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LATE JURASSIC (KIMMERIDGIAN) COMATULIDS (CRINOIDEA, COMATULIDA) FROM THE ŁÓDŹ DEPRESSION (CENTRAL POLAND)

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Abstract: Kimmeridgian carbonate facies from the southern margin of the Łódź Depression are rich in crinoid remains, dominated by stalked forms. Free-living comatulids (adult stemless crinoids), however, have remained largely undocumented in this area, with only a single specimen reported to date. Our newly collected material includes several dozen comatulid remains, primarily represented by centrodorsals. These specimens are assigned to *Solanocrinites* sp., *Comatulina* sp., *Palaeocomaster* cf. *karsensis* Radwańska, and *Semiometra petitclerci* (Caillet). In addition, stalked comatulids belonging to the family Thiolliericrinidae are documented, including *Thiolliericrinus flexuosus* Goldfuss and *Solonaerium* cf. *sigillatum* (Quenstedt), the latter two species being reported from Poland for the first time. This study also provides a review of the Kimmeridgian stalked crinoids (Isocrinida, Millericrinida, Cyrtocrinida) and Upper Jurassic comatulids previously recorded from Poland. The new occurrences originate from lower Kimmeridgian sponge-bivalve-oncoid biostromal limestones and marly limestones, as well as from thin-bedded marls and marly limestones. Within the epicontinental platform of the northern Tethyan shelf, these facies represent mid- to outer-platform transgressive successions. Their development was particularly pronounced during the late Oxfordian to early Kimmeridgian (up to the Hypselocyclum Zone) limestone-dominated platform stage and continued into the marl-dominated platform stage of the early Kimmeridgian (Hypselocyclum-Divisum zones).

Key words: Carbonate platform deposits, sponge-bivalve-oncoid biostromes, transgressive successions, sea lilies diversity.

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INTRODUCTION

Crinoid remains are notably abundant in the Kimmeridgian strata of the Kleszczów Graben, numbering in the hundreds of thousands (Krajewski *et al.*, 2019; this study). These assemblages, however, are dominated by stalked forms. Krajewski *et al.* (2016) confirmed the presence of isocrinid columnals (Isocrinida, *Isocrinus* sp.) and millericrinid pluricolumnals (Millericrinida, Millericrinida indet.) in the Kimmeridgian sediments of the Złoczew Graben. They also documented the occurrence of free-swimming roveacrinids, represented by saccocomids (Roveacrinida, *Saccocoma*), in certain facies.

The most comprehensive study to date on stalked crinoids from the Łódź Depression demonstrated that these forms are widespread and locally form extremely dense concentrations (Krajewski *et al.*, 2019). That work described and illustrated columnals, pluricolumnals, brachials, cirrals, and pluricirrals belonging to the following taxa: *Isocrinus amblyscalaris* (Thurmann, in Thurmann and Étallon), *I.* cf. *pendulus* (von Meyer), *Balanocrinus brachiospina* Hess, *Balanocrinus* sp., *B. pentagonalis* (Goldfuss), *B. subteres* (Münster, in Goldfuss), and Millericrinida indet.

Kimmeridgian stalked crinoids have also been recorded from adjacent regions, including the Mesozoic margin of the Holy Cross Mountains, the Polish Jura Chain, and the Pieniny Klippen Belt (for summary see Tab. 1). All these localities are situated within southern Poland (Fig. 1A).

Furthermore, saccocomids have been recorded from several regions of southern Poland, including the Polish Jura Chain, the Pieniny Klippen Belt, the Outer Carpathians (exotic limestones), and the Tatra Mountains (Głuchowski, 1987; Matyszkiewicz, 1996; Jach *et al.*, 2012 Kowal-Kasprzyk *et al.*, 2020). Isolated occurrences of stemless comatulids (Comatulida) have also been reported from both central and southern Poland; these are discussed in detail below (see Table 2 in the Discussion).

In the past four years, numerous stalked comatulids, commonly referred to in the literature as ‘’feather stars’’ (e.g., Messing, 1997), have been collected from the Kleszczów Graben. These sessile crinoids, characterized by limited mobility and high susceptibility to predation, display a range of morphological, behavioral, chemical, and other protective adaptations, and can be an excellent indicator of the palaeoenvironment.

Table 1

Stalked crinoids recorded from the Kimmeridgian of Poland, with taxonomic authorities and literature references.

Crinoid group	Crinoid taxa	Area	Reference
isocrinids	*Isocrinus* sp.	Pieniny Klippen Belt, Polish Jura Chain	Głuchowski (1987); Borszcz *et al.* (2009)
	Isocrinus ambyscalaris	Holy Cross Mountains; Łódź Depression	Radwańska (2005); Krajewski *et al*. (2019)
	Isocrinus cingulatus	Polish Jura Chain	Borszcz *et al.* (2009)
	Isocrinus pendulus	Polish Jura Chain	Borszcz *et al.* (2009); Gorzelak and Salamon (2009)
	Isocrinus cf. *pendulus*	Łódź Depression	Krajewski *et al*. (2019)
	Balanocrinus sp.	Pieniny Klippen Belt; Łódź Depression	Głuchowski (1987); Krajewski *et al*. (2019)
	Balanocrinus brachiospina	Łódź Depression	Krajewski *et al*. (2019)
	Balanocrinus pentagonalis	Pieniny Klippen Belt Polish Jura Chain; Łódź Depression	Głuchowski (1987); Borszcz *et al.* (2009); Krajewski *et al*. (2019)
	Balanocrinus subteres	Pieniny Klippen Belt; Polish Jura Chain; Łódź Depression	Głuchowski (1987); Borszcz *et al.* (2009); Krajewski *et al*. (2019)
millericrinids	Millericrinida indet.	Holy Cross Mountains; Polish Jura Chain; Łódź Depression	Wolkenstein *et al.* (2008); Borszcz *et al.* (2009); Krajewski *et al*. (2019)
	Apiocrinites sp.	Holy Cross Mountains	Radwańska (2005)
	Angulocrinus echinatus	Holy Cross Mountains	Radwańska (2005)
	Liliocrinus sp.	Holy Cross Mountains	Radwańska (2005)
	Pomatocrinus mespiliformis	Holy Cross Mountains	Salamon and Zatoń (2005)
cyrtocrinids	?*Eudesicrinus* sp.	Pieniny Klippen Belt	Głuchowski (1987)
	Gammarocrinites sp.	Pieniny Klippen Belt	Głuchowski (1987)
	Gammarocrinites compressus	Pieniny Klippen Belt	Głuchowski (1987)
	Dolichocrinus cf. *aberrans*	Pieniny Klippen Belt	Głuchowski (1987)
	Phyllocrinus sp.	Pieniny Klippen Belt	Głuchowski (1987)
	Pilocrinus moussoni	Pieniny Klippen Belt	Głuchowski (1987)
	Remisovicrinus sp.	Pieniny Klippen Belt	Głuchowski (1987)

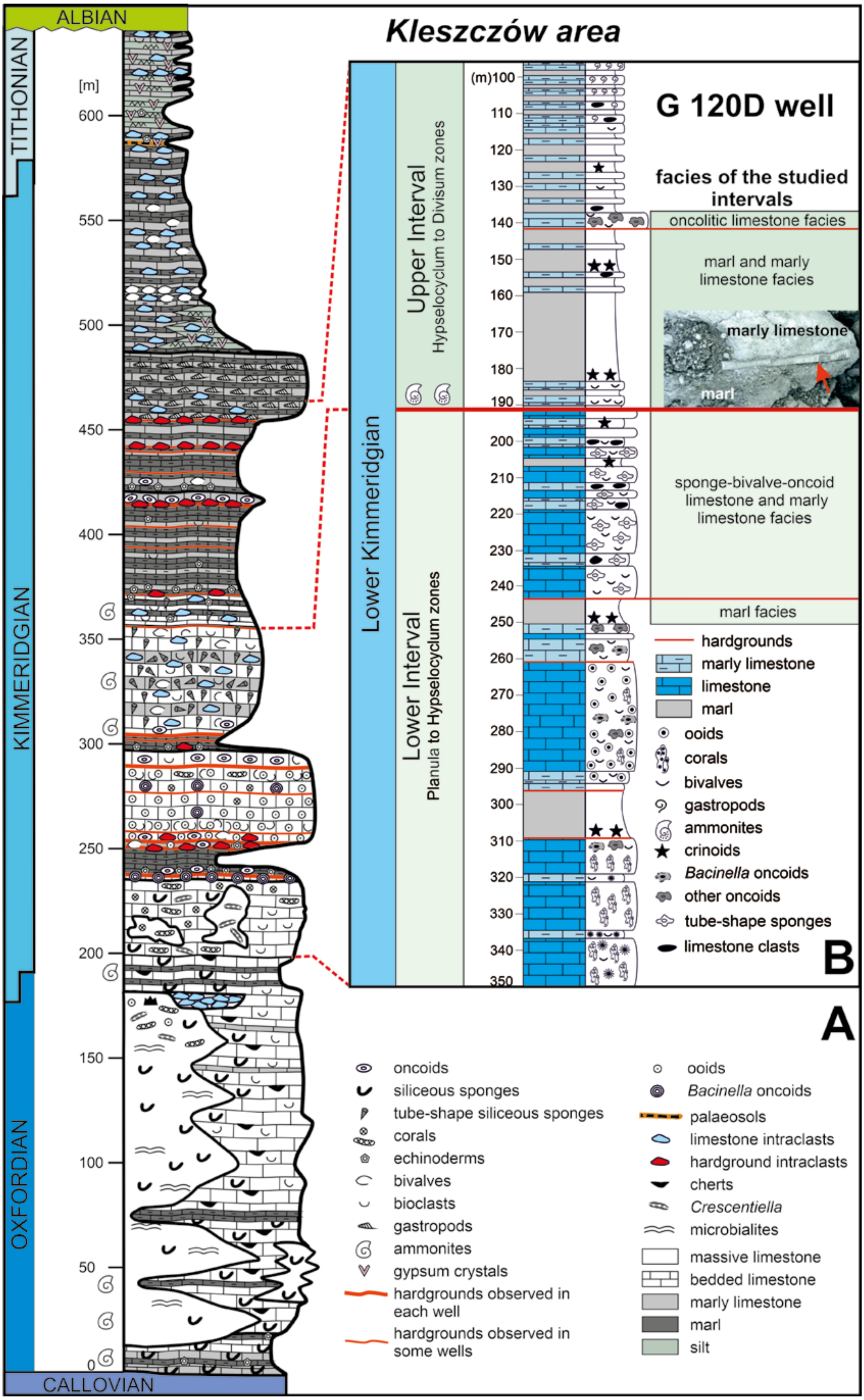

Fig. 1. Research area and lithology of Upper Jurassic strata in central Poland. **A.** Lithostratigraphic column of Upper Jurassic strata of the Kleszczów area with location of the studied interval (after Olchowy *et al*., 2019; modified). **B.** Synthetic lithological column (G 120D well) of the lower Kimmeridgian sedimentary succession from the study area, with location of described Lower and Upper intervals and facies types.

GEOLOGICAL SETTING

The studied crinoids derive from the Kimmeridgian succession of the Kleszczów Graben, central Poland. This area lies within the Radomsko Folds (southern Łódź Depression, Kleszczów region), close to the boundary between two major tectonic domains: the Fore-Sudetic Monocline and the Szczecin-Miechów Synclinorium (Żelaźniewicz *et al*., 2011; see fig. 1 in Krajewski *et al.*, 2019). The Upper Jurassic succession in the study area exceeds 600 m in thickness and comprises alternating limestones, marly limestones, marls, and marly-silts (Fig. 1; e.g., Niemczycka and Brochwicz-Lewiński, 1988; Kutek, 1994; Kutek and Zeiss, 1997; Krajewski *et al*., 2014; Wierzbowski, 2017; Olchowy *et al*., 2019; Olchowy and Krajewski, 2020; Słonka *et al*., 2025). During the Late Jurassic, central and southern Poland formed part of an epicontinental carbonate platform on the northern shelf of the Tethys Ocean (e.g., Matyja *et al*., 1989; Ziegler, 1990; Matyszkiewicz, 1997; Gutowski *et al*., 2005). Platform development and sedimentation were primarily controlled by sea-level and climatic fluctuations, together with synsedimentary tectonics that periodically reshaped the platform morphology (Kutek, 1994; Matyszkiewicz *et al*., 2012; Krajewski *et al*., 2017, 2018).

Biostratigraphic data from ammonites in the Szczerców area indicate the presence of lower–middle Oxfordian facies (Cordatum, Plicatilis, and Transversarium zones; Główniak, 1991) and lower Kimmeridgian facies (Hypselocyclum Zone; Wierzbowski, 2017). The uppermost deposits in the southern Łódź Depression belong to the Coquina and Pałuki formations, representing the Kimmeridgian–lower Tithonian ("Volgian"; e.g., Kutek, 1994; Kutek and Zeiss, 1997; Olchowy *et al*., 2019; Ziarek and Krajewski, 2025).

The interval analyzed here comprises a 250 m thick of lower Kimmeridgian deposits (e.g., Wierzbowski, 2017; Olchowy *et al*., 2019). Based on detailed composite lithofacies profiles (Fig. 1), two principal intervals can be distinguished: (1) a "Lower Interval", dominated by limestone facies types, spanning the lower Kimmeridgian up to the Hypselocyclum Zone (Wierzbowski, 2017), and (2) an "Upper Interval", dominated by marl facies, corresponding to the Burzenin Formation *sensu* Wierzbowski (2017). The boundary between these intervals is marked by a condensed horizon rich in ammonites, assigned to the Hypselocyclum Zone, Lothari Subzone (Wierzbowski, 2017). This condensation level is interpreted as reflecting a major palaeoceanographic event on the northern Tethyan shelf, which perhaps coinciding with the transition from the so-called COK megasequence (Callovian–Oxfordian–lower Kimmeridgian) to the LUK megasequence (lower–upper Kimmeridgian; Kutek, 1994; Olchowy *et al*., 2019; cf. Wierzbowski, 2017).

In the Kleszczów sector of the Łódź Depression, diverse limestone, marly limestone, and marl facies have been distinguished, representing depositional environments of the outer, middle, and inner carbonate platform (e.g., Olchowy *et al*., 2019). Within the studied succession, numerous facies and microfacies document transgressive–regressive cycles separated by hardground surfaces (Krajewski *et al*., 2014; Olchowy *et al*., 2019). Key facies types include: coral and pelitic limestones, oncoid limestones, ooid limestones, sponge-bivalve limestone-marl facies, pelitic and bioclastic marly limestones, and marls (see facies types 7–18 in Olchowy *et al*., 2019 for details).

MATERIALS AND METHODS

The material studied comprises 34 comatulid centrodorsals. Moreover, field and laboratory studies resulted in the collection of more than 10,000 stalked crinoid remains and 87 echinoid specimens. Numerous bivalves, annelids, sponges, and corals were also observed.

All specimens originate from the Bełchatów Lignite Mine and are housed in the Geological Museum of the Faculty of Natural Sciences, University of Silesia in Katowice, Poland, under the acronym collection number: 8–3800.

Comatulids and echinoids were collected during macroscopic field searches. Isocrinid remains were extracted from weathered Kimmeridgian sediments treated with hot water. Approximately 100 kg of weathered sediment was processed. Samples were wet-sieved through a mesh column (Ø1.0, 0.315, and 0.1 mm), and the residues were dried at 180°C. From each macerated sample, a randomly selected 0.2 kg of residue was selected for microscopic examination. Invertebrate remains were hand-picked under an Olympus SZX7-TR30 binocular microscope. Larger limestone fragments were treated with glauber salt (mainly three or four cycles of boiling-thawing). The mixture was then washed using running hot tap water, screened on a sieve column (Ø1.0, 0.315 and 0.1 mm-mesh respectively), and finally dried at 180°C.

Comatulids are represented by centrodorsals and cups. Specimens were cleaned using an ultrasonic bath to remove clay minerals. Where necessary, further cleaning was carried out by immersion in heated (100°C) hydrogen peroxide.

The thin sections were prepared in the grinding laboratory of the AGH University of Science and Technology, Kraków. Photographs of the figured specimens (Figs 2, 3) were taken using a Nikon D7500 camera equipped with Tokina 10 mm and Sigma 17–70 mm lenses.

RESULTS

61 comatulid remains have been classified as:

1. *Solanocrinites* sp. – four centrodorsals and one calyx;
2. *Comatulina* sp. – three centrodorsals;
3. *Palaeocomaster* cf. *karsensis* Radwańska – four centrodorsals;
4. *Semiometra petitclerci* (Caillet) – 28 centrodorsals;
5. *Thiolliericrinus flexuosus* Goldfuss – twelve centrodorsals and eight columnals;
6. *Solonaerium* cf. *sigillatum* (Quenstedt) – 1 centrodorsal.
7. More than 10,000 isocrinid remains have been classified as:
8. Isocrinidae subfam. and gen. indet. – more than 4,000 radials, basals, brachials, columnals, pluricolumnals, cirrals, and pluricirrals;
9. *Isocrinus amblyscalaris* (Thurmann, in Thurmann and Éttalon) – more than 1,000 columnals, pluricolumnals, brachials, cirrals, and pluricirrals;

10. *Isocrinus pendulus* (von Meyer) – 340 columnals and pluricolumnals;
11. *Balanocrinus* sp. – 1,120 radials, columnals and pluricolumnals;
12. *Balanocrinus brachiospina* Hess – 580 basals, brachials, columnals, and pluricolumnals;
13. *Balanocrinus pentagonalis* (Goldfuss) – 120 columnals and pluricolumnals;
14. *Balanocrinus subteres* (Münster in Goldfuss) – 2,100 columnals and pluricolumnals;
15. Millericrinida indet. – more than 1,000 radials, columnals, pluricolumnals, and holdfasts; for detailed description see Krajewski *et al*. (2019);
16. *Pomatocrinus mespiliformis* (von Schlotheim) – two cups;
17. *Millericrinus* sp. – two cups.

Other echinoderms

Among the non-crinoid echinoderm remains, the most abundant are asteroid marginal plates (about 200 specimens), referred to as *Pentasteria* sp. Ophiuroid remains are similarly numerous and represented by vertebrae and arm plates, assigned to *Ophioderma spectabilis* Hess and *O. oertlii* Hess. Echinoid material consists mainly of cidaroid spines and test plates (about 100 remains), together with several more or less complete regular echinoids, including:
1. *Rhabdocidaris orbignyana* (Agassiz) – three tests;
2. *Hemicidaris intermedia* (Fleming) – three tests;
3. *Pseudosalenia malogostiana* (Radwańska) – two tests;
4. *Trochotiara kongieli* (Radwańska) – one test.

Crinoid-bearing facies

In the lower Kimmeridgian succession of the Kleszczów area (Fig. 1), mass accumulations of crinoid remains, including comatulids, are found within two distinct facies intervals that are separated by a prominent erosional hardground surface. The lower of these, referred to as the Lower Interval, consists of up to 75 m of thick-bedded sponge-bivalve-oncoid limestone and marly limestone. Its lower part is dominated by bioclastic limestones (packstone-floatstone) containing dispersed bivalves, echinoderms, oncoids, and calcified tube-shaped siliceous sponges. Up section, the facies transitions into sponge-bioclastic limestones and marly limestones (sponge-bioclastic floatstone-bafflestone), several tens of meters thick, interbedded with marls rich in redeposited sponge skeletons and tuberoids (bioclastic-sponge wackestone-floatstone). Crinoids, bivalves, echinoderms, and pelitic fine bioclastic limestone clasts are commonly observed. Within this part of the succession, balanocrinid crinoids are particularly abundant, especially *Balanocrinus subteres*, the largest species of the genus. Toward the top of the Lower Interval, sponge abundance gradually declines, and the succession culminates in several meters of fine bioclastic limestones (wackestones) that are sharply capped by the erosional hardground marking the boundary with the Upper Interval.

The Upper Interval, overlying the hardground, is approximately 35 m thick and composed predominantly of grey, thin-bedded marls with thin intercalations of pelitic marly limestones (fine bioclastic wackestones). These interbeds are typically burrowed and contain scarce fine bioclasts. The basal three meters of this interval are marl-dominated and contain abundant crinoid fragments (including comatulids), echinoderms, and intraclasts of pelitic marly limestone. In this lower portion, balanocrinids again dominate, with *Balanocrinus brachiospina* and *B. subteres* occurring in equal abundance, accompanied by rare *B. pentagonalis*. Higher in the section, marly limestone intercalations up to 30 cm thick become more frequent. The Upper Interval is sharply bounded above by another erosional hardground, which is overlain by oncoid-bioclastic limestone (oncoid floatstone), as illustrated in Figure 1.

Facies interpretation

The crinoid-rich facies of the Kleszczów succession record a series of lower Kimmeridgian transgressive-regressive sequences, each bounded by shallow-water erosional hardgrounds (e.g., Kaźmierczak and Pszczółkowski, 1968; Gruszczyński, 1986; Krajewski *et al*., 2014, 2017; Olchowy *et al*., 2019).

Within the Lower Interval, the sponge-bivalve-oncoid facies is dominated by sponge-rich biostromes, primarily composed of redeposited skeletons of tubular calcified siliceous sponges (cf. Olchowy *et al*., 2019). These deposits are best classified as parabiostromes or allobiostromes (*sensu* Kershaw, 1994; Flügel, 2004), although in some cases, *in-situ* preservation of sponge skeletons led to the formation of autoparabiostromes (Kershaw, 1994). Such facies typically formed in mid- to outer-platform environments along the northern Tethys shelf, accumulating in moderately deep waters (from several tens of metres to ~100 m), between fair-weather and storm wave base. They were deposited on near-horizontal to gently inclined carbonate ramps (e.g., Trammer, 1989; Leinfelder *et al*., 1996; Matyszkiewicz, 1997; Schmid *et al*., 2001; Olóriz *et al*., 2003; Flügel, 2004; Gutowski *et al*., 2005; Krajewski *et al.*, 2018; Krajewski and Olchowy, 2023). The redeposition of sponge skeletons within marly limestone beds (allobiostromes) is most likely linked to tectonic reorganization of the carbonate platform and related sea-level oscillations (Krajewski *et al*., 2016; Olchowy *et al*., 2019). As such, the sponge-bivalve-oncoid facies mark the final stage of Oxfordian–lower Kimmeridgian carbonate platform development, culminating in the formation of a hardground and a transition toward marl-dominated sedimentation in the Upper Interval. This Upper Interval is characterized by marl and marly limestone facies, representing outer-platform deposits laid down during a new transgressive–regressive cycle (Krajewski *et al*., 2019; Olchowy *et al*., 2019). The lower portion, enriched in ammonites and crinoids, corresponds to the transgressive systems tract. It is overlain by fine-grained, burrowed marls deposited during maximum flooding. In the upper part of the interval, the growing presence of marly limestone intercalations, along with the development of a shallow-water hardground, indicates a gradual shallowing and progradation into mid- and inner-platform environments. This phase ends with the deposition of oncoid limestone (Fig. 1; Olchowy *et al*., 2019), marking the culmination of the sequence.

SYSTEMATIC PALAEONTOLOGY

Remark: Taxonomy and terminology follow Hess and Messing (2011), Salamon *et al*. (2022), and Płachno *et al*. (2024).

Order Comatulida Clark, 1908
Suborder Comatulidina Clark, 1908
Superfamily Solanocrinitoidea Jaekel, 1918
Family Solanocrinitidae Jaekel, 1918
Genus *Solanocrinites* Goldfuss, 1829, in Goldfuss 1826–1844

Type species: *Solanocrinites costatus* Loriol, 1882–1889, p. 526.

Solanocrinites sp.
Fig. 2A, B

Material: Four centrodorsals and one calyx. GIUS 8–3800Ss.
Measurements: Centrodorsal diameter in basal part: 2.00–2.51 mm; centrodorsal diameter in proximal part: 1.99–2.51 mm; centrodorsal height: 1.66–1.82 mm; cirrus scar sockets diameter: 0.54–1.01 mm.
Description: Centrodorsals are more or less 5-sided, truncated conical. Aboral apex is flat or slightly concave. 10 columns consist of 1 to 3 large and extremely large oval cirrus sockets. Cirrus sockets are separated by ridges. Basals are rod-shaped and are exposed interradially. Radials are large, trapezoidal, steep, and they are distinctly overhanging. Their interarticular ligament area is low. Adoral muscle fossae are low and form narrow bands along the adoral edge or low triangular areas separated by a median notch. Radial cavity is moderately deep and very extensive, reaching 70% of the cup diameter.
Discussion: The specimens under study may represent a new species previously unknown to science. The only representative of the genus *Solanocrinites* recorded from the Upper Jurassic deposits of Poland was *S. sanctacrucensis* Radwańska, 2005. The latter author documented six calyces, four centrodorsals, and a single radial plate from the Kimmeridgian of Małogoszcz in southern Poland. Unlike the currently recorded specimens, the specimens described by Radwańska (2005) had centrodorsals whose aboral side was sharply pointed (see pl. 4, fig. 1d in Radwańska, 2005). Centrodorsals described herein are flat. Another Kimmeridgian *Solanocrinites* is *S. costatus* Loriol, 1882–1889, known from Germany, France, and Switzerland. This species has a flat aboral side of the calyx, but its radials do not overhang the centrodorsal (comp. fig. 38a in Hess and Messing, 2011). The form most similar to *Solanocrinites* sp. from the Bełchatów area is *S. gresslyi* (Étallon, 1862), known from the Oxfordian of France. This species is characterized by a flat aboral apex, a centrodorsal extending towards the proximal part, and distinctly overhanging radials (cf. fig. 34 in Étallon, 1862). However, *S. gresslyi* has so far been documented exclusively from Oxfordian deposits.
Occurrence: Middle Jurassic (Bajocian?, Bathonian)–Upper Jurassic (Tithonian): Germany, France, Switzerland. Poland: Łódź Depression (Platynota-Hypselocyclum Zone).

Genus *Comatulina* d'Orbigny, 1852 in 1850–1852

Type species: *Cmatulina costata*; nom. nov. pro *Solanocrinites costatus* Goldfuss, 1829 in 1826–1844.

Comatulina sp.
Fig. 2C

Material: Three centrodorsals. GIUS 8–3800Cs.
Measurements: Centrodorsal diameter in basal part: 0.50–0.81 mm; centrodorsal diameter in proximal part: 1.69–1.91 mm; centrodorsal height: 1.50–1.92 mm; cirrus scar sockets diameter: 0.24–0.39 mm.
Description: Centrodorsals are truncated conical to truncated subhemispherical, circular. Aboral apex is rounded. Cirrus sockets are grouped in 10 columns. There are 1 to 3 cirrus sockets per column. They are closely spaced, rounded, and separated by distinct ridges. Adoral side of centrodorsal is flat and smooth; in one case, small, irregular furrows are visible.

May have irregular furrows around centrodorsal cavity. Cavity in centrodorsal is circular and small.
Discussion: Radwańska (2005) listed four comatulid taxa from the Kimmeridgian of central Poland: *Comatulina* sp.; *Comatulina* cf. *beltremieuxi* (Loriol, 1882–1889); *Comatulina malogostiana* Radwańska, 2005; and *Comatulina peroni* (Loriol, 1882–1889). All of these forms exhibit 15 cirrus socket-bearing columns (with up to 17 in *Comatulina* sp.), which clearly distinguishes them from the specimens described herein. It should also be noted that the *Comatulina* specimens from Bełchatów represent juvenile individuals. As Hess and Messing (2011) observed, adult comatulids may possess more than 10 columns - typically between 11 and 15, and in exceptional cases, up to 20.
Occurrence: Upper Jurassic (Oxfordian)–Upper Cretaceous (Coniacian) of Algeria, France, Germany, Poland, Portugal, Spain, and Switzerland, early Kimmeridgian of Łódź Depression (Platynota-Hypselocyclum Zone), Poland. Radwańska (2005) mentioned *Comatulina* sp. as having large, low and cylindrical centrodorsals reaching up to 13 mm in diameter, with up to 17 columns of 2 or 3, closely spaced, large cirrus sockets from the early Kimmeridgian of Holy Cross Mountains (Katroliceras divisum Zone; Skorków Lumachelle Member).

Genus *Palaeocomaster* Gislén, 1924

Type species: *Actinometra guirandi* Loriol, 1882–1889, p. 535.

Palaeocomaster cf. *karsensis* Radwańska, 2005
Fig. 3E

Material: Four centrodorsals. GIUS 8–3800Pk.
Measurements: Centrodorsal diameter in basal part: 2.90–4.51 mm; centrodorsal diameter in proximal part: 2.99–4.91 mm; centrodorsal height: 1.80–3.02 mm; cirrus scar sockets diameter: 0.34–0.99 mm.
Description: Centrodorsals are low and discoidal, slightly 5-sided, and truncated. Aboral apex is large and flat. It

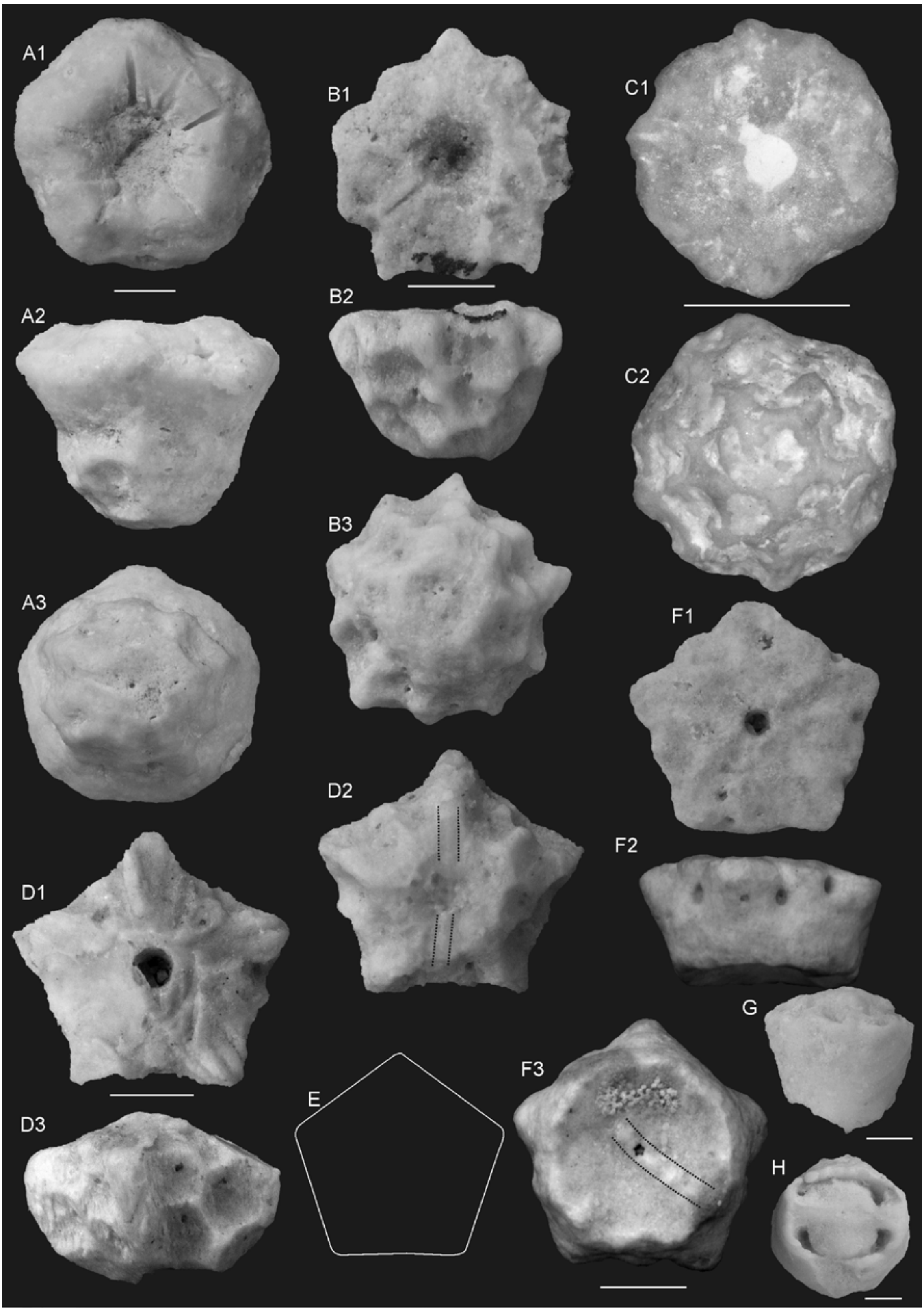

Fig. 2. Comatulids from the lower Kimmeridgian of the Kleszczów Graben, central Poland [except E, which shows a schematic drawing of the centrodorsal of *Solonaerium sigillatum* (Quenstedt) in proximal view; redrawn from Klikushin (1987)]. Scale bar – 1 mm. **A, B.** *Solanocrinites* sp.; A1 – calyx, proximal view; A2 – calyx, lateral view; A3 – calyx, distal view; B1 – centrodorsal, proximal view; B2 – centrodorsal, lateral view; B2 – centrodorsal, distal view. **C.** *Comatulina* sp., centrodorsal; C1 – proximal view; C2 – distal view. **D.** *Solonaerium* cf. *sigillatum* (Quenstedt), centrodorsal; D1 – proximal view; D2 – distal view; D3 – lateral view. **E.** Drawing of the centrodorsal in proximal view of *Solonaerium sigillatum* (Quenstedt), taken from Klikushin, 1987. Not to scale. **F–H.** *Thiolliericrinus flexuosus* Goldfuss, cenntrodorsal and columnals; F1 – centrodorsal, proximal view; F2 – centrodorsal, lateral view; F3 – centrodorsal, distal view (facet to stem); G – proximalmost columnal, lateral view; H – proximalmost columnals, articular facet, proximal view. Dashed line indicates the course of the fulcral ridge on the distal side of the centrodordsals.

may be smooth, although in some specimens it is rugose. Cirrus sockets are abraded, but they do not appear to be very densely packed and do not form distinct columns. They are irregular. Basals are invisible. Radials are wide and concealed; their height corresponds to that of the centorodorsal. Ligament fossae are triangular. Adoral muscle fossae are small, triangular, or reduced to narrow bands along the adoral edge. Radial cavity is moderately deep and very extensive, reaching 60% of the cup diameter.

Discussion: The present specimens resemble *Palaeocomaster karsensis* Radwańska, 2005, described from the Kimmeridgian of Małogoszcz in southern Poland. Radwańska (2005) noted that the centrodorsals she examined were covered with discoidal elements and numerous (approximately 50), deeply incised, relatively small cirrus sockets. In the specimens currently recovered from the Kleszczów Graben, the lateral surfaces are eroded, making it difficult to accurately determine the number of cirrus sockets. However, it appears that the sockets were neither as numerous nor as small as those observed in the material from Małogoszcz.

Occurrence: Early Kimmeridgian of Holy Cross Mountains (Katroliceras divisum Zone; Skorków Lumachelle Member). *P.* cf. *karsensis* is present in Łódź Depression (Platynota-Hypselocyclum Zone), Poland.

Family Thiolliericrinidae Clark, 1908
Genus *Thiolliericrinus* Éttalon, 1859

Type species: *Thiolliericrinus flexuosus* Goldfuss (1831, in Goldfuss 1826–1844, p. 186).

Thiolliericrinus flexuosus Goldfuss
(1831, in Goldfuss 1826–1844)
Fig. 2F–H

1831 *Thiolliericrinus flexuosus* – Goldfuss in Goldfuss, 1826–1844, p. 186.

Material: 12 centrodorsals and 8 columnals. GIUS 8–3800Tf.

Measurements: Centrodorsal diameter in basal part: 3.60–6.01 mm; centrodorsal diameter in proximal part: 5.23–8.11 mm; centrodorsal height: 3.70–5.02 mm; cirrus scar sockets diameter: 0.40–1.19 mm.

Description: Centrodorsal is truncated conical, low, sometimes irregular. It has a single, mostly irregular, few cirrus sockets forming a single circlet. Sockets are mainly small, in some cases larger with visible nerve canal, elliptical to circular in outline. They are more or less widely separated. Some of them have distinct articular ridge, others do not. Some of the sockets are replaced by structureless fossae. The free surface of the centrodorsal between the cirrus sockets is smooth like that of the external radial surface. Basals are commonly covered with a porous calcitic plug. Radial cavity is small and circular. Proximal part of centrodorsal is covered with a distinct dorsal star. Stem to facet is large and circular. Columnals are barrel-shaped and relatively high. The most proximal columnal is rosette-like. They have straight or concave latera. Articular facet is circular or ellipsoidal. Fulcral ridge is serrated in some columnals. Marginal ridge is twinned, with twins almost perpendicular to each other on both sides of the columnal. Lumen is small and circular. It cannot be excluded that, at least, some columnals belong to another thiolliericrinid *Solonaerium* cf. *sigillatum* described below.

Remark: Thiolliericrinids have been reported from Poland only two times. Salamon *et al*. (2006, 2020) described their columnals from the Tithonian of Owadów-Brzezinki, central Poland, and from the Valanginian of Leszna Górna, southern Poland.

Occurrence: Oxfordian and Kimmeridgian of France, early Kimmeridgian of Łódź Depression (Platynota-Hypselocyclum Zone), Poland.

Genus *Solonaerium* Étallon, in Thurmann and Étallon, 1861

Type species: *Solanocrinites costatus* Goldfuss, 1831, in Goldfuss 1826–1844, partim, = *S. sigillatum* Quenstedt, 1876.

Solonaerium cf. *sigillatum* (Quenstedt, 1876)
Fig. 2D, E

Material: One centrodorsal. GIUS 8–3800Ssig.

Measurements: Centrodorsal diameter in basal part: 1.60 mm; centrodorsal diameter in proximal part: 3.53 mm; centrodorsal height: 2.02 mm; cirrus scar sockets diameter: 0.39–0.59 mm.

Description: Centrodorsal is truncated conical, stellate in proximal part, and with extremely large and closely touching cirrus sockets arranged in 10 columns of 2 or 3 sockets per column. Majority of cirrus sockets have a distinct fulcral ridge and large nerwve canal. Aboral apex is rounded. Central cavity is rather small and circular, distinctly protruding. Facet to stem is large, circular, covering almost the entire distal part of the centrodorsal. Nerve canal is small and circular. Fulcral ridge is narrow and raised.

Remarks: Étallon (1862) classified the specimen illustrated by Goldfuss (1831) in Goldfuss (1826–1844, fig. 51/2) and described by the latter as *Solanocrinites costatus* as a species probably belonging to *Thiolliericrinus*. In turn, Thurmann and Étallon (1861) named the same specimen *Solonaerium costatus*, and Quenstedt (1876) assigned it to his new species *Comatula sigillata*. Klikushin (1987) refigured Goldfuss's and Quenstedt's specimens under *S. sigillatum*.

Discussion: Previously, *Solonaerium* was only known from Germany, and all individuals there have moderately high centordorsals with large and closely touching cirrus sockets arranged in 10 columns of 2 or 3 sockets (Kliksuhin, 1987, and literature cited therein), which makes German finds similar to the Polish specimen. The difference between them is related to the shape of the centrodorsal in proximal view, which in the German forms is pentagonal (comp. Fig. 2E); the Polish form, however, has a substellate centrodorsal (Fig. 2D1). Based on a single specimen, it is difficult to determine whether this variation falls within the scope of intraspecific variation.

Occurrence: Kimmeridgian of Germany, early Kimmeridgian of Łódź Depression (Platynota-Hypselocyclum Zone), Poland.

Superfamily Notocrinoidea Mortensen, 1918
Family Notocrinidae Mortensen, 1918
Genus *Semiometra* Gislén, 1924

Type species: *Antedon impress* Carpenter (1881, p. 135).

Semiometra petitclerci (Caillet, 1923)
Fig. 3A–D

1923 *Antedon petitclerci* – Caillet, p. 125, pl. 1, figs 1–3.

2003 *Semiometra ithiensis* – Helm, Reuter and Schülke, p. 519, text-figs 4A–E, 5A–D.

2007 *Semiometra petitclerci* (Caillet) – Radwańska, p. 165, text-fig. 3, pls 1, 2.

Material: 28 centrodorsals. GIUS 8–3800Sp.

Measurements: Centrodorsal diameter in proximal part: 1.23–3.61 mm; centrodorsal height: 0.70–2.01 mm; cirrus scar sockets diameter: 0.20–0.49 mm.

Description: Centrodorsals are ragged at margins, circular, bowl-shaped to hemispherical, they are relatively small and low. Dorsal part of centrodorsal is flat; ventral side is distinctly concave. Edges of centrodorsals are thin and limited to a single irregular whorl of cirrus sockets. Central cavity constitutes a maximum of 30% of centrodorsal diameter. Cirrus sockets are small and crowded. They are commonly regularly alternating and not forming columns, numbering more than 30 in total. Sockets do not possess distinct articular tubercles and marginal crenulae. Basals are not exposed. In one of the individuals, a relic of radials has been preserved (see Fig. 3B2), but they are so heavily eroded that it is difficult to say anything about them.

Remarks: Radwańska (2007) recalled that Caillet (1923) established *Semiometra petitclerci* based on limited material comprising one centrodorsal and two cups. Caillet suggested that small radials and brachial plates recovered from the same strata as the centrodorsal and cups might belong to this taxon. However, Radwańska (2007) disagreed with this interpretation, arguing that there is no evidence to support such an assumption, as the absence of illustrations and the presence of abundant small-sized ossicles from other crinoids prevent verification. This view was later supported by Hess (2014). Both Radwańska (2007) and Hess (2014) noted that specimens collected by Radwańska in northern Poland (Bielawy/Wapienno sequence, Couiavia region) differ from the type series described by Caillet (1923) in having fewer cirrus sockets and a less convex centrodorsal. Specifically, the Polish specimens exhibit a maximum of 27 cirrus sockets per centrodorsal, whereas the French material has approximately 40.

Discussion: It is worth noting that among currently documented centrodorsals, the number of cirrus sockets is quite variable, ranging from more than 20 up to sometimes more than 30 per individual. Additionally, the variation in centrodorsal shape, from bowl-shaped to hemispherical, should be interpreted as intraspecific variability, as demonstrated in Late Cretaceous congeners (e.g., Jagt, 1999; Radwańska, 2007). This pattern is clearly observable in material from the Łódź Graben, where numerous bowl-shaped centrodorsals occur alongside distinctly hemispherical forms.

Occurrence: Oxfordian of France, late Oxfordian of the Couiavia region, Poland, early Kimmeridgian of Łódź Depression (Platynota-Hypselocyclum Zone), Poland.

DISCUSSION

Comatulids (Comatulida A. H. Clark) represent one of nine post-Paleozoic crinoid orders, alongside Holocrinida, Encrinida, Isocrinida, Millericrinida, Hyocrinida, Cyrtocrinida, Roveacrinida, and several taxa of uncertain affinity (Hess and Messing, 2011). Their fossil record extends back to the Late Triassic (e.g., Hess, 1951, 2014). In modern oceans, comatulids constitute the most diverse crinoid lineage, occurring worldwide in both shallow and deep marine environments (Hess, 1999; Salamon, 2008a–c; Salamon *et al.*, 2022).

According to Hess and Messing (2011), the order Comatulida includes three suborders: (i) Comatulidina A. H. Clark, characterized by the loss of the stalk in the adult stage; and two stalk-retaining groups in adulthood, (ii) Bourgueticrinina Sieverts-Doreck, and (iii) Guillecrinina Mironov and Sorokina. Within Comatulidina, the extinct family Thiolliericrinidae (Jurassic–Cretaceous) was distinguished by A. H. Clark. Members of this family retained a stem, which initially led Rasmussen (1961) to classify them as belonging to an uncertain order. However, Rasmussen (1978) later placed them within Comatulida as Thiolliericrinidae, primarily due to the presence of a centrodorsal commonly bearing cirri. Thiolliericrinids also share morphological features with bourgueticrinids (Bourgueticrinina Sieverts-Doreck, in Ubaghs, 1953), notably columnals with synarthrial articulations. These columnals closely resemble those of bourgueticrinids and are further distinguished by a terminal disk bearing an obliquely oriented synarthrial articulation relative to the substrate. Hess and Messing (2011) included thiolliericrinids within comatulids, proposing that they evolved from *Solanocrinites*-like ancestors through paedomorphosis during the Jurassic.

Comatulids from the Upper Jurassic of Poland – an overview

Among comatulid skeletal elements, the centrodorsal is widely regarded as the most diagnostically significant and robust ossicle, serving as the primary basis for generic identification. Specimens preserving centrodorsals articulated with basal and radial plates are exceedingly rare (cf. tab. 1 in Salamon *et al.*, 2022). This reliance on isolated centrodorsals results from the high susceptibility of comatulids to post-mortem disarticulation processes, which rapidly fragment their skeletons shortly after death (e.g., Meyer and Meyer, 1986; Salamon *et al.*, 2022, and references therein). This taphonomic pattern is consistently reflected in the Upper Jurassic fossil record from Poland, where centrodorsals dominate the assemblages, radials are recovered less frequently, and articulated arms or pinnules have yet to be documented (see Tab. 2).

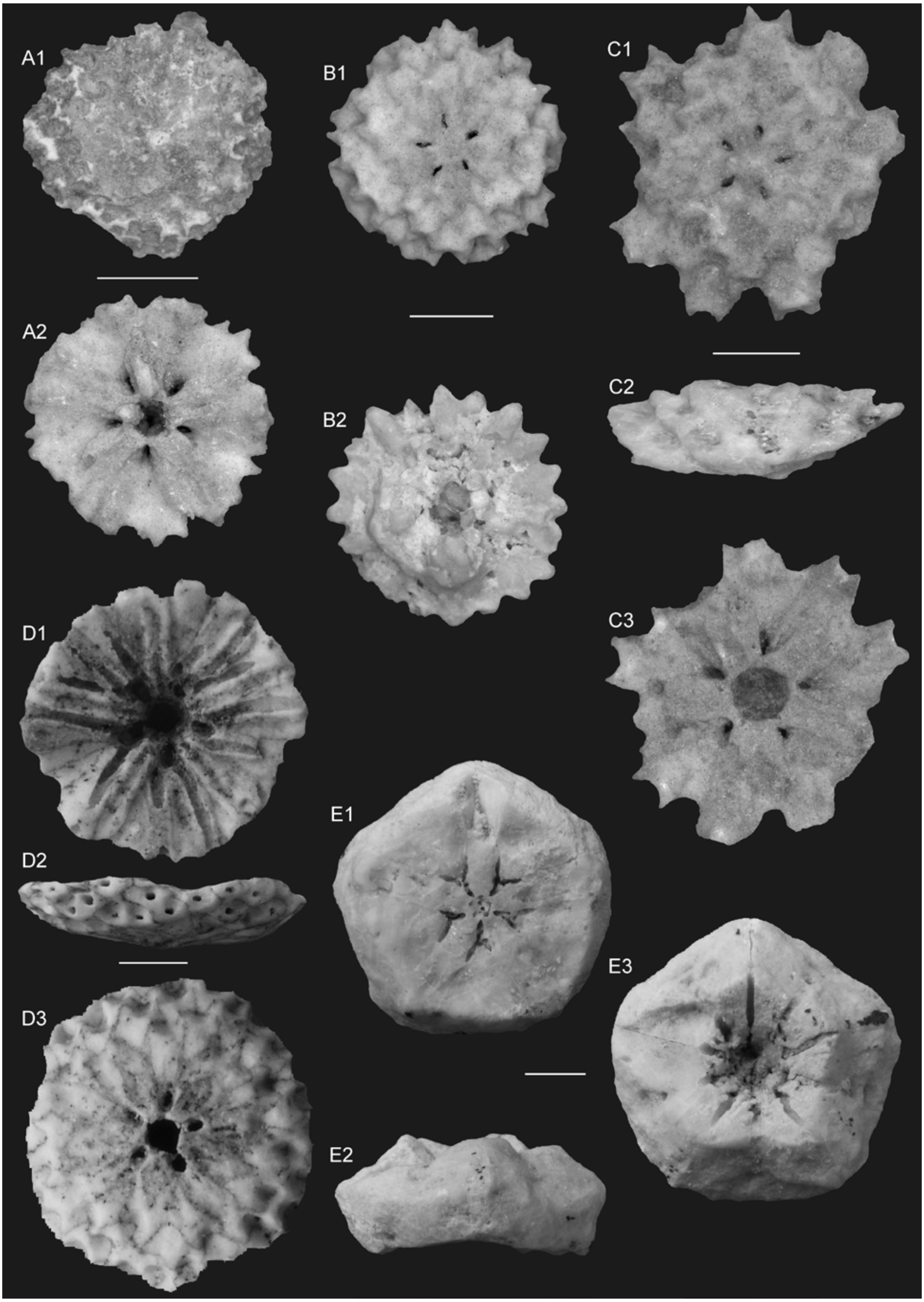

Fig. 3. Comatulids from the lower Kimmeridgian of the Kleszczów Graben, central Poland. Scale bar = 1 mm. **A**–**D.** *Semiometra petitclerci* (Caillet); A1 – centrodorsal, distal view; A2 – centrodorsal, proximal view; B1 – centrodorsal, distal view; B2 – centordorsal with radial relic, proximal view; C1 – centrodorsal, distal view; C2 – lateral view; C3 – proximal view; D1 – centrodorsal, proximal view; D2 – lateral view; D3 – distal view. **E.** *Palaecomaster* cf. *karsensis* Radwańska, centrodorsal; E1 – distal view; E2 – lateral view; E3 – proximal view.

Table 2

Upper Jurassic comatulid crinoids, recorded from Poland

Comatulid taxa/ age/area	Characters of cup/ centrodorsal	Characters of basals/ radials	Characters of arms/ brachials/ pinnulars/ pinnules/stems	References
Semiometra pe-titclerci (Caillet, 1923)/Late Oxford-ian to early Kimme-ridgian/Couiavia and Łódź Depression	Centrodorsals small and low, slightly bowl-shaped, with a flat dorsal part. Ventral side concave. Edges of centrodorsal thin and limited to a single irregular whorl of cirrus sockets. Dorsal star prominent and composed of narrow, deep slits, and surro-unded by wide cirrus-free area. Remaining part of aboral sur-face covered by cirrus sockets, numbering about 27 in total. Cirrus sockets closely spaced, transversally oval in outline, moderately deep and adorned with small cirral lumen.	Basals distinctly exposed at interradial points. Radial ring high. Radials trapezoidal and tall. Articular facets deeply concave and reaching centro-dorsal edge only interradially. Aboral ligament pit low, wide and shallow. Interarticular ligament pits broadly triangu-lar and shallow. Adoral muscle fields deeply incised, tall. They are subtriangular. Radial cavity narrow, tube-shaped, and extended at upper edge along interradial suture.	–	Radwańska (2007); current study
Comatulina sp./ Kimmeridgian/Holy Cross Mountains and Łódź Depression	Centrodorsal small to large, low cylindrical, truncated coni-cal to truncated subhmeisphe-rical, up to 17 columns, con-sisting of 2 or 3 cirrus sockets. Cirri sockets large and oval, deeply incised, with a large lumen. Total number of cirrus sockets is 49. Adoral side of centrodorsal with a very narrow cavity. Aboral apex rounded or sharp.	–	–	Radwańska (2005); current study
Comatulina peroni (de Loriol, 1889)/ Kimmeridgian/Holy Cross Mountains	Centrodorsal moderately tall, truncated conical to discoi-dal. 15 columns of large and closely spaced cirrus sockets. Aboral side of the centrodorsal large, flat or slightly concave, and covered by granules. Cirrus sockets oval and deep. It has a large lumen. Centro-dorsal cavity is shallow.	Basals exposed at interradial points. Radial ring lower than the overhanging centrodorsal. Radials trapezoidal, with a very low free aboral surface, and distinctly undulated aboral margin. Articular facet of radials tall and oblique. Aboral ligament fossae low and with a large and oval ligament pit. Interarticular ligament fossae triangular. Adoral muscular fossae arc-shaped.	–	Radwańska (2005)
Comautlina malogostiana Radwańska, 2005/ Kimmeridgian/Holy Cross Mountains and Łódź Depression	Centrodorsal moderately tall, conically hemispherical. 15 columns of a 1 to 3 closely spaced cirrus sockets. Aboral side of centrodorsal pointed with a single, centrally placed cirrus socket, surroun-ded by 5 small ones. Cirrus sockets oval and deep and with a small lumen. Maximum number of cirrus sockets is 41.	Basals exposed in interradial points, rhomboidal in cross-section. Radial ring taller than centrodorsal and overhanging. Radials trapezoidal. They have a very high free aboral surface. Articular facet of radials tall and steep. Aboral ligament fossa large with a long and deep ligament pit. Interarti-cular ligament fossae tall and triangular. Adoral muscular fossae low, arc-shaped. Radial cavity large and deep.	–	Radwańska (2005); current study

Comatulid taxa/ age/area	Characters of cup/ centrodorsal	Characters of basals/ radials	Characters of arms/ brachials/ pinnulars/ pinnules/stems	References
Palaeocomaster sp./ Kimmeridgian/Holy Cross Mountains	Centrodorsal large, pentagonal in outline, low discoidal, with irregularly arranged cirrus sockets. Cirrus sockets not arranged in distinct columns. Centrodorsal aboral side large and flattened, concave, and covered by radial furrows. Cirrus sockets large and oval in outline, deeply incised. Their maximum number is 34.	–	–	Radwańska (2005)
Palaeocomaster karsensis Radwańska, 2005/Kimmeridgian/ Holy Cross Mountains	Centrodorsal large, discoidal with numerous deeply incised, relatively small cirrus sockets in maximum number of 50, not well arranged in distinct columns.	Basals invisible. Radial ring low, not overhanging. Radials with very low free aboral surface. Articular facet fairly steep.	–	Radwańska (2005)
Palaeocomaster cf. *karsensis* Radwańska, 2005/Kimmeridgian/Holy Cross Mountains	Centrodorsals low, discoidal, 5-sided, and truncated. Aboral apex is large and flat. Cirrus sockets do not appear to be very densely packed and do not form distinct columns. They are irregular. Radial cavity is moderately deep and very extensive.	Radials wide and concealed; their height corresponds to that of the centrodorsal. Ligament fossae triangular. Adoral muscle fossae small, triangular, or rarely reduced to narrow bands along adoral edge.	–	Borszcz *et al*. (2009); current study
Solanocrinites sp./ Kimmeridgian/Łódź Derpression	Centrodorsals 5-sided, truncated conical. Aboral apex flat or slightly concave. 10 columns consisting of 1 to 3 large and oval cirrus sockets. Cirrus sockets separated by ridges. Radial cavity moderately deep and extensive.	Basals rod-shaped and exposed interradially. Radials large, trapezoidal, steep, overhanging. Interarticular ligament area low. Adoral muscle fossae low and forming narrow bands along adoral edge or low triangular areas, separated by a median notch.	–	current study
Solanocrinites sanctacrucensis Radwańska, 2005/ Kimmeridgian/Holy Cross Mountains	Centrodorsals truncated conical. 10 columns of 3 and closely spaced cirrus sockets. Aboral side of centrodorsal sharply pointed. Cirrus sockets large, oval in outline with a large lumen.	Basals inconspicuous. Radial ring lower than centrodorsal and overhanging. Radials low trapezoidal, with moderately large aboral surface. Articular facet of radials relatively steep. Aboral ligament fossae large. Interarticular ligament fossae moderately tall and triangular in outline. Adoral muscular fossae low and arc-shaped. Radial cavity deep and large.	–	Radwańska (2005)
Thiolliericrinus flexuosus Goldfuss (1831, in 1826–1844)/Kimmeridgian/Łódź Derpression	Centrodorsal truncated conical, low, sometimes irregular. Proximal part of centrodorsal covered with distinct dorsal star. It has a single circlet, made up of few, mostly irregular cirrus sockets. Sockets small, in some cases larger with visible nerve canal, elliptical to circular in outline. Less or more	Basals covered with a porous calcitic plug.	Columnals barrel-shaped, high. The most proximal columnal rosette-like. They have straight or concave latera. Articular facet circular or ellipsoidal. Fulcral ridge serrated in some columnals.	

Comatulid taxa/ age/area	**Characters of cup/ centrodorsal**	**Characters of basals/ radials**	**Characters of arms/ brachials/ pinnulars/ pinnules/stems**	**References**
	widely separated. Some of the sockets replaced by structureless fossae. Free surface of the centrodorsal between the cirrus sockets smooth. Facet to stem large and circular. Radial cavity small and circular.		Marginal ridge twinned, with twins almost perpendicular to each other on both sides of the columnal. Lumen small and circular.	current study
Solonaerium cf. *sigillatum* (Quenstedt, 1876)/ Kimmeridgian/Łódź Derpression	Centrodorsal truncated conical, stellate in proximal part, with extremely large and closely touch cirrus sockets, arranged in 10 columns of 2 or 3 sockets per column. Majority of cirrus sockets have distinct fulcral ridge and large nerve canal. Aboral apex rounded. Central cavity small and circular, protruding. Facet to stem large, circular, covering almost the entire distal part of the centrodorsal. Nerve canal small and circular. Fulcral ridge narrow and raised.	–	–	current study
Thiolliericrinidae gen. et sp. indet./ Tithonian/Outer Carpathians	–	–	Columnals are of varying size, mainly discoidal, rarely barrel-shaped, sub-cylindrical or hourglass-shaped. Articular facet circular or ellipsoidal. Fulcral ridge may be serrated. Marginal ridge twinned, with twins almost perpendicular to each other on both sides of columnal. Lumen small and circular.	Salamon *et al.* (2020)

Other comatulids from the Jurassic of Poland

Salamon and Zatoń (2007) documented two comatulid taxa from the Middle Jurassic (Bathonian) deposits of the Polish Jura Chain in southern Poland. Their material included brachial plates exhibiting syzygial articulations on the distal side, which were tentatively assigned to *Paracomatula helvetica* Hess, 1951. However, this taxonomic attribution should be treated with caution, as similar articulation types are also present in several Jurassic isocrinid taxa, rendering precise identification based solely on articulation morphology problematic. Notably, the illustrated specimens also include a centrodorsal confidently referred to *Palaeocomaster* sp., suggesting the presence of multiple comatulid lineages within the assemblage.

Subsequently, Salamon (2008b) described additional comatulid remains from the Middle Jurassic (Callovian) black clay deposits of the Łuków area in eastern Poland. Among the material were brachial plates with syzygial articulations, provisionally assigned to Paracomatulidae sp. et gen. indet. However, as with the Bathonian material, this assignment remains tentative due to overlapping morphological features among comatulid and isocrinid taxa. In the same study, Salamon (2008b) also figured a centrodorsal element attributed to *Palaeocomaster* sp., further supporting the occurrence of this genus in the Polish Jurassic (see Tab. 3 for specimen details).

CONCLUSIONS

Crinoids represent a conspicuous component of the benthic macrofauna within the Kimmeridgian strata of the Łódź Depression (central Poland). However, until recently, the record from this region was strikingly depauperate regarding free-living comatulids, with only a single taxon formally identified. The present study addresses this gap through the first comprehensive documentation of disarticulated and partially articulated comatulid remains, revealing a taxonomically diverse assemblage that includes *Solanocrinites* sp.,

Table 3

Jurassic comatulid crinoids, recorded from Poland.

Comatulid taxa/age/area	**Characters of cup/centrodorsal**	**Characters of basals/ radials**	**Characters of arms/ brachials/ pinnulars/ pinnules/ stems**	**References**
Palaeocomaster sp./ Bathonian/Polish Jura Chain	Centrodorsal low, circular, with a large cirrus-free on the dorsal area. Radial cavity wide and circular. Articulum high and steep, with triangular interarticular ligament fossae. Dorsal side convex, with 3 irregular marginal circles and 12 cirrus sockets in total. Cirrus sockets large. Radial cavity deep.	Basal rod-shaped, exposed in the interradial point.	–	Salamon and Zatoń (2007)
Palaeocomaster sp./ Callovian/*Łuków* clays	Centrodorsal low, pentagonal in outline, with irregularly arranged cirrus sockets. Radial cavity narrow and circular. Aboral apex flattened. Dorsal side strongly abraded. Cirrus sockets large and small, oval or circular in outline.	–	–	Salamon (2008b)

Comatulina sp., *Palaeocomaster* cf. *karsensis* Radwańska, and *Semiometra petitclerci* (Caillet). These taxa co-occur with stalked representatives of the family Thiolliericrinidae, notably *Thiolliericrinus flexuosus* Goldfuss and *Solonaerium* cf. *sigillatum* (Quenstedt), the latter representing the first documented occurrences of these species in Poland.

To date, a total of 21 stalked crinoid taxa have been recognized from the Polish Kimmeridgian, comprising 9 isocrinids, 5 millericrinids, and 7 cyrtocrinids. This diversity profile underscores the ecological complexity and tiering strategies of Late Jurassic echinoderm communities on the northern periphery of the Tethys Ocean. With the addition of 11 comatulid taxa, the crinoid assemblage now exhibits a previously underestimated diversity, extending not only the taxonomic spectrum but also providing critical insights into the macroevolutionary dynamics of comatulid radiation during the Late Jurassic.

Moreover, the documentation of *Palaeocomaster* sp., previously recorded from the Bathonian of the Polish Jura Chain and the Callovian of the Łuków Clays, reflects a broader temporal and palaeogeographic distribution of this genus across the Polish segment of the Tethyan shelf. This suggests evolutionary persistence and ecological plasticity across multiple depositional settings and tectonosedimentary regimes.

The stratigraphic distribution of crinoid remains reveals a marked concentration within a pivotal sedimentary interval corresponding to the transition between two evolutionary stages of the epicontinental platform in central Poland. These include: (i) the late Oxfordian–early Kimmeridgian phase of carbonate-dominated platform sedimentation (up to the Hypselocyclum Zone), and (ii) the early Kimmeridgian onset of marl-dominated deposition (Hypselocyclum–Divisum zones), demarcated by a regionally extensive hardground indicative of sedimentary condensation and early diagenetic cementation under reduced sedimentation rates.

Crinoid remains are especially abundant within sponge-bivalve-oncoid biostromal limestones and associated thin-bedded marls to marly limestones. These facies are interpreted as mid- to outer-ramp deposits formed under relatively low-energy, open-marine conditions during a pronounced phase of eustatic transgression. These strata record not only the palaeoecological context of crinoid diversification but also reflect broader palaeogeographic and climatic dynamics operating across the northern Tethyan margin during the Late Jurassic.

The data contribute to a growing body of evidence challenging previous assumptions about the provinciality and ecological homogeneity of Kimmeridgian crinoid communities in Central Europe, revealing instead a complex, dynamic, and taxonomically rich benthic system that awaits further high-resolution palaeobiological and stratigraphic investigation.

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