorhinus jurassicus* WOODWARD, 1918 (NHML P11211, holotype) (= *Phorcynis catulina* THIOLLIÈRE, 1852), Eichstätt
Fig. A. Overview of the specimen. **Figs. B–N.** Isolated scales of unknown position, apical view (I in lateral view).

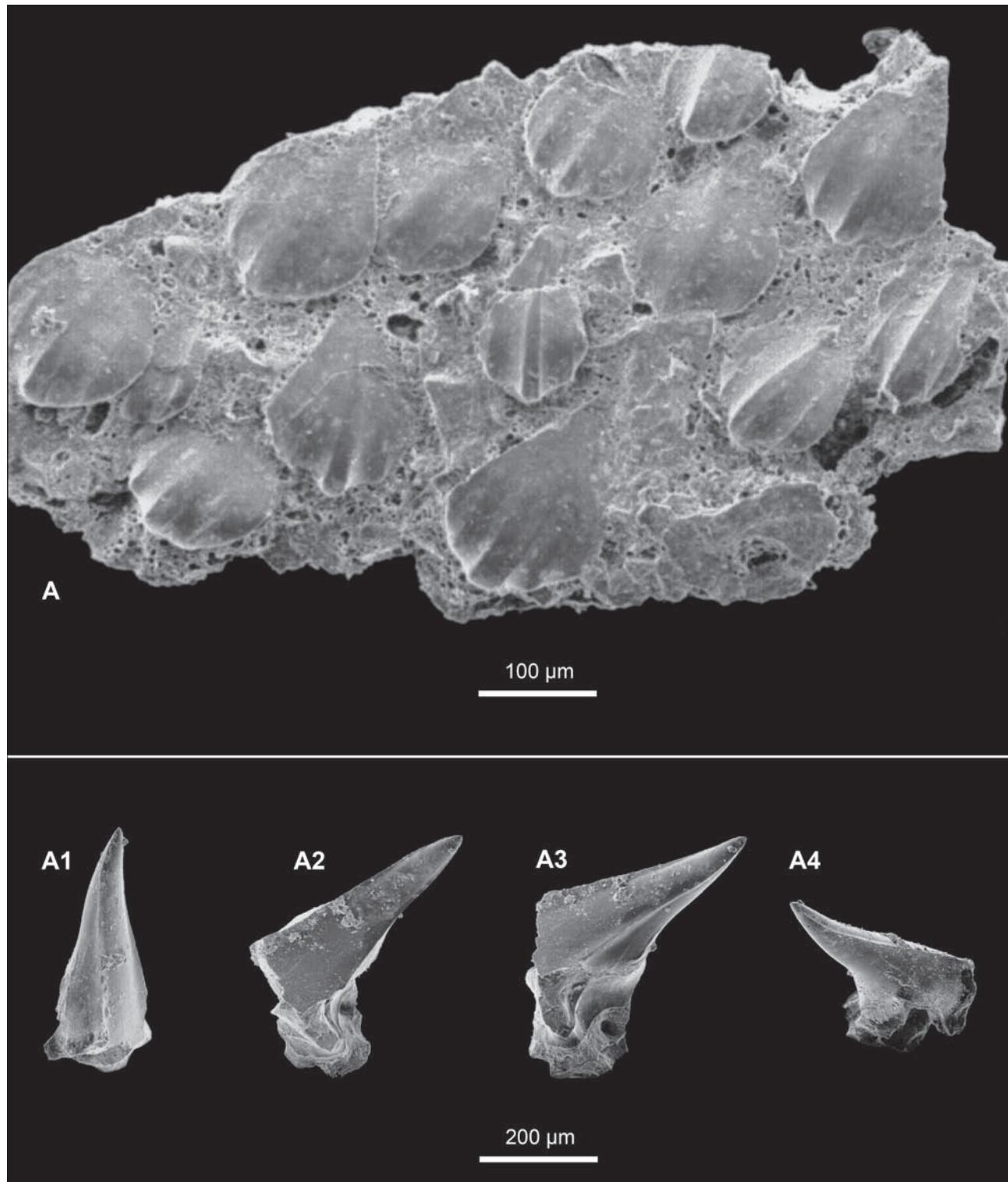


Plate 34. *Crossorhinus jurassicus* WOODWARD, 1918 (NHML P11211, holotype) (= *Phorcynis catulina* THIOLLIÈRE, 1852), Eichstätt

Upper part

Fig. A. Associated scales of unknown position, apical view.

Lower part

Fig. A. Oral tooth, basal part of the crown and root damaged; 1, 2 – labio-lateral, 3 – lateral, 4 – linguo-lateral view.



Plate 35. *Palaeoscyllium minus* WOODWARD, 1889 (NHML P5541, holotype) (? = *Phorcynis catulina* THIOLLIÈRE, 1852), Eichstätt

Fig. A. Overview of the specimen. **Figs. B–J.** Isolated scales. – **B, D, E, G–J.** Scales of unknown position, apical view. **C.** Associated scales of unknown position, apical view. **F.** Scale of unknown position; 1 – antero-lateral, 2 – apical view.

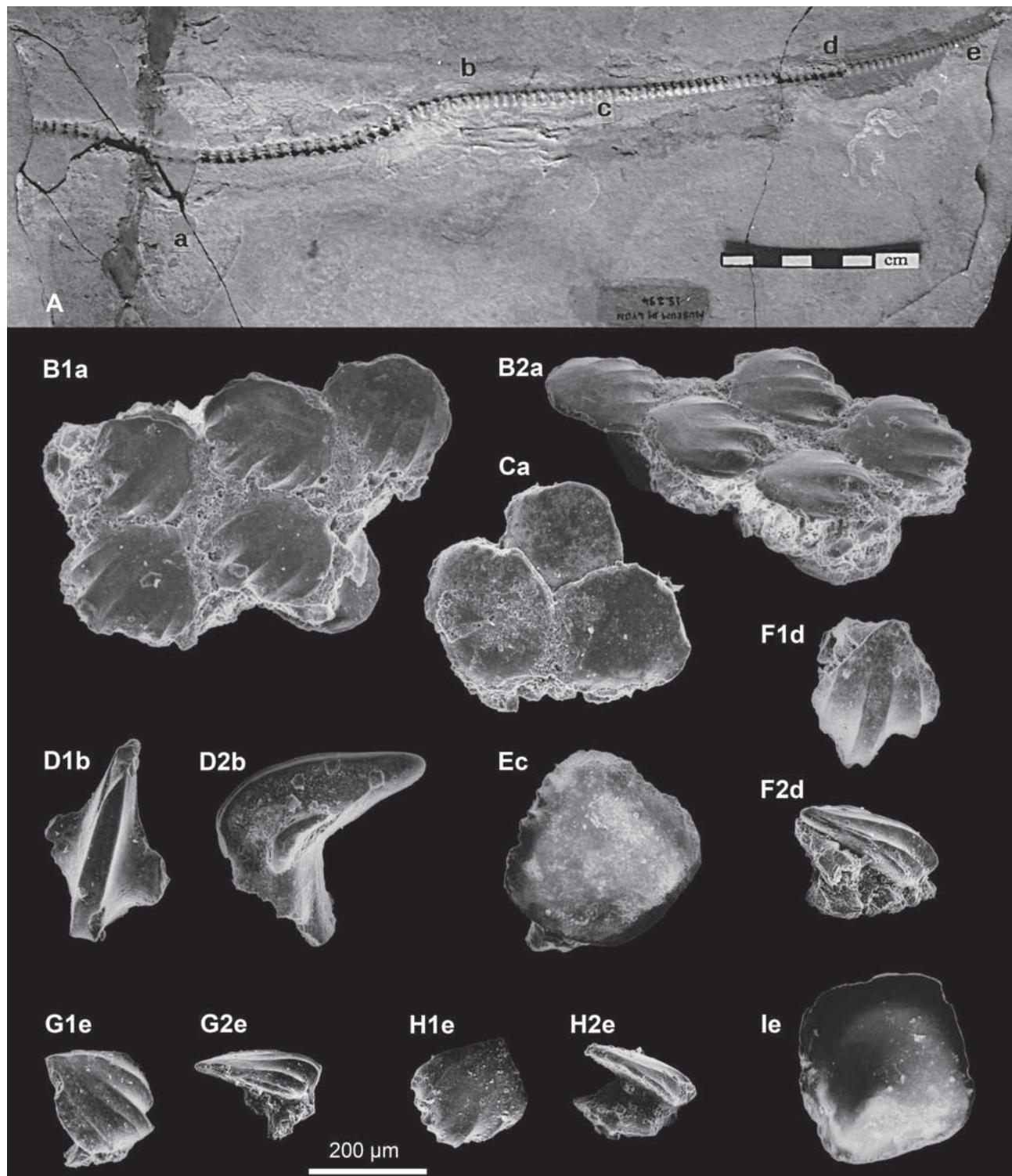


Plate 36. *Phorcynis catulina* THIOLLIÈRE (MHNL 15.294), Cerin

Fig. A. Overview of the specimen. **Figs. B–I.** Isolated scales. – **B1a, B2a.** Associated scales from the pectoral fin; 1 – apical, 2 – lateral view. **Ca.** Associated scales from the pectoral fin sampled from the fin surface opposite to B1a and B2a, apical view. **D1b, D2b.** Scale from the posterior trunk region; 1 – apical, 2 – lateral view. **Ec.** Scale from anterior tail region, apical view. **F1d, F2d.** Scale from dorsal lobe of the caudal fin; 1 – apical, 2 – lateral view. **G1e, G2e, H1e, H2e.** Scale from the posterior end of the ventral lobe of the caudal fin; 1 – apical, 2 – lateral view. **Ie.** Scale from the posterior end of the ventral lobe of the caudal fin, apical view.

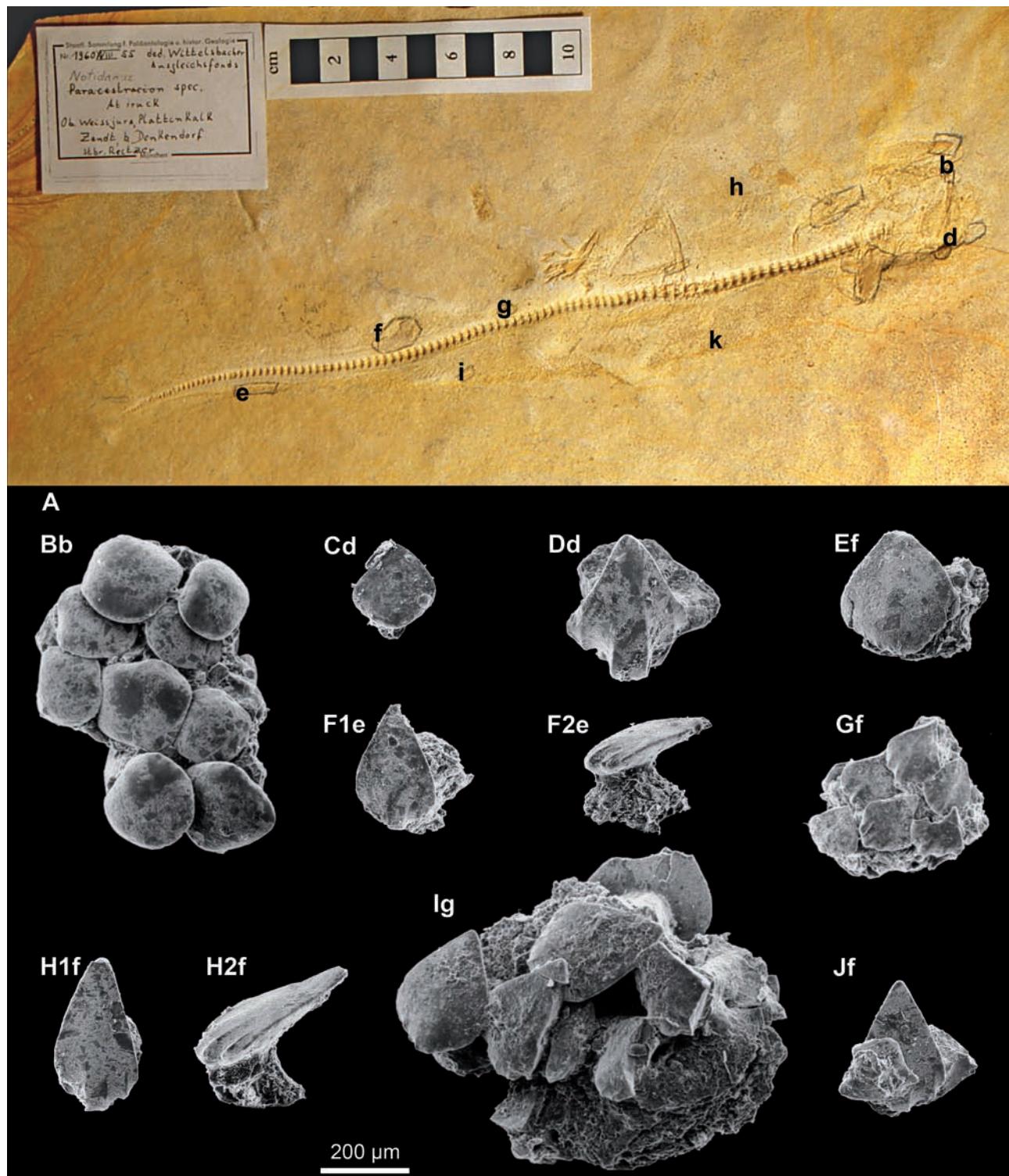


Plate 37. *Phorcynis* sp. (BSPHG 1960-XVIII-55), Zandt

Fig. A. Overview of the specimen. **Figs. B–J.** Isolated scales. – **Bb.** Associated scales, possibly from the lower jaw, apical view. **Cd, Dd.** Scales from the cranial region, apical view. **Ef.** Scale from the middle tail region, apical view. **F1e, F2e.** Scale from the caudal fin; 1 – apical, 2 – lateral view. **Gf.** Associated scales from the middle tail region, apical view. **H1f, H2f.** Scale from the middle tail region; 1 – apical, 2 – lateral view. **Ig.** Associated scales from the anterior tail region, apical view. **Jf.** Scale from the middle tail region, apical view.

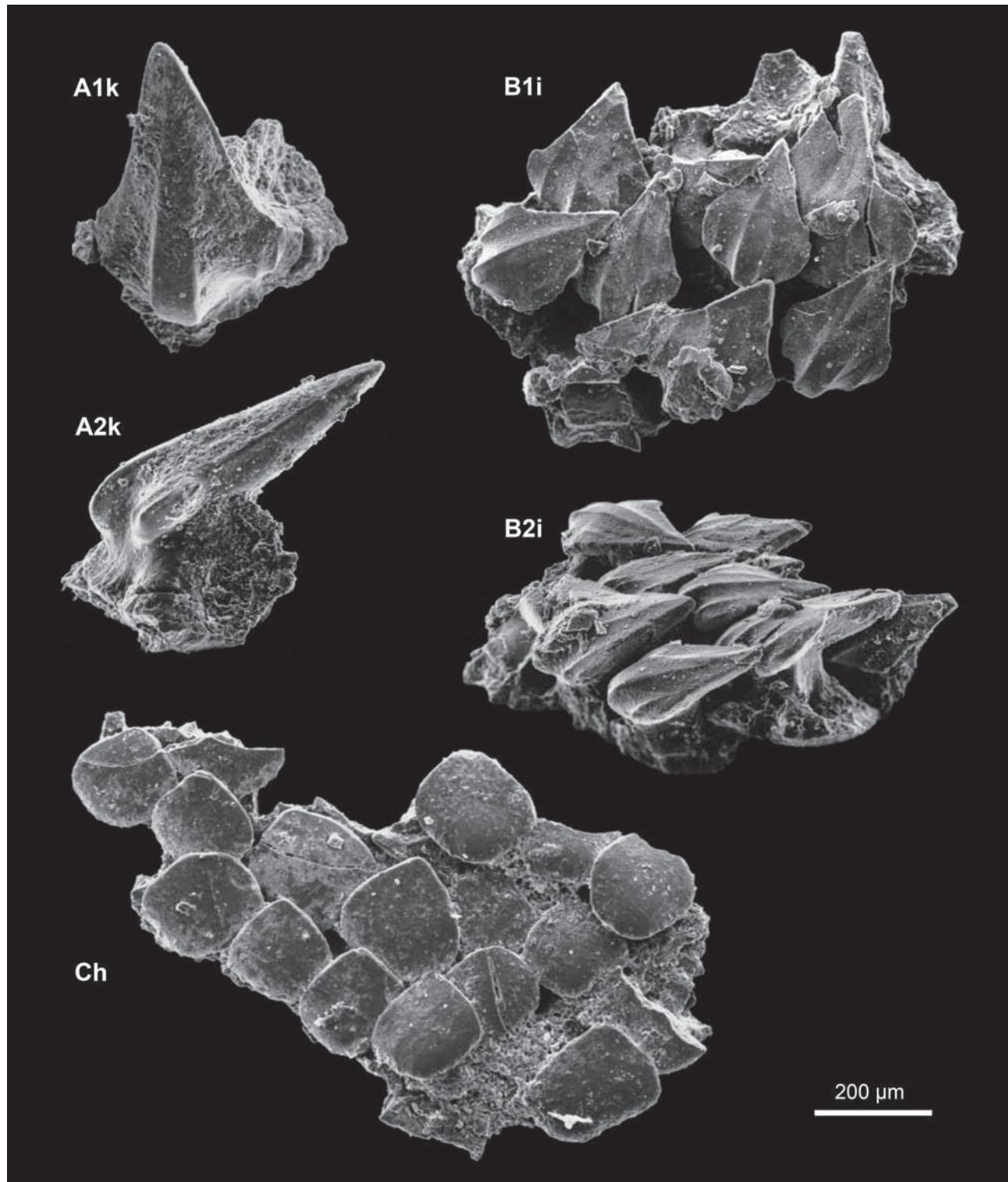


Plate 38. *Phorcynis* sp. (BSPHG 1960-XVIII-55), Zandt

Figs. A–C. Isolated scales. – **A1k, A2k.** Scale from middle trunk region; 1 – apical, 2 – lateral view. **B1i, B2i.** Associated scales from the anterior tail region; 1 – apical, 2 – lateral view. **Ch.** Associated scales, possibly from the pectoral fin, apical view.

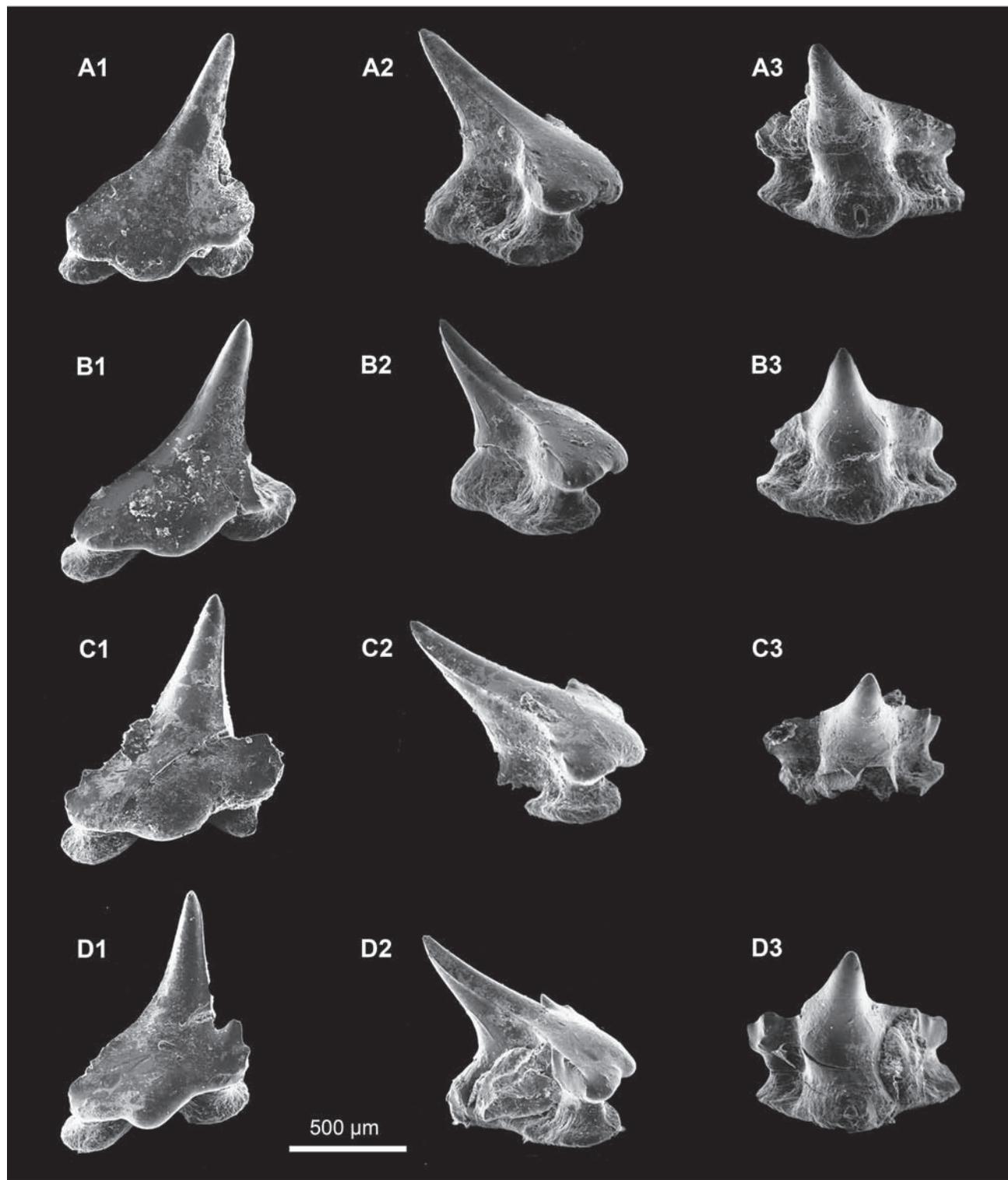


Plate 39. *Phorcynis* sp. (BSPHG 1960-XVIII-55), Zandt

Figs. A–D. Anterior or antero-lateral oral teeth; 1 – labial, 2 – lateral, 3 – lingual view.

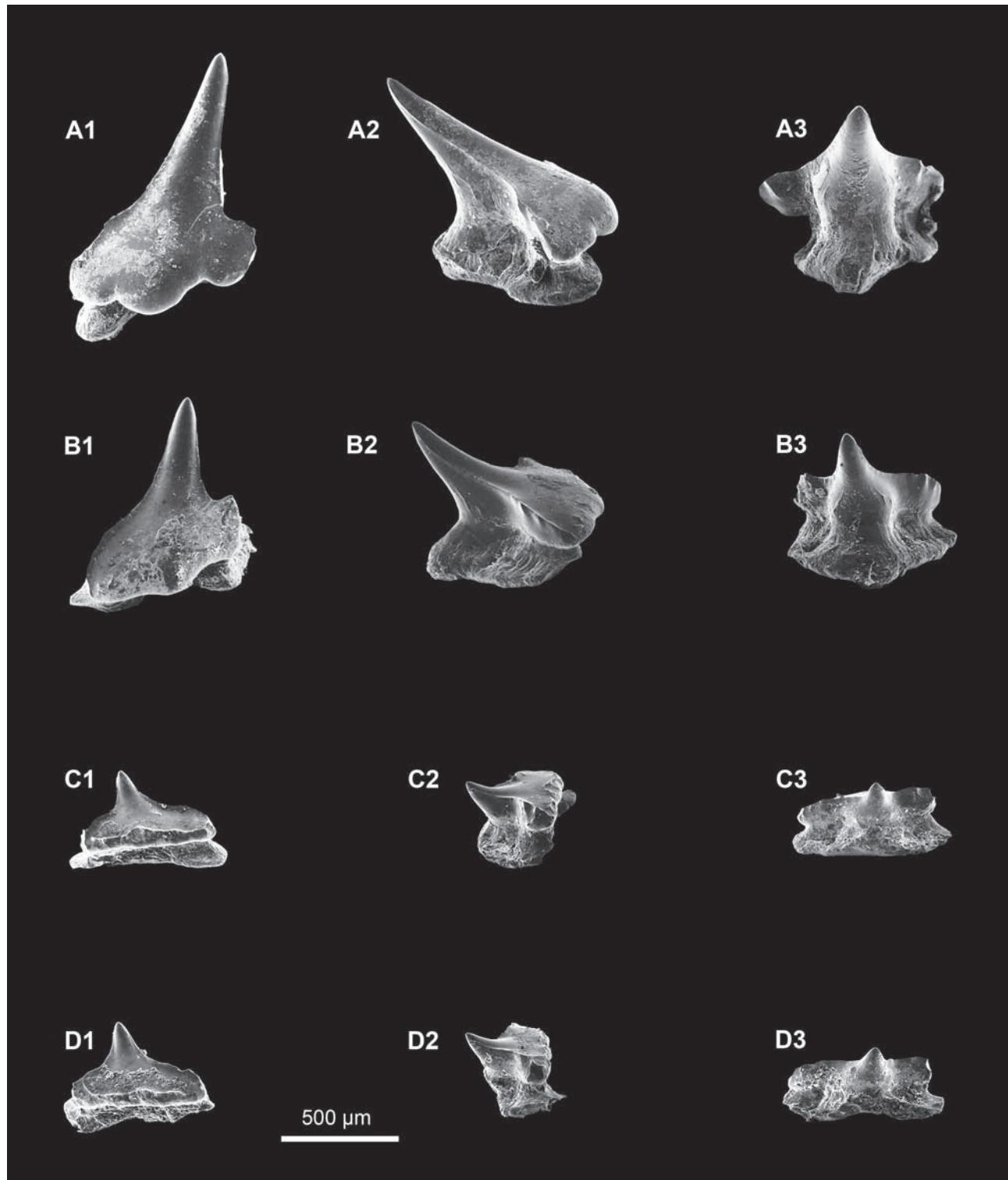


Plate 40. *Phorcynis* sp. (BSPHG 1960-XVIII-55), Zandt

Figs. A–D. Oral teeth. – A. Anterior or antero-lateral tooth. B. Lateral tooth. C–D. Posterior teeth. 1 – labial, 2 – lateral, 3 – lingual view.

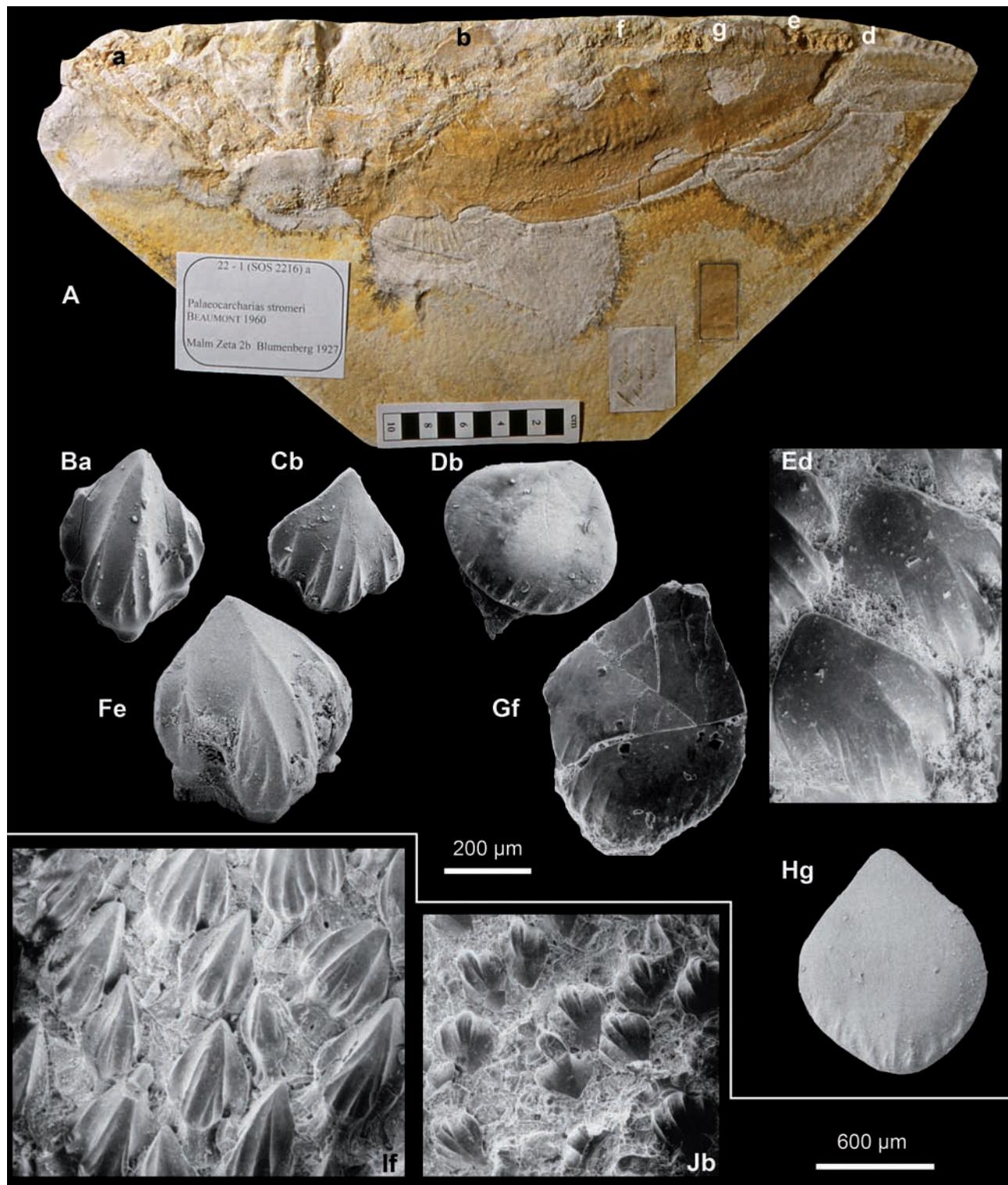


Plate 41. *Palaeocarcharias stromeri* DE BEAUMONT, 1960 (JME 22-1a, SOS 2216a, part), Blumenberg

Fig. A. Overview of the specimen. **Figs. B–J.** Isolated scales. – **Ba.** Disarticulated scale found between the oral teeth, apical view. **Cb, Db.** Scales from the anterior trunk region, apical view. **Ed.** Associated scales from the anterior tail region, apical view. **Fe.** Scale from the posterior trunk region, apical view. **Gf.** Scale from the middle trunk region, apical view. **Hg.** Scale from the posterior trunk region, apical view. **If, Jb.** Associated scales from the middle trunk region; apical view.

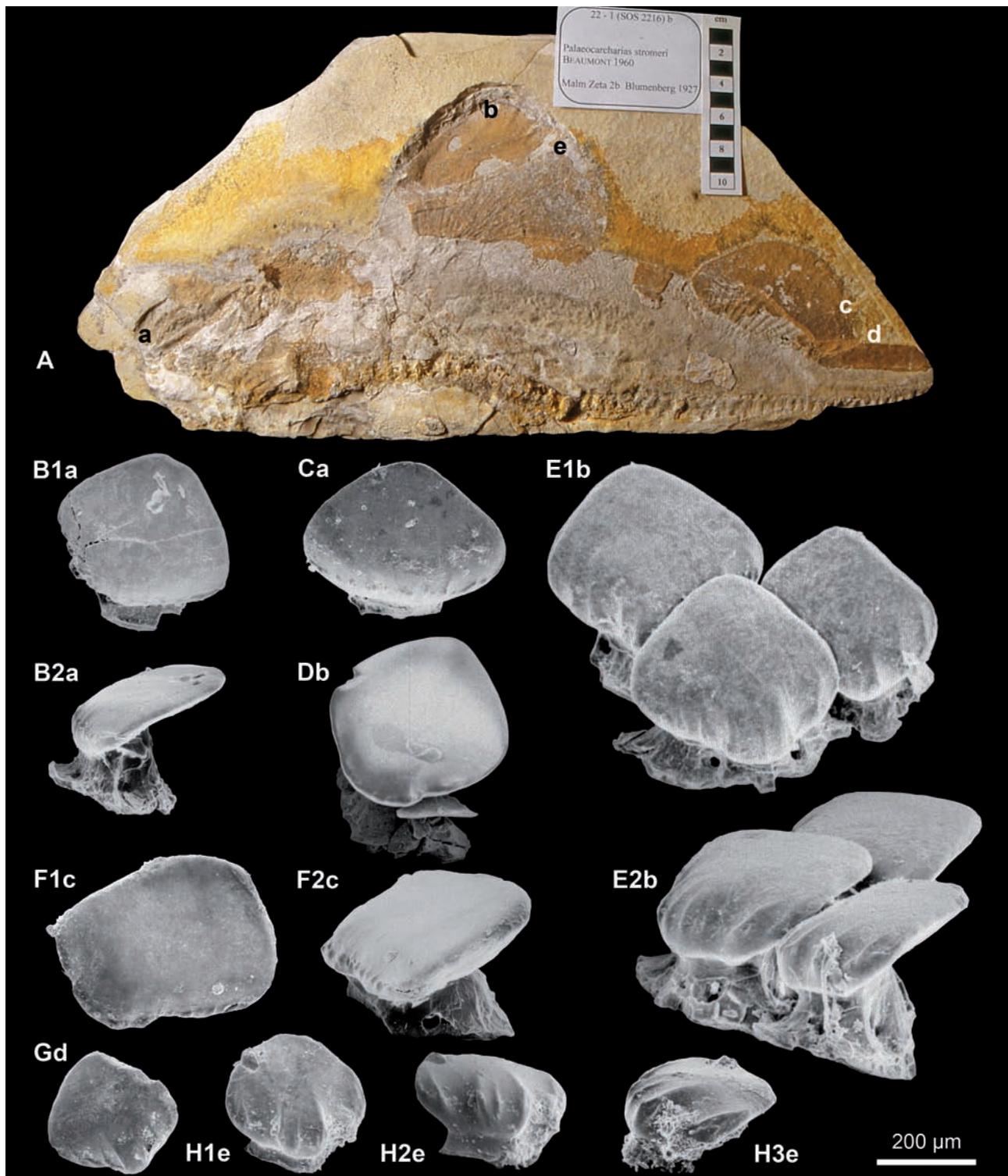


Plate 42. *Palaeocarcharias stromeri* DE BEAUMONT, 1960 (JME 22-1a, SOS 2216b, counterpart), Blumenberg

Fig. A. Overview of the specimen. **Figs. B–H.** Isolated scales. – **B1a, B2a.** Scale from the rostral region; 1 – apical, 2 – lateral view. **Ca.** Scale from the rostral region, apical view. **Db.** Scale from the distal part of the pectoral fin, apical view. **E1b, E2b.** Associated scales from the distal part of the pectoral fin; 1 – apical, 2 – lateral view. **F1c, F2c.** Scale from the distal part of the pelvic fin; 1 – apical, 2 – lateral view. **Gd.** Scale from the anal fin, apical view. **H1e, H2e, H3e.** Scale from the distal part of the pectoral fin; 1 – apical, 2 – anterior, – lateral view.

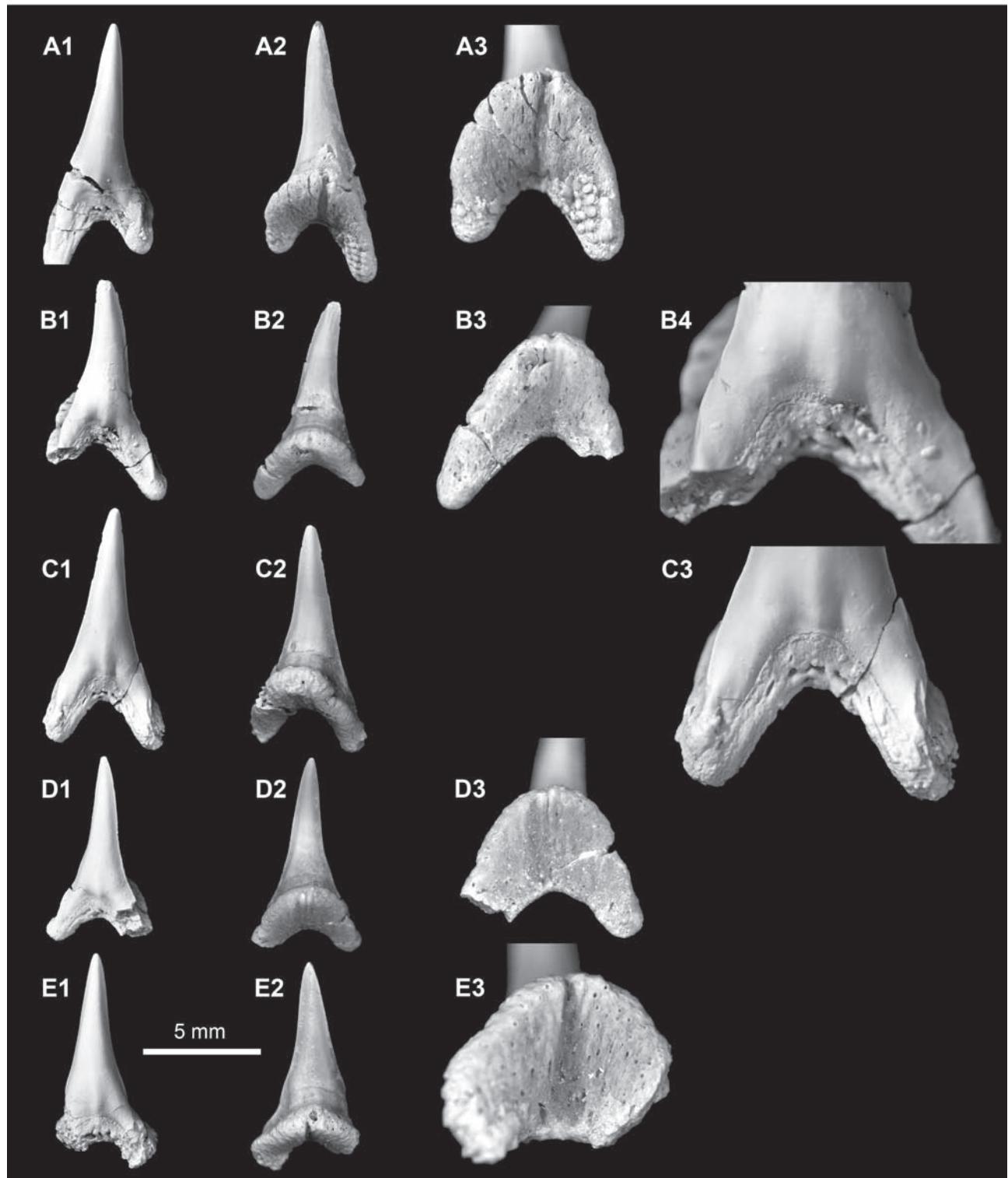


Plate 43. *Palaeocarcharias stromeri* DE BEAUMONT, 1960 (JME 22-1a, SOS 2216a, part), Blumenberg

Figs. A–E. Anterior or antero-lateral oral teeth; 1 – labial, 2 – lingual view. – **A3, B3, D3, E3.** Tooth root in basal view (not to scale). **B4, C3.** Basal part of crown in labial view (not to scale).

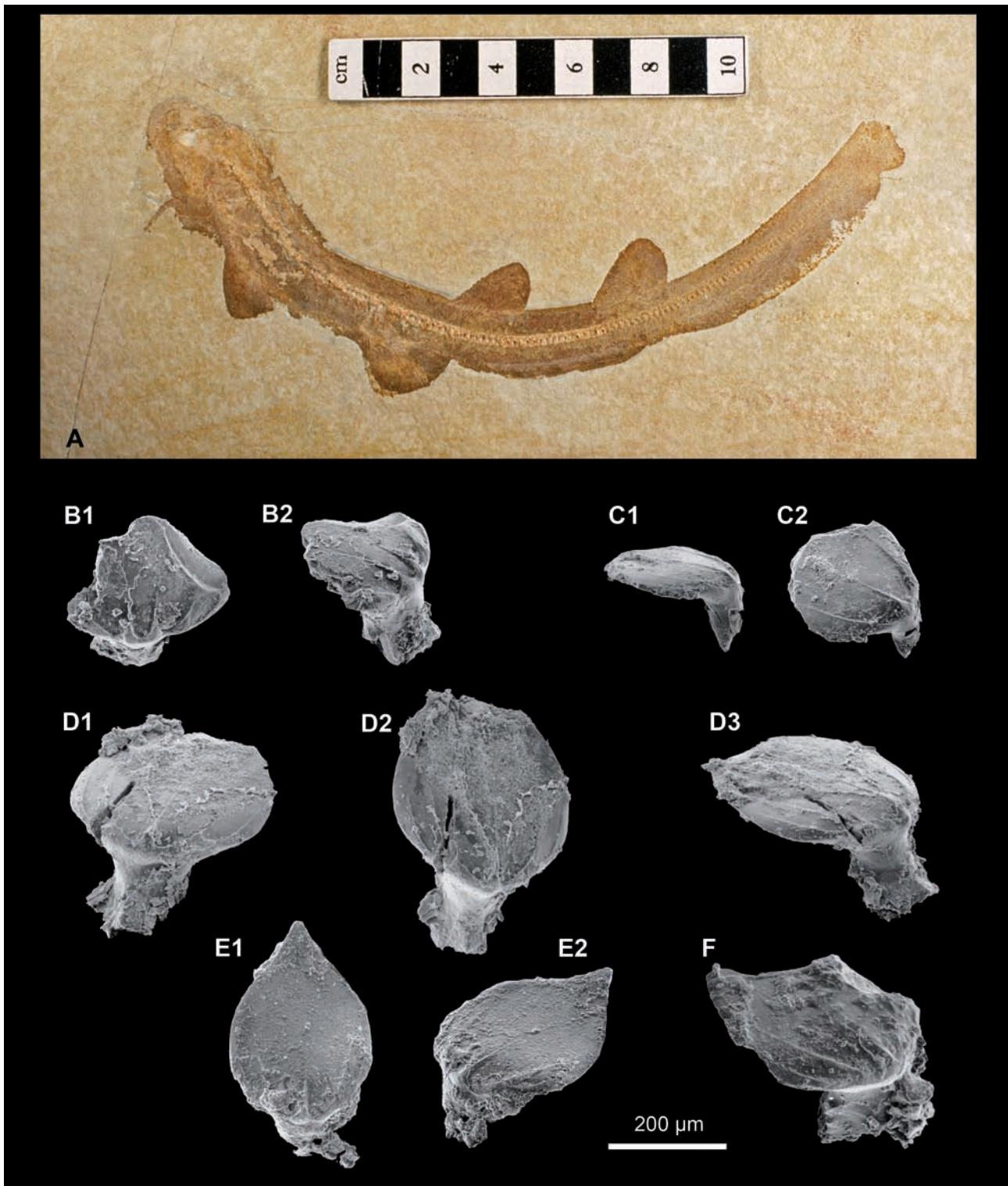


Plate 44. *Bavarscyllium tischlingeri* THIES, 2005 (SOS 4124, holotype), Eichstätt

Fig. A. Overview of the specimen. **Figs. B–F.** Isolated scales. – **B1, B2.** Scale of unknown position; 1 – apical, 2 – apico-lateral view. **C1, C2.** Scale of unknown position; 1 – lateral, 2 – apical view. **D1, D2, D3.** Scale of unknown position; 1 – latero-anterior, 2 – apical, 3 – lateral view. **E1, E2.** Scale of unknown position; 1 – apical, 2 – apico-lateral view. **F.** Scale of unknown position, apico-lateral view.

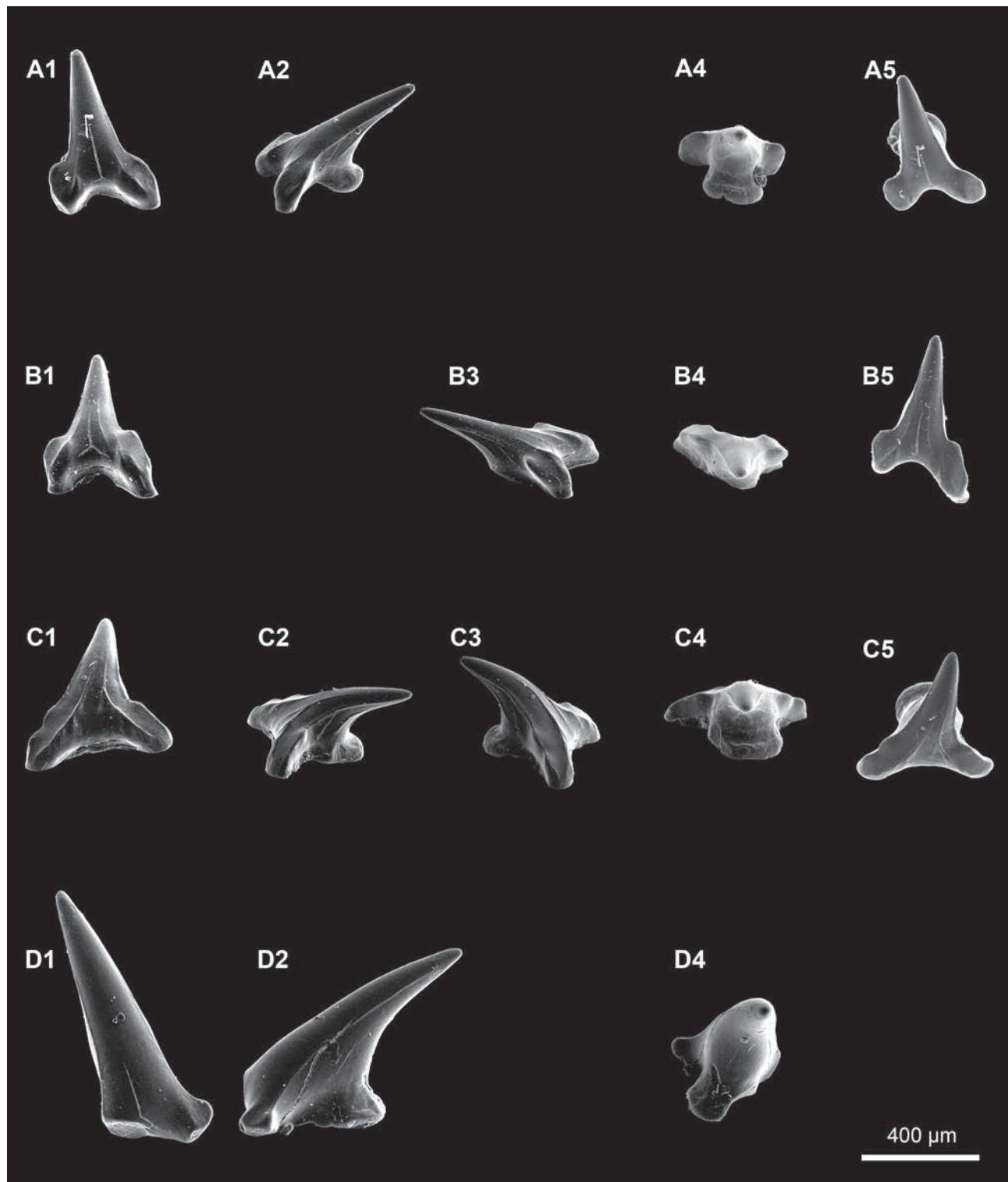


Plate 45. *Bavariscyllum tischlingeri* THIES, 2005 (SOS 4124, holotype), Eichstätt

Figs. A–D. Oral teeth. – A. Antero-lateral tooth. B. Lateral tooth. C. Distal tooth. D. Anterior tooth. 1 – labial, 2, 3 – lateral, 4 – lingual, 5 – apico-labial view.

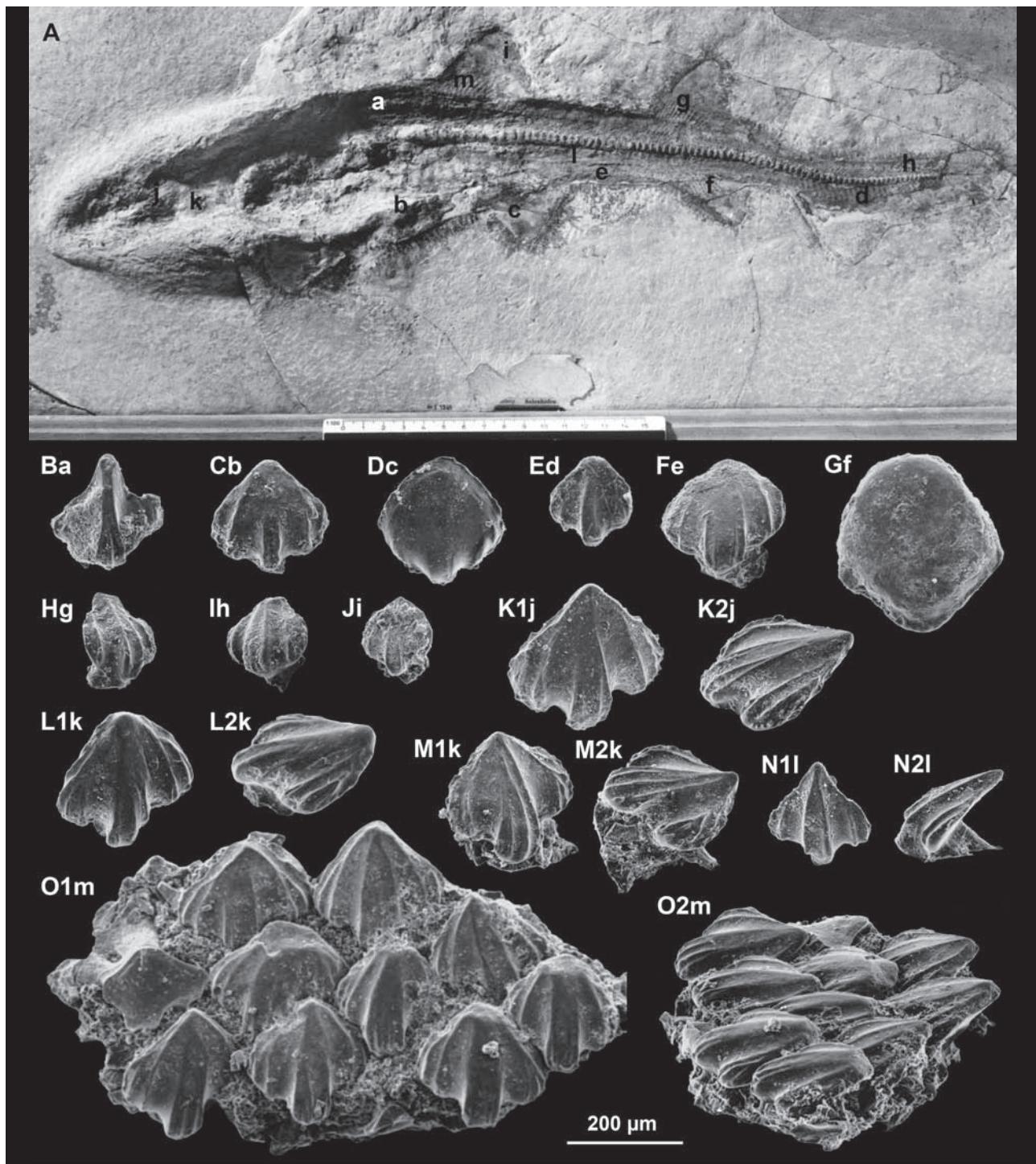


Plate 46. *Palaeoscyllium formosum* WAGNER, 1857 (BSPHG AS-I-1365, holotype), Solnhofen

Fig. A. Overview of the specimen. **Figs. B–O.** Isolated scales. – **Ba.** Scale from the dorsal middle trunk region, apical view. **Cb.** Scale from the ventral middle trunk region, apical view. **Dc.** Scale from the pelvic fin, apical view. **Ed.** Scale from the ventral lobe of the caudal fin, apical view. **Fe.** Scale from the ventral anterior tail region, apical view. **Gf.** Scale from the base of the anal fin, apical view. **Hg.** Scale from the base of the second dorsal fin, apical view. **Ih.** Scale from the dorsal lobe of the caudal fin, apical view. **Ji.** Scale from the distal part of the first dorsal fin, apical view. **K1j, K2j.** Scale from the dorsal cranial region; 1 – apical, 2 – lateral view. **L1k, L2k, M1k, M2k.** Scales from the posterior cranial region; 1 – apical, 2 – lateral view. **N1l, N2l.** Scales from the anterior tail region; 1 – apical, 2 – lateral view. **O1m, O2m.** Associated scales from the base of the first dorsal fin; 1 – apical, 2 – lateral view.

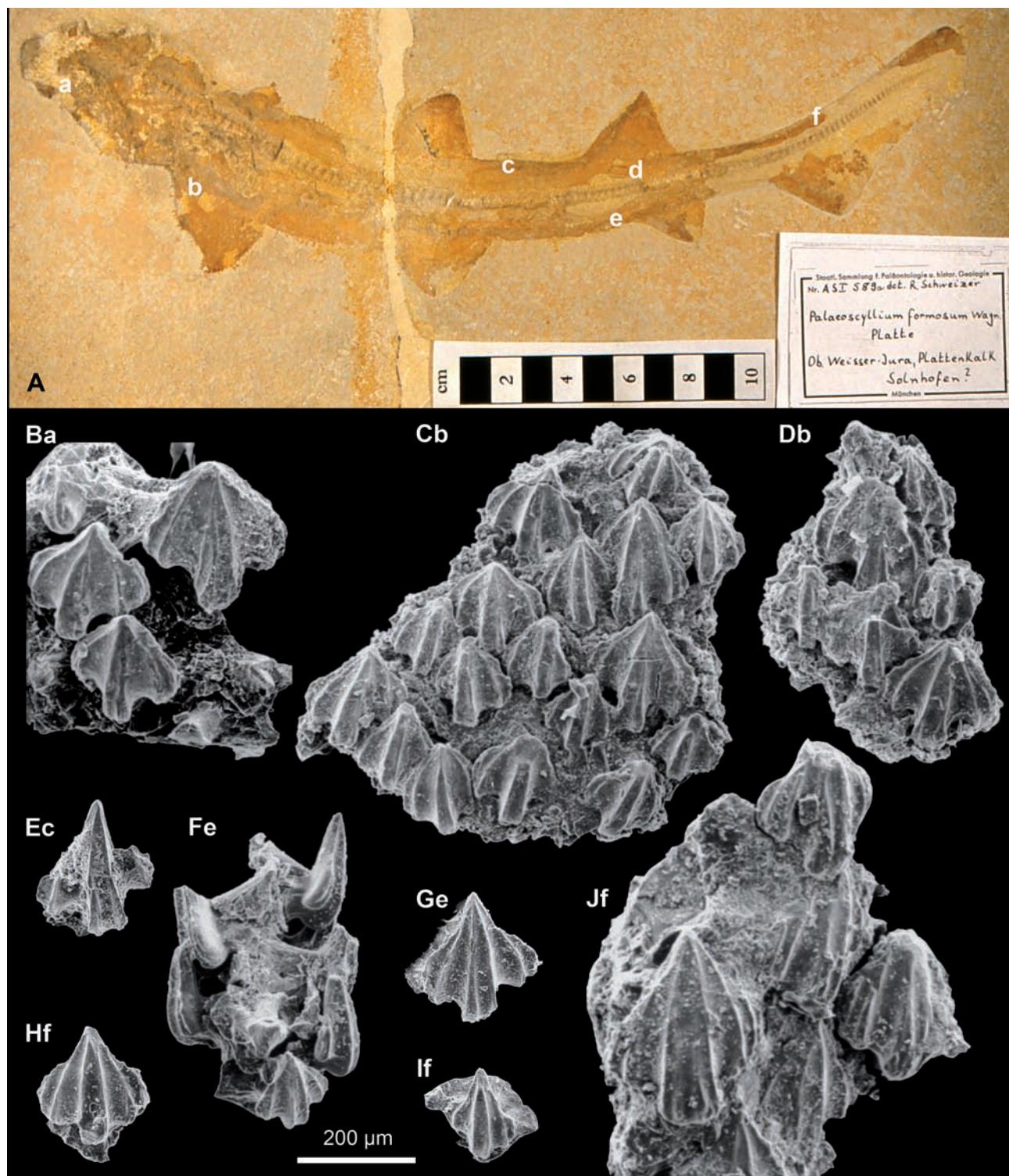


Plate 47. *Palaeoscyllium formosum* WAGNER, 1857 (BSPHG AS-I-589a, part), Solnhofen

Fig. A. Overview of the specimen. **Figs. B–J.** Isolated scales. – **Ba.** Associated scales from the cranial region, apical view. **Cb, Db.** Associated scales from the base of the pectoral fin, apical view. **Ec.** Scale from the dorsal middle trunk region between the dorsal fins, apical view. **Fe.** Associated scales from the ventral middle tail region in front of anal fin, apical view. **Ge.** Scale from the ventral middle tail region in front of anal fin, apical view. **Hf, If.** Scales from the dorsal lobe of the caudal fin, apical view. **Jf.** Associated scales from the dorsal lobe of the caudal fin, apical view.

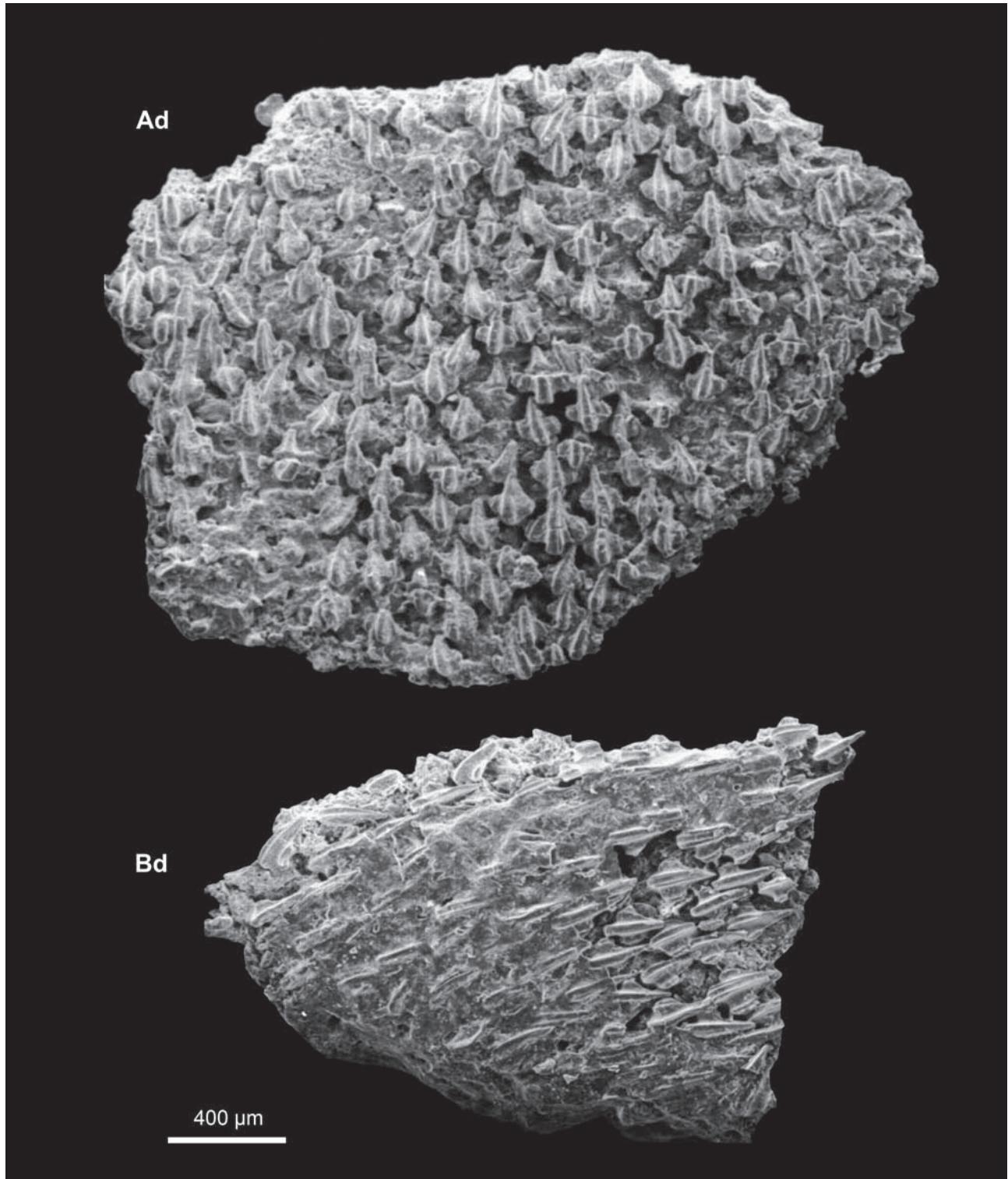


Plate 48. *Palaeoscyllium formosum* WAGNER, 1857 (BSPHG AS-I-589a, part), Solnhofen

Figs. A–B. Isolated scales. – **Ad, Bd.** Associated scales from the dorsal middle tail region below the second dorsal fin; 1 – apical, 2 – lateral view.

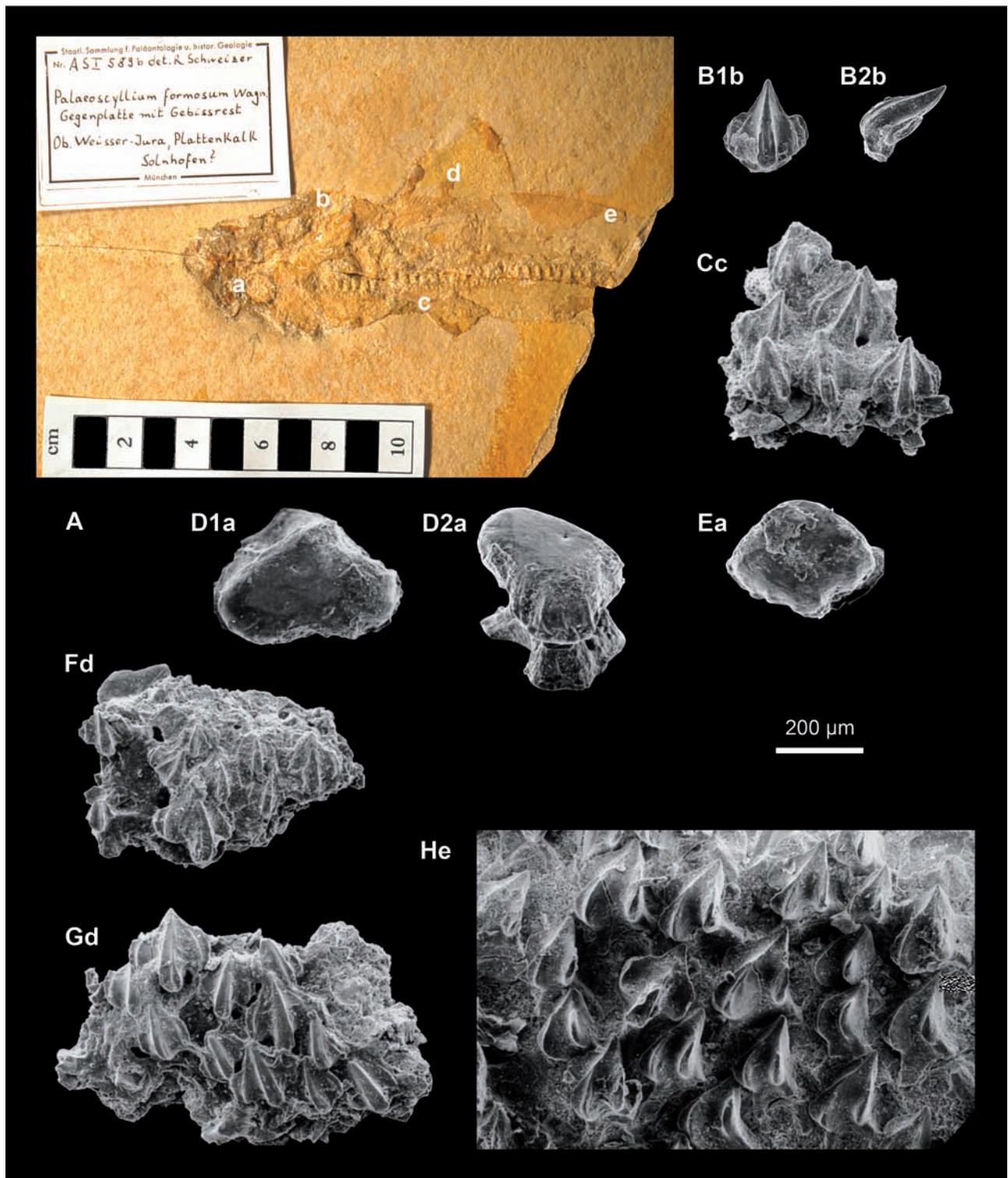


Plate 49. *Palaeoscyllium formosum* WAGNER, 1857 (BSPHG AS-I-589b, counterpart), Solnhofen

Fig. A. Overview of the specimen. **Figs. B–H.** Isolated scales. – **B1b**, **B2b**. Scale from the lateral cranial region; 1 – apical, 2 – lateral view. **Cc**. Associated scales from the anterior trunk region, apical view. **D1a**, **D2a**. Scale from the rostral region; 1 – apical, 2 – lateral view. **Ea**. Scale from the rostral region, apical view. **Fd**, **Gd**. Associated scales from the pectoral fin, apical view. **He**. Associated scales from the middle trunk region, apical view.

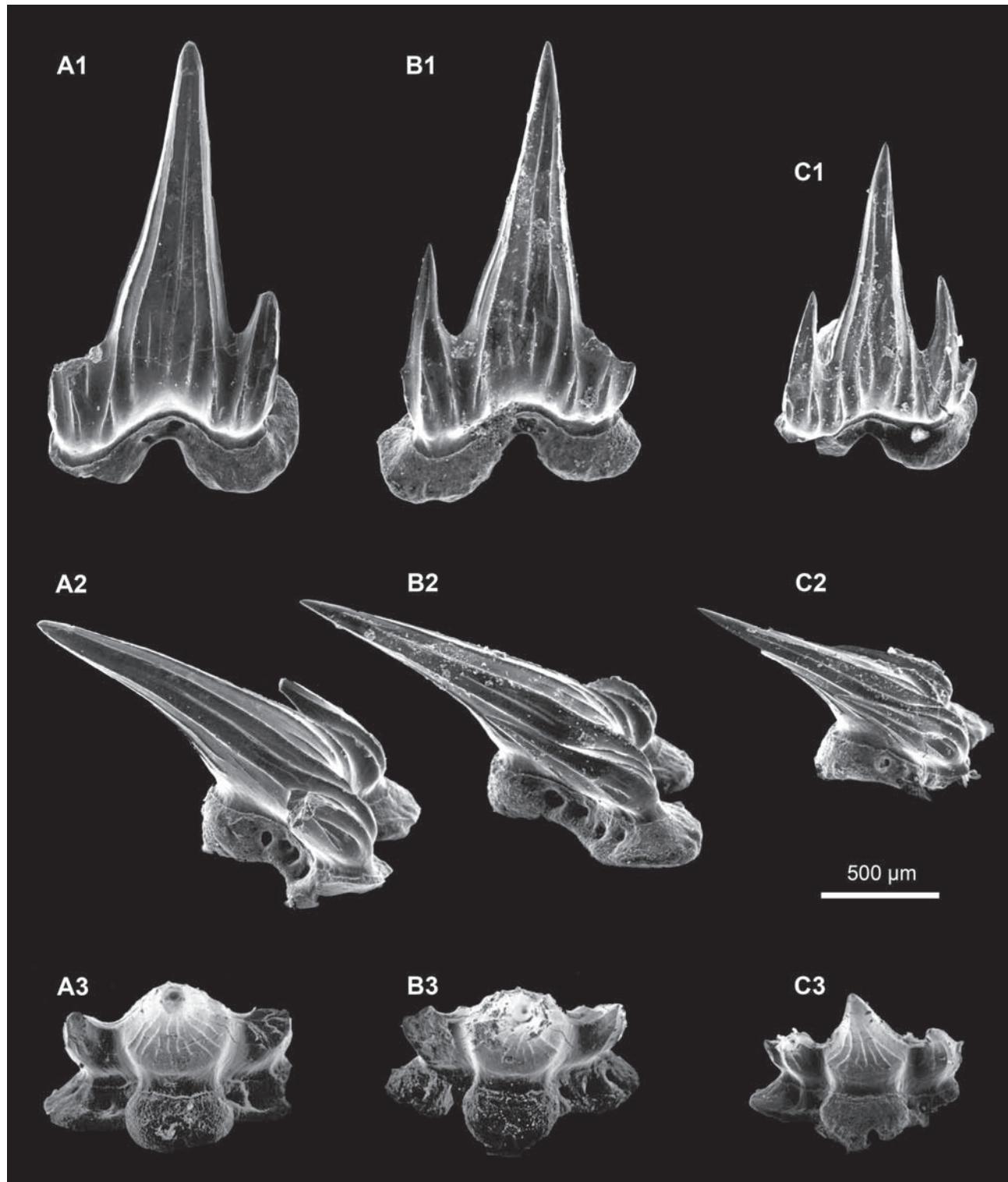


Plate 50. *Palaeoscyllium formosum* WAGNER, 1857 (BSPHG AS-I-589a), Solnhofen

Figs. A–C. Oral teeth. – A–B. Anterior oral teeth. C. Antero-lateral (or symphyseal) tooth. 1 – labial, 2 – lateral, 3 – lingual view.

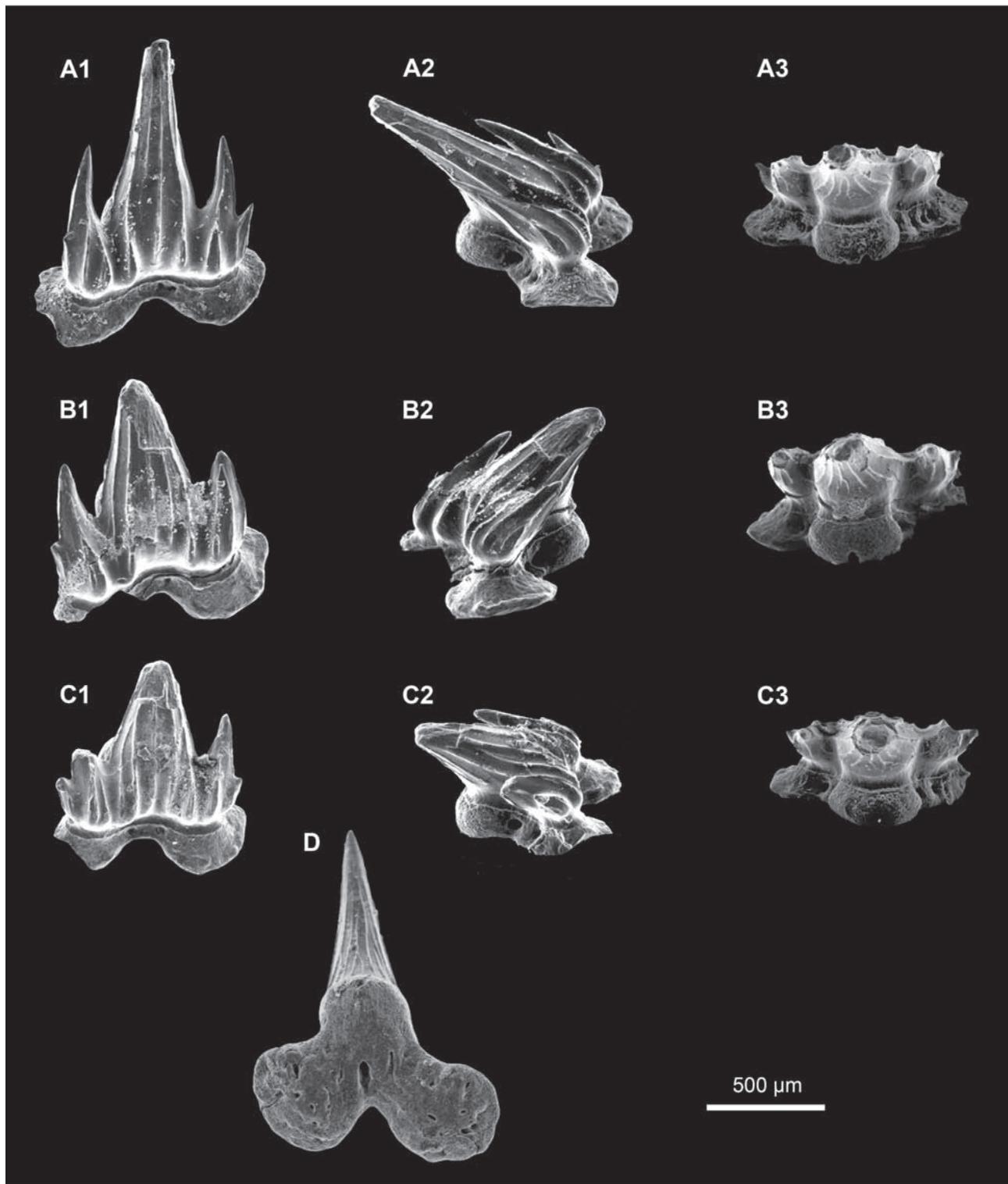


Plate 51. *Palaeoscyllium formosum* WAGNER, 1857 (BSPHG AS-I-589a), Solnhofen

Figs. A–D. Oral teeth. – A. Antero-lateral tooth. B–C. Lateral teeth. D. Tooth in basal view. 1 – labial, 2 – lateral, 3 – lingual view.

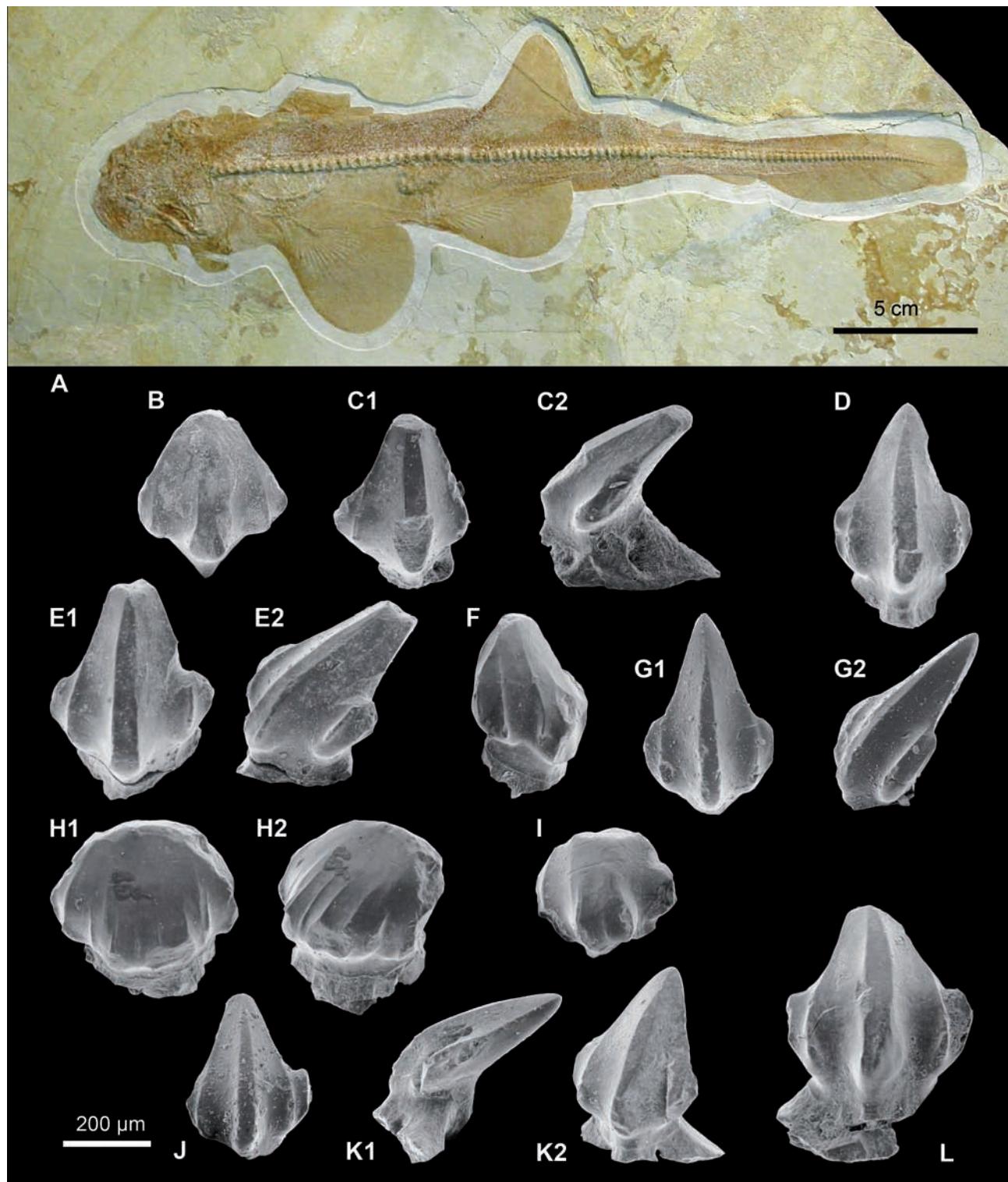


Plate 52. *Palaeoscyllium* ? sp. (BMMS BSP1993-XVIII), Brunn

Fig. A. Overview of the specimen. **Figs. B–L.** Isolated scales of unknown position. – **B, D, F, I, J, L.** Isolated scales, apical view. **C1, C2, G1, G2.** Isolated scales; 1 – apical, 2 – lateral view. **E1, E2, H1, H2.** Isolated scales; 1 – apical, 2 – antero-lateral view. **K1, K2.** Isolated scales; 1 – lateral, 2 – antero-apical view.

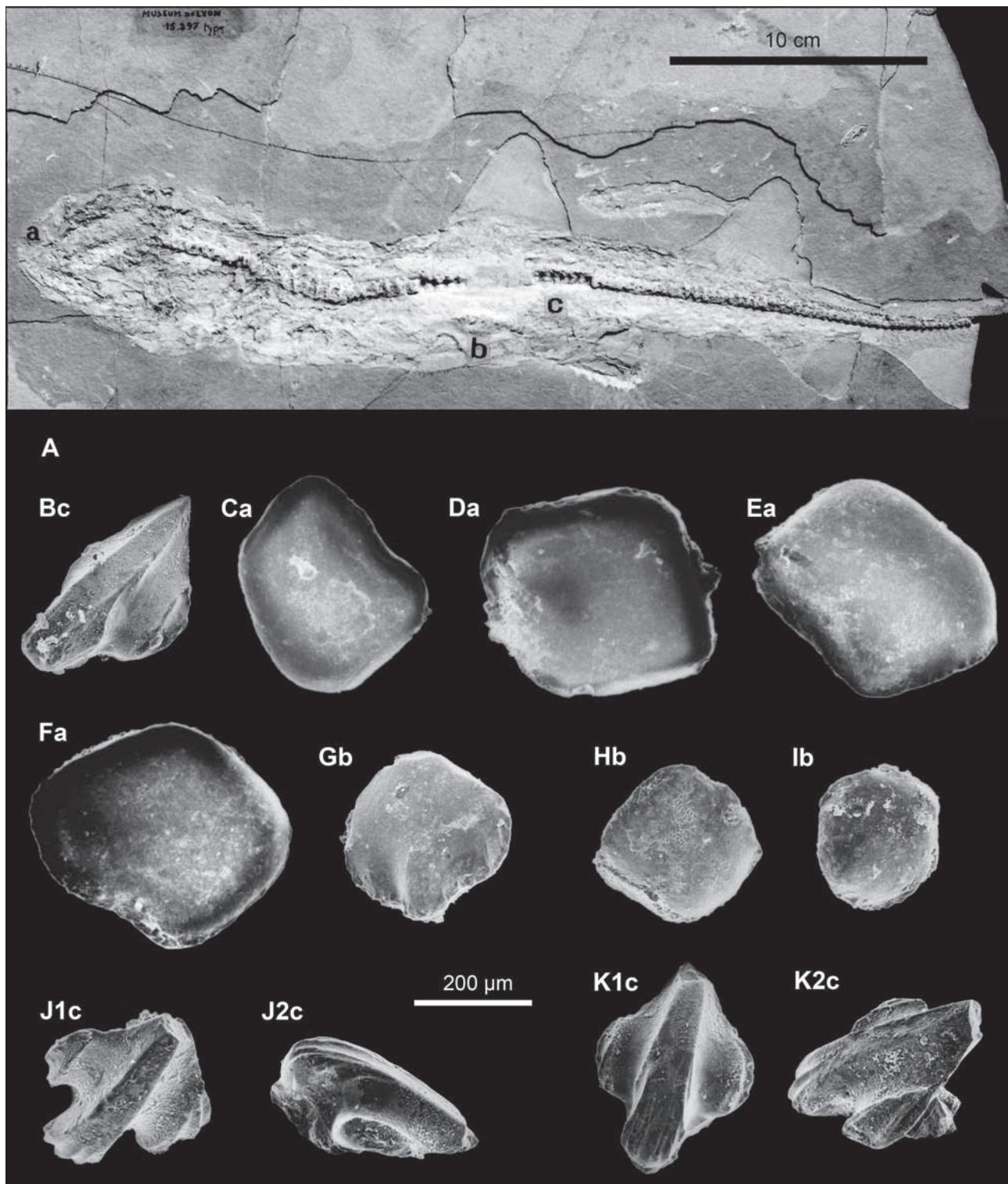


Plate 53. *Corysodon cirinensis* SAINT-SEINE, 1949 (MHNL 15.297, holotype), Cerin

Fig. A. Overview of the specimen. **Figs. B–K.** Isolated scales. – **Bc.** Scale from the posterior trunk region, apical view. **Ca, Da, Ea.** Scales from rostral region, apical view. **Gb, Hb, Ib.** Scales from the posterior trunk region, apical view. **J1c, J2c, K1c, K2c.** Scales from the posterior trunk region; 1 – apical, 2 – lateral view.

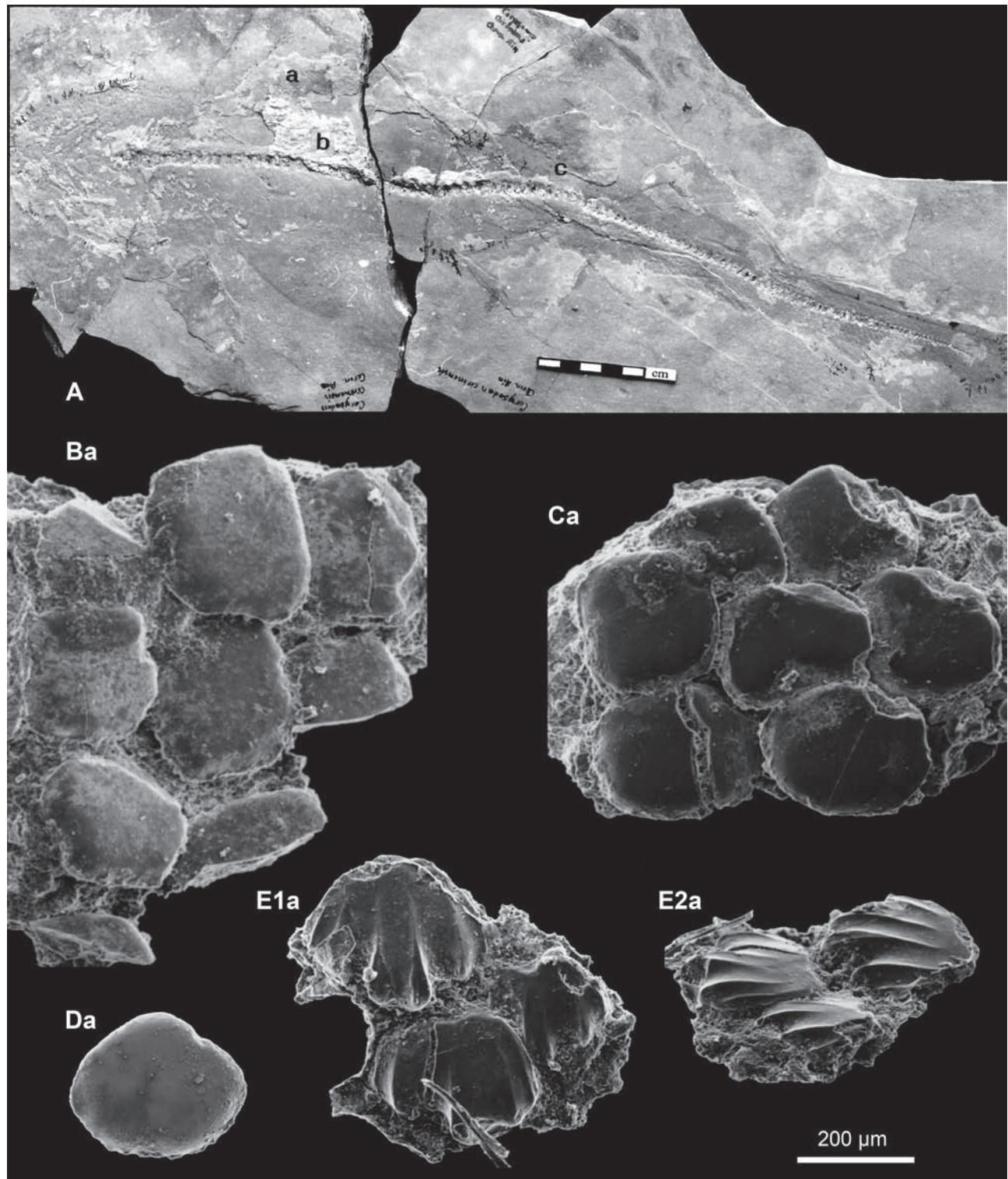


Plate 54. *Corysodon cirinensis* SAINT-SEINE, 1949 (FCL, paratype), Cerin

Fig. A. Overview of the specimen. **Figs. B–E.** Isolated scales. – **Ba, Ca.** Associated scales from the ventral surface of the pectoral fin, apical view. **Da.** Scale from the (ventral surface?) of the pectoral fin, apical view. **E1a, E2a.** Associated scales from dorsal surface of the pectoral fin; 1 – apical, 2 – lateral view.

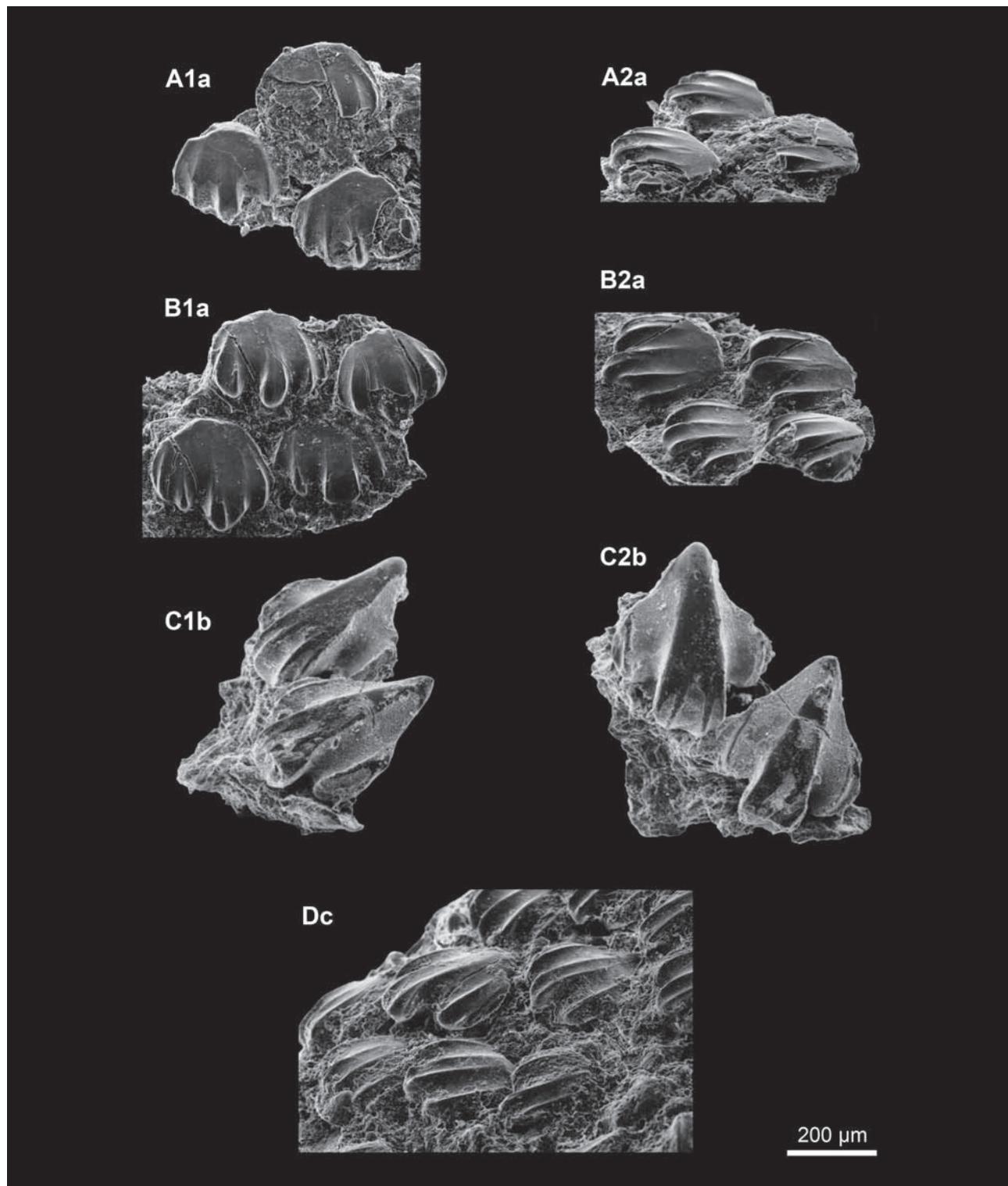


Plate 55. *Corysodon cirinensis* SAINT-SEINE, 1949 (FCL, paratype), Cerin

Figs. A–D. Isolated scales. – **A1a, A2a, B1a, B2a.** Associated scales from dorsal surface of the pectoral fin; 1 – apical, 2 – lateral view. **C1b, C2b.** Scales from the anterior trunk region; 1 – apical, 2 – lateral view. **Dc.** Associated scales from the posterior trunk region, apical view.

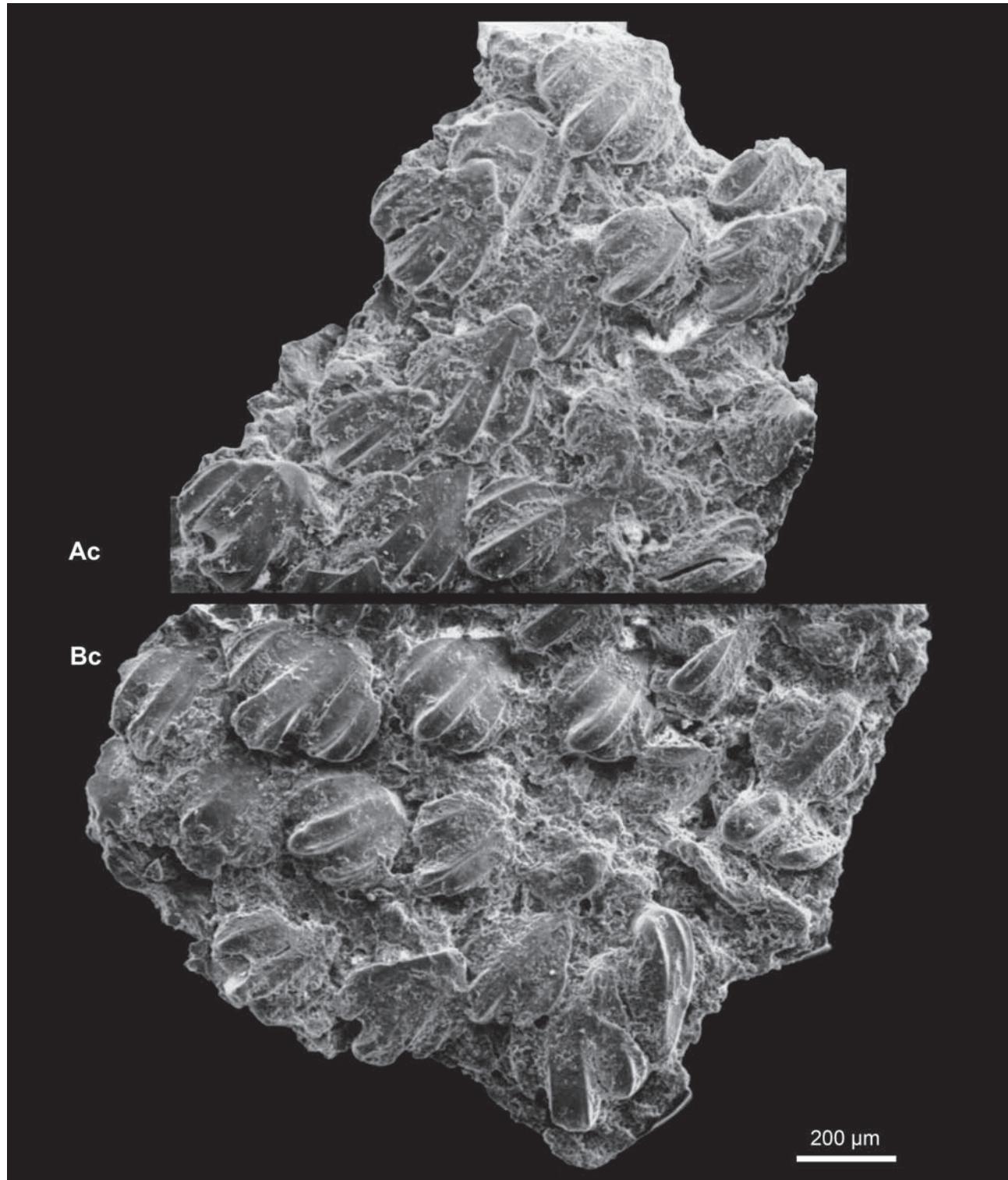


Plate 56. *Corysodon cirinensis* SAINT-SEINE, 1949 (FCL, paratype), Cerin

Figs. A–B. Isolated scales. – Ac, Bc. Associated scales from the posterior trunk region, apical view.

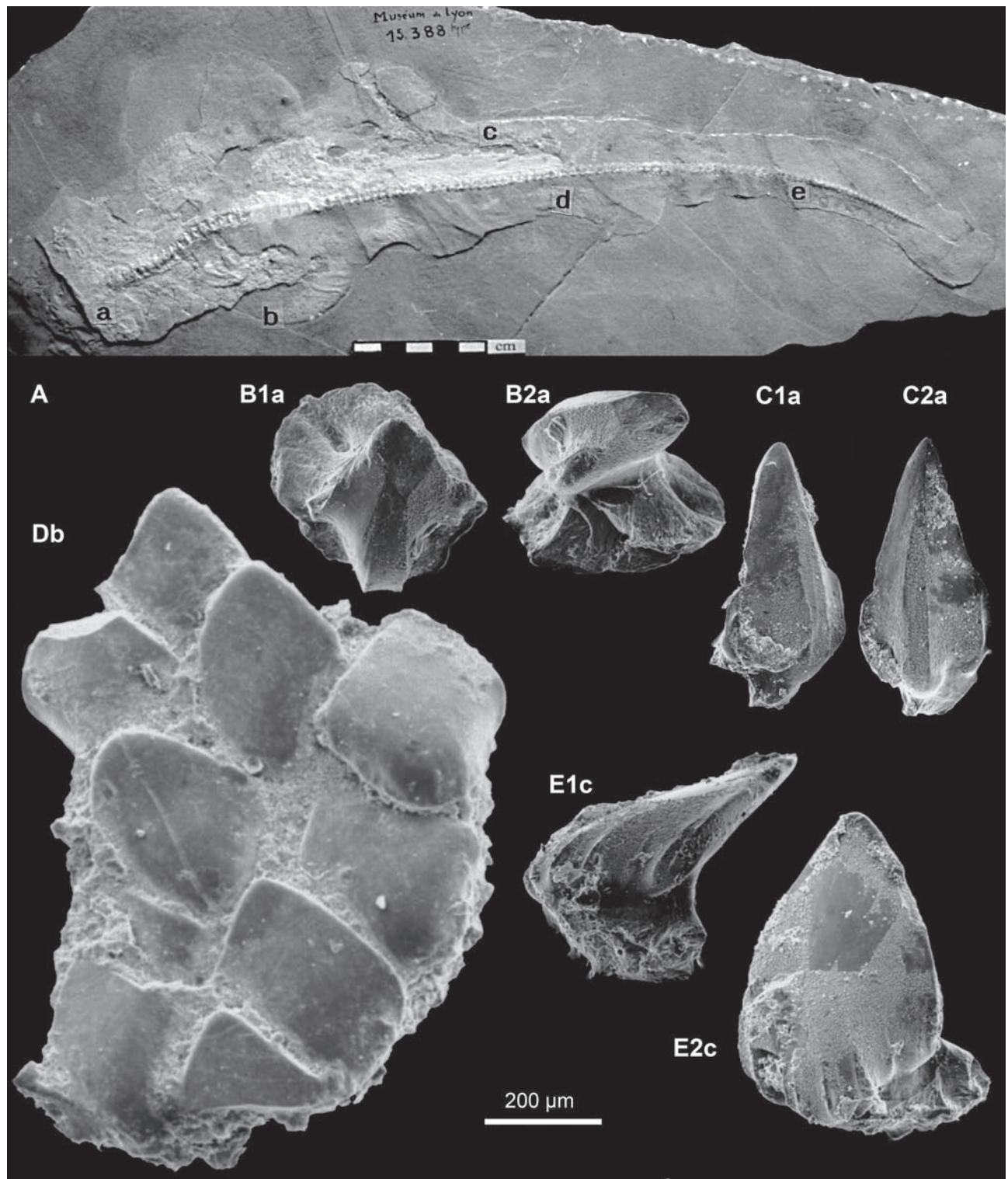


Plate 57. *Corysodon cirinensis* SAINT-SEINE, 1949 (MHNL 15.388), Cerin

Fig. A. Overview of the specimen. **Figs. B–E.** Isolated scales. – **B1a, B2a, C1a, C2a.** Scales from the dorsal cranial region; 1 – apical, 2 – lateral view. **Db.** Associated scales from the pectoral fin, apical view. **E1c, E2c.** Scale from the anterior tail region; 1 – apical, 2 – lateral view.

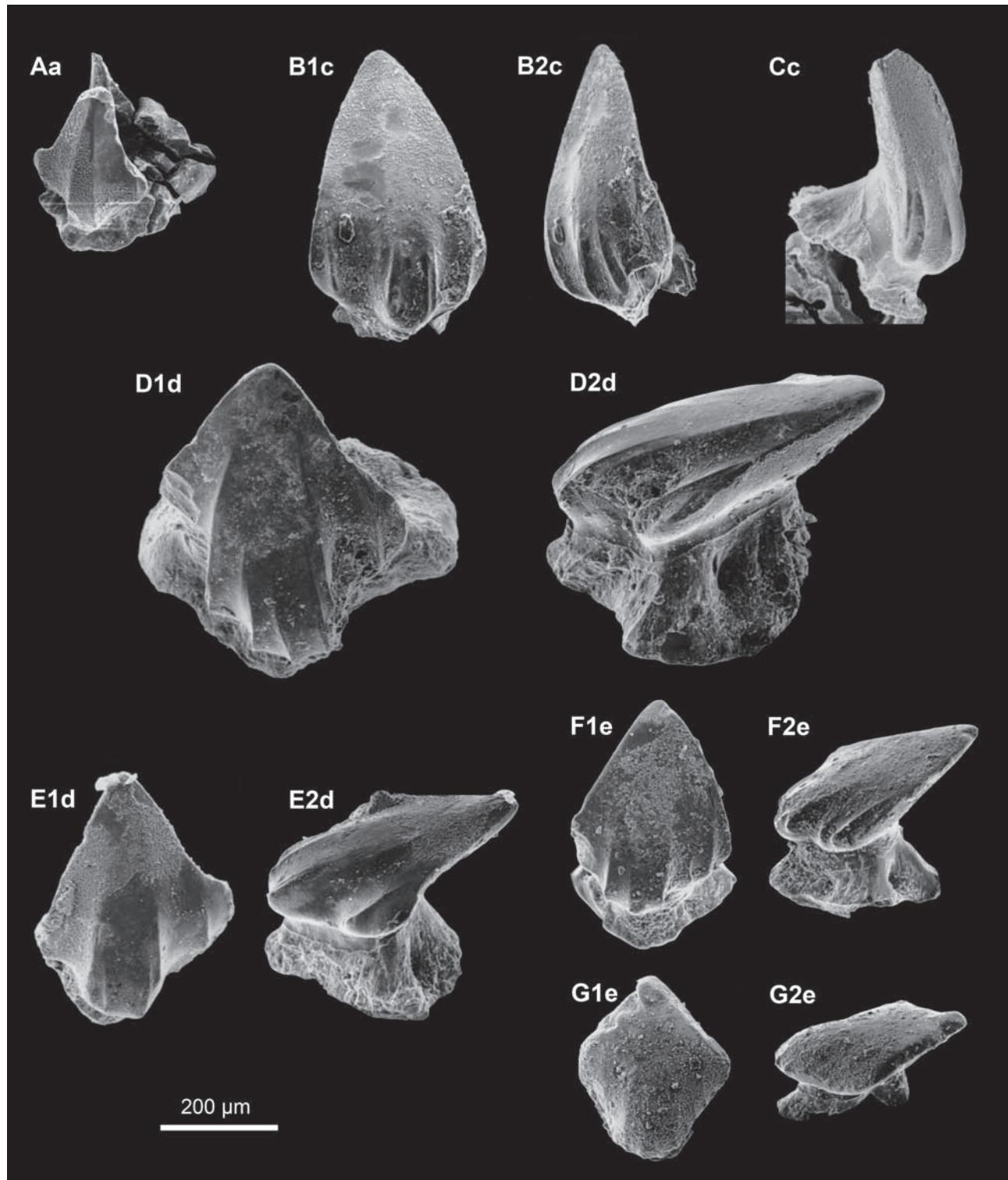


Plate 58. *Corysodon cirinensis* SAINT-SEINE, 1949 (MHNL 15.388), Cerin

Figs. A–G. Isolated scales. – **Aa.** Scale from the dorsal cranial region, apical view. **B1c, B2c.** Scale from the anterior tail region; 1 – apical, 2 – lateral view. **Cc.** Scale from the anterior tail region, lateral view. **D1d, D2d, E1d, E2d.** Scales from the anterior tail region in front of second dorsal fin; 1 – apical, 2 – lateral view. **F1e, F2e, G1e, G2e.** Scales from the caudal fin; 1 – apical, 2 – lateral view.

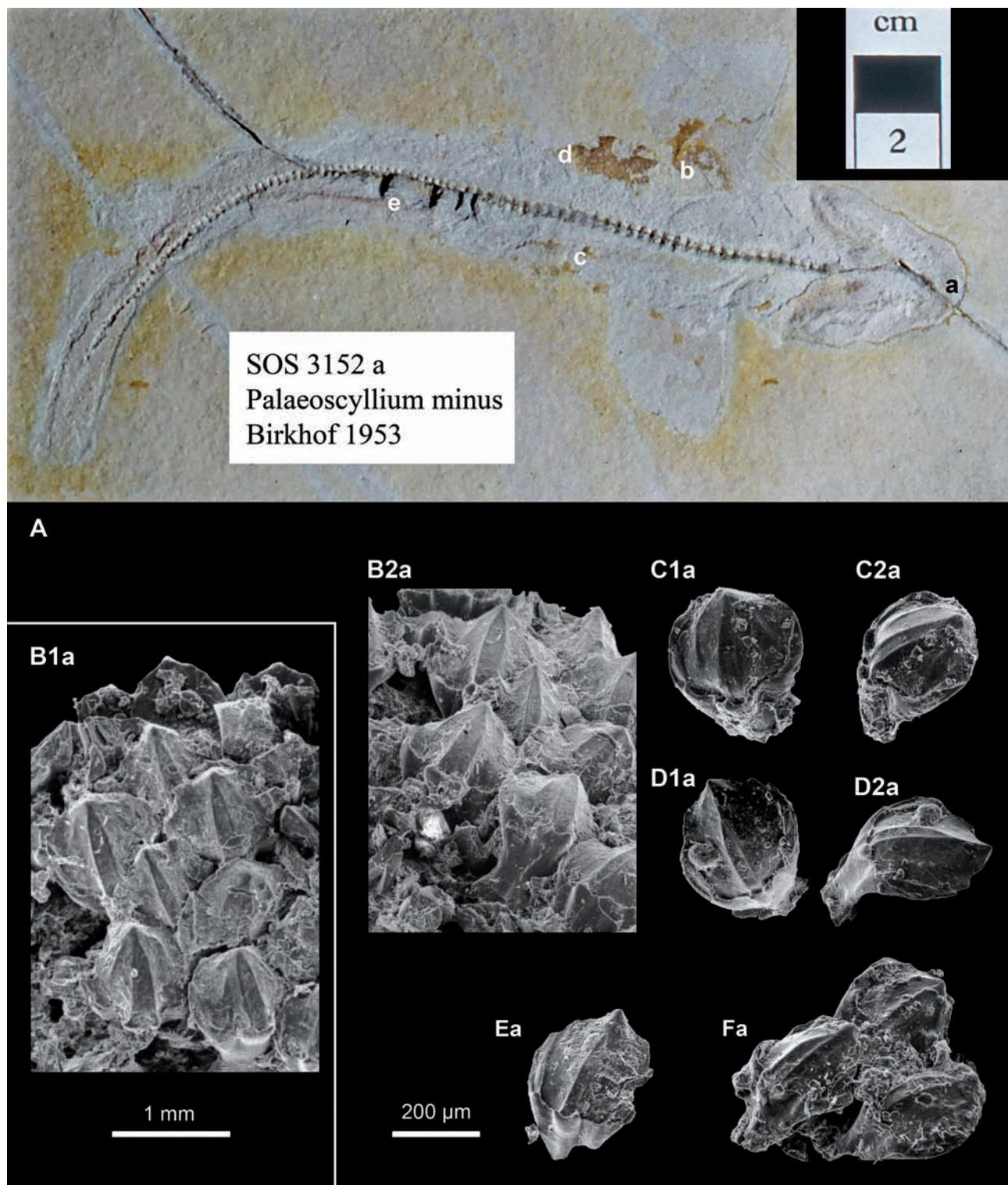


Plate 59. *Synechodus* sp. (SOS 3152a, part), Birkhof

Fig. A. Overview of the specimen. **Figs. B–F.** Isolated scales. – **B1a, B2a.** Associated scales from the rostral region; 1 – apical, 2 – anterior view. **C1a, C2a, D1a, D2a.** Scales from the rostral region; 1 – apical, 2 – lateral view. **Ea.** Scale from the rostral region, apical view. **Fa.** Associated scales from the rostral region, apical view.

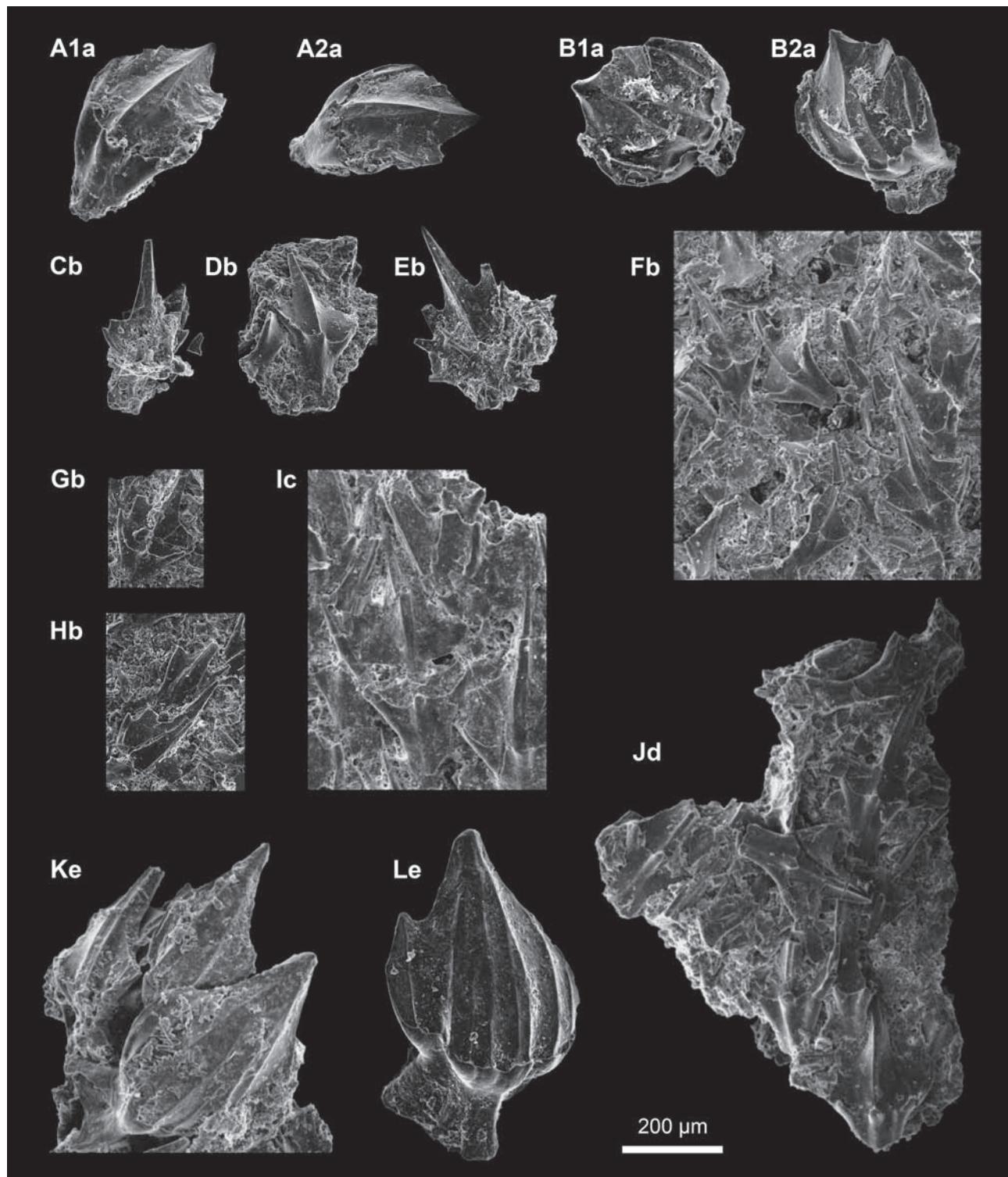


Plate 60. *Synechodus* sp. (SOS 3152a, part), Birkhof

Figs. A–L. Isolated scales. – **A1a, A2a, B1a, B2a.** Scales from the rostral region; 1 – apical, 2 – lateral view. **Cb, Db, Eb.** Scales from the pectoral fin, apical view. **Fb.** Associated scales from the pectoral fin, anterior and apical views. **Gb.** Scale from the pectoral fin, anterior view. **Hb.** Associated scales from the pectoral fin, apical view. **Ic.** Associated scales from the middle trunk region, apical view. **Jd.** Associated scales from the middle trunk region, apical view. **Ke.** Associated scales from posterior body region in apical to oblique anterior view. **Le.** Scale from anterior teil region, apical view.

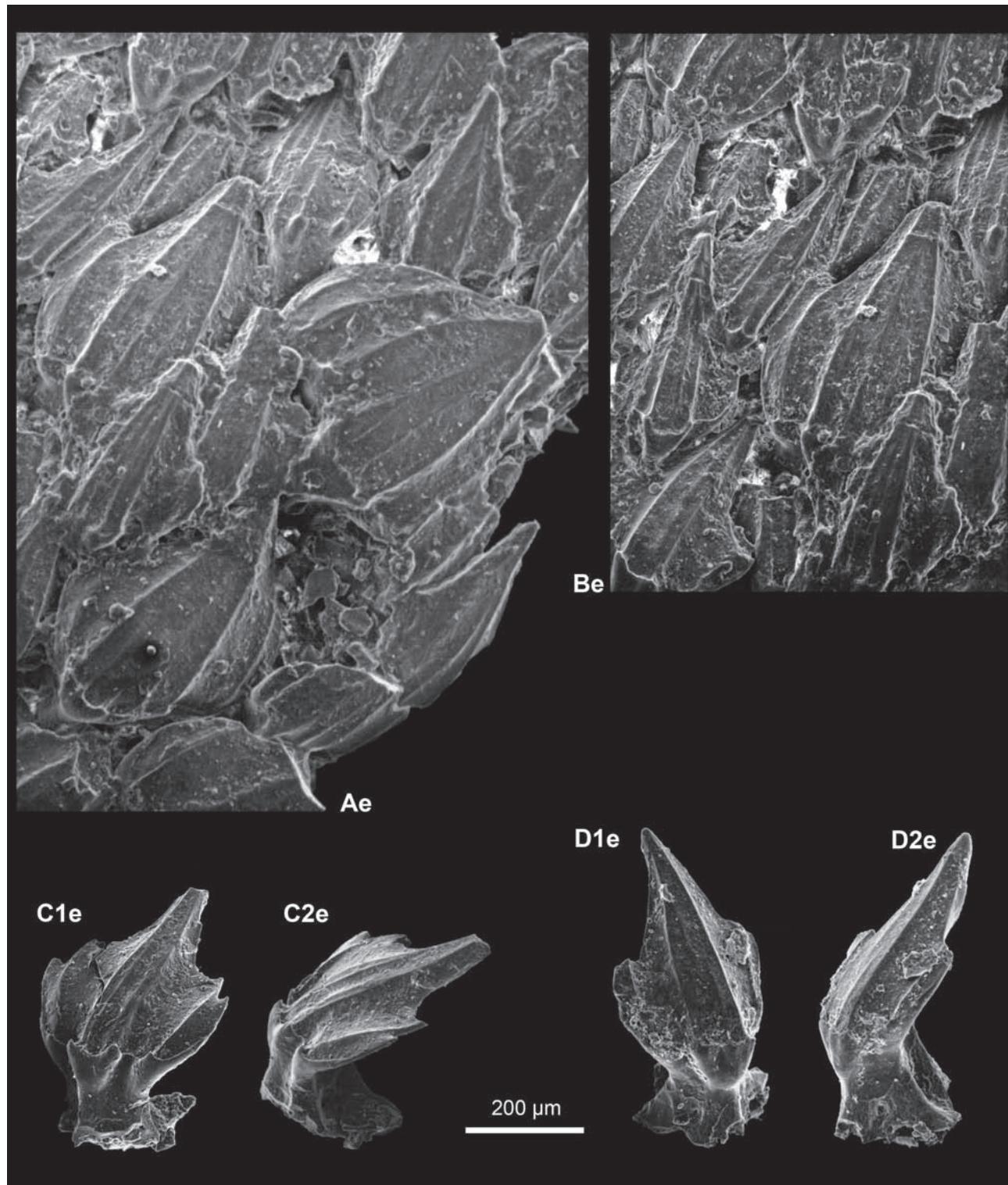


Plate 61. *Synechodus* sp. (SOS 3152a, part), Birkhof

Figs. A–D. Isolated scales. – **Ae.** Associated scales from anterior tail region, apical view. **Be.** Associated scales from anterior tail region, anteroapical view. **C1e, C2e.** Scale from anterior tail region; 1 – anteroapical, 2 – lateral view. **D1e, D2e.** Scale from anterior tail region; 1 – apical, 2 – lateral view.

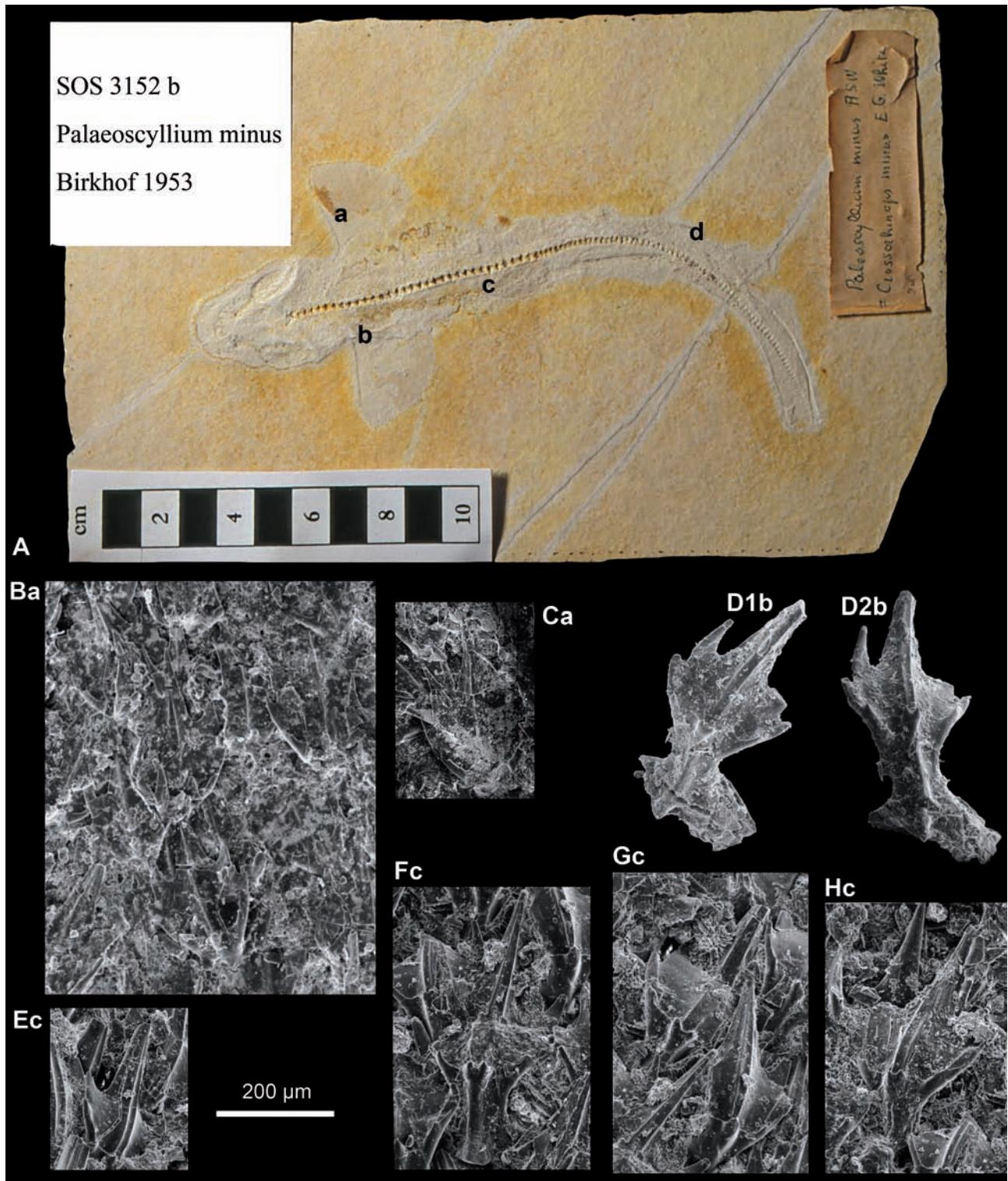


Plate 62. *Synechodus* sp. (SOS 3152b, counterpart), Birkhof

Fig. A. Overview of the specimen. **Figs. B–H.** Isolated scales. – **Ba, Ca.** Associated scales from the pectoral fin, apical view. **D1b, D2b.** Scale from the anterior trunk region; 1 – apical, 2 – anterior view. **Ec, Fc, Gc, Hc.** Associated scales from the middle to posterior trunk region, apical views.

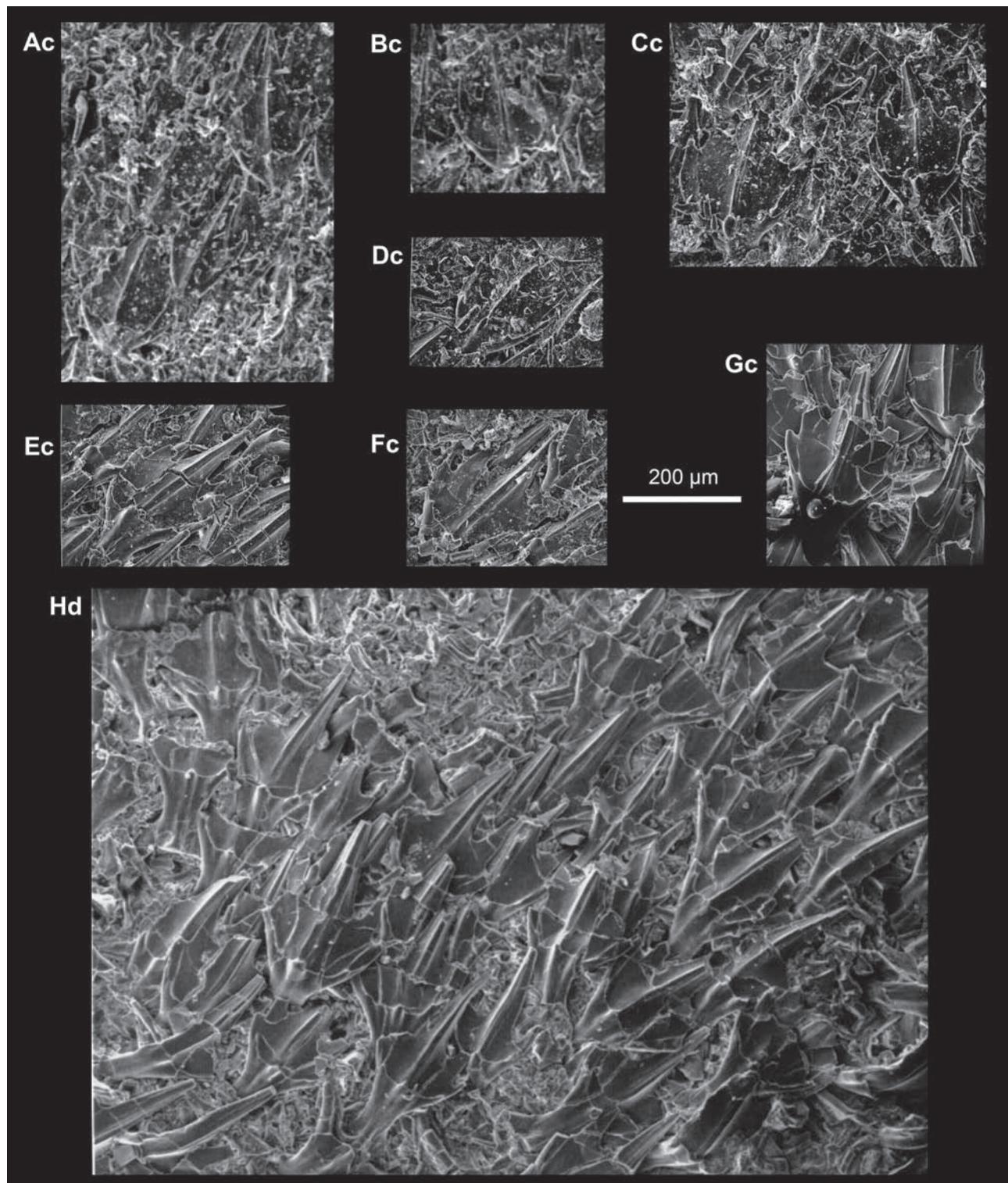


Plate 63. *Synechodus* sp. (SOS 3152b, counterpart), Birkhof

Figs. A–H. Isolated scales. – **Ac, Bc, Cc, Dc, Ec, Fc, Gc.** Associated scales from the middle to posterior trunk region, apical views. **Hd.** Associated scales from the middle tail region, apical view.

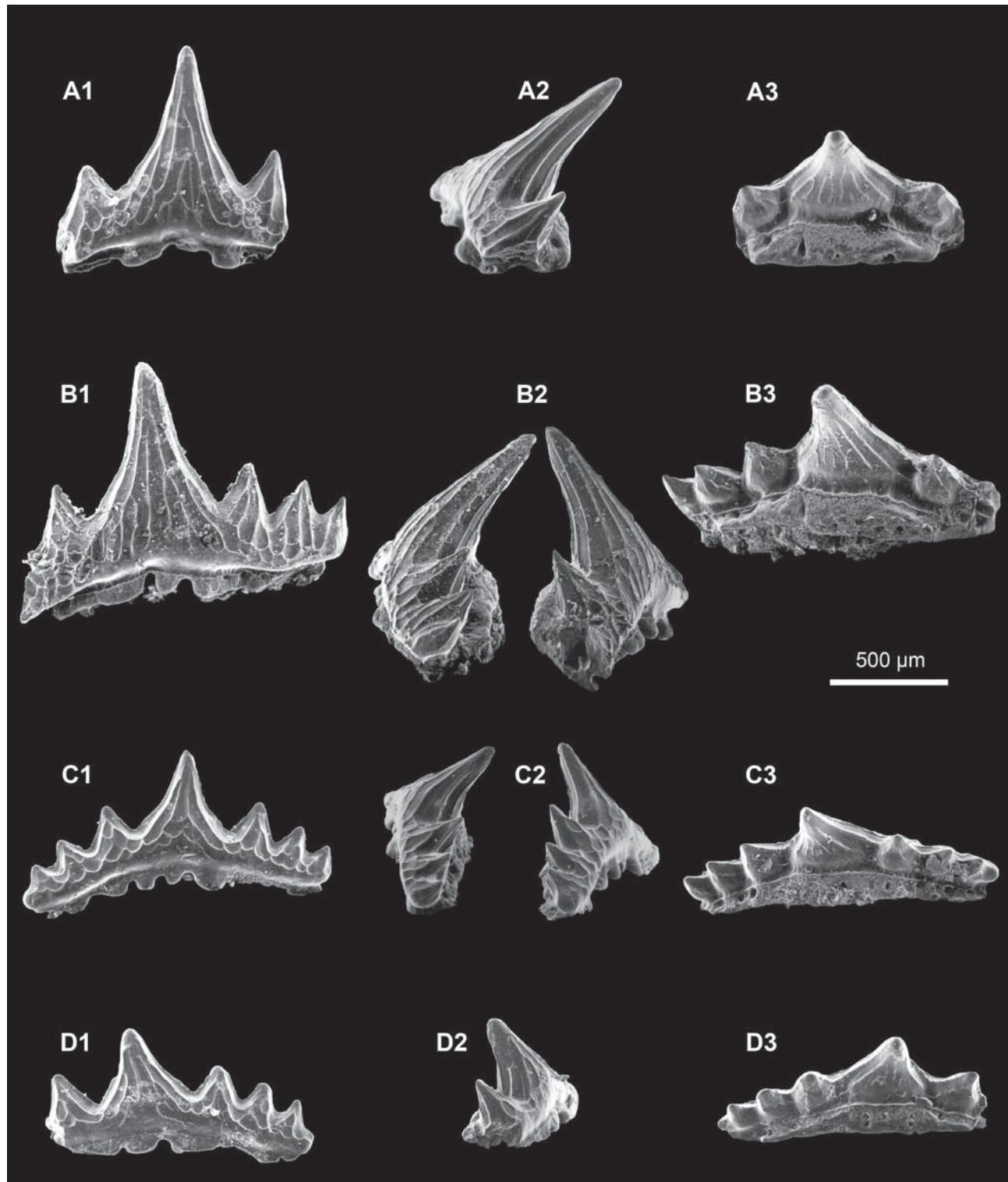


Plate 64. *Synechodus* sp. (SOS 3152a), Birkhof

Figs. A–D. Oral teeth. – **A.** Anterior tooth. **B.** Antero-lateral tooth. **C.** Postero-lateral tooth. **D.** Posterior tooth. 1 – labial, 2 – lateral, 3 – lingual view.

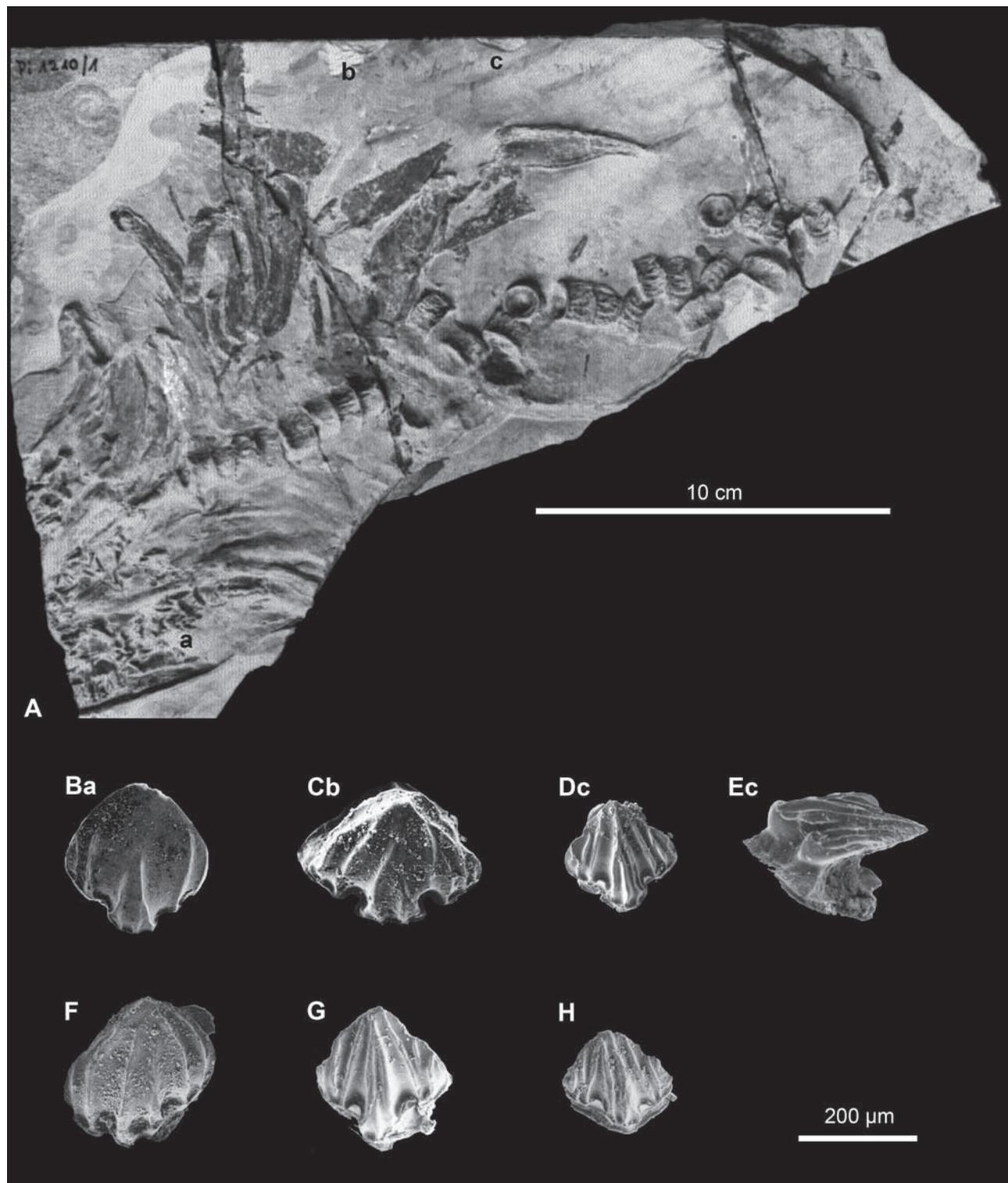


Plate 65. *Paraorthacodus jurensis* (SCHWEIZER, 1964) (GPIT Pi 1210/1), Nusplingen

Fig. A. Overview of the specimen. **Figs. B–H.** Isolated scales. – **Ba.** Scale from the cranial region, apical view. **Cb.** Scale from the pectoral fin, apical view. **Dc.** Scale from the middle trunk region, apical view. **Ec.** Scale from the middle trunk region, lateral view. **F, G, H.** Scales of unknown position, apical view. – All samples and negatives by courtesy of W.-E. REIF, Figs. B–C already published by REIF (1973).

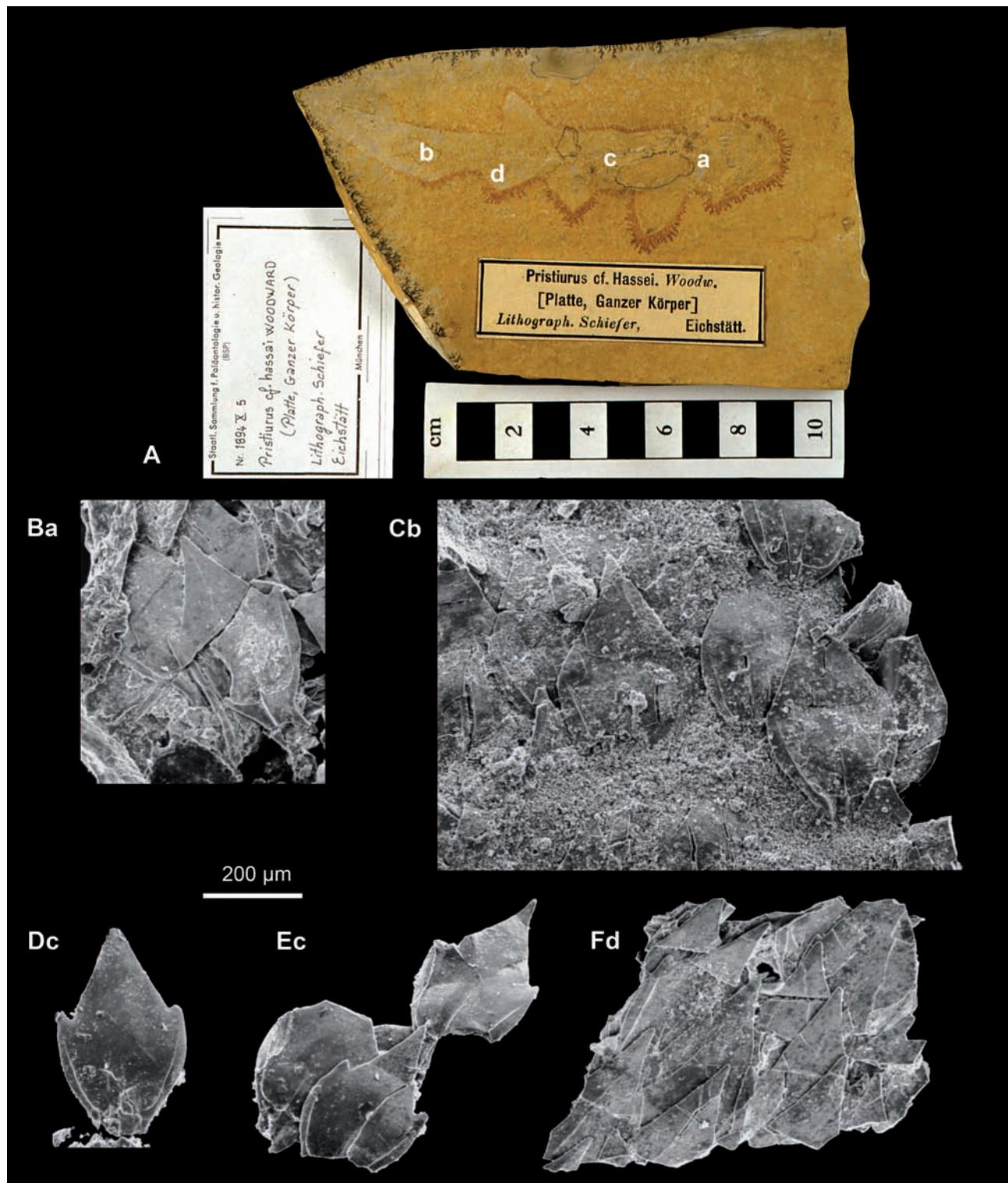


Plate 66. *Paraorthacodus* sp. (BSPHG 1894-X-5), Eichstätt

Fig. A. Overview of the specimen. **Figs. B–F:** Isolated scales. – **Ba.** Associated scales from the anterior trunk region, apical view. **Cb.** Associated scales from the ventral lobe of the caudal fin, apical view. **Dc.** Scale from the middle trunk region, apical view. **Ec.** Associated scales from the middle trunk region, apical view. **Fd.** Associated scales from the anal fin, apical view.

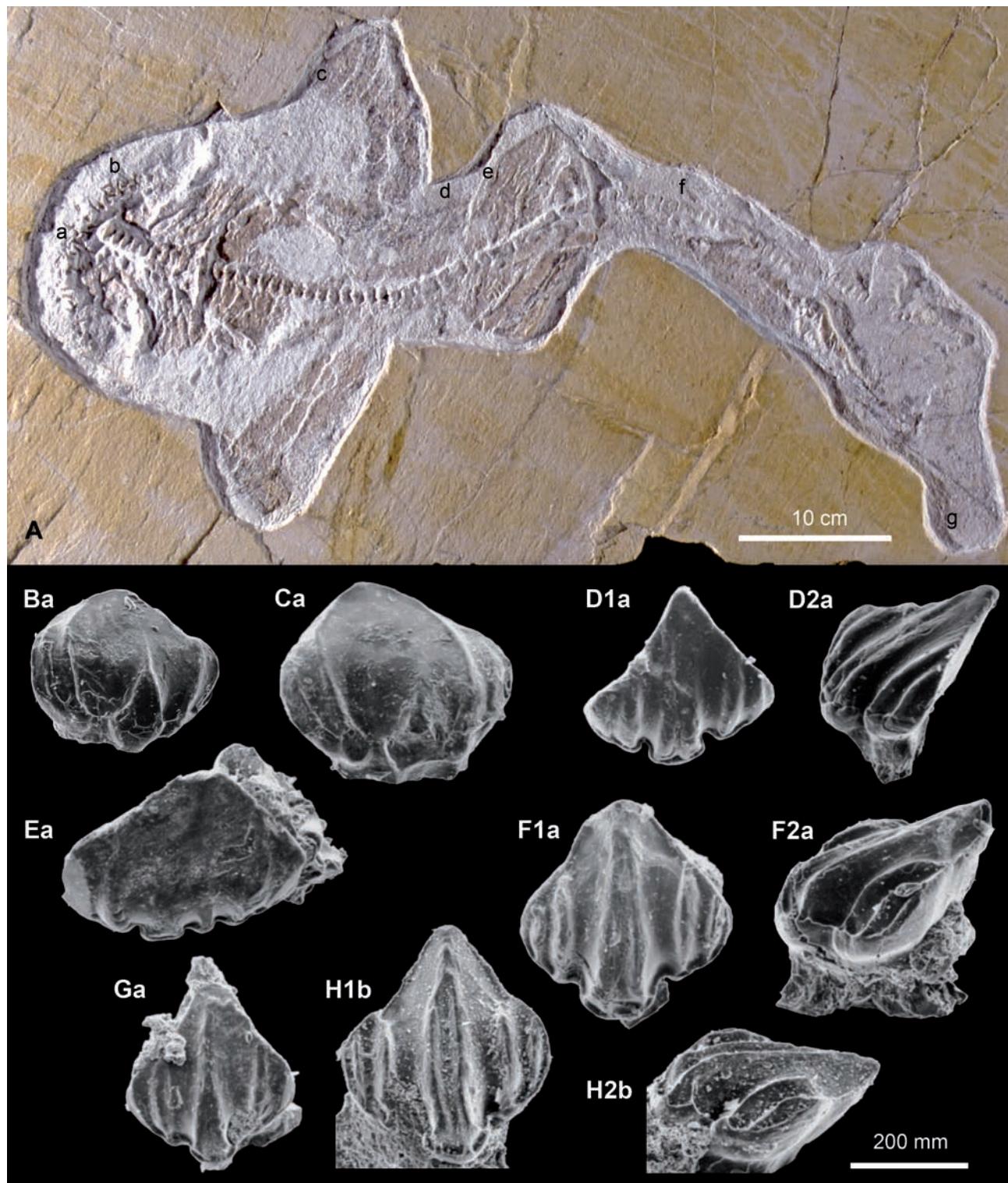


Plate 67. *Spenodus macer* (QUENSTEDT, 1852) (SMNS 80142/44), Egesheim

Fig. A. Overview of the specimen. **Figs. B–H.** Isolated scales. – **Ba, Ca, Ea, Ga.** Scales from the symphyseal region, apical view. **D1a, D2a, F1a, F2a.** Scales from the symphyseal region; 1 – apical, 2 – lateral view. **H1b, H2b.** Scale from the rostral region; 1 – apical, 2 – lateral view.

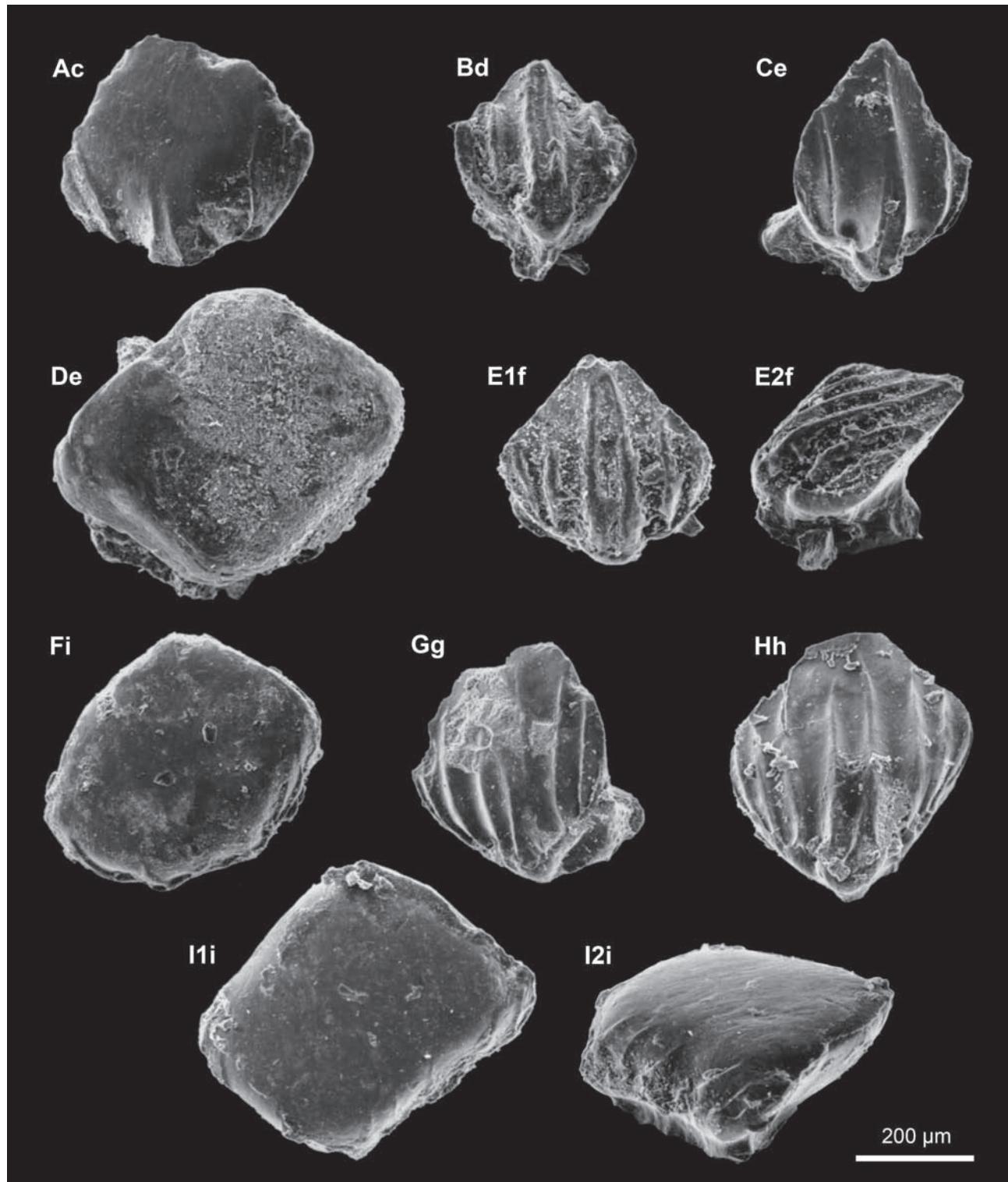


Plate 68. *Spenodus macer* (QUENSTEDT, 1852 (SMNS 80142/44), Egesheim

Figs. A–I. Isolated scales. – **Ac.** Scale from the pectoral fin, apical view. **Bd.** Scale from the middle trunk region, apical view. **Ce, De.** Scales from the pelvic fin, apical view. **E1f, E2f.** Scale, possibly from the anal fin; 1 – apical, 2 – lateral view. **Fi.** Scale from the cranial region, apical view. **Gg.** Scale from the distal part of the dorsal lobe of the caudal fin, apical view. **Hh.** Scale from the proximal part of the dorsal lobe of the caudal fin, apical view. **I1i, I2i.** Scale from the cranial region; 1 – apical, 2 – lateral view.

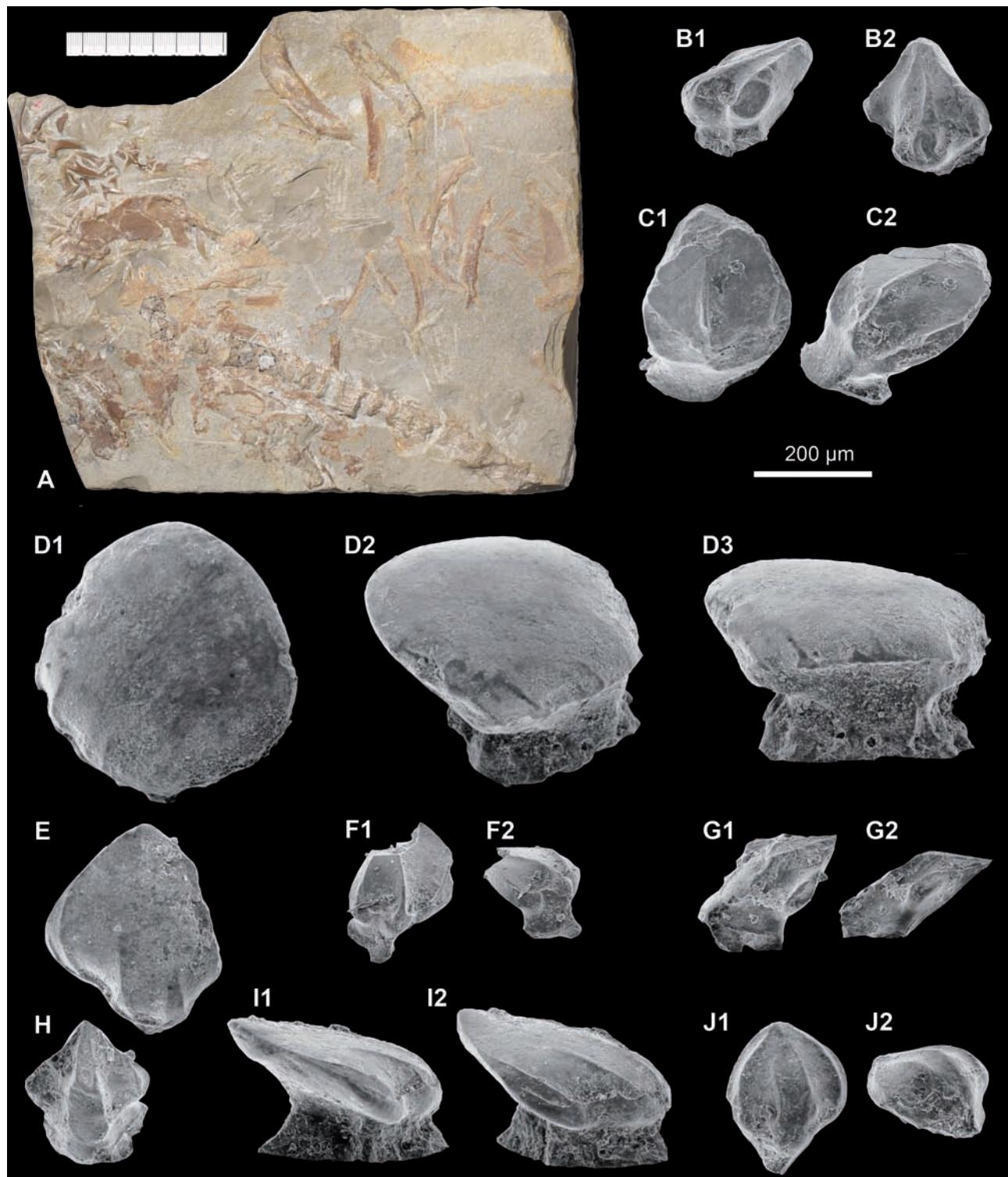


Plate 69. *Sphenodus nitidus* WAGNER, 1862 (BSPHG AS-VIII-647, holotype), Solnhofen

Fig. A. Overview of the specimen. **Figs. B–J.** Isolated scales. – **B.** Scale of unknown position; 1 – lateral, 2 – apical view. **C.** Scale of unknown position; 1 – apical, 2 – apico-lateral view. **D.** Scale of unknown position; 1 – apical, 2 – apico-lateral, 3 – antero-lateral view. **E, H.** Scales of unknown position, apical view. **F.** Scale of unknown position; 1 – apical, 2 – apico-lateral view. **G.** Scale of unknown position; 1 – apico-lateral, 2 – lateral view. **I.** Scale of unknown position; 1 – lateral, 2 – apico-lateral view. **J.** Scale of unknown position; 1 – apical, 2 – antero-lateral view.

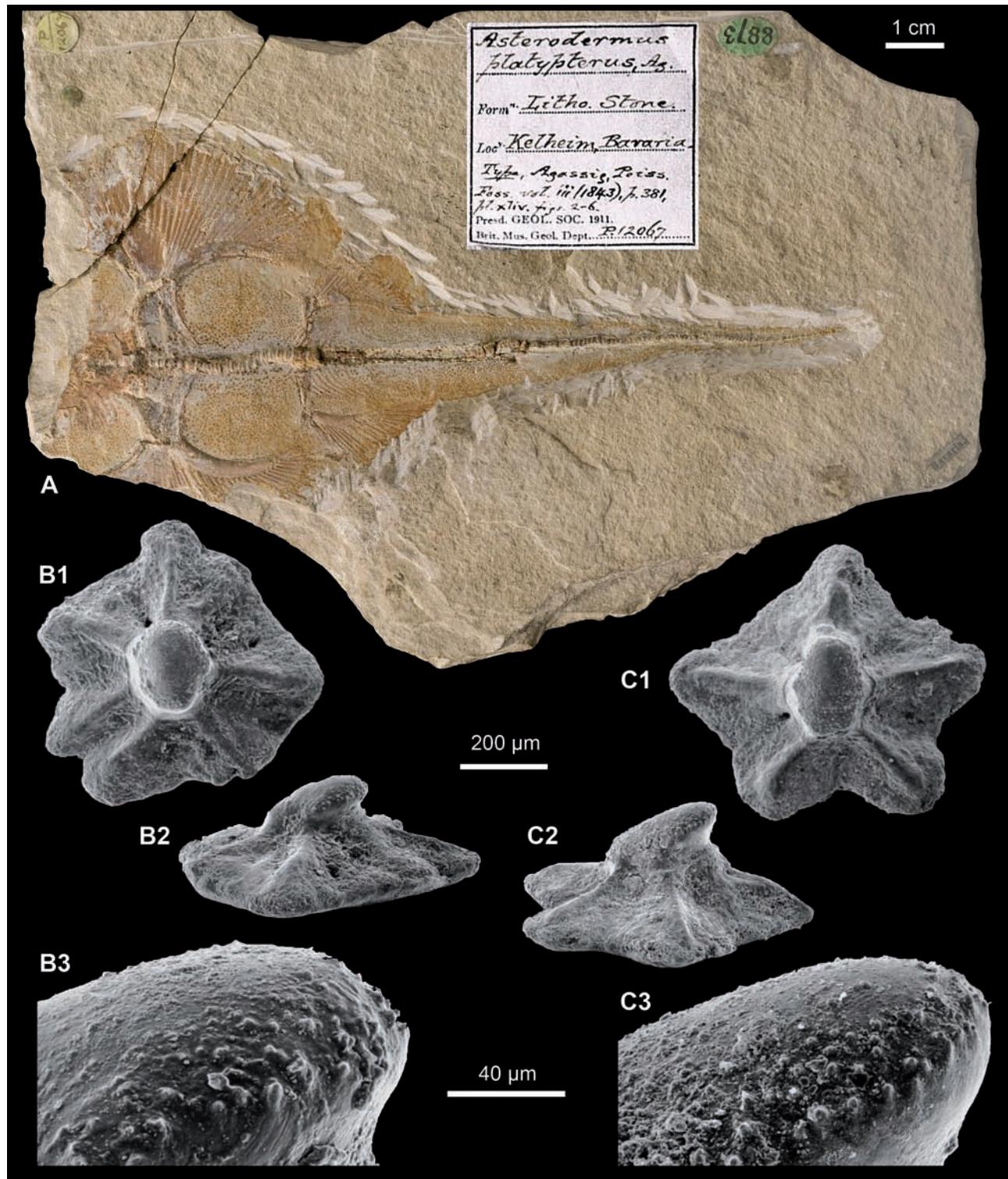


Plate 70. *Asterodermus platypterus* AGASSIZ, 1843 (NHML P12067, holotype), Kelheim

Fig. A. Overview of the specimen. Figs. B–C. Isolated thorns of unknown position; 1 – apical, 2 – lateral view, 3 – enlarged lateral view of the tip of the thorn.

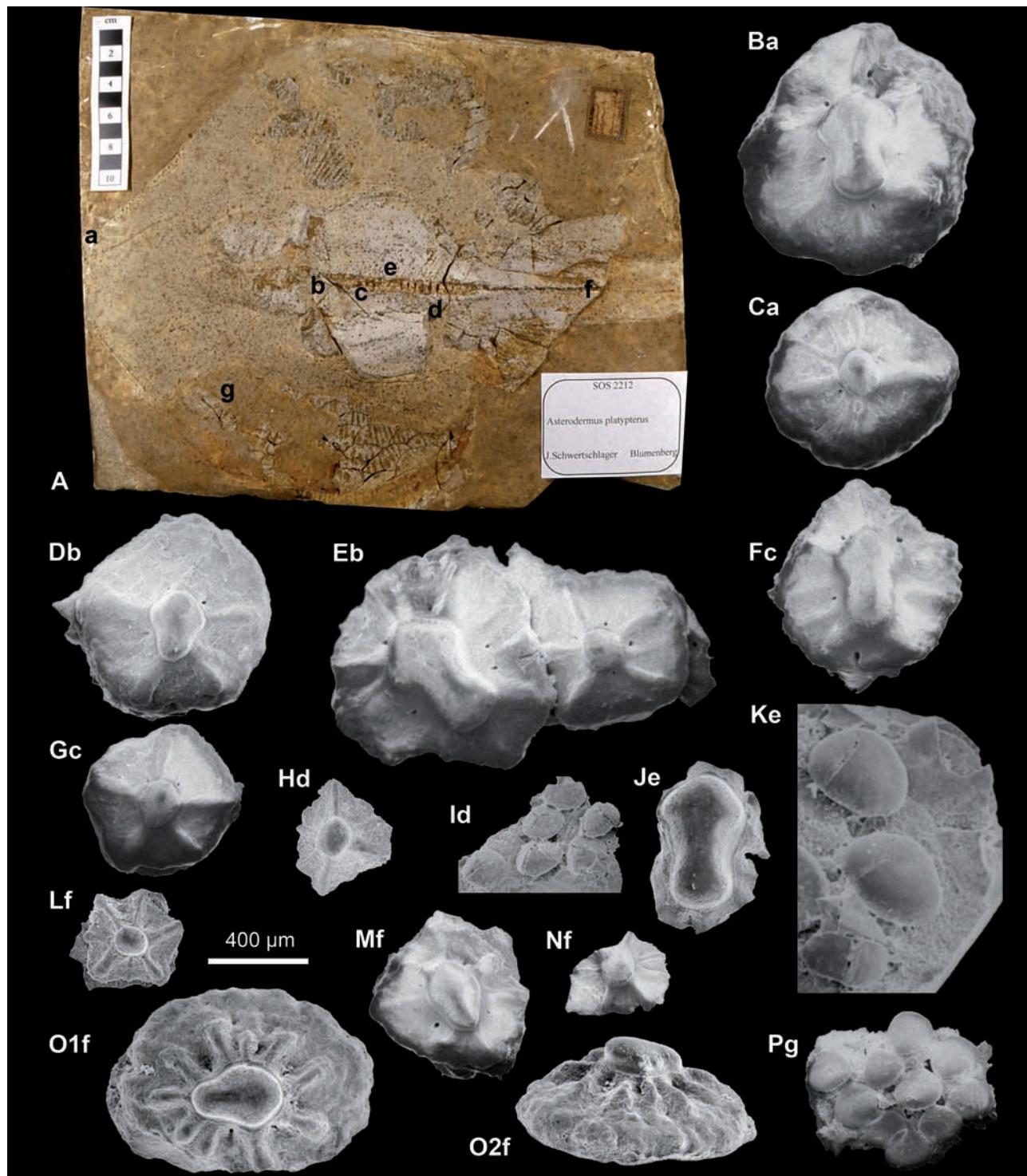


Plate 71. *Asterodermus platypterus* AGASSIZ, 1843 (SOS 2212), Blumenberg

Fig. A. Overview of the specimen. **Figs. B–P.** Isolated thorns and scales. – **Ba, Ca.** Malar thorns from the rostral region, apical view. **Db, Eb.** Nuchal thorns, apical view. **Fc, Gc.** Dorsal thorns from the middle trunk region, apical view. **Hd.** Dorsal thorn from the middle trunk region, apical view. **Id.** Associated scales from the middle trunk region, apical view. **Je.** Dorsal thorn from the middle trunk region, apical view. **Ke.** Associated scales from the middle trunk region, antero-apical view. **Lf, Mf, Nf.** Dorsal thorn from the anterior tail region, apical view. **O1f, O2f.** Dorsal thorn from the anterior tail region; 1 – apical, 2 – lateral view. **Pg.** Associated scales from the pectoral fin, apical view.

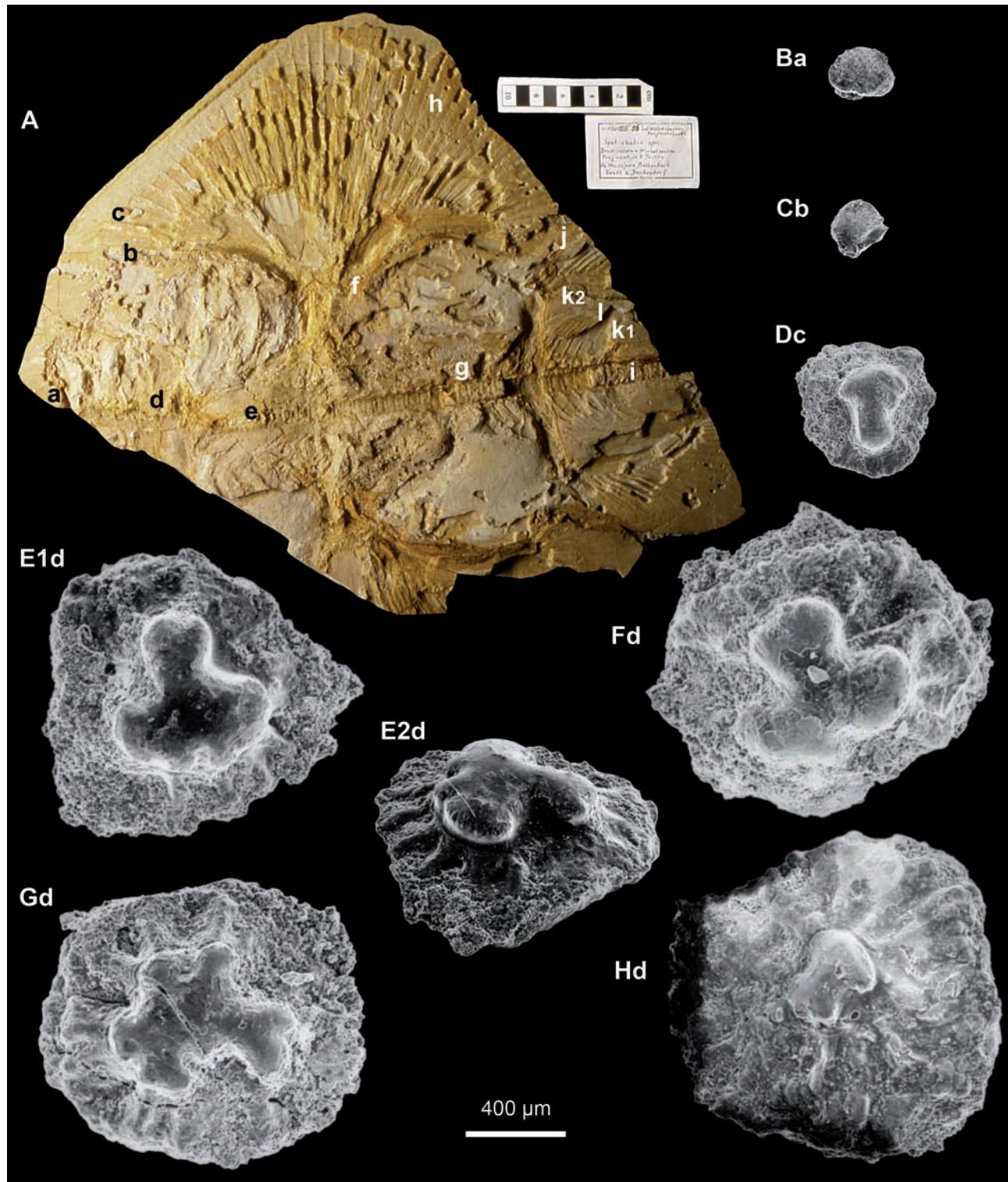


Plate 72. *Asterodermus* sp. (BSPHG 1960-XVIII-56, part), Zandt

Fig. A. Overview of the specimen. **Figs. B–H.** Isolated thorns and scales. – **Ba.** Scale from the cranial region, apical view. **Cb.** Scale from the pectoral fin, apical view. **Dc.** Malar thorn, apical view. **E1d, E2d.** Cranial (orbital?, interorbital?) thorn; 1 – apical, 2 – lateral view. **Fd, Gd, Hd.** Cranial (orbital?, interorbital?) thorns, apical view.

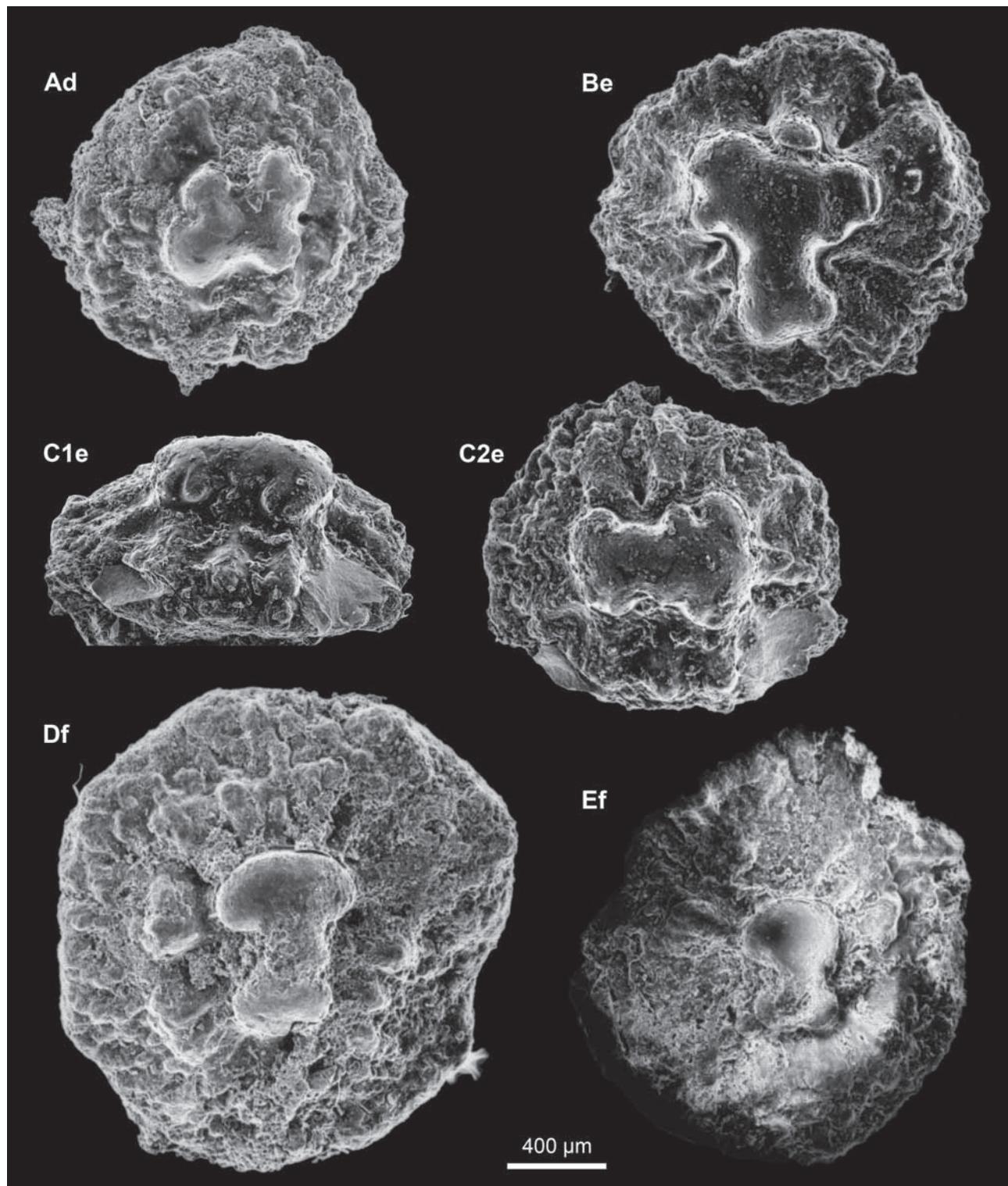


Plate 73. *Asterodermus* sp. (BSPHG 1960-XVIII-56, part), Zandt

Figs. A–E. Isolated thorns. – **Ad.** Cranial (orbital?, interorbital?) thorn, apical view. **Be.** Nuchal thorn, apical view. **C1e, C2e.** Nuchal thorn; 1 – apical, 2 – lateral view. **Df, Ef.** Scapular thorns, apical view.

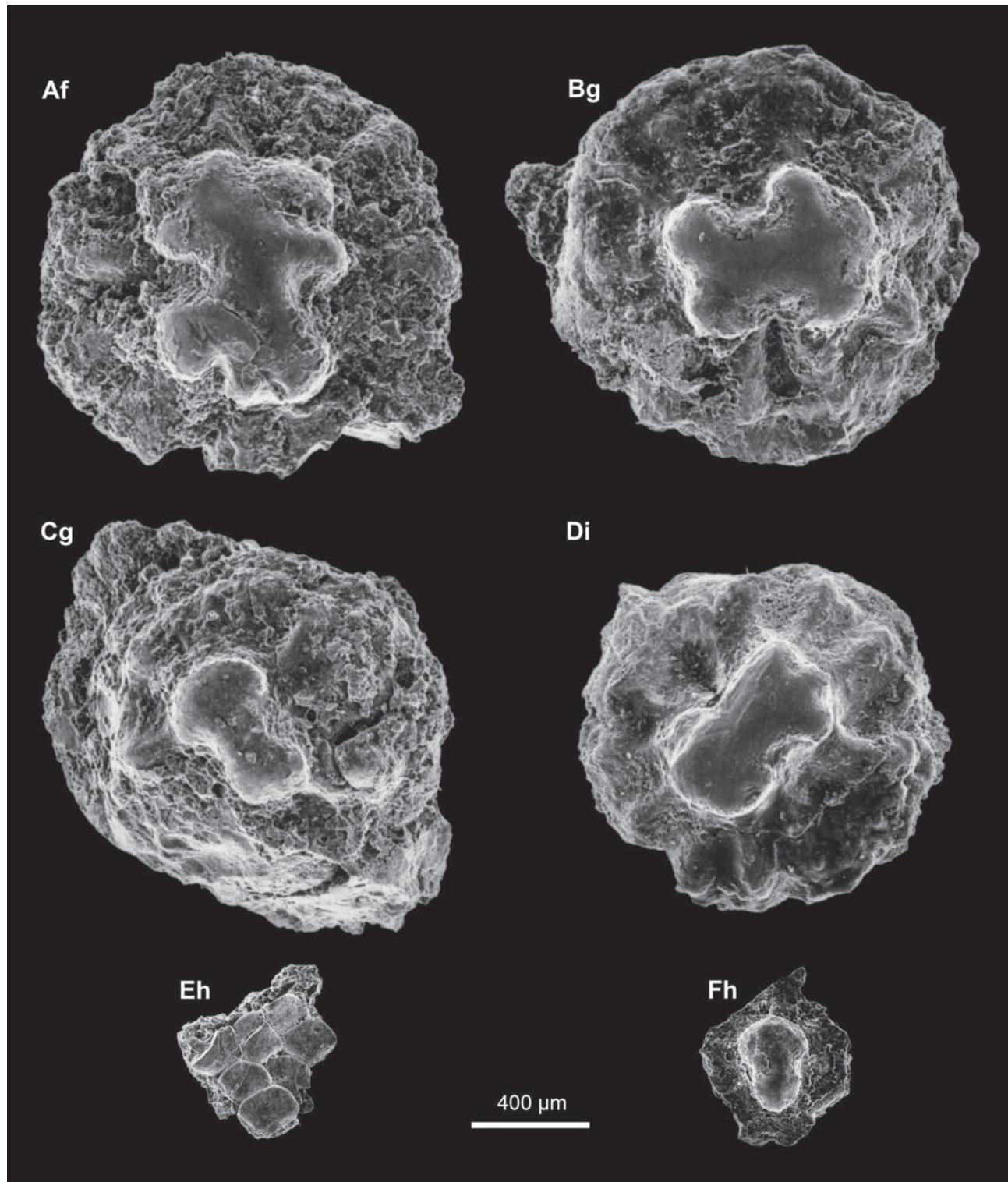


Plate 74. *Asterodermus* sp. (BSPHG 1960-XVIII-56, part), Zandt

Figs. A–F. Isolated thorns and scales. – **Af.** Scapular thorns, apical view. **Bg, Cg.** Dorsal thorns from the middle trunk region, apical view. **Di.** Dorsal thorn from the posterior trunk region, apical view. **Eh.** Associated scales from the pectoral fin, apical view. **Fh.** Alar (?) thorn, apical view.

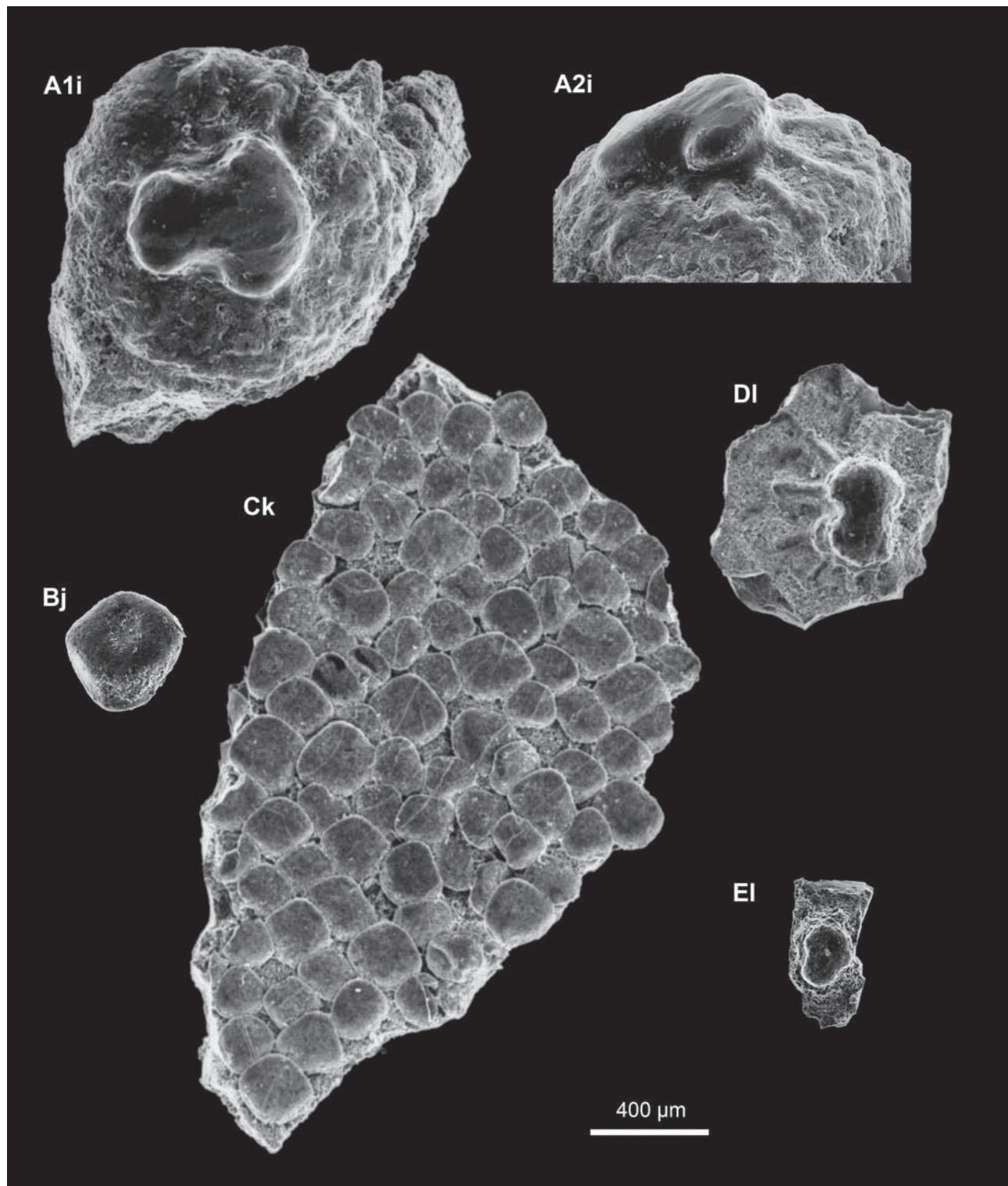


Plate 75. *Asterodermus* sp. (BSPHG 1960-XVIII-56, part), Zandt

Figs. A–E. Isolated thorns and scales. – **A1i, A2i.** Dorsal thorn from the posterior trunk region; 1 – apical, 2 – lateral view. **Bj.** Scale from posterior edge of the pectoral fin, apical view. **Ck.** Associated scales from the pelvic fin, apical view. **Di, El.** Dorsal thorn from the posterior trunk region, apical view.

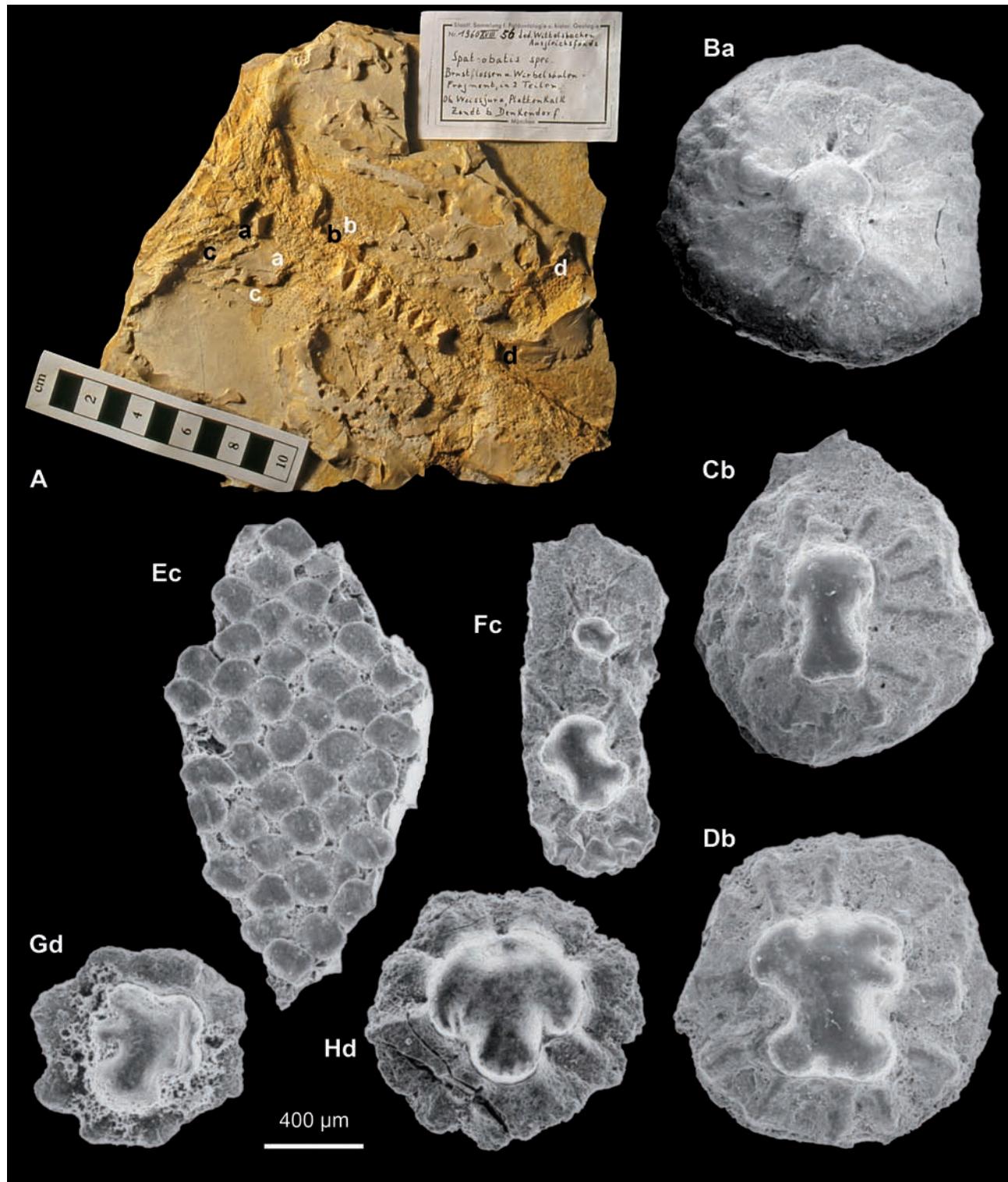


Plate 76. *Asterodermus* sp. (BSPHG 1960-XVIII-56, counterpart), Zandt

Fig. A. Overview of the specimen. **Figs. B–H.** Isolated thorns and scales. – **Ba, Cb, Db, Fc.** Dorsal thorns from the middle trunk region behind the pectoral girdle, apical view. **Ec.** Associated scales from the middle trunk region behind the pectoral girdle, apical view. **Gd, Hd.** Dorsal thorns from the posterior trunk region, apical view.

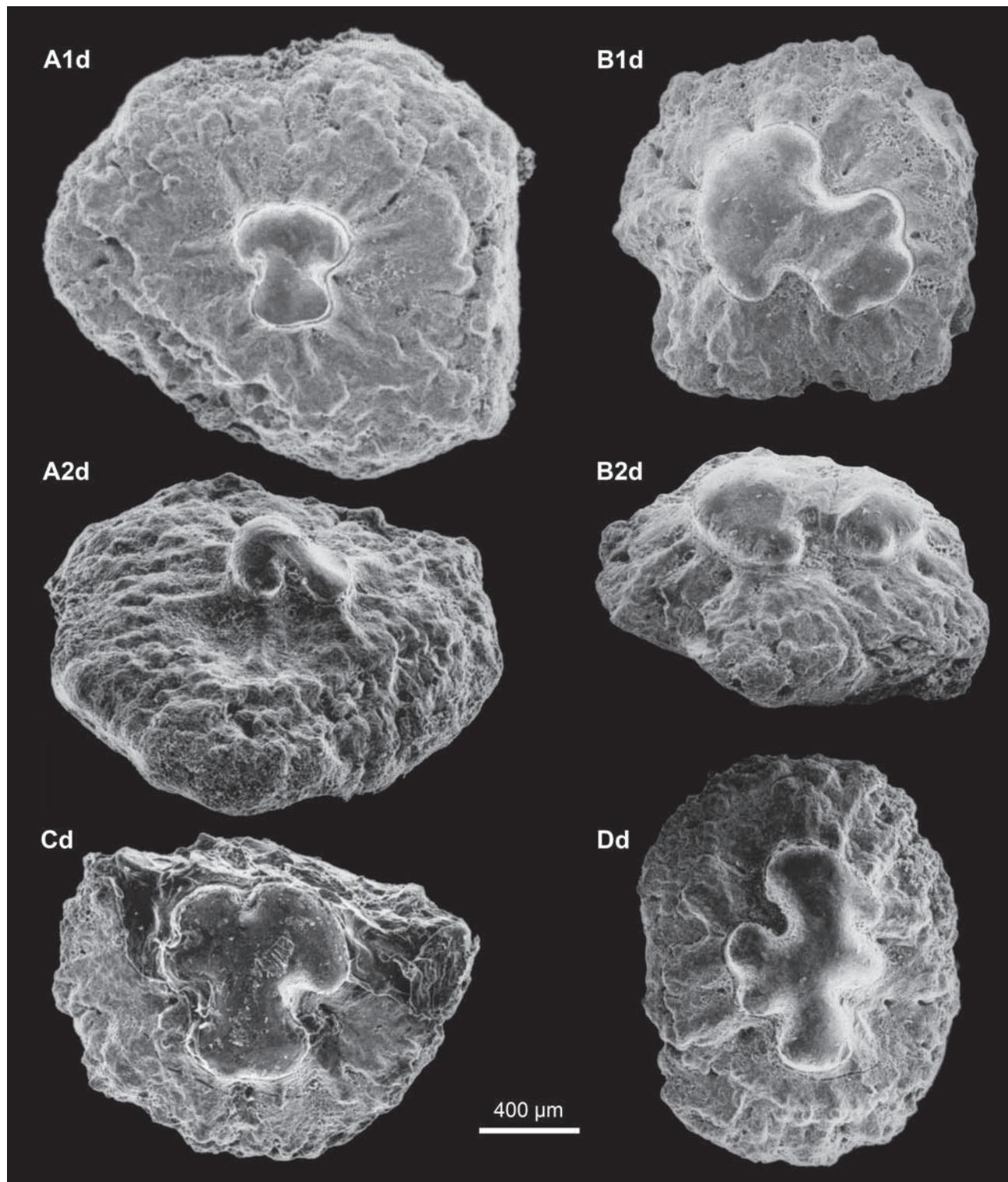


Plate 77. *Asterodermus* sp. (BSPHG 1960-XVIII-56, counterpart), Zandt

Figs. A–D. Isolated thorns. – A1d, A2d, B1d, B2d. Dorsal thorns from the posterior trunk region; 1 – apical, 2 – lateral view.
Cd, Dd. Dorsal thorns from the posterior trunk region, apical view.

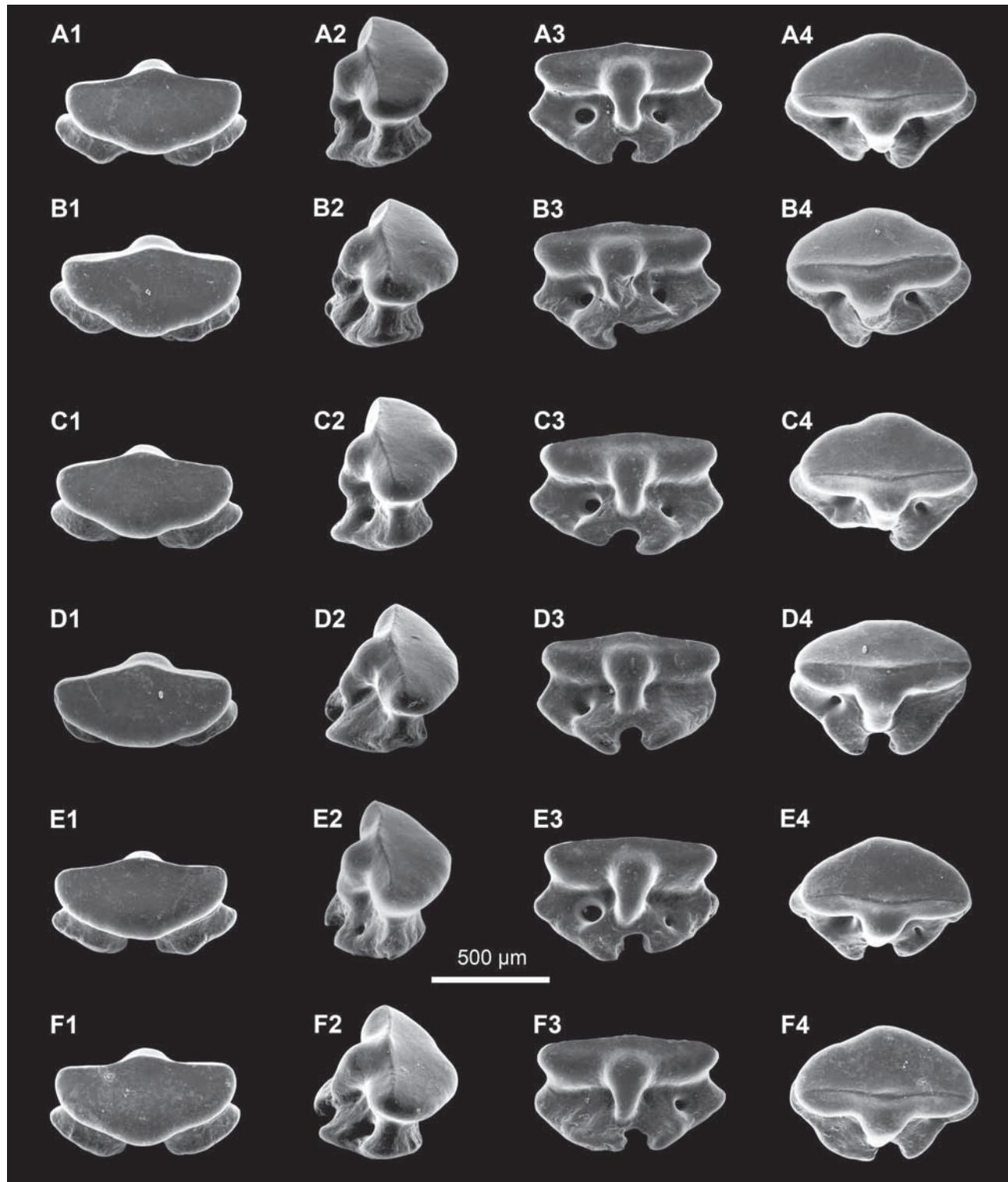


Plate 78. *Asterodermus* sp. (BSPHG 1960-XVIII-56, part), Zandt

Figs. A–F. Antero-lateral oral teeth from the upper jaw; 1 – labial, 2 – lateral, 3 – lingual, 4 – apical view.

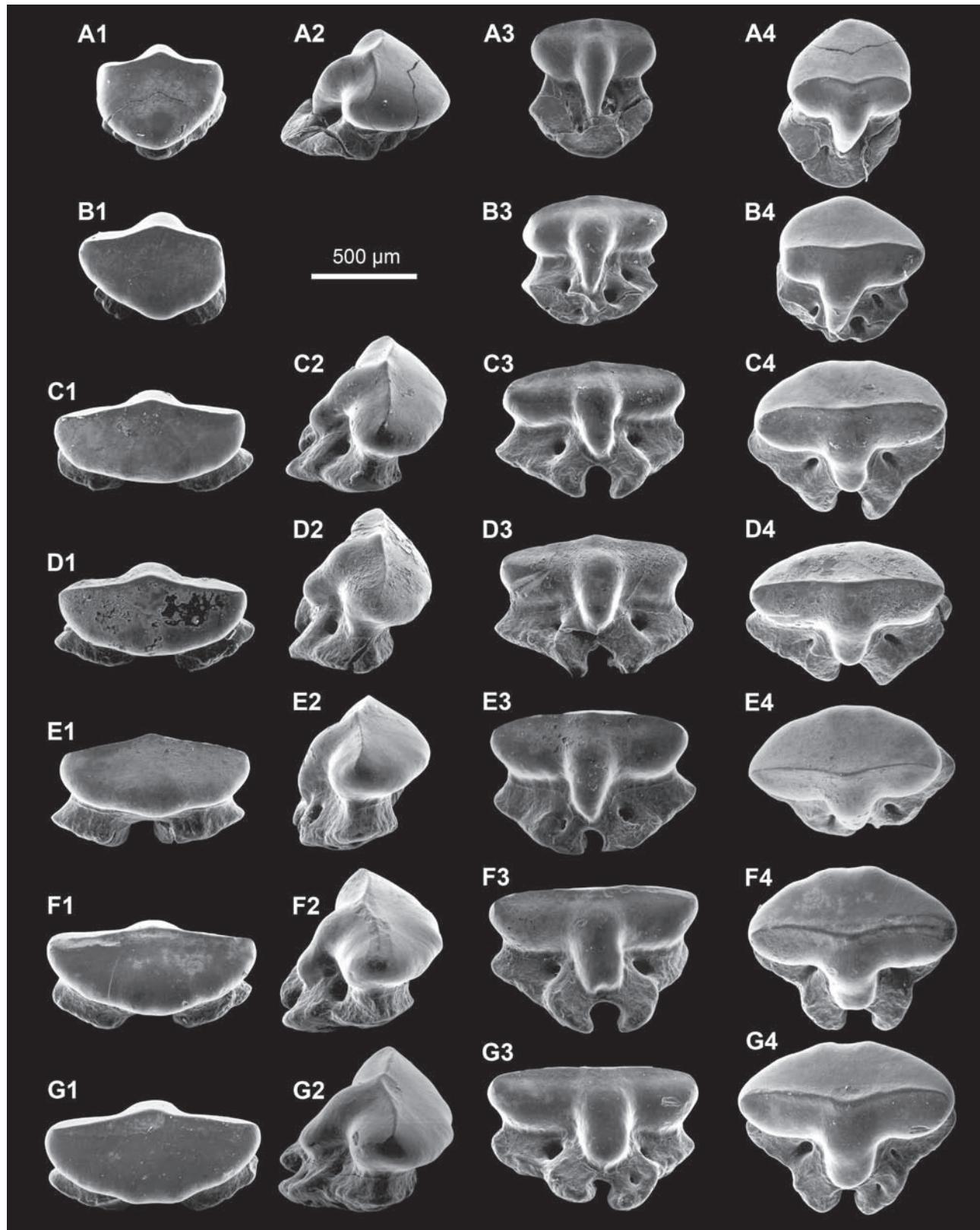


Plate 79. *Asterodermus* sp. (BSPHG 1960-XVIII-56, part), Zandt

Figs. A–G. Anterior oral teeth from the lower jaw near the symphysis; 1 – labial, 2 – lateral, 3 – lingual, 4 – apical view.

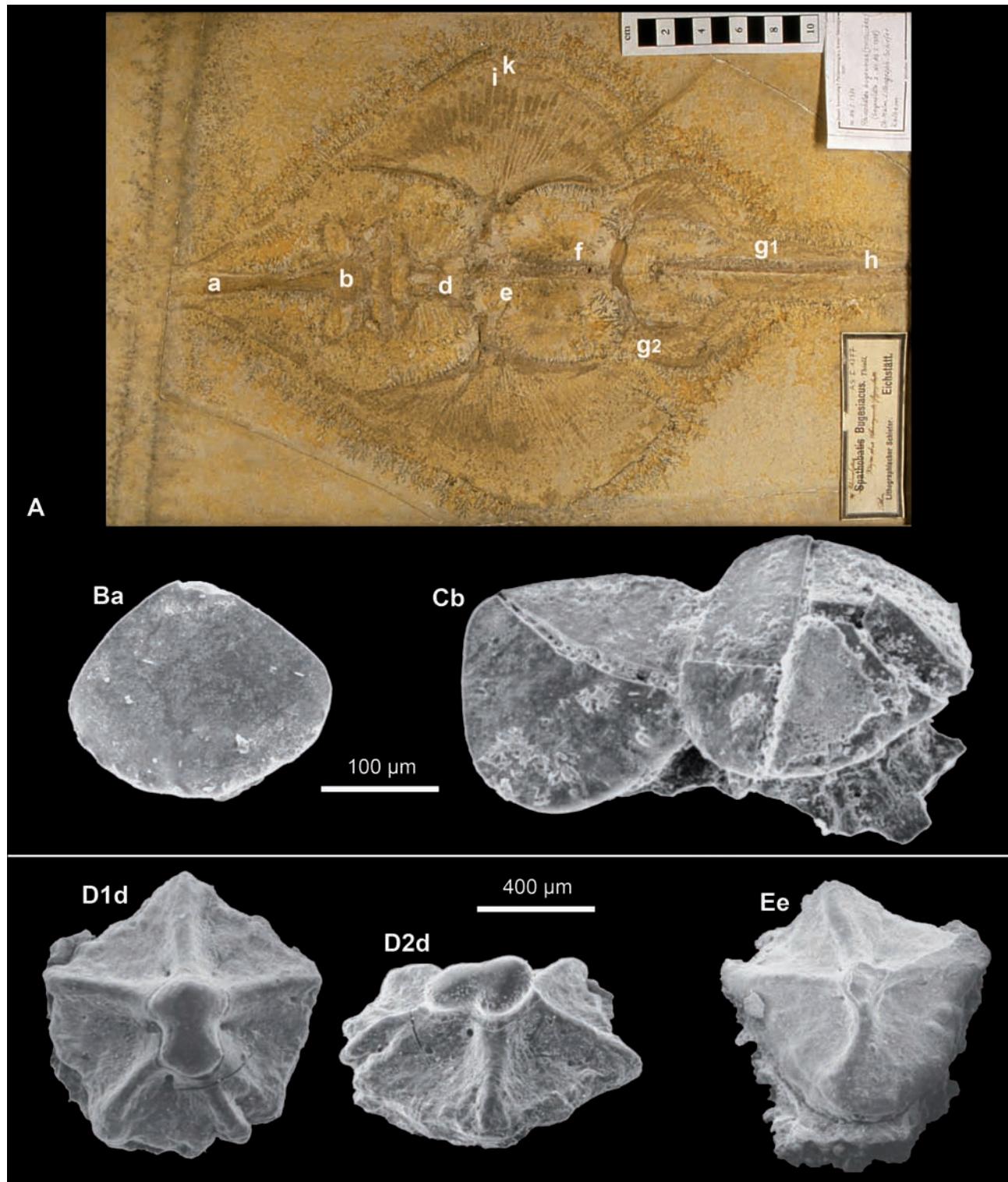


Plate 80. *Asterodermus* sp. (BSPHG AS-I-1377), Kelheim

Fig. A. Overview of the specimen. **Figs. B–E.** Isolated scales and thorns. – **Ba.** Scale from the rostral region, apical view. **Cb.** Associated scales from the basal part of the rostrum, antero-apical view. **D1d, D2d.** Nuchal thorn; 1 – apical, 2 – lateral view. **Ee.** Dorsal (nuchal?) thorn, apical view.

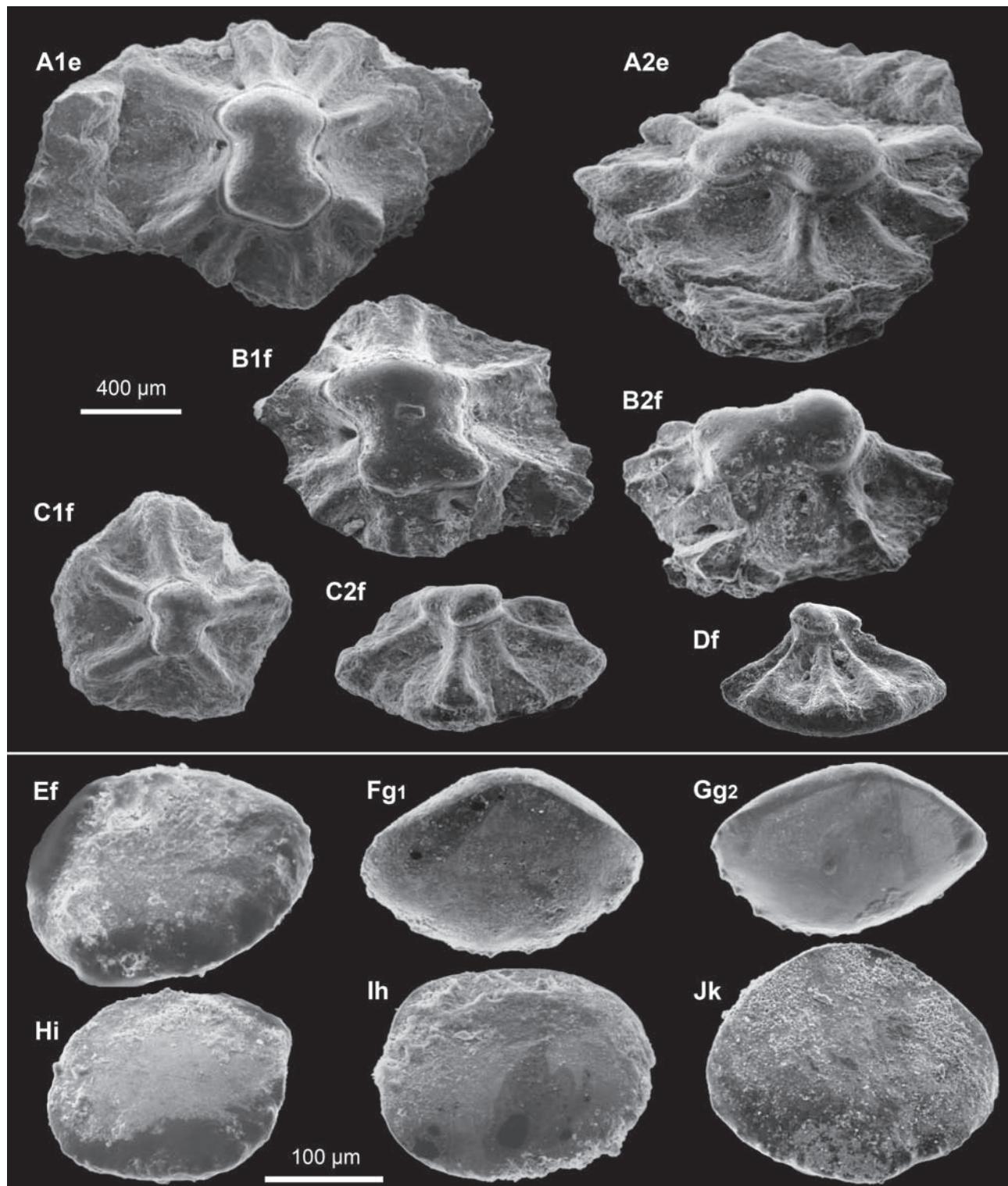


Plate 81. *Asterodermus* sp. (BSPHG AS-I-1377), Kelheim

Figs. A–J. Isolated thorns and scales. – **A1e, A2e.** Dorsal (nuchal?) thorn; 1 – apical, 2 – lateral view. **B1f, B2f, C1f, C2f.** Dorsal thorns from the middle trunk region; 1 – apical, 2 – lateral view. **Df.** Dorsal thorn from the middle trunk region, lateral view. **Ef.** Scale from the middle trunk region, apical view. **Fg1.** Scale from right pelvic fin, apical view. **Gg2.** Scale from left pelvic fin, apical view. **Hi, Jk.** Scales from pectoral fin, apical view. **Ih.** Scale from anterior tail region, apical view.

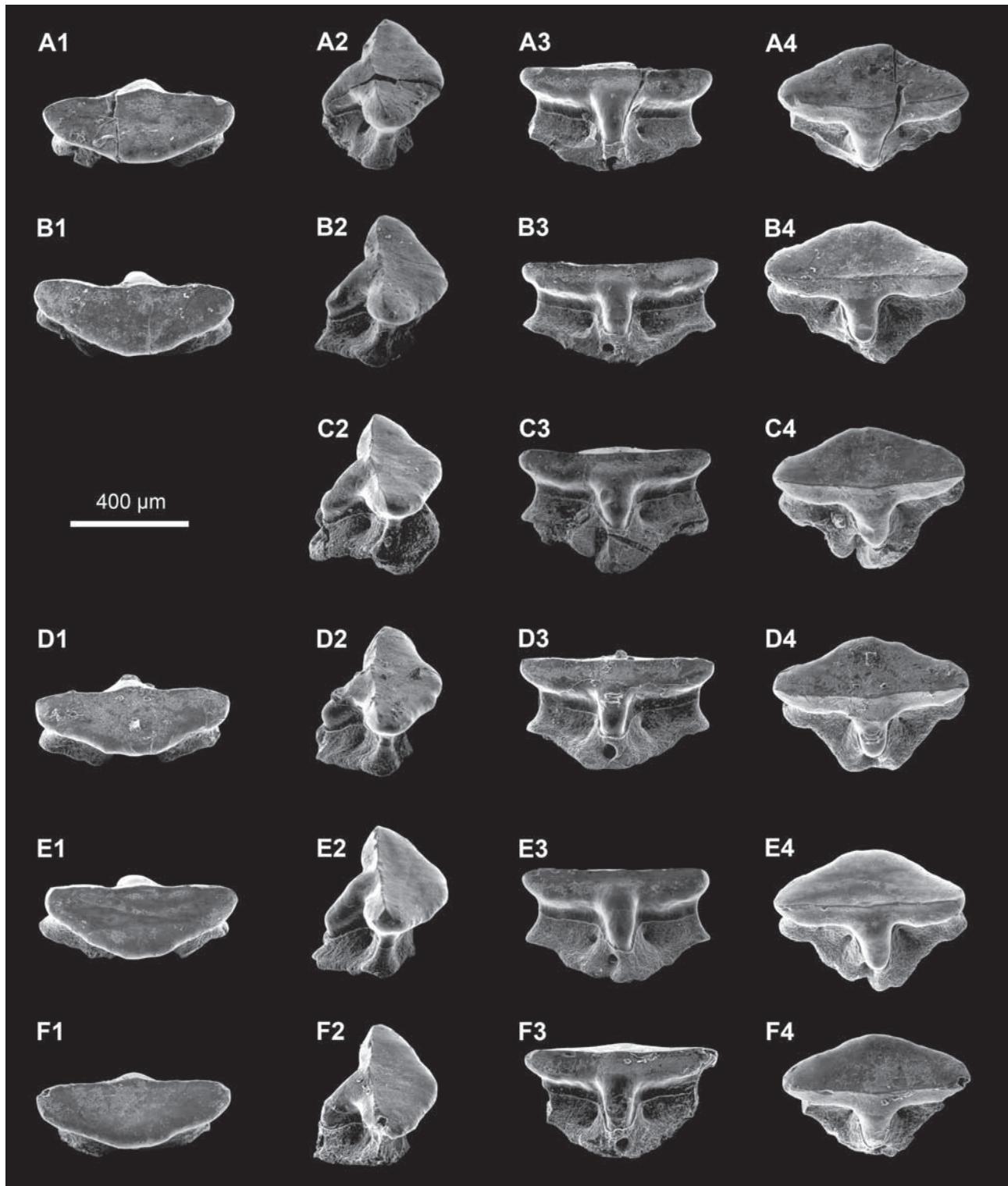


Plate 82. *Asterodermus* sp. (BSPHG AS-I-1377), Kelheim

Figs. A–F. Anterior oral teeth from near the symphysis; 1 – labial, 2 – lateral, 3 – lingual, 4 – apical view.

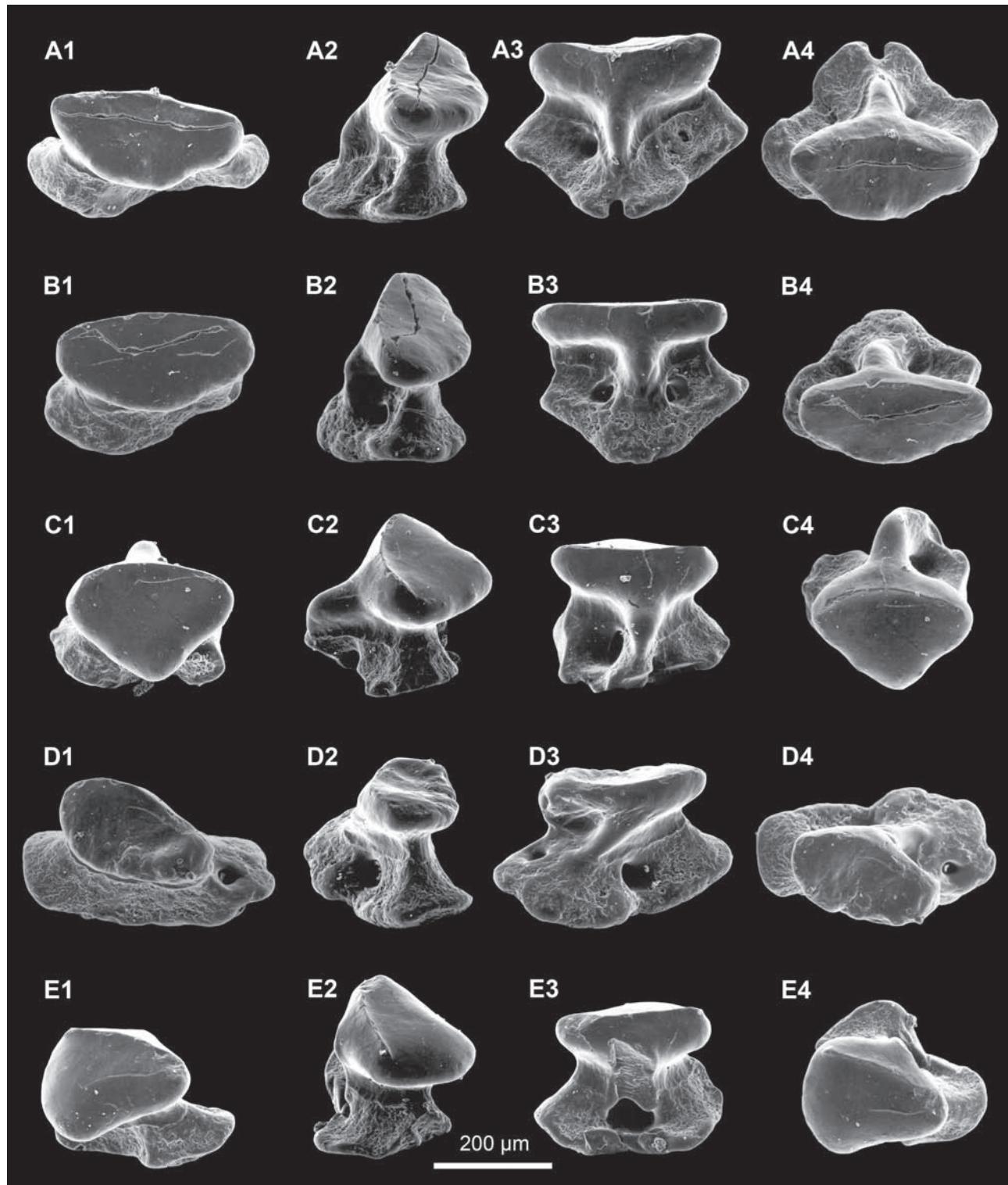


Plate 83. *Asterodermus* sp. (BSPHG AS-I-1377), Kelheim

Figs. A–E. Posterior oral teeth; 1 – labial, 2 – lateral, 3 – lingual, 4 – apical view.

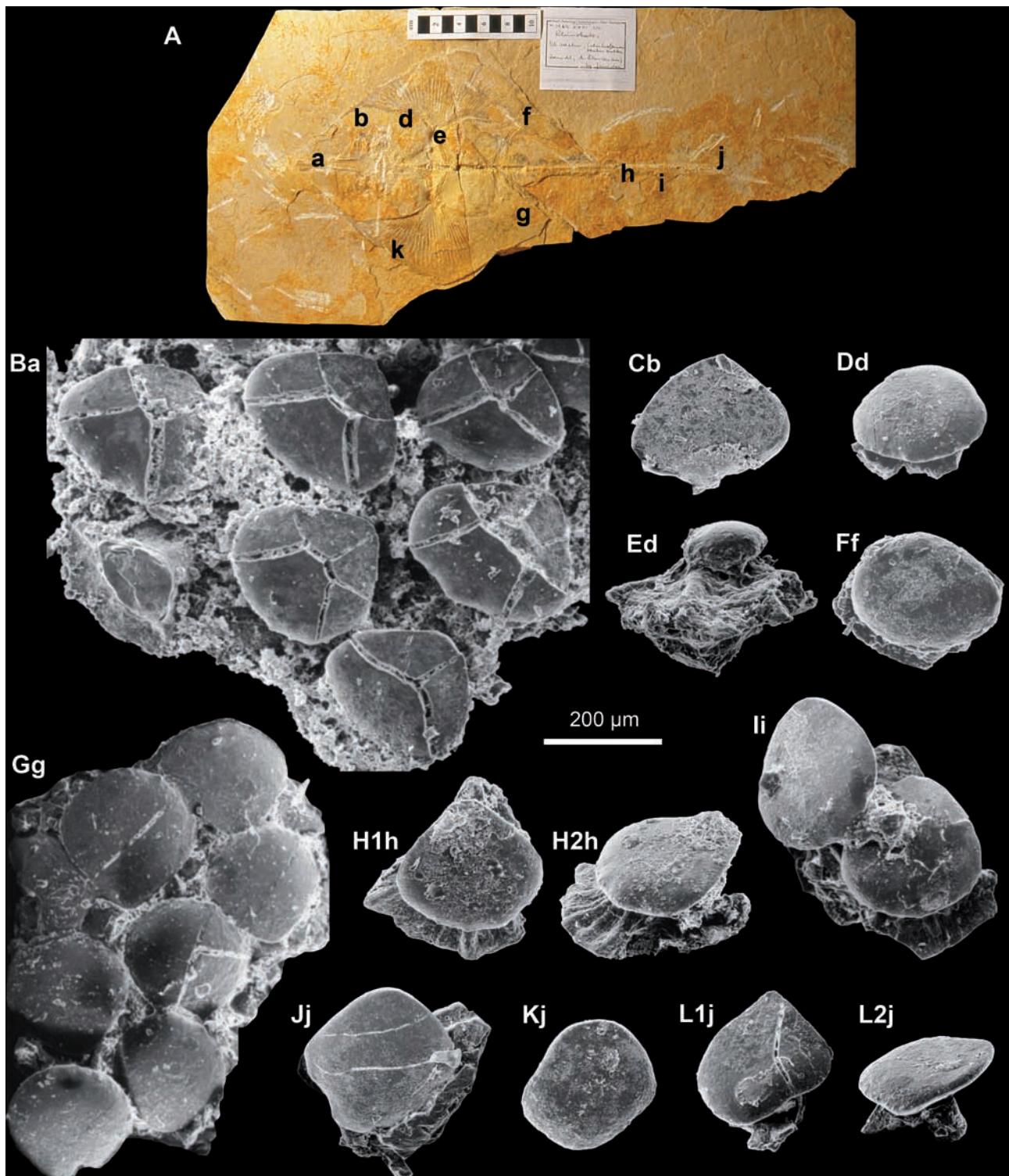


Plate 84. *Asterodermus* sp. (BSPHG 1964-XXIII-577), Zandt

Fig. A. Overview of the specimen. **Figs. B–L.** Isolated scales and thorns. – **Ba.** Associated scales from the rostral region, apical view. **Cb.** Scale from the lateral cranial region, apical view. **Dd.** Scale from the lateral cranial region, apical view. **Ed.** Thorn from the lateral cranial region, lateral view. **Ff.** Scale from the right pelvic fin, apical view. **Gg.** Associated scales from the left pelvic fin, apical view. **H1h, H2h.** Scale from the anterior tail region; 1 – apical, 2 – lateral view. **Ii.** Associated scales from the middle tail region, apical view. **Jj, Kj.** Scales from the caudal fin, apical view. **L1j, L2j.** Scales from the caudal fin; 1 – apical, 2 – lateral view.

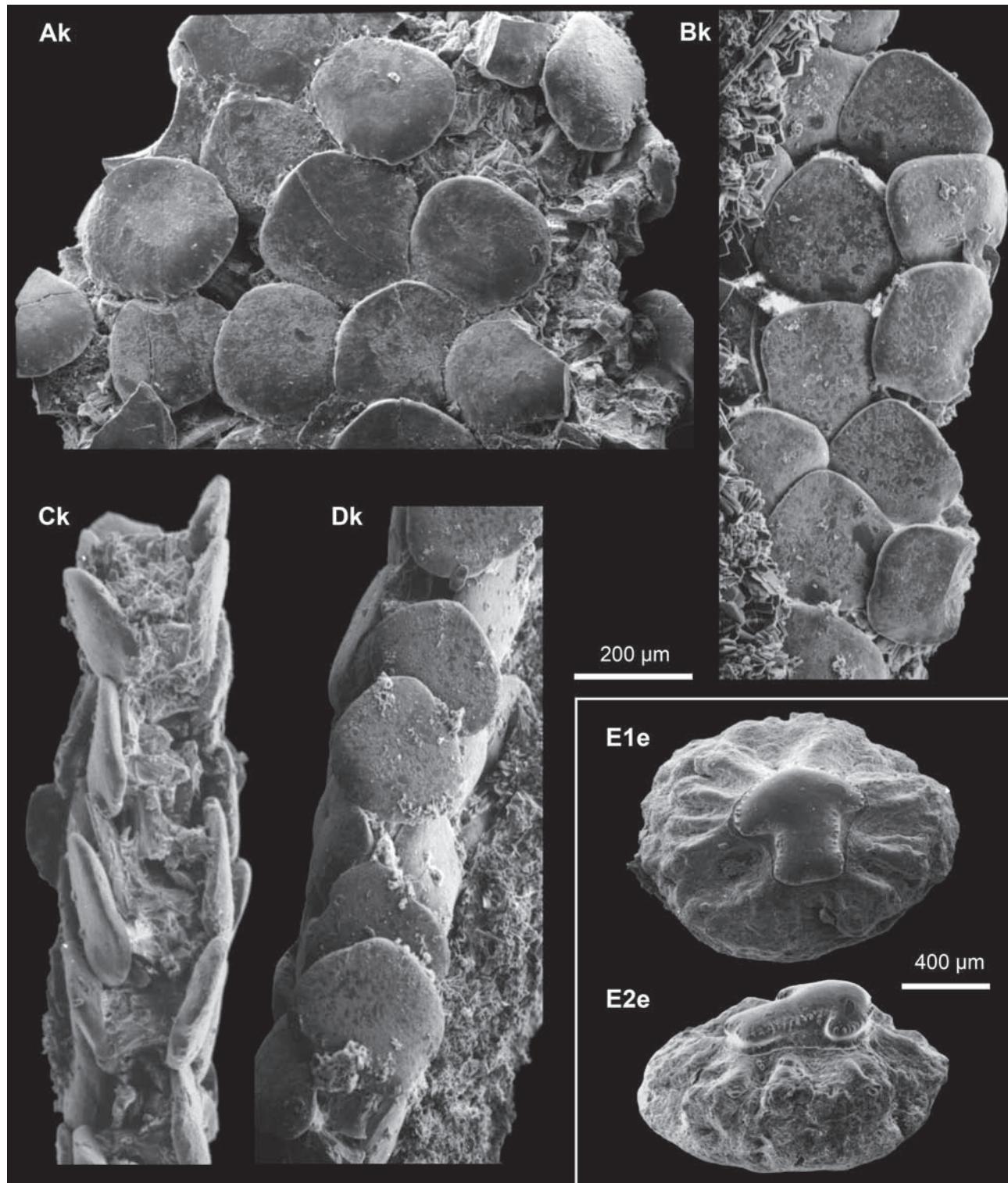


Plate 85. *Asterodermus* sp. (BSPHG 1964-XXIII-577), Zandt

Figs. A–E. Isolated scales and thorns. – **Ak.** Sample from the lateral edge of the left pectoral fin with associated scales forming the dorsal and ventral surfaces of the fin, dorsal view. **Bk.** Same sample, ventral view. **Ck.** Same sample, transverse section. **Dk.** Same sample, median view (onto the edge of the fin). **E1e, E2e.** Scapular thorn; 1 – apical, 2 – lateral view.

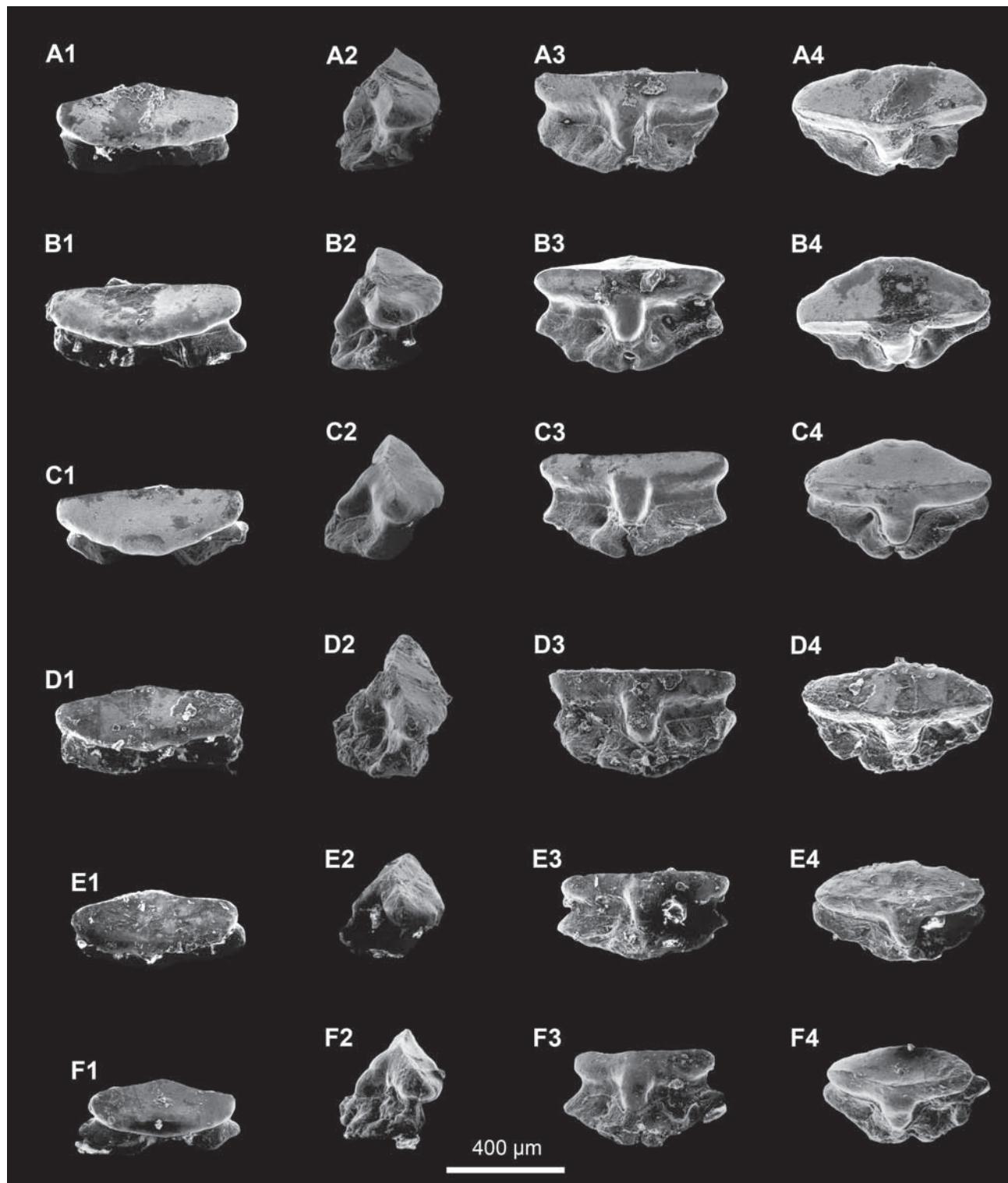


Plate 86. *Asterodermus* sp. (BSPHG 1964-XXIII-577), Zandt

Figs. A-F. Lateral oral teeth (presumably representing a mixture of teeth from both jaws); 1 – labial, 2 – lateral, 3 – lingual, 4 – apical view.

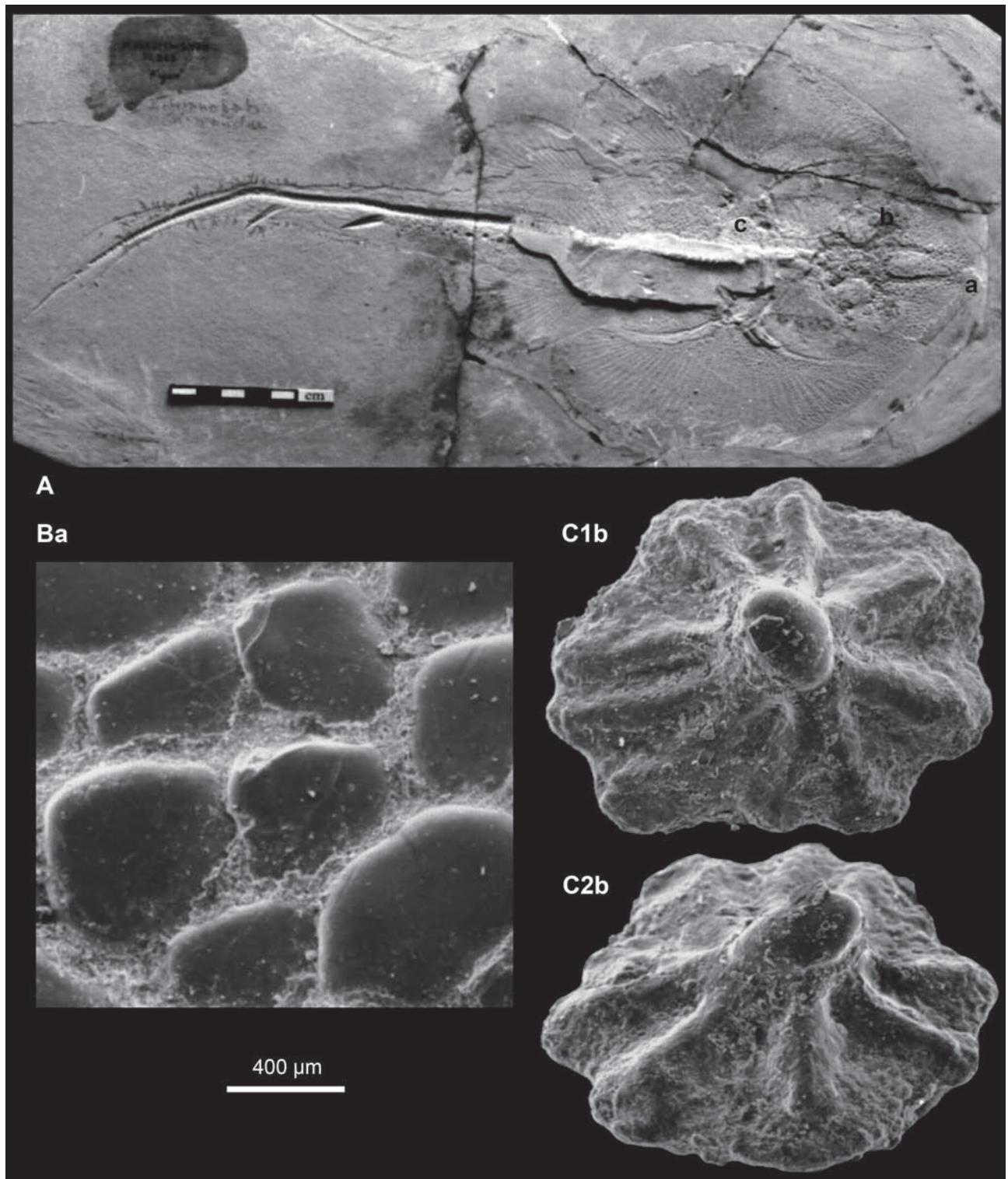


Plate 87. *Belemnobatis sismondae* THIOLLIÈRE, 1852 (MHNL 15.263), Cerin

Fig. A. Overview of the specimen. Figs. B–C. Isolated scales and thorns. – Ba. Associated scales from the rostral region, apical view. C1b, C2b. Orbital thorn; 1 – apical, 2 – lateral view.

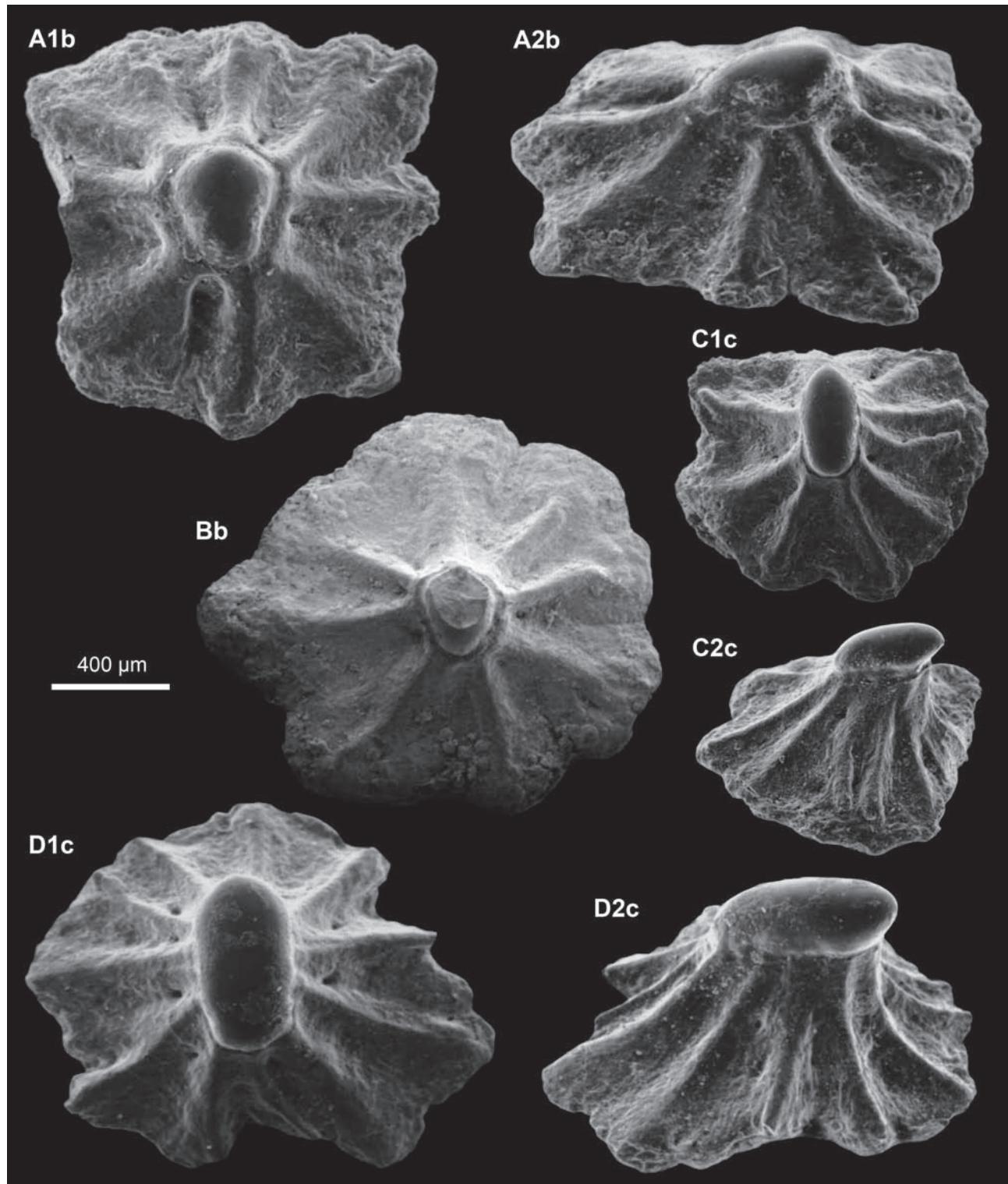


Plate 88. *Belemnobatis sismondae* THIOLLIÈRE, 1852 (MHNL 15.263), Cerin

Figs. A–D. Isolated thorns. – A1b, A2b. Orbital thorn; 1 – apical, 2 – lateral view. Bb. Orbital thorn, apical view. C1c, C2c, D1c, D2c. Nuchal thorns; 1 – apical, 2 – lateral view.

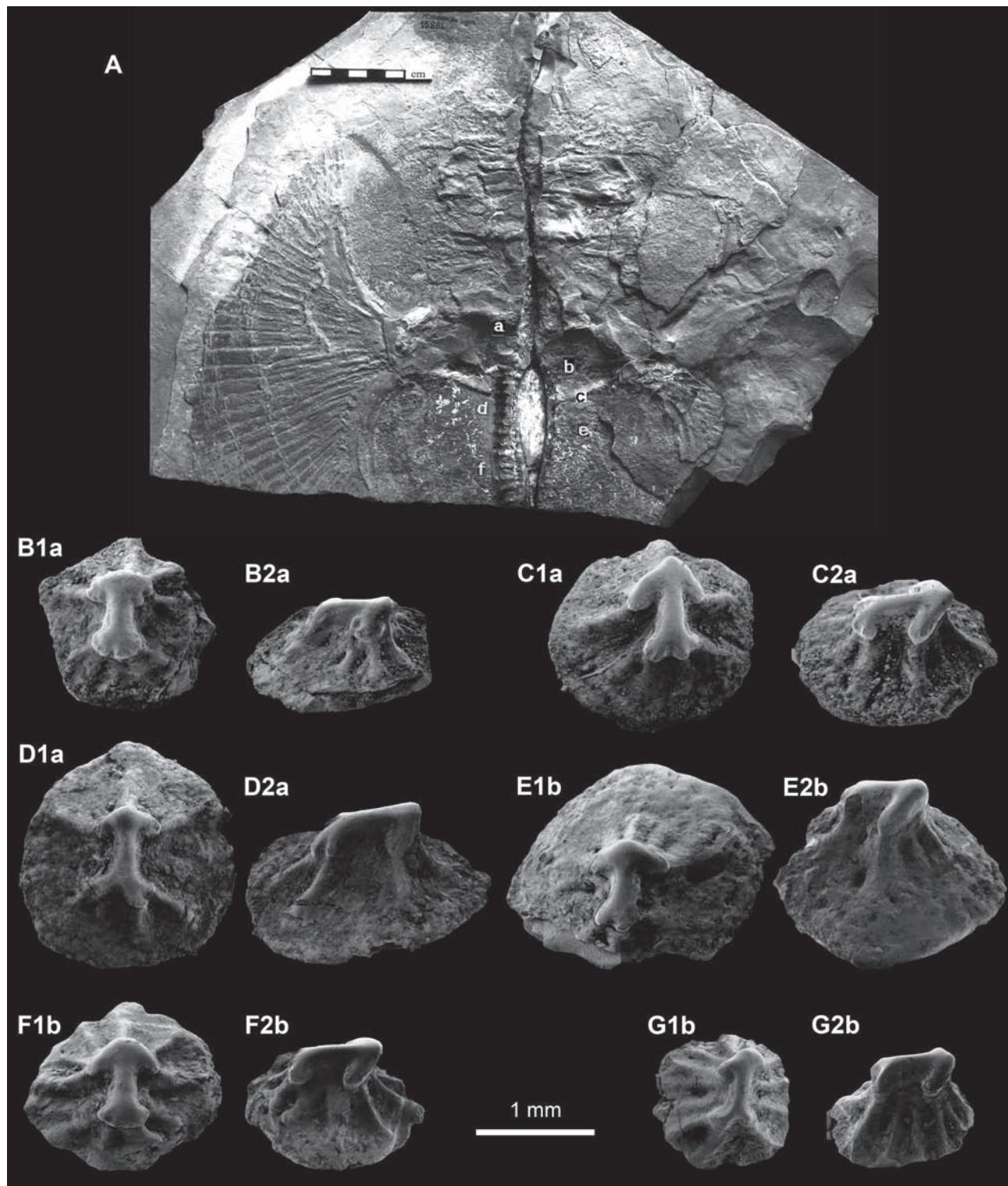


Plate 89. *Belemnobatis sismondae* THIOLLIÈRE, 1852 (MHNL 15.264), Cerin

Fig. A. Overview of the specimen. Figs. B–G. Isolated thorns. – B1a, B2a, C1a, C2a, D1a, D2a, E1b, E2b, F1b, F2b, G1b, G2b. Nuchal thorns; 1 – apical, 2 – lateral view.

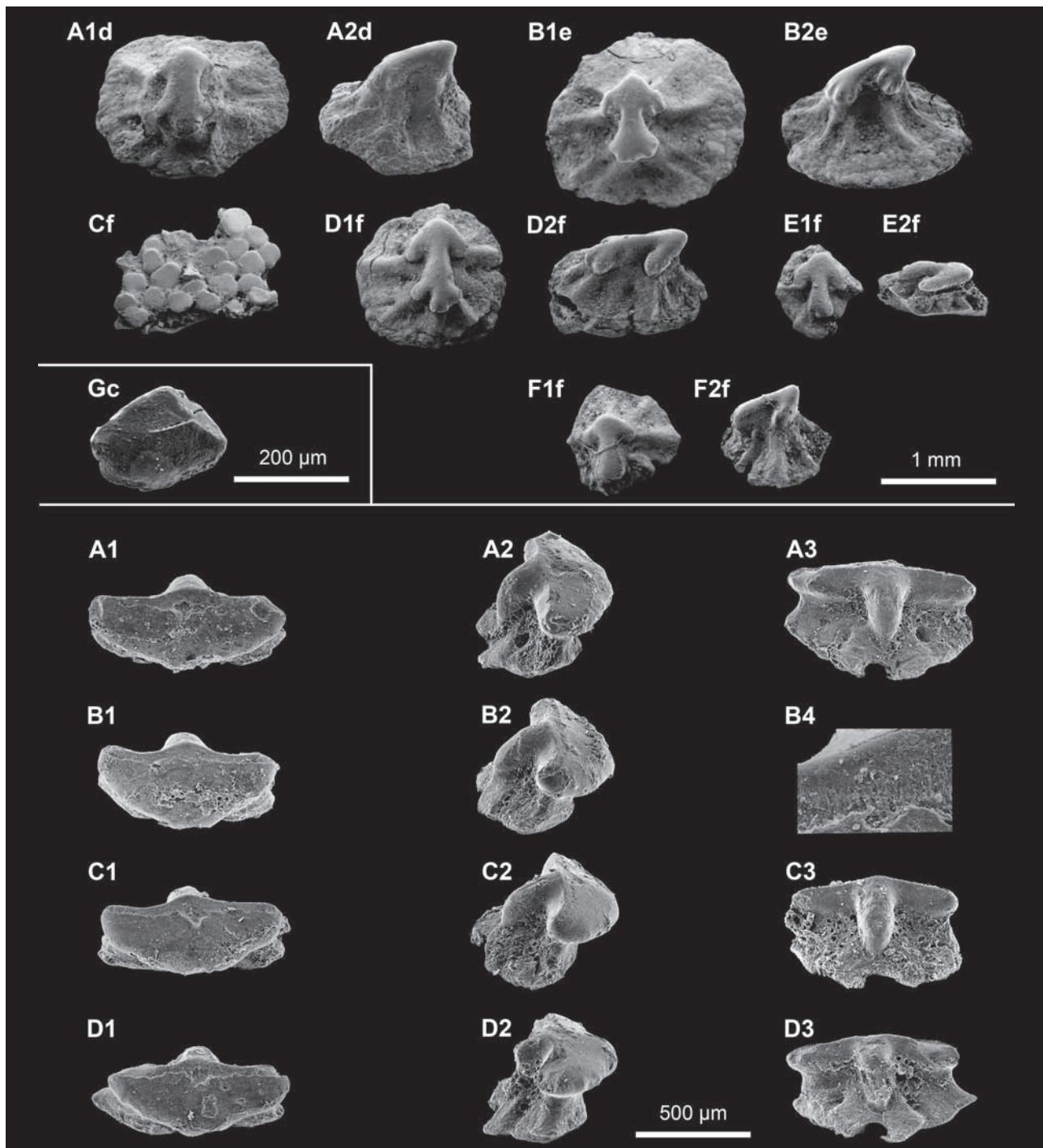


Plate 90. *Belemnobatis sismondae* THIOLLIÈRE, 1852 (MHNL 15.264), Cerin

Upper part

Figs. A–F. Isolated thorns and scales. – **A1d, A2d, B1e, B2e.** Dorsal thorns from the anterior trunk region; 1 – apical, 2 – lateral view. **Cf.** Associated scales from the middle trunk region, apical view. **D1f, D2f, E1f, E2f, F1f, F2f.** Dorsal thorns from the middle trunk region; 1 – apical, 2 – lateral view. **Gc.** Scale from anterior trunk region, apical view.

Lower part

Figs. A–D. Lateral oral teeth from the left side of the upper jaw; 1 – labial, 2 – lateral, 3 – lingual view. – **B4.** Enameloid at the transverse apical crown ridge consisting of shiny layered enameloid (at the bottom of the figure) and single crystallite enameloid (in the middle and upper part of the figure) (not to scale).

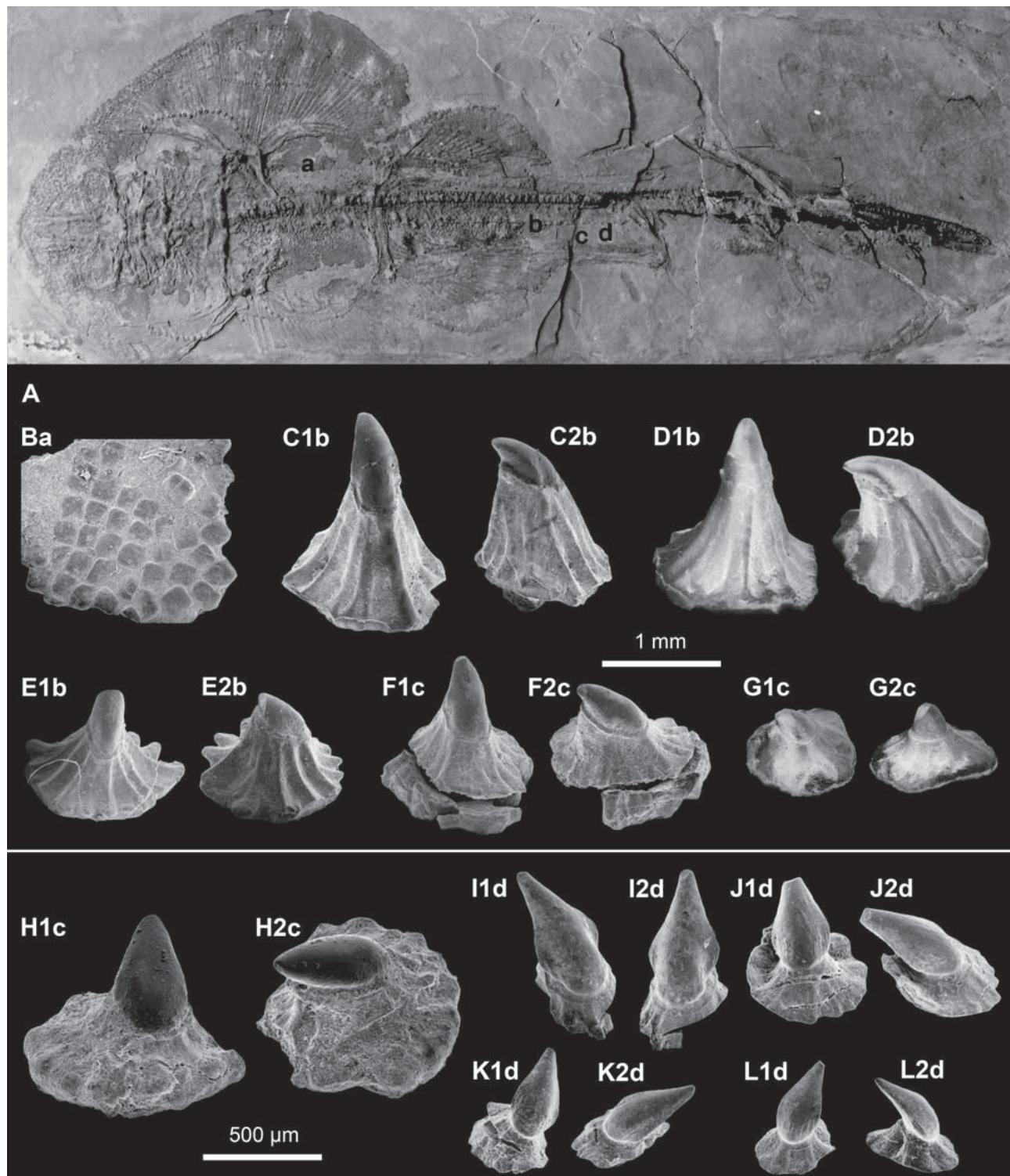


Plate 91. *Belemnobatis sismondae* THIOLLIÈRE, 1852 (MHNL 15.753), Cerin

Fig. A. Overview of the specimen. **Figs. B–L.** Isolated thorns and scales. – **Ba.** Associated scales from middle trunk region, apical view. **C1b, C2b, D1b, D2b, E1b, E2b.** Dorsal thorns from the posterior trunk region; 1 – anterior, 2 – lateral view. **F1c, F2c, G1c, G2c, H1c, H2c.** Thorns from the anterior tail region; 1 – anterior, 2 – lateral view. **I1d, I2d.** Disarticulated thorns found in the matrix near the right pterygopodium, antero-lateral views. **J1d, J2d, K1d, K2d, L1d, L2d.** Disarticulated thorns found in the matrix near the right pterygopodium; 1 – anterior, 2 – lateral view.

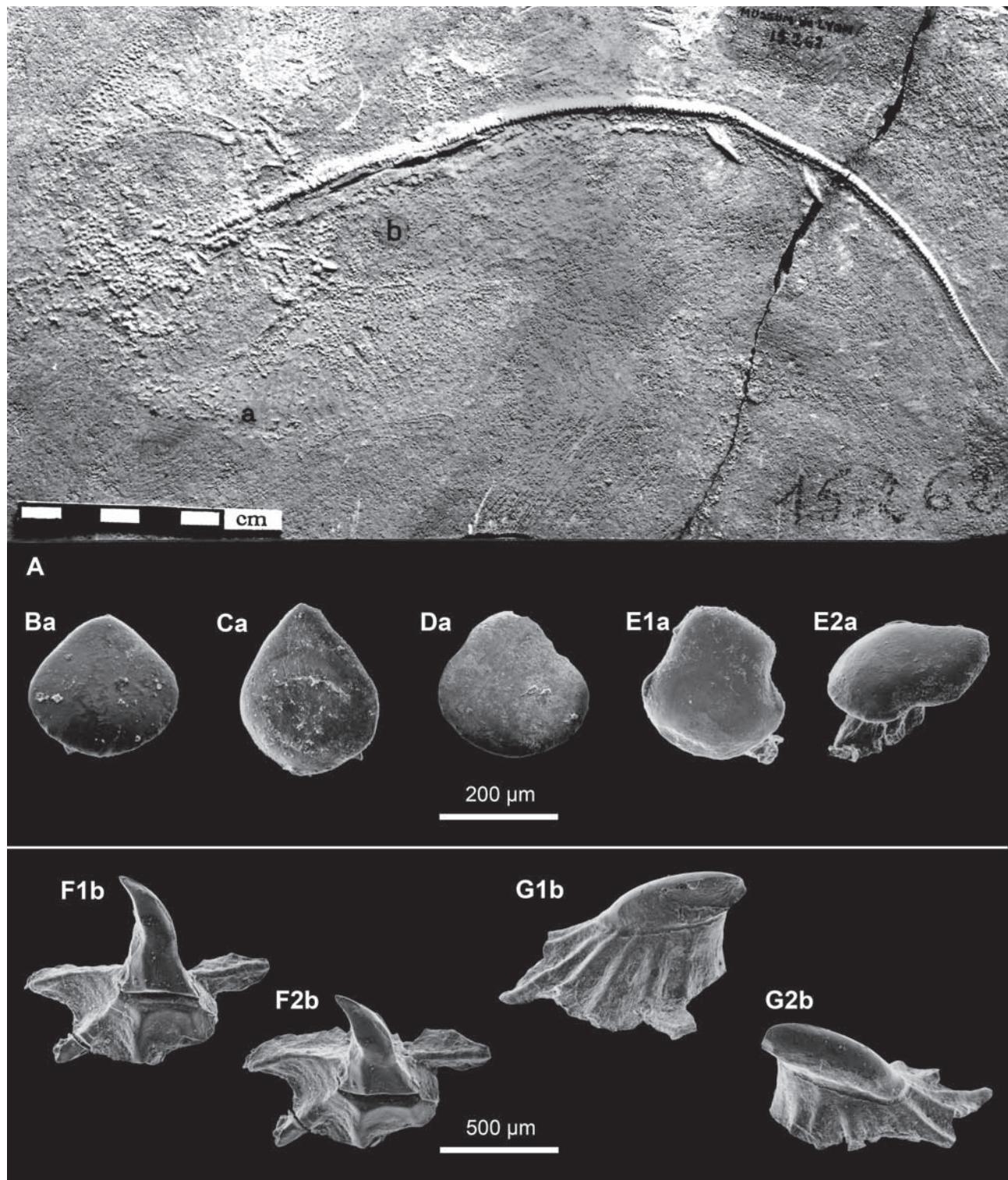


Plate 92. *Belemnobatis sismondae* THIOLLIÈRE, 1852 (MHNL 15.262), Cerin

Fig. A. Overview of the specimen. **Figs. B–G.** Isolated scales. – **Ba, Ca, Da.** Scales from the pectoral fin, apical view. **E1a, E2a.** Scale from the pectoral fin; 1 – apical, 2 – lateral view. **F1b, F2b.** Thorn from the middle trunk region; 1 – lateral, 2 – latero-anterior view. **G1b, G2b.** Thorn from the middle trunk region, right and left lateral view.

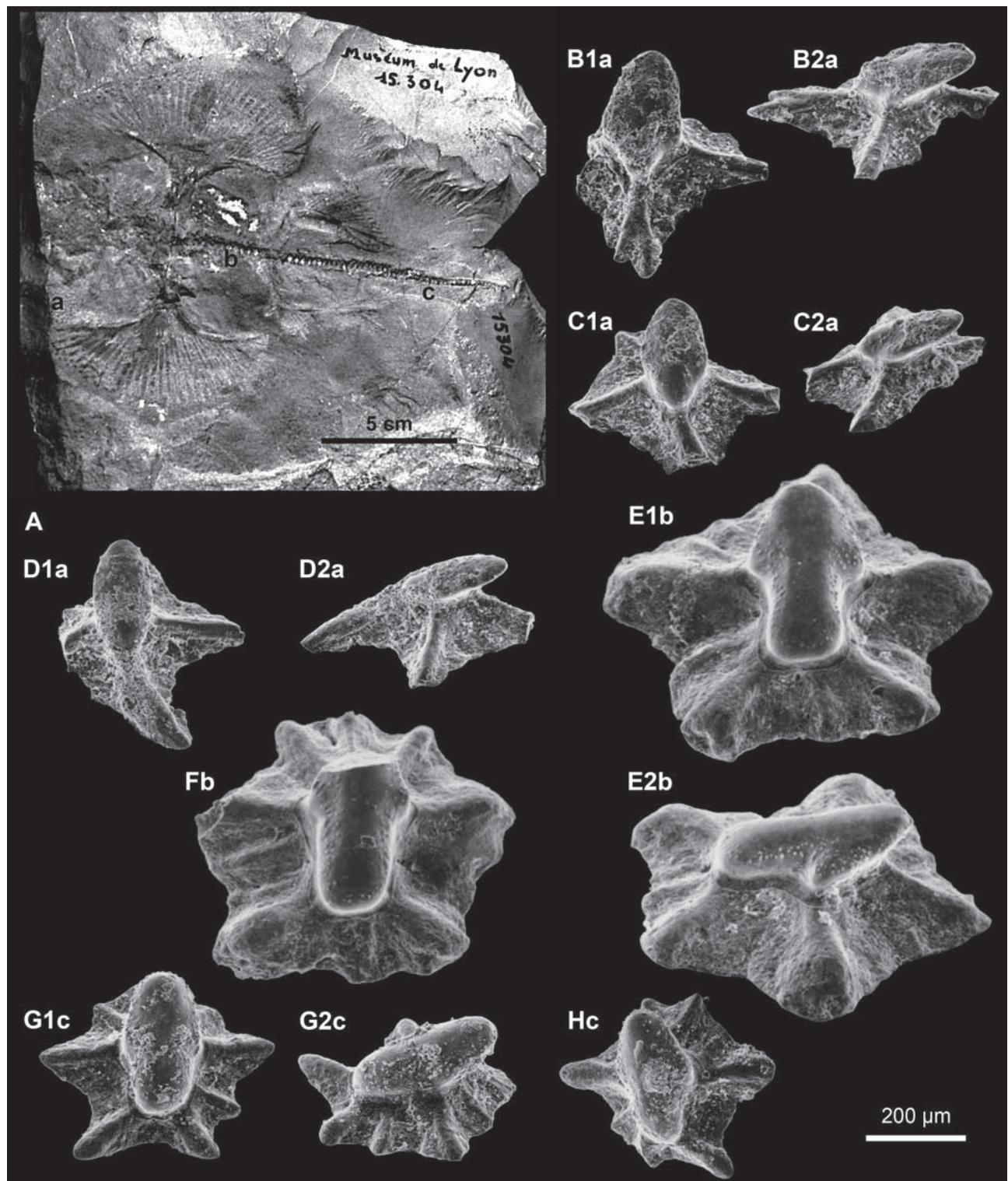


Plate 93. *Belemnobatis sismondae* THIOLLIÈRE, 1852 (MHNL 15.304), Cerin

Fig. A. Overview of the specimen. **Figs. B–H.** Isolated thorns. – **B1a, B2a, C1a, C2a, D1a, D2a.** Dorsal thorns from the lateral cranial region; 1 – antero-apical, 2 – lateral view. **E1b, E2b.** Dorsal thorn from the middle trunk region; 1 – antero-apical, 2 – lateral view. **Fb.** Dorsal thorn from the middle trunk region, apical view. **G1c, G2c.** Dorsal thorn from the anterior tail region; 1 – antero-apical, 2 – lateral view. **Hc.** Dorsal thorn from the anterior tail region, apical view.

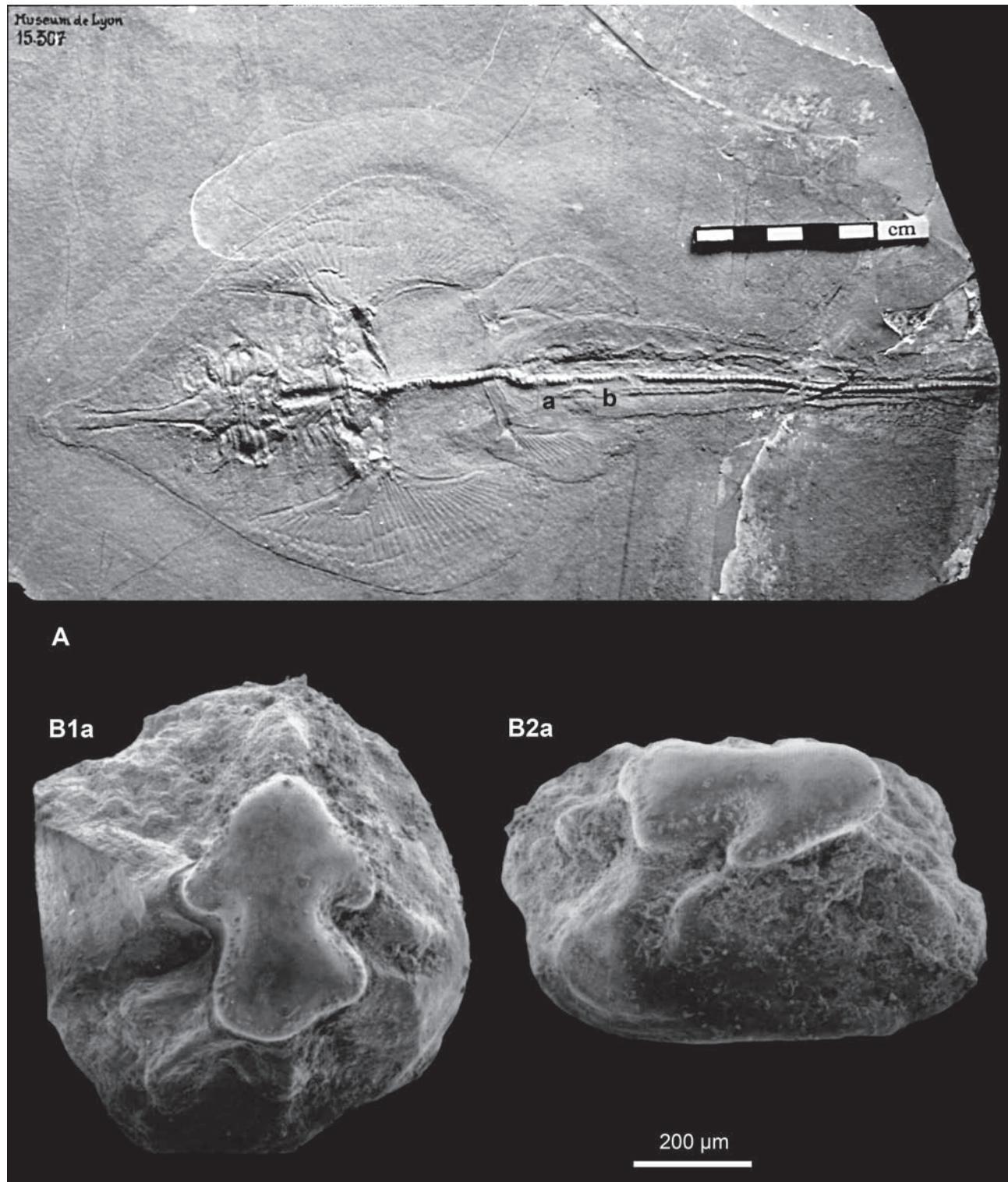


Plate 94. *Spathobatis bugesiacus* THIOLLIÈRE, 1852 (MHNL 15.307, holotype), Cerin

Fig. A. Overview of the specimen. Fig. B. Dorsal thorn from the posterior trunk region; 1 – apical, 2 – lateral view.

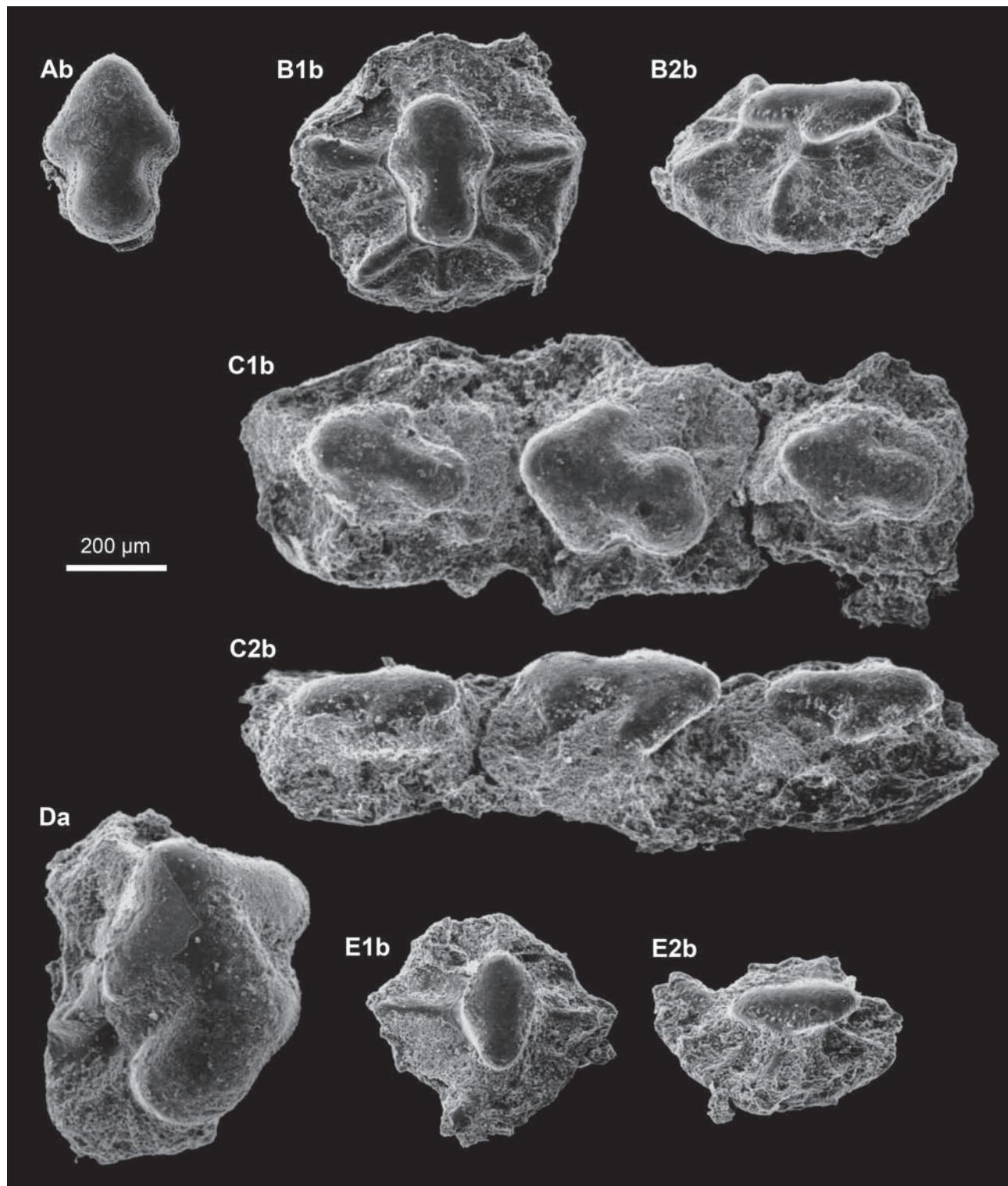


Plate 95. *Spathobatis bugesiacus* THIOLLIÈRE, 1852 (MHNL 15.307, holotype), Cerin

Figs. A–E. Isolated thorns. – **A1b.** Dorsal thorn from the posterior trunk region, apical view. **B1b, B2b.** Dorsal thorn from the posterior trunk region; 1 – apical, 2 – lateral view. **C1b, C2b.** Row of three dorsal thorns from the posterior trunk region (part of the median row of thorns?); 1 – apical, 2 – lateral view. **D1a.** Dorsal thorn from the posterior trunk region, latero-apical view. **E1b, E2b.** Dorsal thorn from the posterior trunk region; 1 – apical, 2 – lateral view.

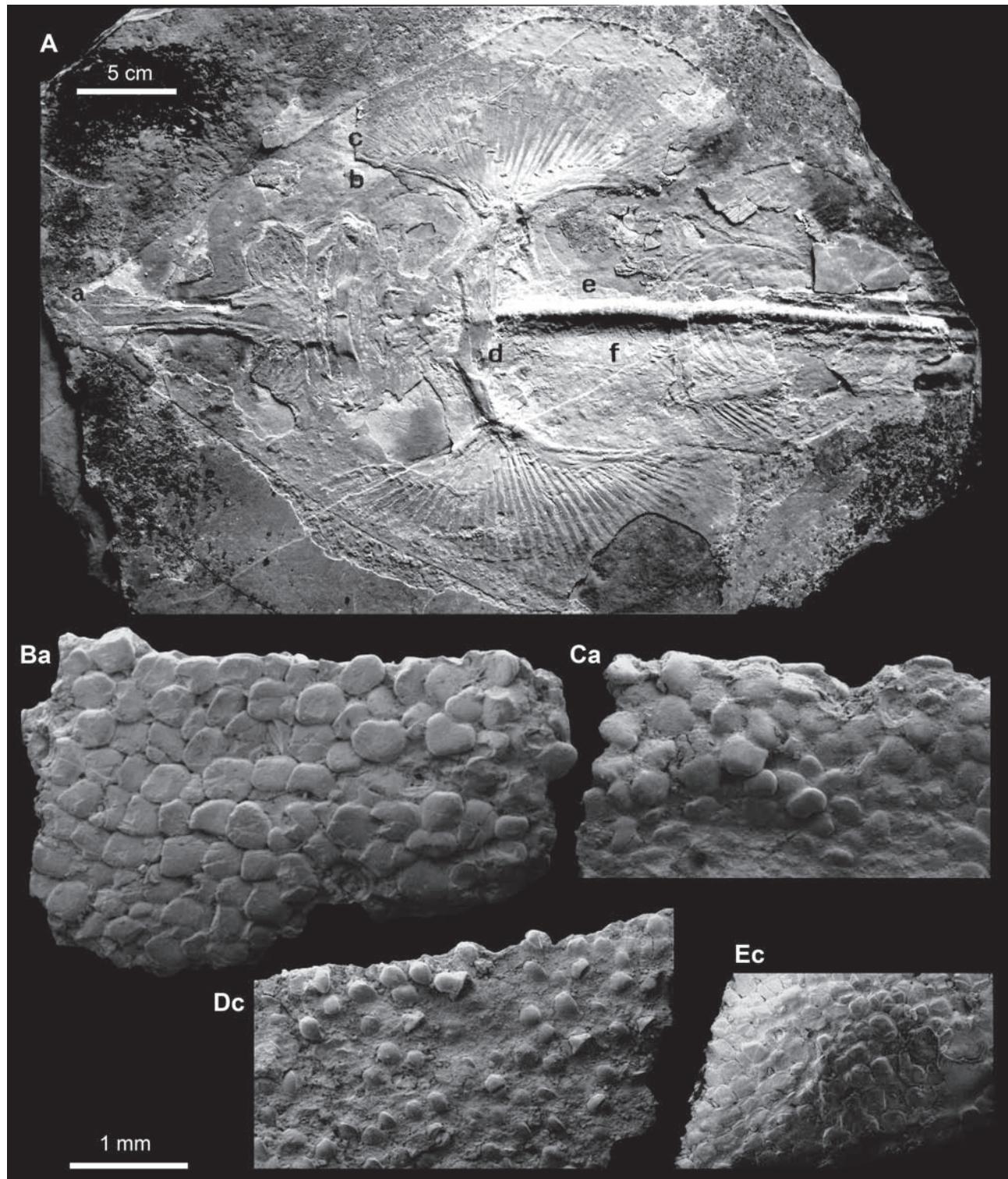


Plate 96. *Spathobatis bugesiacus* THIOLLIÈRE, 1852 (MHNL 15.308), Cerin

Fig. A. Overview of the specimen. **Figs. B–E.** Isolated scales. – **Ba.** Associated scales from the ventral surface of the tip of the rostrum, apical view. **Ca.** Associated scales from the dorsal surface of the tip of the rostrum, apical view. **Dc, Ec.** Associated scales from the pectoral fin, apical view.

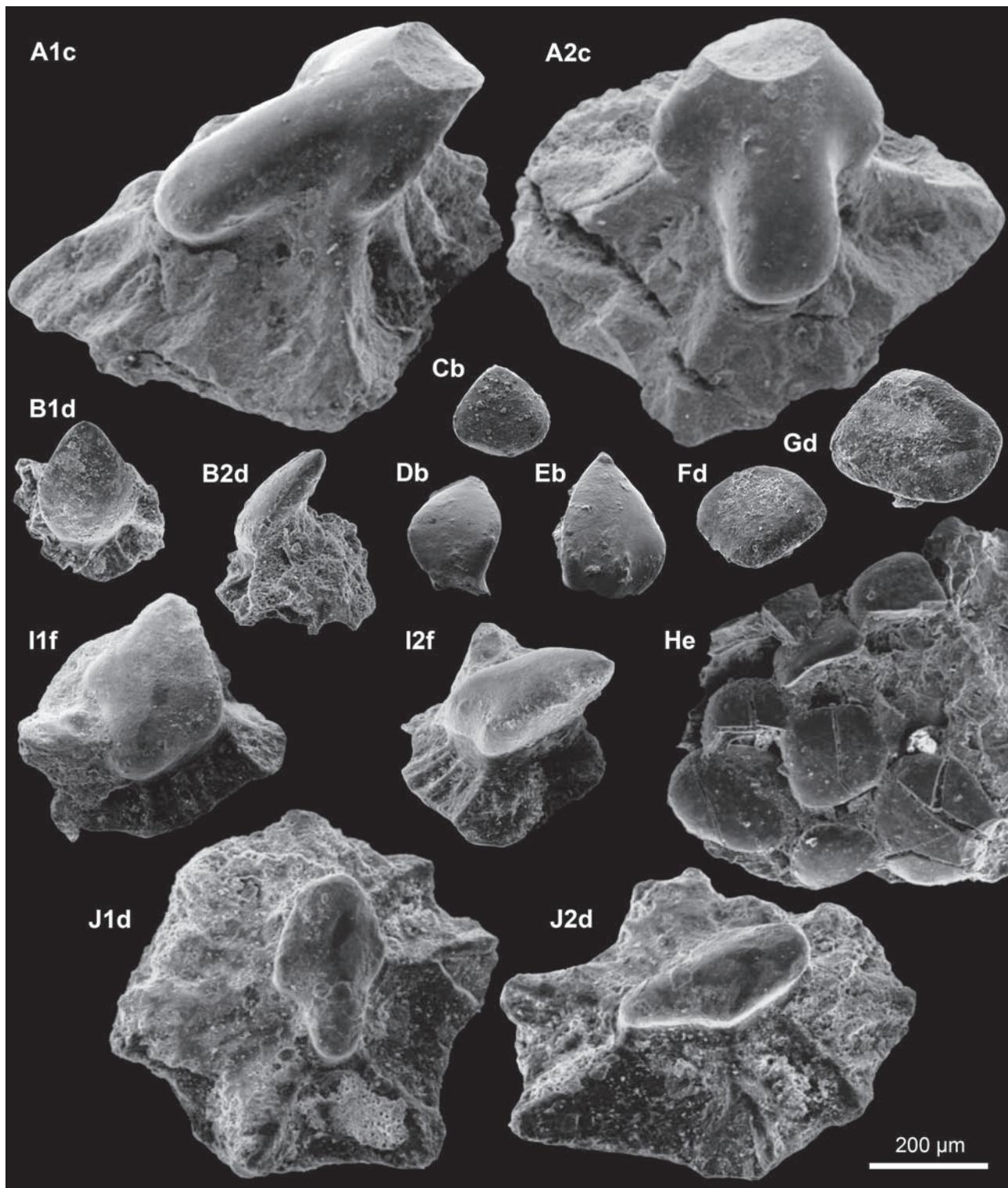


Plate 97. *Spathobatis bugesiacus* THIOLLIÈRE, 1852 (MHNL 15.308), Cerin

Figs. A–J. Isolated thorns and scales. – **A1c, A2c.** Malar thorn; 1 – lateral, 2 – apical view. **B1d, B2d, J1d, J2d.** Nuchal thorns; 1 – apical, 2 – lateral view. **Cb, Db, Eb.** Scales from the lateral cranial region, apical view. **Fd, Gd.** Scales from the anterior trunk region, apical view. **He.** Associated scales from middle trunk region, apical view. **I1f, I2f.** Dorsal thorns from the middle trunk region; 1 – apical, 2 – lateral view.

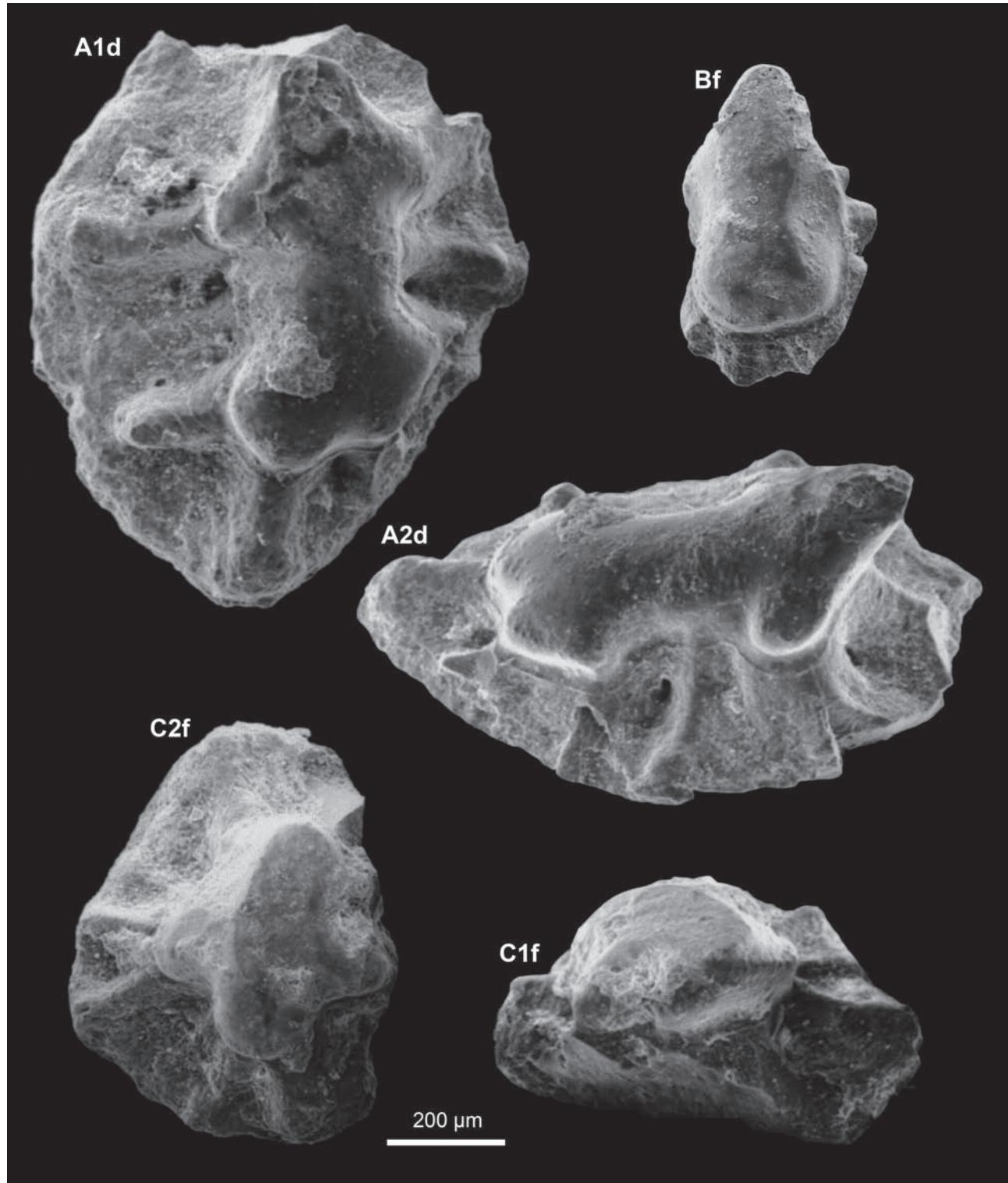


Plate 98. *Spathobatis bugesiacus* THIOLLIÈRE, 1852 (MHNL 15.308), Cerin

Figs. A–C. Isolated thorns. – **A1d, A2d.** Nuchal thorn; 1 – apical, 2 – lateral view. **Bf.** Dorsal thorn from the middle trunk region, apical view. **C1f, C2f.** Dorsal thorn from the middle trunk region; 1 – lateral, 2 – apical view.

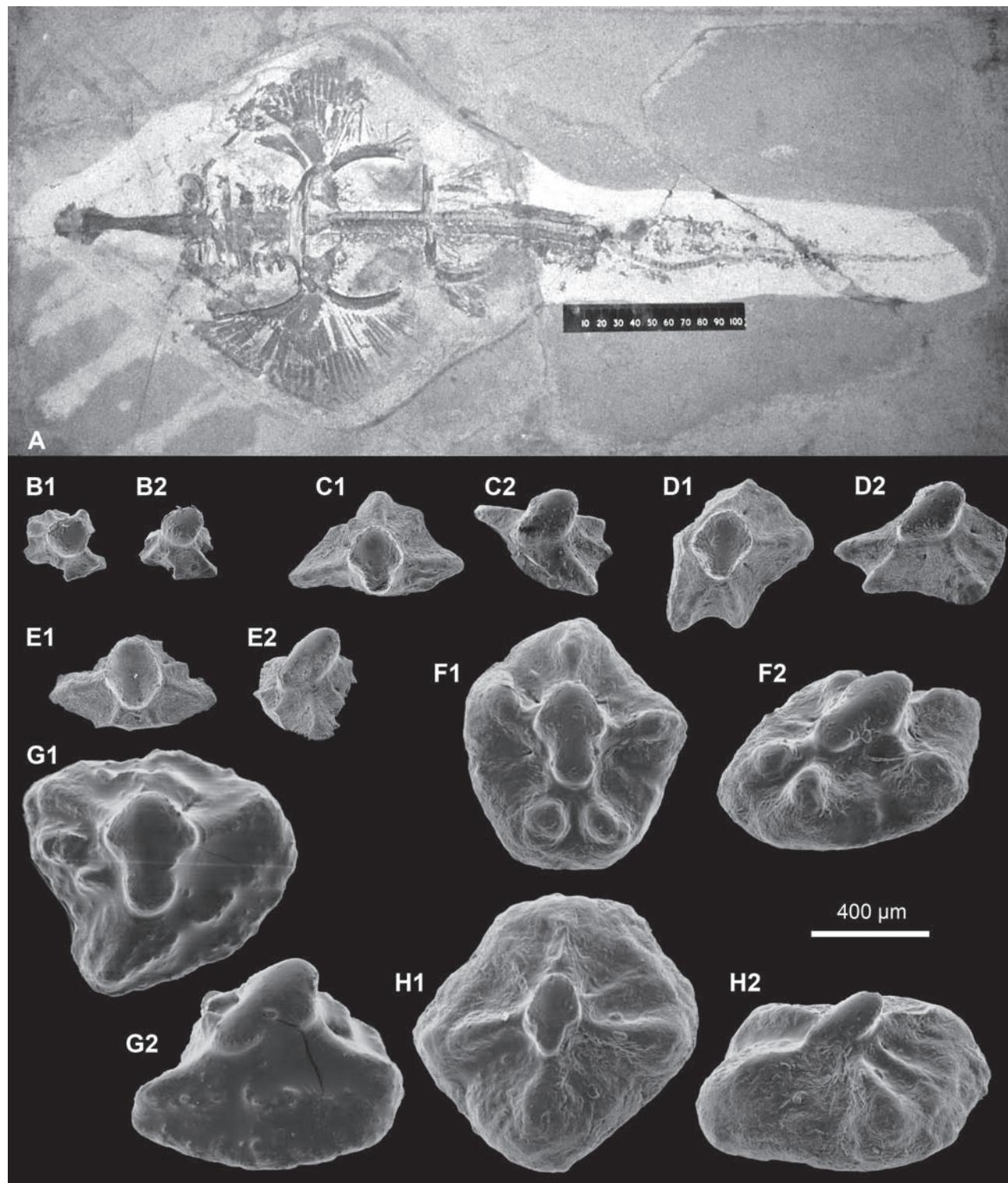


Plate 99. *Spathobatis bugesiacus* THIOLLIÈRE, 1852 (NHML P10934), Cerin

Fig. A. Overview of the specimen. Figs. B–H. Isolated scales and thorns. – B. Scale of unknown position; 1 – apical, 2 – lateral view. C–H. Thorns of unknown position; 1 – apical, 2 – lateral view.

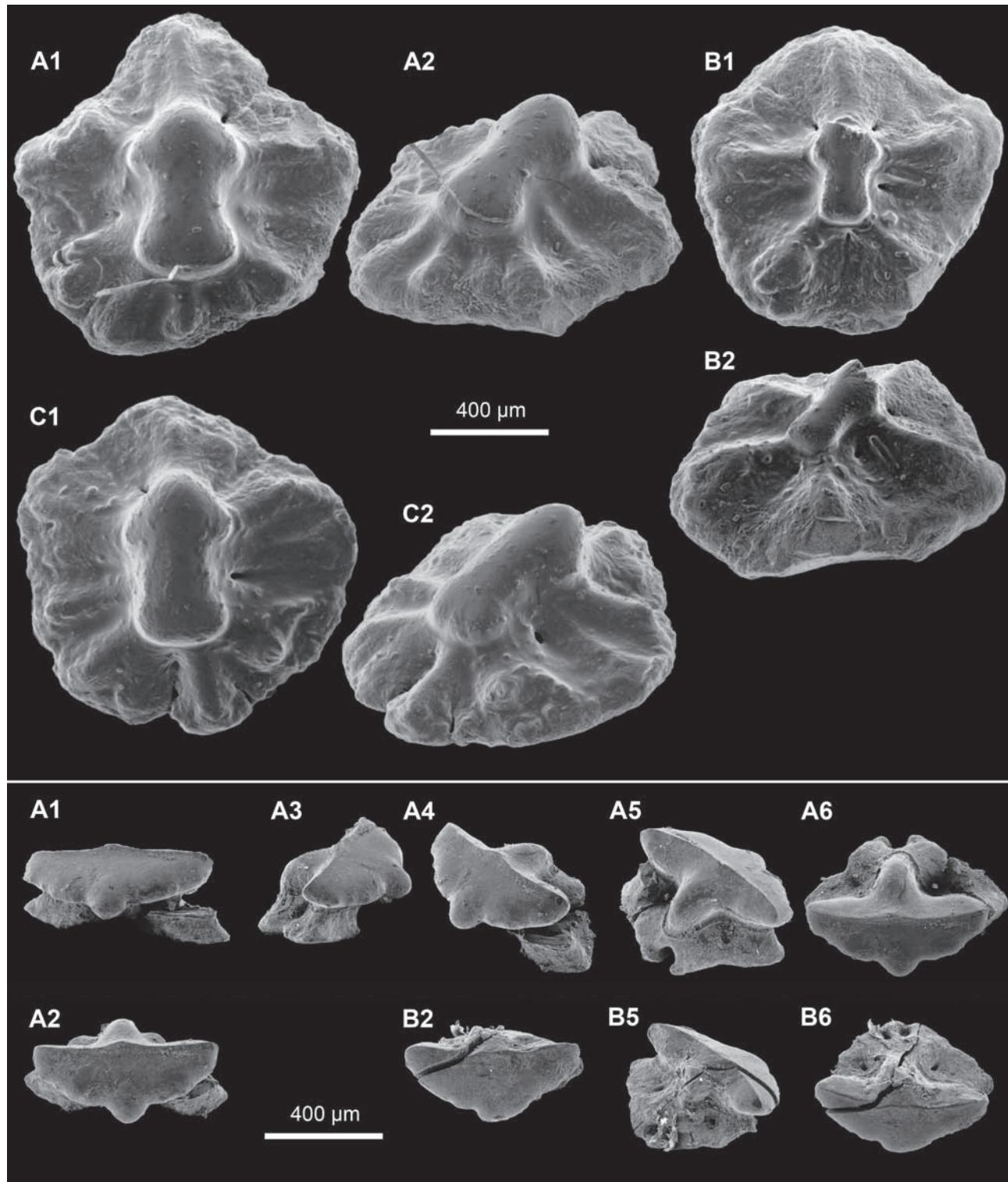


Plate 100. *Spathobatis bugesiacus* THIOLLIÈRE, 1852 (MHNL P10934), Cerin

Upper part

Figs. A–C. Isolated dorsal thorns of unknown position; 1 – apical, 2 – lateral view.

Lower part

Figs. A–B. Oral teeth; 1 – labial, 2 – apico-labial, 4 – lateral, 5 – latero-lingual, 6 – apical view.