

Fig. 146. 1–30, *Discretella discreta* (Müller, 1956). 1–3, MPC25133, from KC01-11. 4–6, MPC25134, from KC01-12. 7–9, MPC25135, from KC01-12. 10–12, MPC25136, from KC01-12. 13–15, MPC25137, from KC01-12. 16–18, MPC25138, from KC01-13. 19–21, MPC25139, from KC01-13. 22–24, MPC25140, from KC02-02. 25–27, MPC25141, from PK01-02. 28–30, MPC25142, from PK01-02. 31–33, *Discretella robustus* (Wang and Wang, 1976), MPC25143, from BT01-03.

1983), Jabal Safra, Oman (Orchard, 2005), British Columbia, Canada (Beranek *et al.*, 2010), and Canadian Arctic (*Euflemingites romunderi* Zone, Orchard, 2008).

***Discretella robustus*** (Wang and Wang, 1976)

Figs. 146.31–146.33, 147–150

?*Ctenognathus discreta* Müller, 1956, p. 821, pl. 95, fig. 24.

*Cratognathodus robustus* Wang and Wang, 1976, p. 397, pl. 3, figs. 21–25.

*Cratognathodus robustus* Wang and Z. H. Wang, 1976. Tian *et al.*, 1983, p. 347, pl. 88, figs. 8, 9.

*Neospathodus discreta* (Müller, 1956). Buryi, 1979, p. 52, pl. 7, figs. 2–6.

*Guangxidella? robustus* (Wang and Wang, 1976). Orchard, 2007a, fig. 1.

**Material examined:** Two specimens, MPC25143, 25144, from BT01-03, four specimens, MPC25145–25148, from BT01-04, six specimens, MPC25149–25154, from BT01-06, one specimen, MPC25155, from BT01-07, four specimens, MPC25156–25159, from BT01-10, one specimen, MPC25160, from BT01-12, five specimens, MPC25161–25165, from BT01-14, four specimens, MPC25166–25169, from BT01-15, two specimens, MPC25170, 25171, from BT02-01, eight specimens, MPC25172–25179, from BT02-02, two specimens, MPC25180, 25181, from BT02-03, two specimens, MPC25182, 25183, from KC01-01, two specimens, MPC25184, 25185, from KC01-10, and one specimen, MPC25186, from KC02-03.

**Description:** Segminate elements 0.43–1.69 mm in length, average 0.64 mm; 0.26–0.91 mm in height, average 0.41 mm; length to height ratio 1.0–2.4, average 1.6 for forty-four specimens. General profile of element triangular or trapezoidal, highest point situated at posterior one-third to posterior margin. Lower margin of element almost straight, posterior part downturned in those specimens whose lower margins are bowed. Almost discrete denticles vary in number from 4 to 13, average 8, sub-erect or gradually reclined posteriorly.

Cusp longer and two times larger than other denticles, bears one to 4 small denticles at posterior end. Element shows sigmoidal shape in lower view. Flared basal cavity sub-rounded and concave with a thin pit. Anterior groove continues to posterior end.

**Remarks:** Typical elements of *Discretella robustus* (Wang and Wang, 1976) have a strongly reclined large posterior cusp with two or three small posterior denticles, exhibits a sigmoidal shape in the lower view, and differs from those of typical *D. discreta* (Müller, 1956). *Ctenognathus discreta* (Müller, 1956, pl. 98, fig. 24) is somewhat similar to *D. robustus*, but it is questionable whether they are conspecific because the cusp of *C. discreta* is broken and the lower view is not illustrated.

**Occurrence:** Described specimens from BT01-03, BT01-04, BT01-06, BT01-07, BT01-10, BT01-12, BT01-14, BT01-15, BT02-01, BT02-01, BT02-03, KC01-01, KC01-10 and KC02-03 within the portion of the *Novispathodus* ex gr. *waageni* Zone that includes the *Flemingites rursiradiatus* beds (lowest Middle Smithian=middle Lower Olenekian), *Urdoceras tulongensis* beds (lower Middle Smithian=middle Lower Olenekian) and *Owenites koeneni* beds (middle Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the Middle Smithian in Nevada (*Meekoceras* beds, Müller, 1956), Qomolangma, Tibet (Wang and Wang, 1976; Tian *et al.*, 1983), and South Primorye, Russia (*Parachirognathus-Furnishius* Zone, Buryi, 1979).

***Discretella* sp. indet. A**

Fig. 151.1–151.18

*Discretella discreta* (Müller, 1956). Bondarenko *et al.*, 2013, p. 60, figs. 7.1, 7.2.

**Material examined:** Two specimens, MPC25187, 25188, from BT02-02, one specimen, MPC25189, from KC01-10, two specimens, MPC25190, 25191, from KC02-02, and

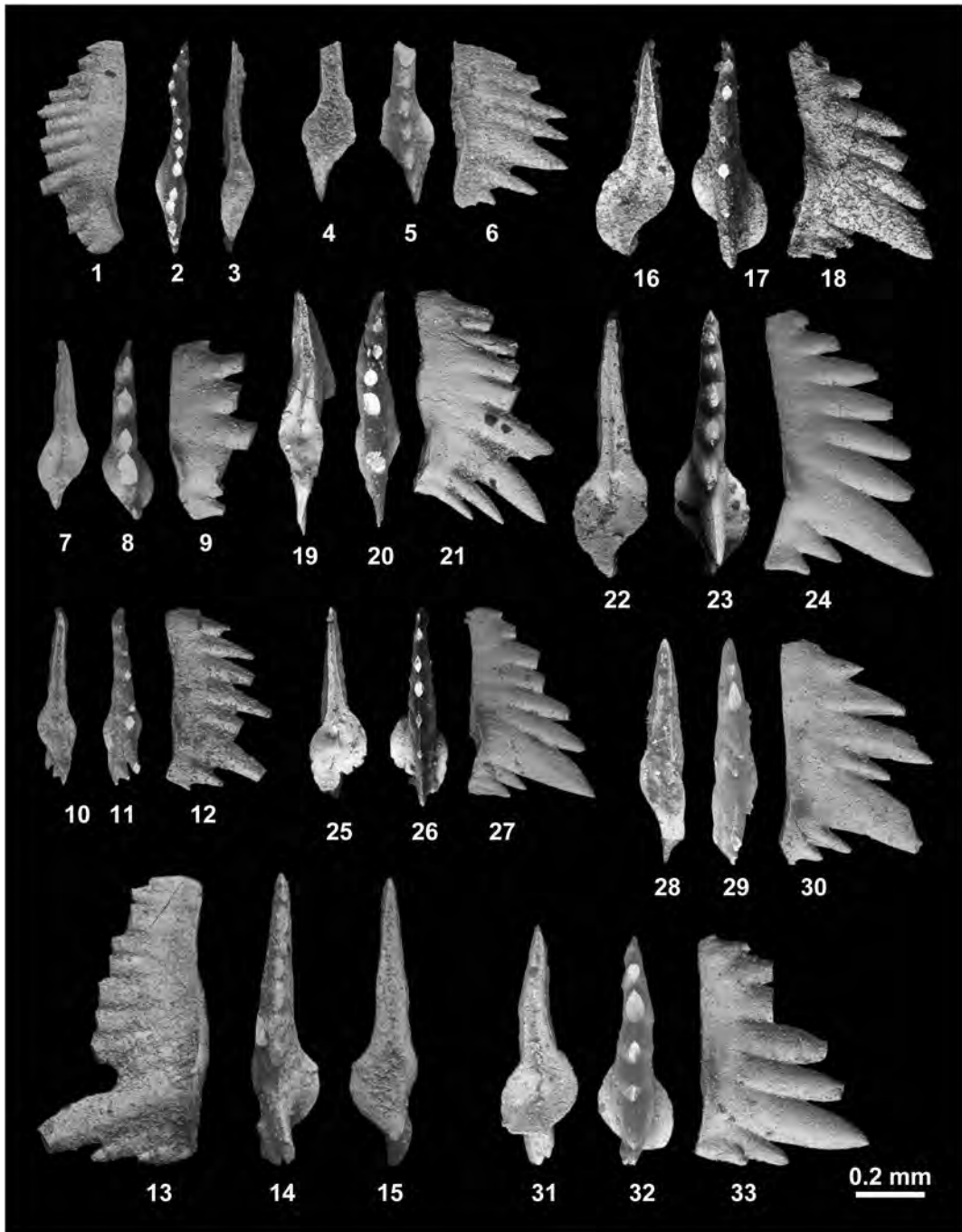


Fig. 147. *Discretella robustus* (Wang and Wang, 1976). 1–3, MPC25144, from BT01-03. 4–6, MPC25145, from BT01-04. 7–9, MPC25146, from BT01-04. 10–12, MPC25147, from BT01-04. 13–15, MPC25148, from BT01-04. 16–18, MPC25149, from BT01-06. 19–21, MPC25150, from BT01-06. 22–24, MPC25151, from BT01-06. 25–27, MPC25152, from BT01-06. 28–30, MPC25153, from BT01-06. 31–33, MPC25154, from BT01-06.

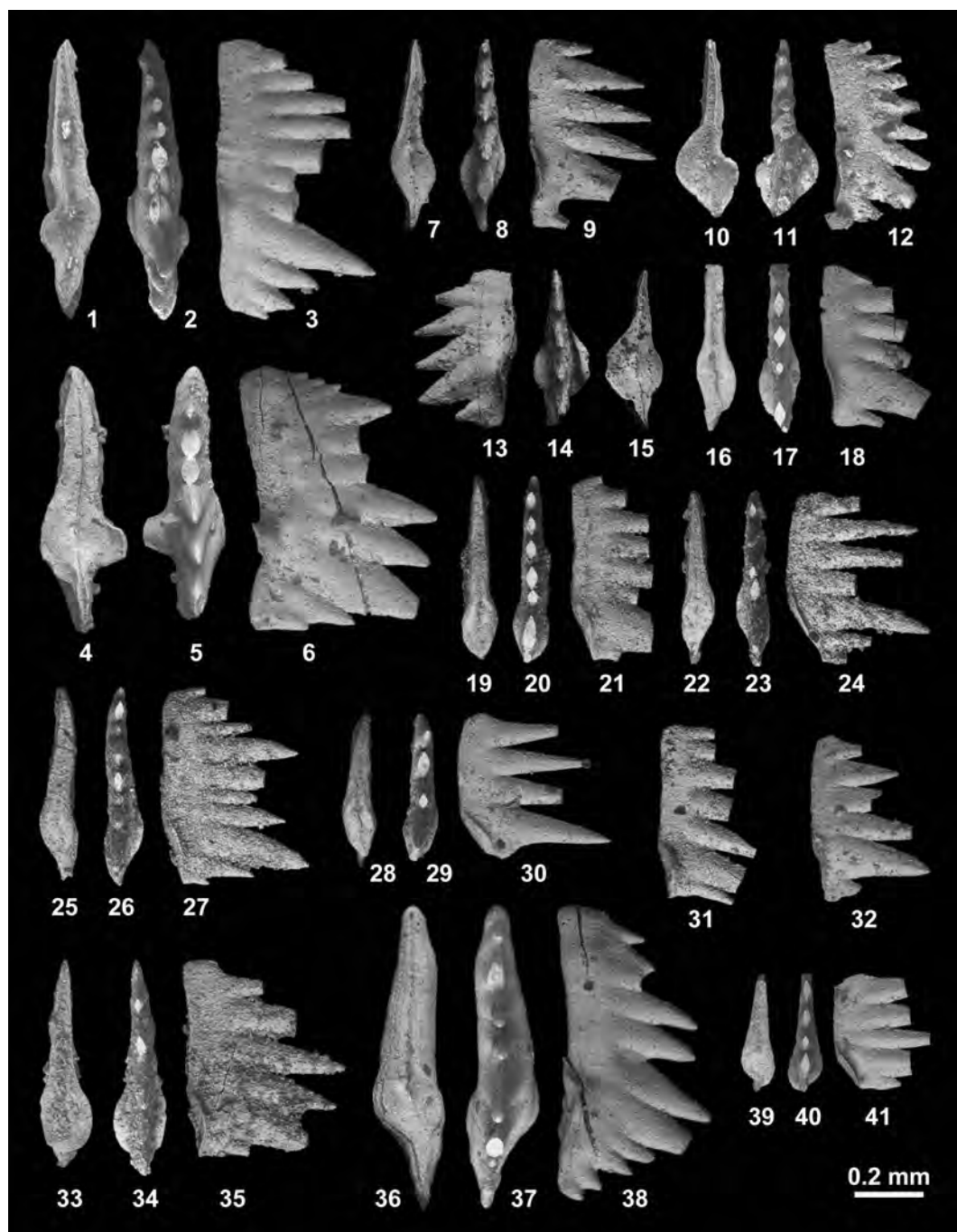


Fig. 148. *Discretella robustus* (Wang and Wang, 1976). 1–3, MPC25155, from BT01-07. 4–6, MPC25156, from BT01-10. 7–9, MPC25157, from BT01-10. 10–12, MPC25158, from BT01-10. 13–15, MPC25159, from BT01-10. 16–18, MPC25160, from BT01-12. 19–21, MPC25161, from BT01-14. 22–24, MPC25162, from BT01-14. 25–27, MPC25163, from BT01-14. 28–30, MPC25164, from BT01-14. 31, MPC25165, from BT01-14. 32, MPC25166, from BT01-15. 33–35, MPC25167, from BT01-15. 36–38, MPC25168, from BT01-15. 39–41, MPC25169, from BT01-15.



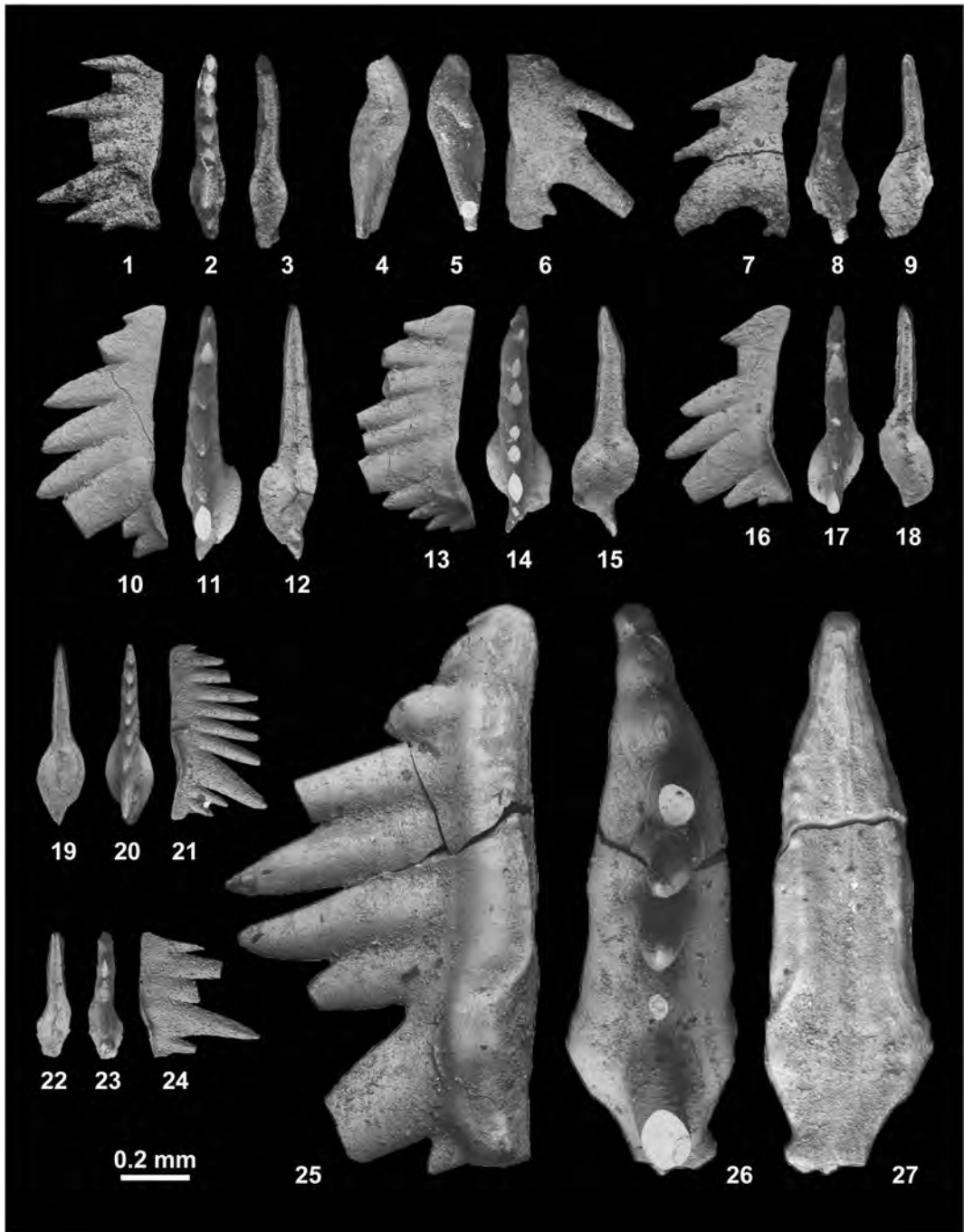


Fig. 149. *Discretella robustus* (Wang and Wang, 1976). 1–3, MPC25170, from BT02-01. 4–6, MPC25171, from BT02-01. 7–9, MPC25172, from BT02-02. 10–12, MPC25173, from BT02-02. 13–15, MPC25174, from BT02-02. 16–18, MPC25175, from BT02-02. 19–21, MPC25176, from BT02-02. 22–24, MPC25177, from BT02-02. 25–27, MPC25178, from BT02-02.

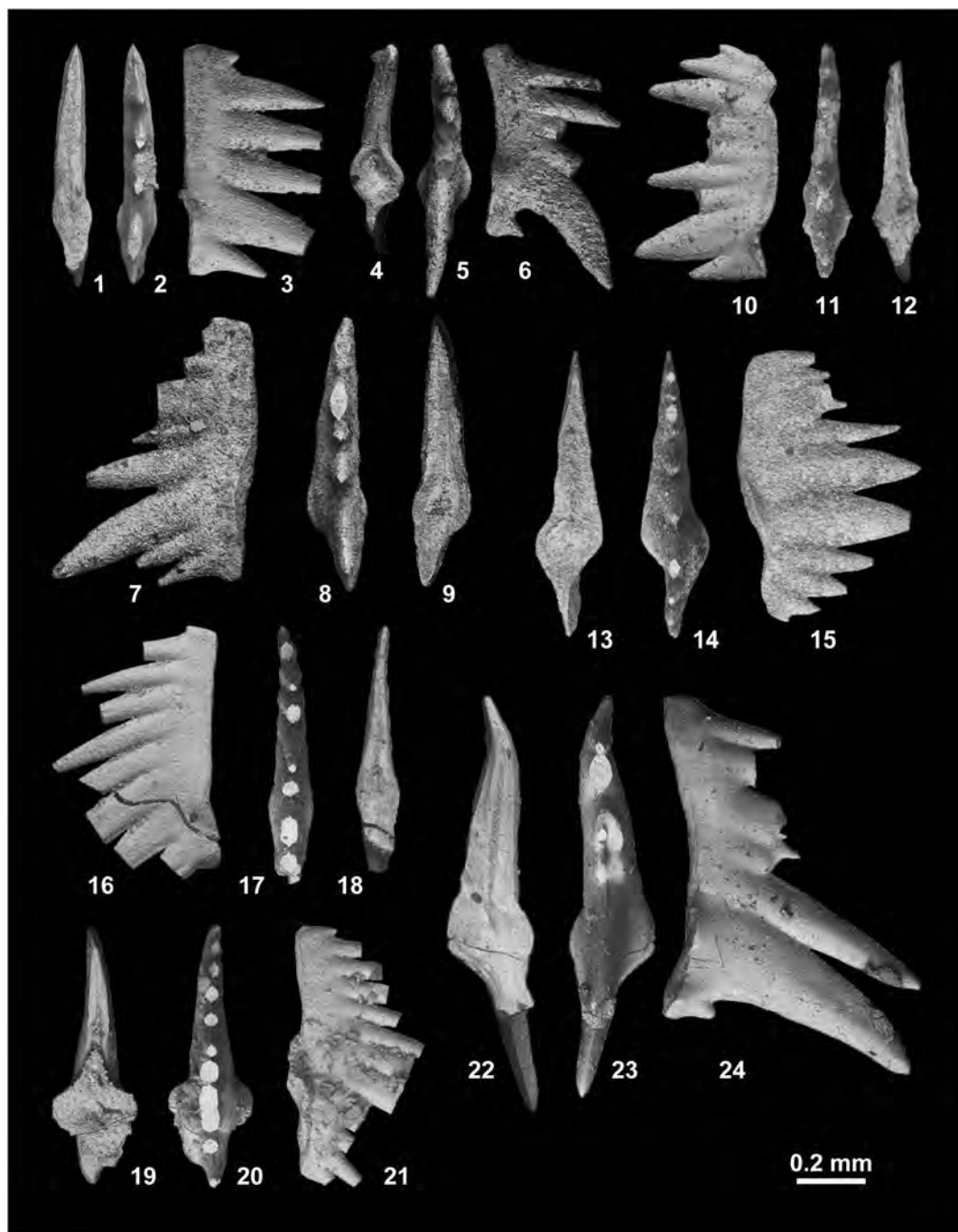


Fig. 150. *Discretella robustus* (Wang and Wang, 1976). 1–3, MPC25179, from BT02-02. 4–6, MPC25180, from BT02-03. 7–9, MPC25181, from BT02-03. 10–12, MPC25182, from KC01-01. 13–15, MPC25183, from KC01-01. 16–18, MPC25184, from KC01-10. 19–21, MPC25185, from KC01-10. 22–24, MPC25186, from KC02-03.

one specimen, MPC25192, from KC02-03.

*Description:* Triangular segminate elements 0.43–0.73 mm in length, average 0.57 mm; 0.31–0.58 mm in height, average 0.49 mm; length to height ratio 0.7–1.4, average 1.2 for six specimens. Discrete, triangular denticles vary in number from 3 to 5, average 4, revealing showing gradual size increase posteriorly. Largest denticle twice the size of others, and strongly inclined posteriorly. Small, triangular marginal process situated at posterior end. Lower margin generally straight or weakly upturned in anterior part, and downturned or slightly deflected upward in posterior part. Element exhibits sigmoidal shape in lower view. Sub-rounded basal cavity elongated posteriorly. Shallow furrow extends from basal pit to anterior end.

*Remarks:* The described specimens are triangular in lateral view and sigmoidal in lower view. These features indicate a close phylogenetic relationship with *Discretella robustus* (Wang and Wang, 1976). The first appearance of *D. sp. indet. A* occurs higher than that of *D. robustus* in the Bac Thuy Formation. This evidence suggests that *D. sp. A* probably evolved from *D. robustus* during early Middle Smithian time.

The number of denticles on the described specimens apparently decreases with younger-aged taxa. Specimens from the *Urdoceras tulongensis* beds have five denticles, but those from the *Owenites koeneni* beds bear only four denticles. The size of the cusp also gradually increases in younger-aged taxa.

Specimens described as *Discretella discreta* (Müller, 1956) from South Primorye, Russia by Bondarenko *et al.* (2013, p. 60, Fig. 7.1, 7.2) are identical to *D. sp. indet. A*.

*Occurrence:* Described specimens from BT02-02, KC01-10, KC02-02 and KC02-03 within the portion of the *Novispathodus ex gr. waageni* Zone that includes the *Urdoceras tulongensis* beds (lower Middle Smithian=middle Lower Olenekian) and the *Leyeceras* and the *Guodunites* horizons of the *Owenites koen-*

*eni* beds (middle to upper Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the *Anasibirites nevolini* Zone (Upper Smithian) in South Primorye, Russia (Bondarenko *et al.*, 2013).

#### *Discretella* sp. indet. B

Fig. 151.19–151.24

*Material examined:* Two specimens, MPC25193, 25194, from BT01-03.

*Description:* Two laterally compressed segminate elements 0.53–0.56 mm in length; 0.32–0.36 mm in height; length to height ratio 1.6–1.7. Laterally compressed, erect spine-like denticles total 9 and 11 in number. Cusp situated in middle part of element. Denticle size gradually decreases both anteriorly and posteriorly. Basal margin shows biangular shape in lateral view. Anterior part of elements appears sigmoidal or straight in lower view. Basal cavity sub-rounded and elongated posteriorly. Shallow groove extends from basal pit to anterior end.

*Remarks:* Described specimens have completely discrete denticles and a sub-rounded basal cavity. These features are common in *Discretella discreta* (Müller, 1956). However, the biangular lateral shape of the element is similar to that of *Conservatella conservativa* (Müller, 1956). Thus, this feature indicates that these specimens are probably ancestral to *C. conservativa*.

*Occurrence:* Described specimens from BT01-03 within the portion of the *Novispathodus ex gr. waageni* Zone in the *Flemingites rursiradiatus* beds (lowest Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

#### *Discretella* sp. indet. C

Fig. 151.25–151.28

*Material examined:* One specimen, MPC25195, from BT01-07.

*Description:* Anterior branched segminate

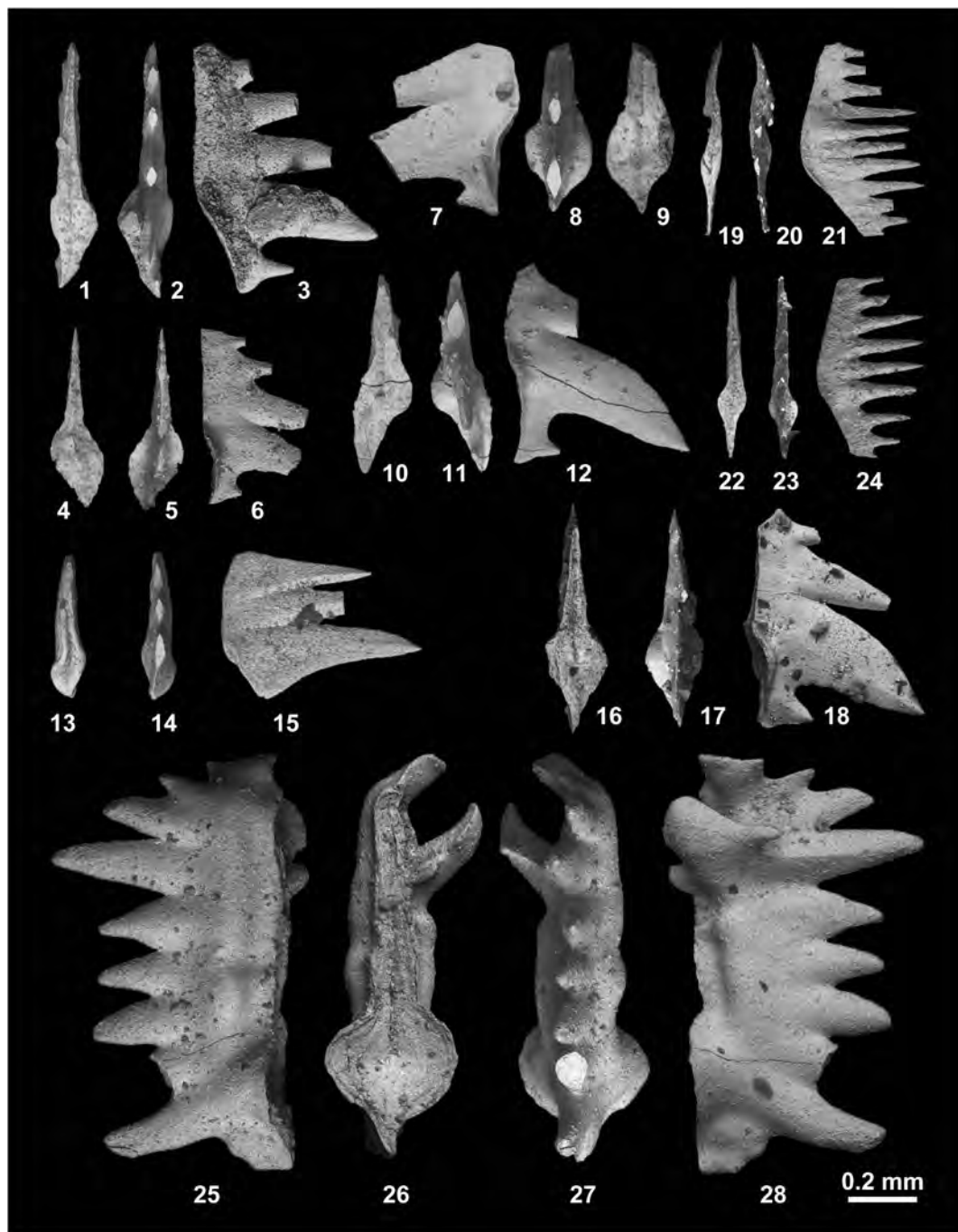


Fig. 151. 1–18, *Discretella* sp. indet. A. 1–3, MPC25187, from BT02-02. 4–6, MPC25188, from BT02-02. 7–9, MPC25189, from KC01-10. 10–12, MPC25190, from KC02-02. 13–15, MPC25191, from KC02-02. 16–18, MPC25192, from KC02-03. 19–24, *Discretella* sp. indet. B from BT01-03. 19–21, MPC25193. 22–24, MPC25194. 25–28, *Discretella* sp. indet. C, MPC25195, from BT01-07.



element 1.23 mm in length; 0.68 mm in height; length to height ratio 1.8. Upper edge consists of node-like robust discrete denticles, with cusp situated in one-third of anterior and posterior (posterior cusp lost). Denticles total 11 in number, including two small, barely remaining posterior denticles. Denticle size decreases from cusp anteriorly and posteriorly, and same in middle part. Lower margin straight. Prominent lateral rib developed. Anterior margin turns 60 degrees to the left in upper view. Branch cusp extends in parallel with anterior margin from left side of anterior one-third, and then turns anteriorly in upper view. Rounded basal cavity situated in posterior with a deep pit in lower view. Broad, deep furrow extends anteriorly and branched at anterior one-third.

*Remarks:* The discrete denticles, including the small posterior ones and the rounded basal cavity suggest that the described specimen belongs to the genus *Discretella*, but no definitive assignment can be made.

*Occurrence:* Specimen from BT01-07 within the portion of the *Novispathodus* ex gr. *waageni* Zone between the *Flemingites rursiradiatus* beds (lowest Middle Smithian = middle Lower Olenekian) and *Urduyceras tulongensis* beds (lower Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

***Discretella* sp. indet. D**

Fig. 152.1–152.6

*Material examined:* Two specimens, MPC25196, 25197, from BT01-07.

*Description:* Two segminate elements 1.0–1.36 mm in length; 0.51–0.67 mm in height; length to height ratio 2.0. General profile of element triangular, slightly bowed lower edge. Upper edge bears several pointed denticles, including one larger posterior cusp with one or two small processes. Cusp three times larger than other denticles, with two pronged ends. Denticles total 9 in number. Lower edge

straight in anterior, downturned in posterior below cusp. Aboral surface broad with rounded basal cavity below cusp. Groove extended to both anterior and posterior ends through basal pit.

*Remarks:* The described specimens differ from other species of *Discretella* in having two pronged cusps and an arched basal margin. However, a definitive species assignment cannot be made due to an insufficient number of specimens. Their lateral profiles are somewhat similar to that of *Guangxidella bransoni* (Müller, 1956), except for the small posterior processes.

*Occurrence:* Described specimens from BT01-07 within the portion of the *Novispathodus* ex gr. *waageni* Zone between the *Flemingites rursiradiatus* beds (lowest Middle Smithian = middle Lower Olenekian) and *Urduyceras tulongensis* beds (lower Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

***Discretella* sp. indet. E**

Fig. 152.7–152.9

*Material examined:* One specimen, MPC25198, from BT01-10.

*Remarks:* The described specimen lacks the anterior part, but it differs from other species of *Discretella* in having a rectangular shaped element, small pole-like denticles, and a triangular shaped posterior cusp.

*Occurrence:* Specimen from BT01-10 within the portion of the *Novispathodus* ex gr. *waageni* Zone between the *Urduyceras tulongensis* beds (lower Middle Smithian = middle Lower Olenekian) and *Leyceras* horizon of the *Owenites koeneni* beds (middle Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

***Discretella* sp. indet. F**

Fig. 152.10–152.12

*Material examined:* One specimen, MPC25199, from BT01-15.

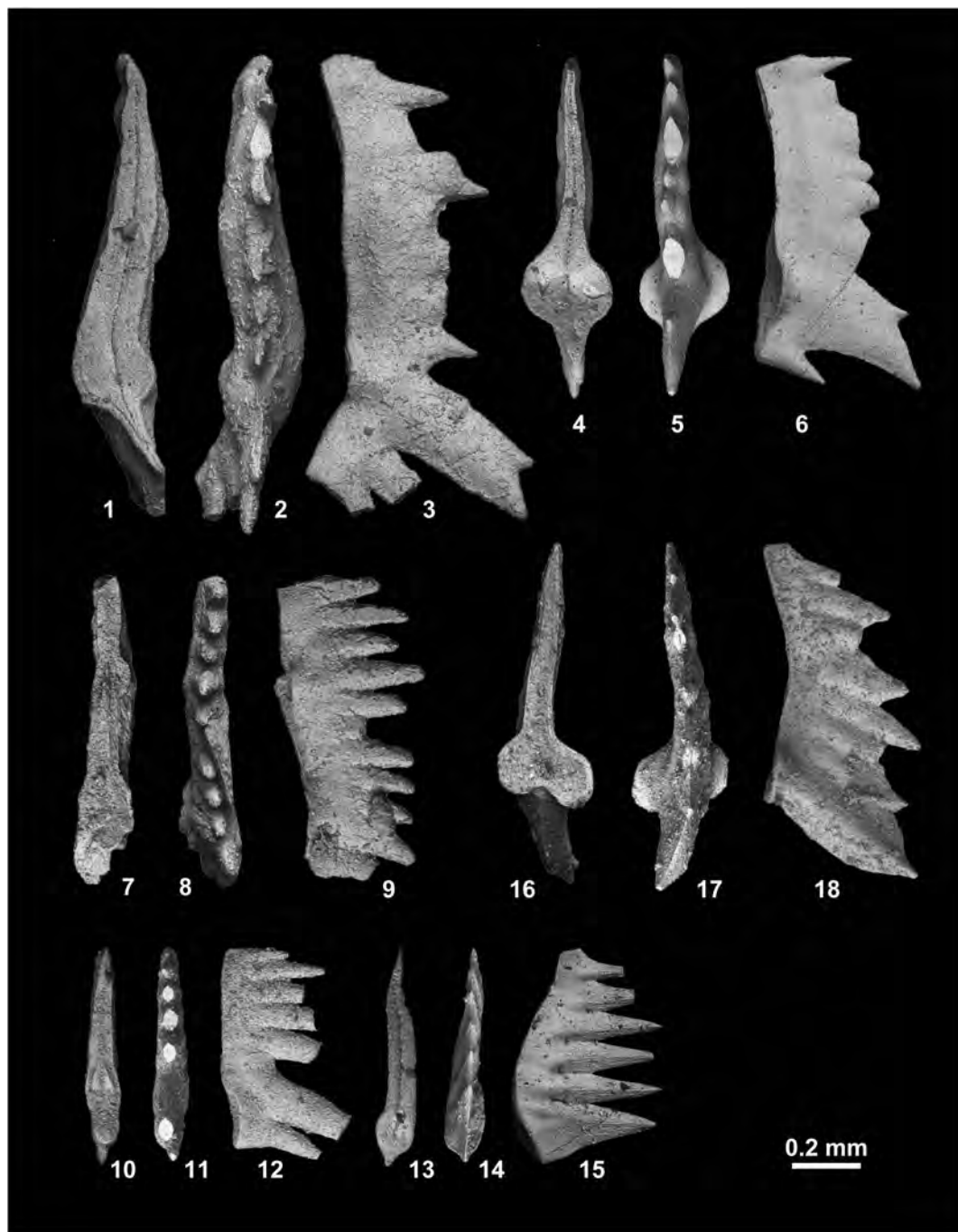


Fig. 152. 1–6, *Discretella* sp. indet. D from BT01-07. 1–3, MPC25196. 4–6, MPC25197. 7–9, *Discretella* sp. indet. E, MPC25198, from BT01-10. 10–12, *Discretella* sp. indet. F, MPC25199, from BT01-15. 13–15, *Discretella* sp. indet. G, MPC25200, from KC02-02. 16–18, *Guangxidella bransoni* (Müller, 1956), MPC25201, from BT01-06.

**Remarks:** The lateral profile of this specimen is similar to that of *Discretella robustus* (Wang and Wang, 1976), but it differs by having a space in front of the cusp and a non-expanded basal cavity.

**Occurrence:** Specimen from BT01-15 within the portion of the *Novispathodus* ex gr. *waageni* Zone above the *Leyceceras* horizon of the *Owenites koeneni* beds (middle Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

***Discretella* sp. indet. G**

Fig. 152.13–152.15

**Material examined:** One specimen, MPC25200, from KC02-02.

**Description:** Laterally compressed segminate element 0.63 mm in length; 0.44 mm height; length to height ratio 1.4. Erect denticles total 6 in number. Lower margin upturned in anterior two-thirds and posterior one-third. Rounded basal cavity slightly wider than the width of element. Shallow groove extends from basal pit to anterior end.

**Remarks:** The described specimen is distinguished from other species of *Discretella* by the strongly upturned anterior lower margin, straight denticles and small basal cavity.

**Occurrence:** Described specimen from KC02-02 within the portion of the *Novispathodus* ex gr. *waageni* Zone represented by the *Guodunites* horizon of the *Owenites koeneni* beds (upper Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Genus ***Gunagxidella*** Zhang and Yang, 1991

**Type species:** *Neoprioniodus bransoni* Müller, 1956.

***Guangxidella bransoni* (Müller, 1956)**

Figs. 152.16–125.18, 153–159, 160.1–160.4

*Neoprioniodus bransoni* Müller, 1956, p. 829, pl. 95, figs. 19–21.

*Neoprioniodus bicuspidatus* Müller, 1956, p. 828, pl. 95,

figs. 16–17.

*Neospathodus bicuspidatus* (Müller, 1956). Solien, 1979, p. 302, pl. 3, figs. 2–3.

*Ozarkordina gigantea* Bui, 1989, p. 409, pl. 31, figs. 10, 14.

multielement apparatuses, *Guangxidella typica* Zhang and Yang, 1991, p. 33, pl. 1, figs. 1a-b, 2a-b.

**Material examined:** Three specimens, MPC25201–25203, from BT01-06, four specimens, MPC25204–25207, from BT01-10, two specimens, MPC25208, 25209, from BT01-14, seven specimens, MPC25210–25216, from BT01-15, six specimens, MPC25217–25222, from BT02-02, ten specimens, MPC25223–25232, from BT02-03, eight specimens, MPC25233–25240, from BT03-01, six specimens, MPC25241–25246, from KC01-07, two specimens, MPC25247, 25248, from KC01-10, and nine specimens, MPC25249–25257, from PK01-02.

**Description:** Bowed segminate elements 0.43–1.45 mm in length, average 0.76 mm; 0.25–0.78 mm in height, average 0.40 mm; length to height ratio 1.3–2.6, average 1.9 for fifty-seven specimens. Bowed carina bears pointed denticles in upper part and more or less in concave lower part. Spine and node-like denticles vary in number from 5 to 12, average 8. Most denticles almost entirely discrete in small specimens, but fused over half of the length in large specimens. Denticle size increases posteriorly. Cusp situated in posterior end, and is two to three times larger than others. Sub-rounded or rectangular, cordiform-like basal cavity branches at posterior end. Width of basal cavity two times width of element. Deep furrow extends from basal pit to anterior end.

**Remarks:** The described specimens show a wide range of intraspecific variation in the form of denticles and basal cavity. However, all specimens share features characterized by the bow-like lateral form and cusp situated in the posterior end. They also include forms (MPC25202, 25211, 25214, etc.) that are very similar to the holotype of *Guangxidella bran-*

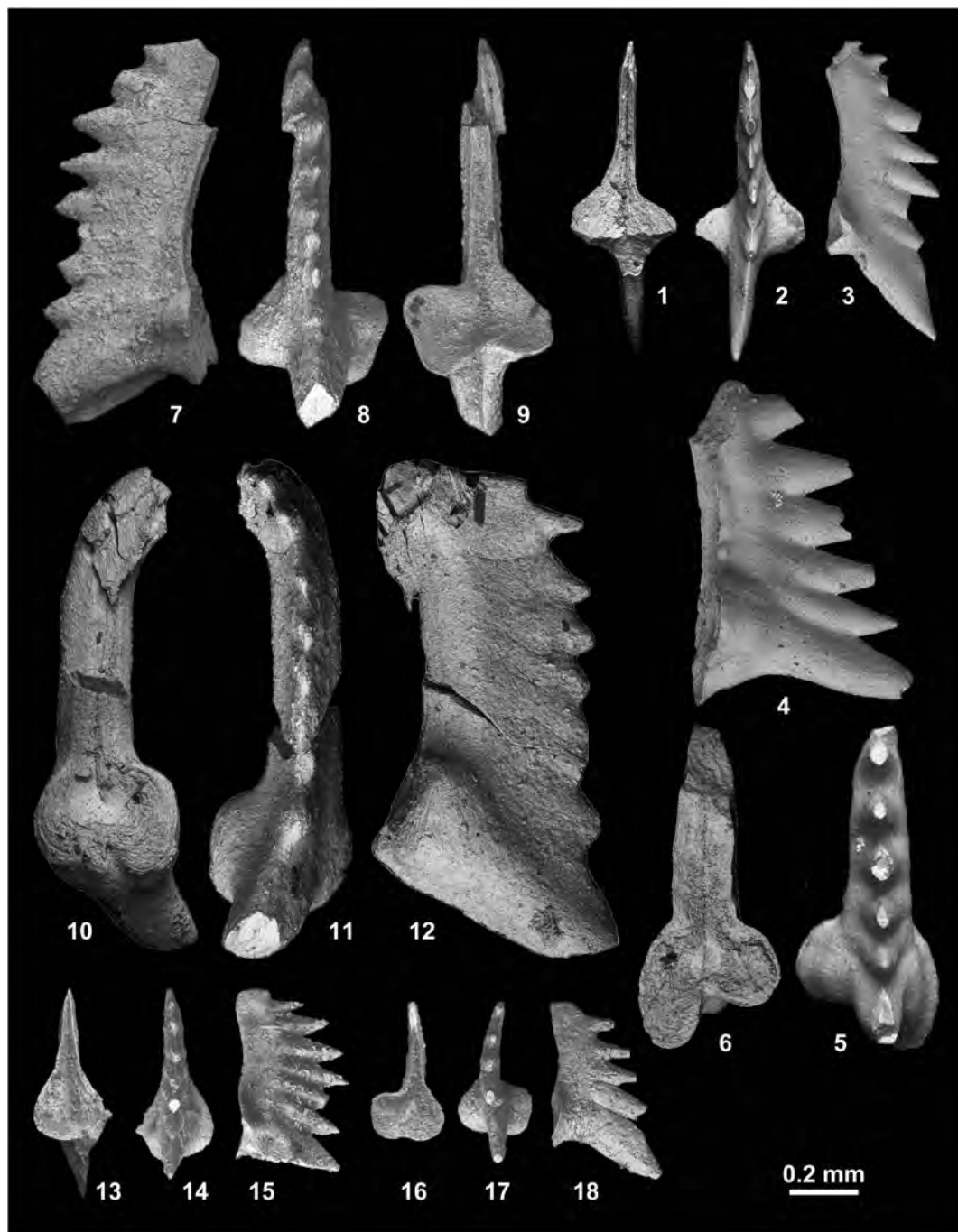


Fig. 153. *Guangxidella bransoni* (Müller, 1956). 1–3, MPC25202, from BT01-06. 4–6, MPC25203, from BT01-06. 7–9, MPC25204, from BT01-10. 10–12, MPC25205, from BT01-10. 13–15, MPC25206, from BT01-10. 16–18, MPC25207, from BT01-10.



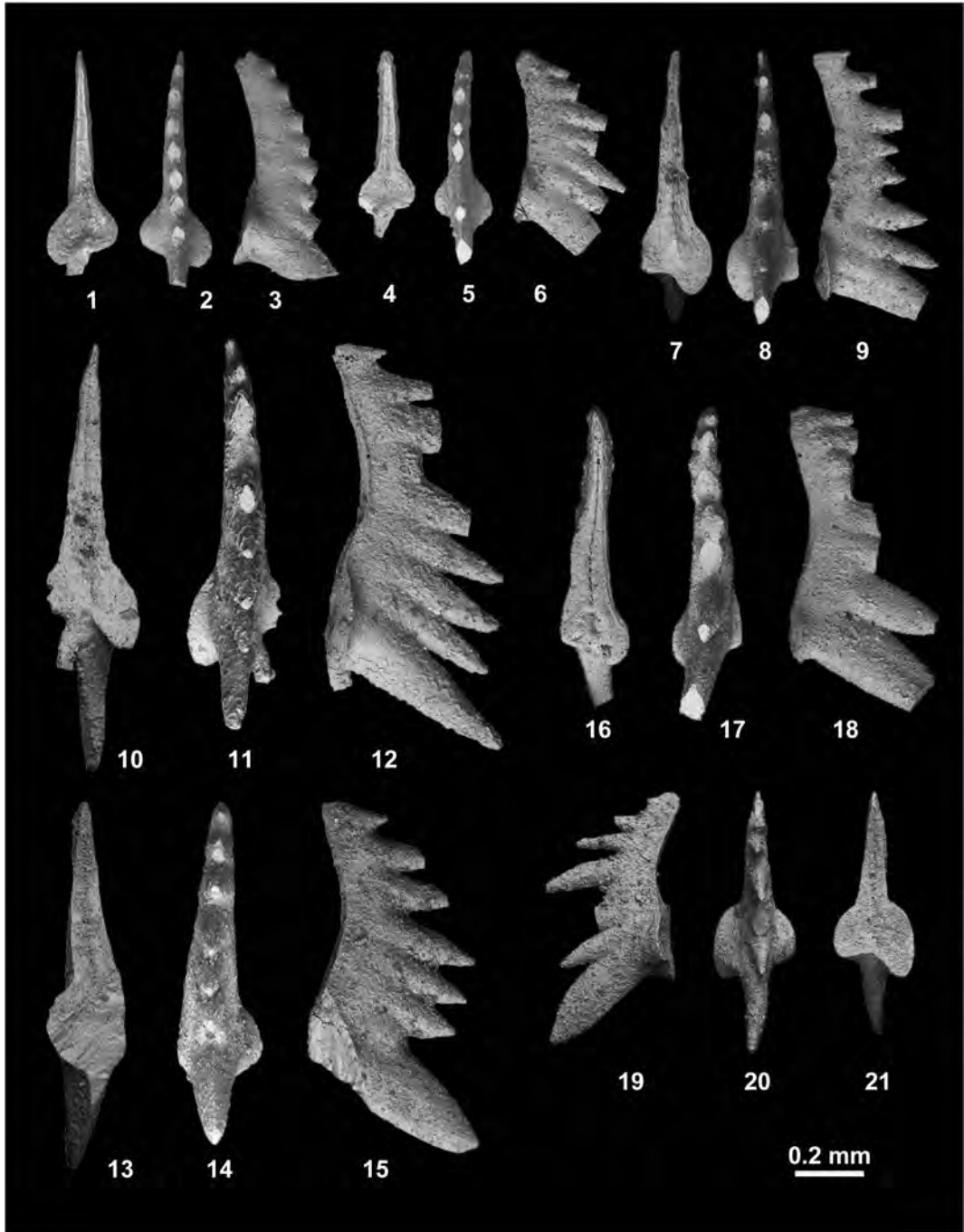


Fig. 154. *Guangxidella bransoni* (Müller, 1956). 1–3, MPC25208, from BT01-14. 4–6, MPC25209, from BT01-14. 7–9, MPC25210, from BT01-15. 10–12, MPC25211, from BT01-15. 13–15, MPC25212, from BT01-15. 16–18, MPC25213, from BT01-15. 19–21, MPC25214, from BT01-15.

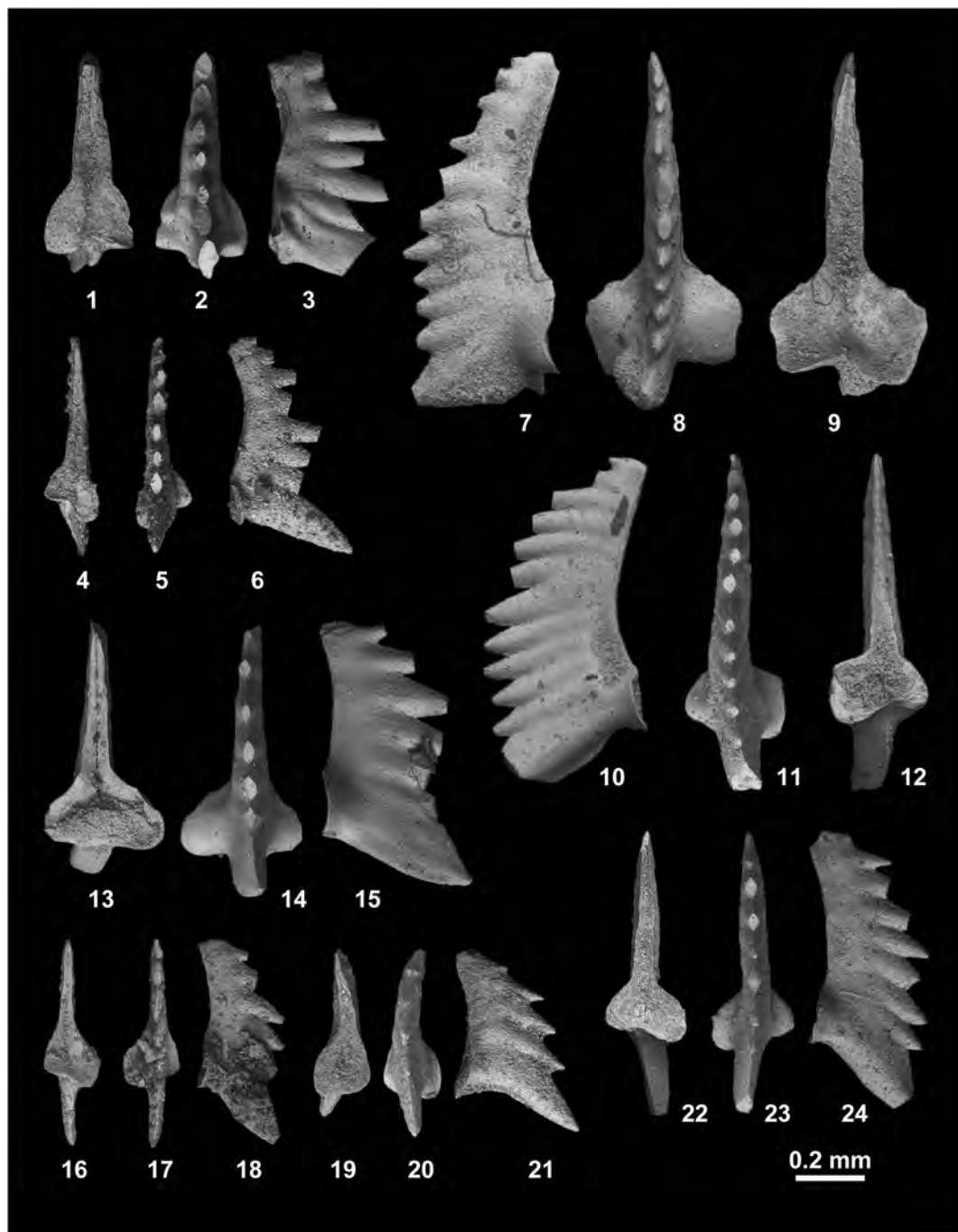


Fig. 155. *Guangxidella bransoni* (Müller, 1956). 1–3, MPC25215, from BT01-15. 4–6, MPC25216, from BT01-15. 7–9, MPC25217, from BT02-02. 10–12, MPC25218, from BT02-02. 13–15, MPC25219, from BT02-02. 16–18, MPC25220, from BT02-02. 19–21, MPC25221, from BT02-02. 22–24, MPC25222, from BT02-02.

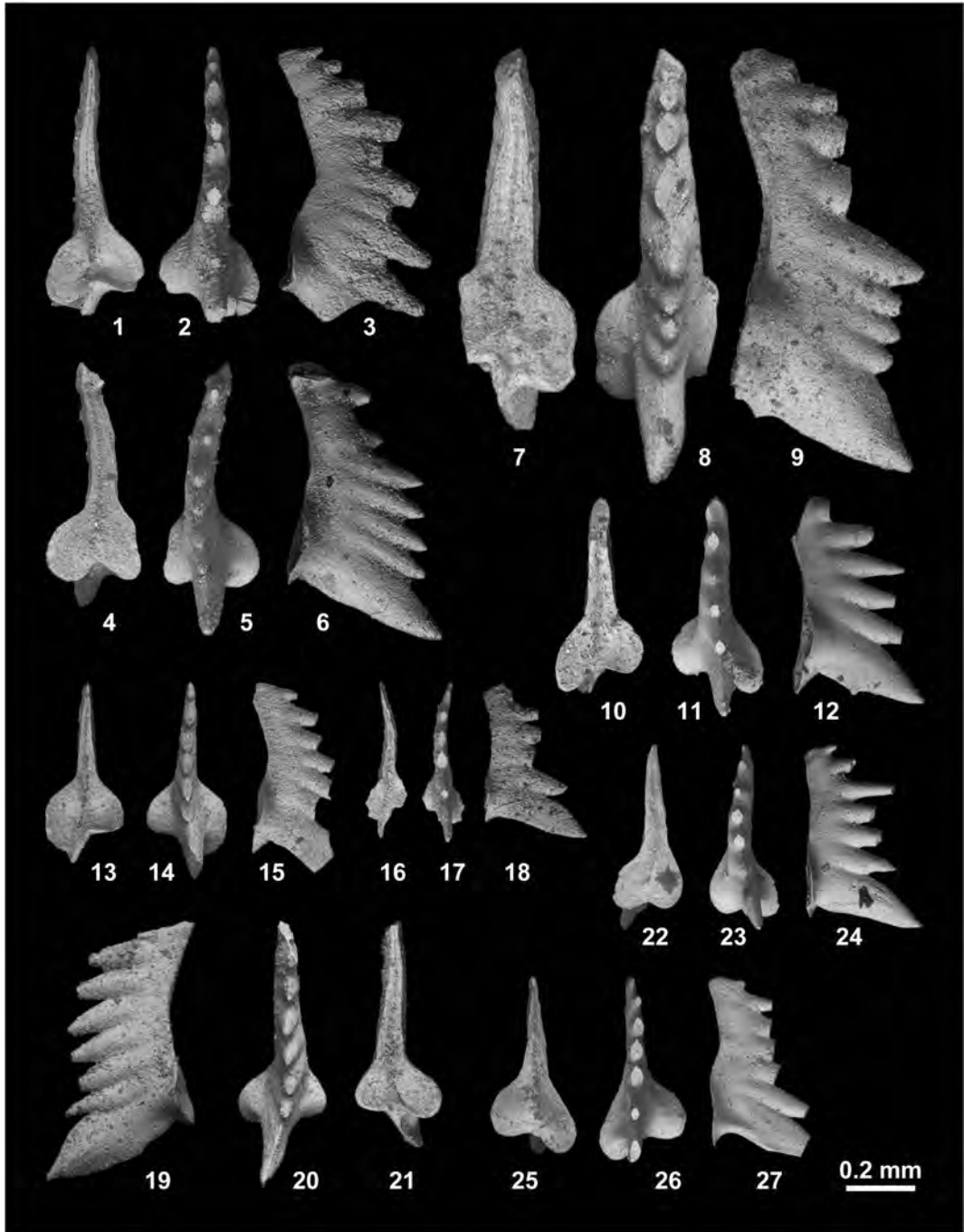


Fig. 156. *Guangxidella bransoni* (Müller, 1956) from BT02-03. 1–3, MPC25223. 4–6, MPC25224. 7–9, MPC25225. 10–12, MPC25226. 13–15, MPC25227. 16–18, MPC25228. 19–21, MPC25229. 22–24, MPC25230. 25–27, MPC23231.

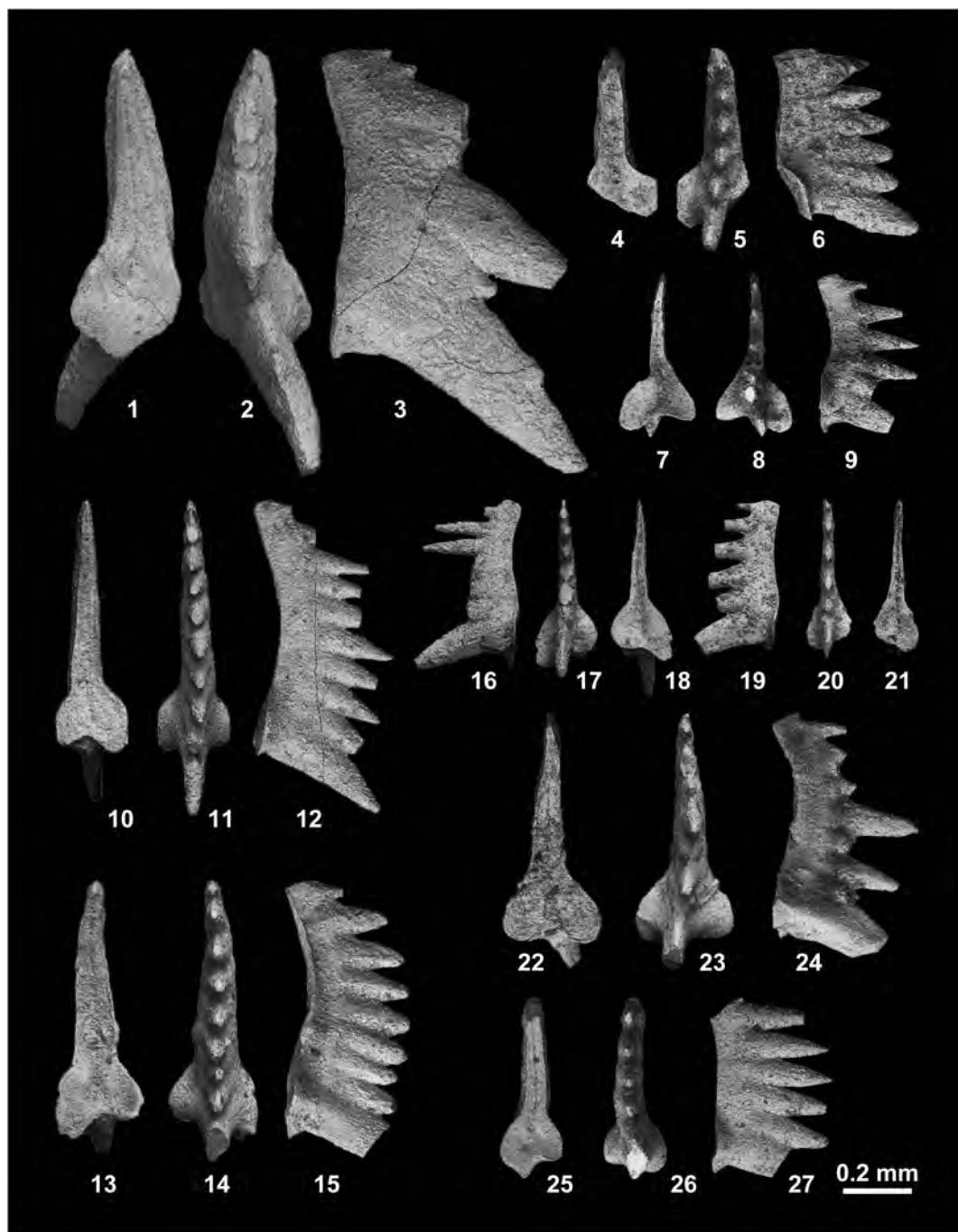


Fig. 157. *Guangxidella bransoni* (Müller, 1956). 1–3, MPC25232, from BT02-03. 4–6, MPC25233, from BT03-01. 7–9, MPC25234, from BT03-01. 10–12, MPC25235, from BT03-01. 13–15, MPC25236, from BT03-01. 16–18, MPC25237, from BT03-01. 19–21, MPC25238, from BT03-01. 22–24, MPC25239, from BT03-01. 25–27, MPC25240, from BT03-01.



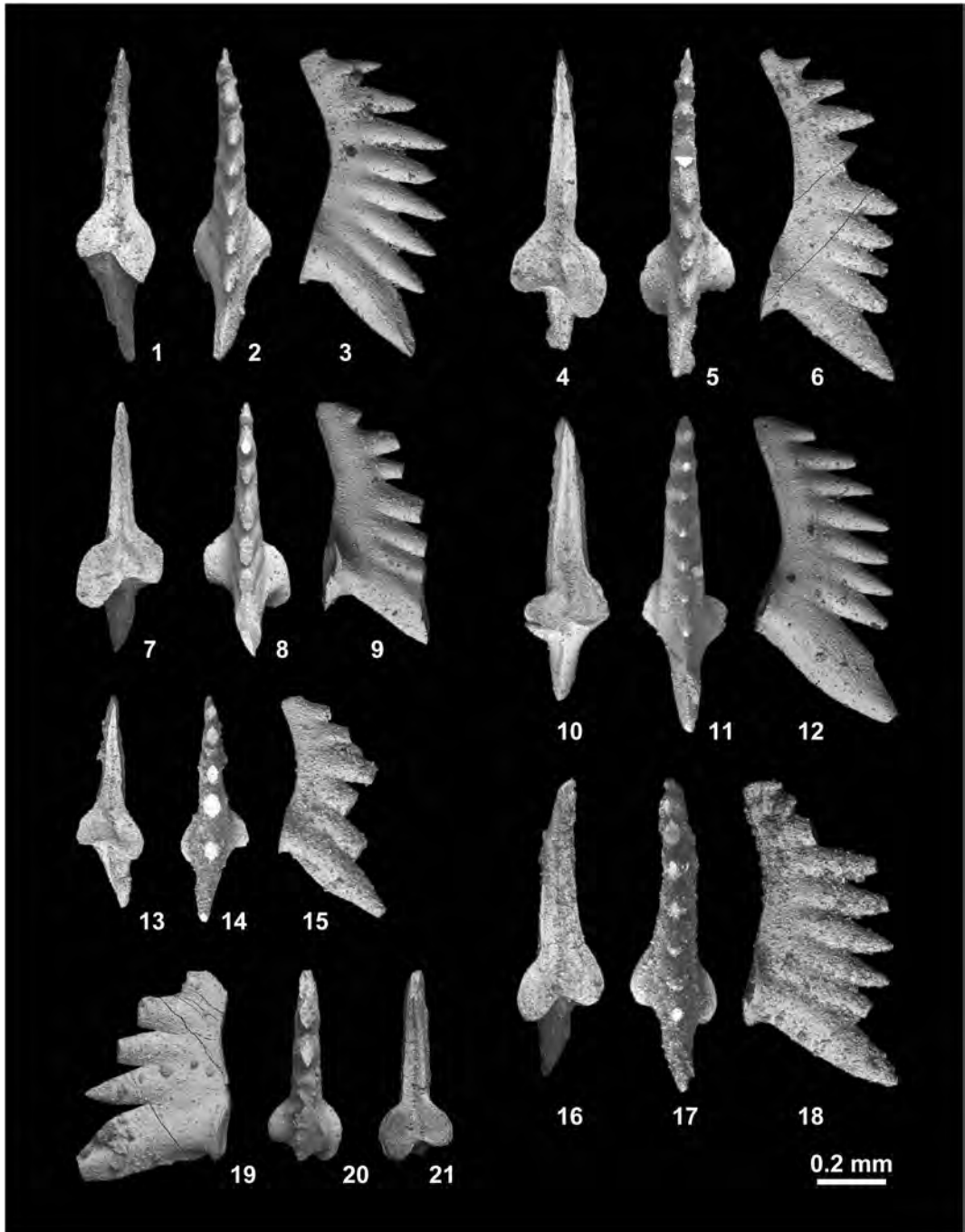


Fig. 158. *Guangxidella bransoni* (Müller, 1956). 1–3, MPC25241, from KC01-07. 4–6, MPC25242, from KC01-07. 7–9, MPC25243, from KC01-07. 10–12, MPC25244, from KC01-07. 13–15, MPC25245, from KC01-07. 16–18, MPC25246, from KC01-07. 19–21, MPC25247, from KC01-10.

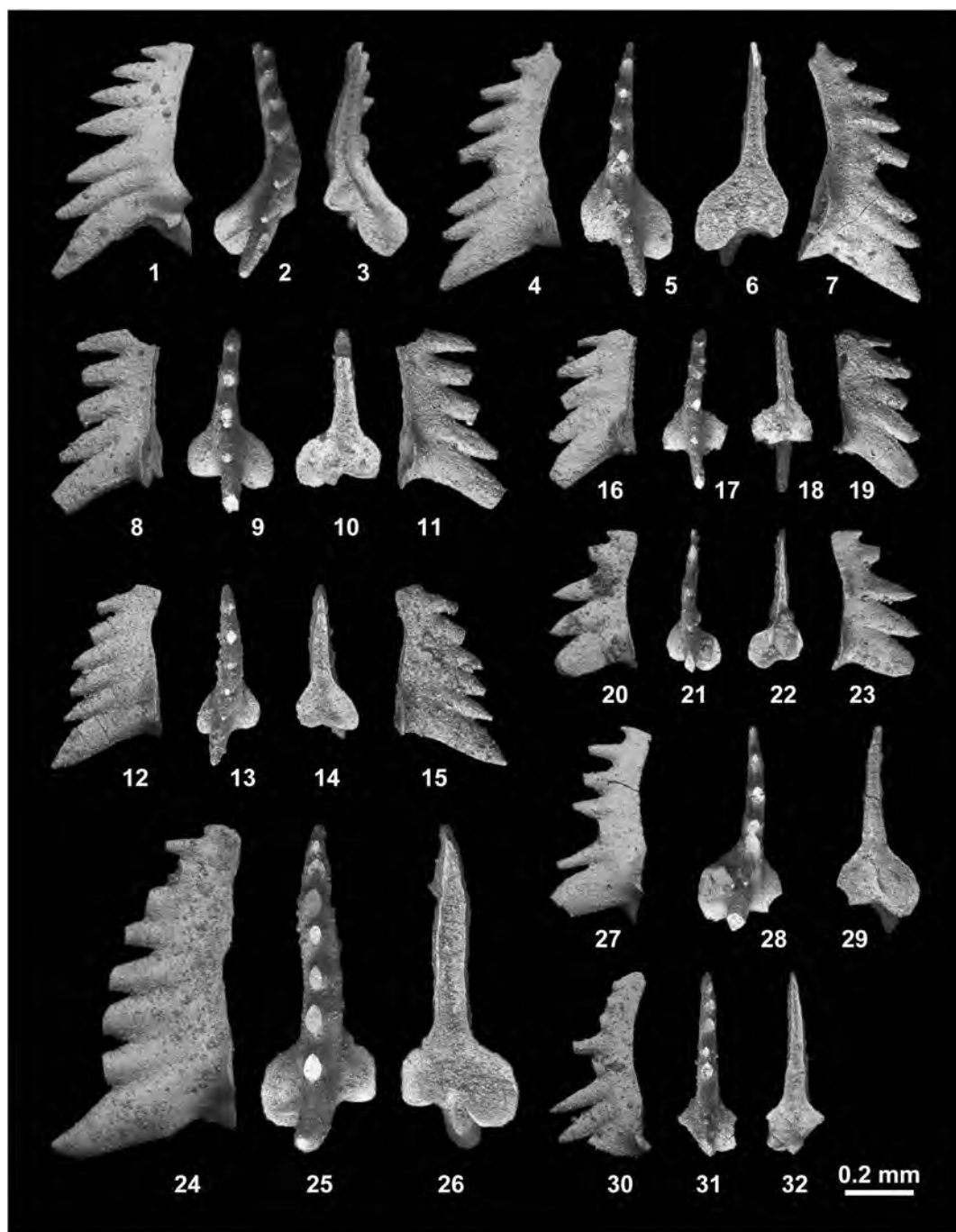


Fig. 159. *Guangxidella bransoni* (Müller, 1956). 1–3, MPC25248, from KC01-10. 4–7, MPC25249, from PK01-02. 8–11, MPC25250, from PK01-02. 12–15, MPC25251, from PK01-02. 16–19, MPC25252, from PK01-02. 20–23, MPC25253, from PK01-02. 24–26, MPC25254, from PK01-02. 27–29, MPC25255, from PK01-02. 30–32, MPC25256, from PK01-02.

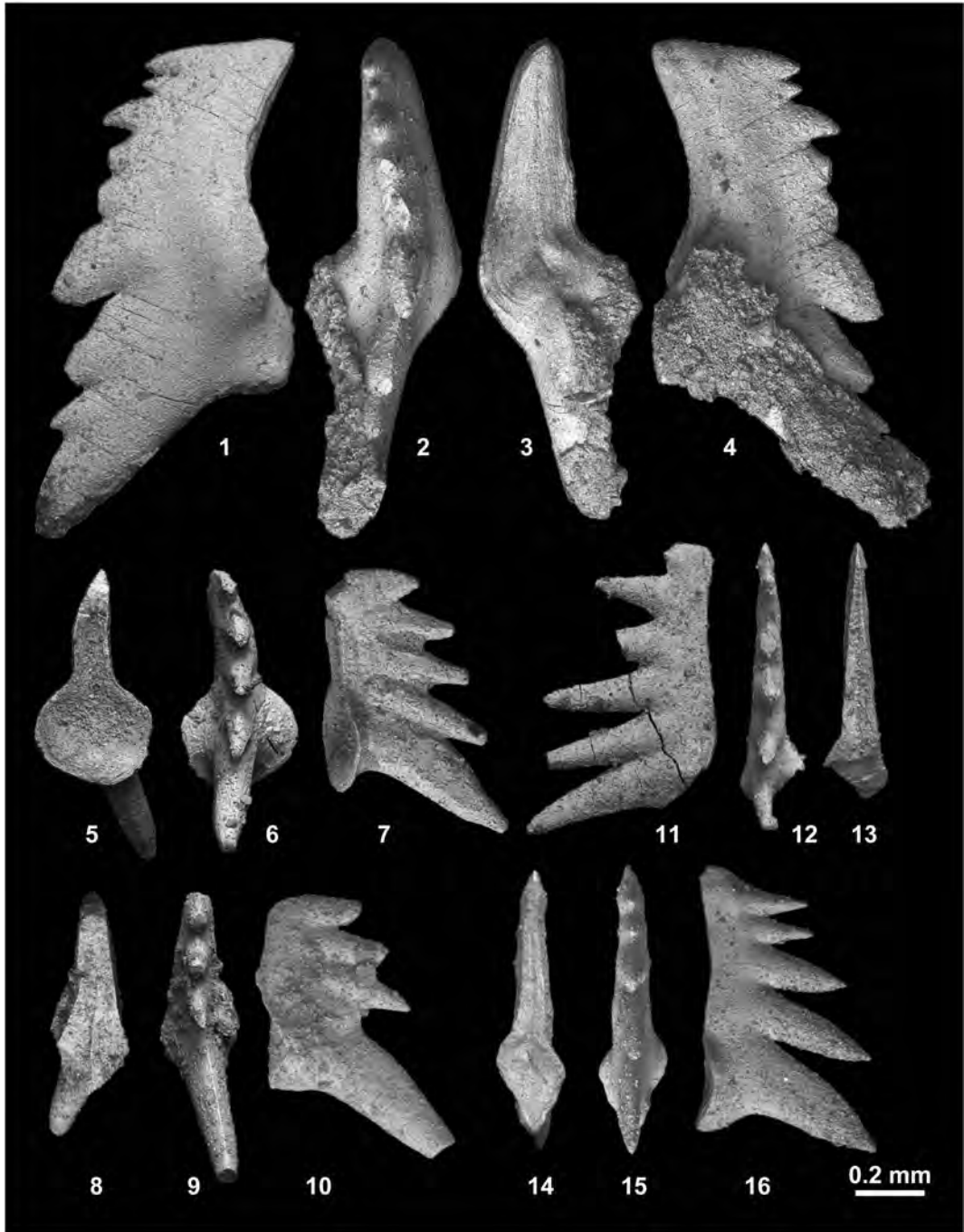


Fig. 160. 1–4, *Guangxidella bransoni* (Müller, 1956), MPC25257, from PK01-02. 5–10, *Guangxidella* sp. indet. A from BT01-06. 5–7, MPC25258. 8–10, MPC25259. 11–16, *Guangxidella* sp. indet. B. 11–13, MPC25260, from BT02-02. 14–16, MPC25261, from KC01-07.

*soni* (Müller, 1956, pl. 95, figs. 20, 21).

*Occurrence:* Described specimens from BT01-06, BT01-10, BT01-14, BT01-15, BT02-02, BT02-03, BT03-01, KC01-07, KC01-10 and PK01-02 within the portion of the *Novispathodus* ex gr. *waageni* Zone that includes the *Urdoceras tulongensis* beds (lower Middle Smithian=middle Lower Olenekian) and the *Leyceceras* horizon of the *Owenites koeneni* beds (middle Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the Middle Smithian at Crittenden Springs, Nevada (*Meekoceras* beds, Müller, 1956), the Luolou Formation, Guangxi, China (*Neospathodus waageni* Zone, Zhang and Yang, 1991), the Thaynes Formation, Utah (*Parachirognathus* Zone, Solien, 1979) and the Tahoe limestone, Southwest Japan (unpublished).

***Guangxidella* sp. indet. A**

Fig. 160.5–160.10

*Material examined:* Two specimens, MPC25258, 25259, from BT01-06.

*Description:* Two triangular segminate elements 0.76 mm in length; 0.54–0.56 mm in height; length to height ratio 1.4. Robust denticles total 4 and 5 in number, reclined posteriorly. Cusp situated in posterior end, three times larger than other denticles. Rounded basal cavity expanded in posterior end. Shallow groove extends from basal pit to anterior end.

*Remarks:* The described specimens are very similar to the juvenile form of *Guangxidella bransoni* (Müller, 1956), but differ in having a larger element size, robust denticles and a rounded basal cavity.

*Occurrence:* Described specimens from BT01-06 within the portion of the *Novispathodus* ex gr. *waageni* Zone between the *Flemingites rursiradiatus* beds (lowest Middle Smithian=middle Lower Olenekian) and *Urdoceras tulongensis* beds (lower Middle Smithian=

middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

***Guangxidella* sp. indet. B**

Figs. 160.11–160.16, 161.1–161.3

*Material examined:* One specimen, MPC25260, from BT02-02, one specimen, MPC25261, from KC01-07, and one specimen MPC25262, from KC01-11.

*Description:* Three triangular segminate elements 0.63–0.84 mm in length, average 0.77 mm; 0.43–0.55 mm in height, average 0.50 mm; length to height ratio 1.5–1.6. Lower margin slightly concave and down-turned posteriorly. Completely discrete and pointed denticles total 5 to 6 in number. Denticle size and inclination gradually increases posteriorly. Cusp situated in posterior end. Sub-rounded basal cavity extends posteriorly. Shallow furrow runs from basal pit to anterior end.

*Remarks:* The described specimens differ from *Guangxidella bransoni* (Müller, 1956) by slightly bowed elements with quite discrete denticles and non-branched basal cavity, and from *Guangxidella* sp. indet. A. by a smaller basal cavity and slender lateral form.

*Occurrence:* Described specimens from BT02-02, KC01-07 and KC01-11 within the portion of the *Novispathodus* ex gr. *waageni* Zone that includes the *Urdoceras tulongensis* beds (lower Middle Smithian=middle Lower Olenekian) and the *Leyceceras* horizon of the *Owenites koeneni* beds (middle Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Subfamily Neogondolellinae Hirsch, 1994

Genus *Eurygnathodus* Staesche, 1964

*Type species:* *Eurygnathodus costatus* Staesche, 1964.

***Eurygnathodus costatus* Staesche, 1964**

Fig. 161.4–161.6

*Eurygnathodus costatus* Staesche, 1964, p. 269, pl. 28, figs. 1–6; Budurov and Pantic, 1973, p. 51, pl. 1,



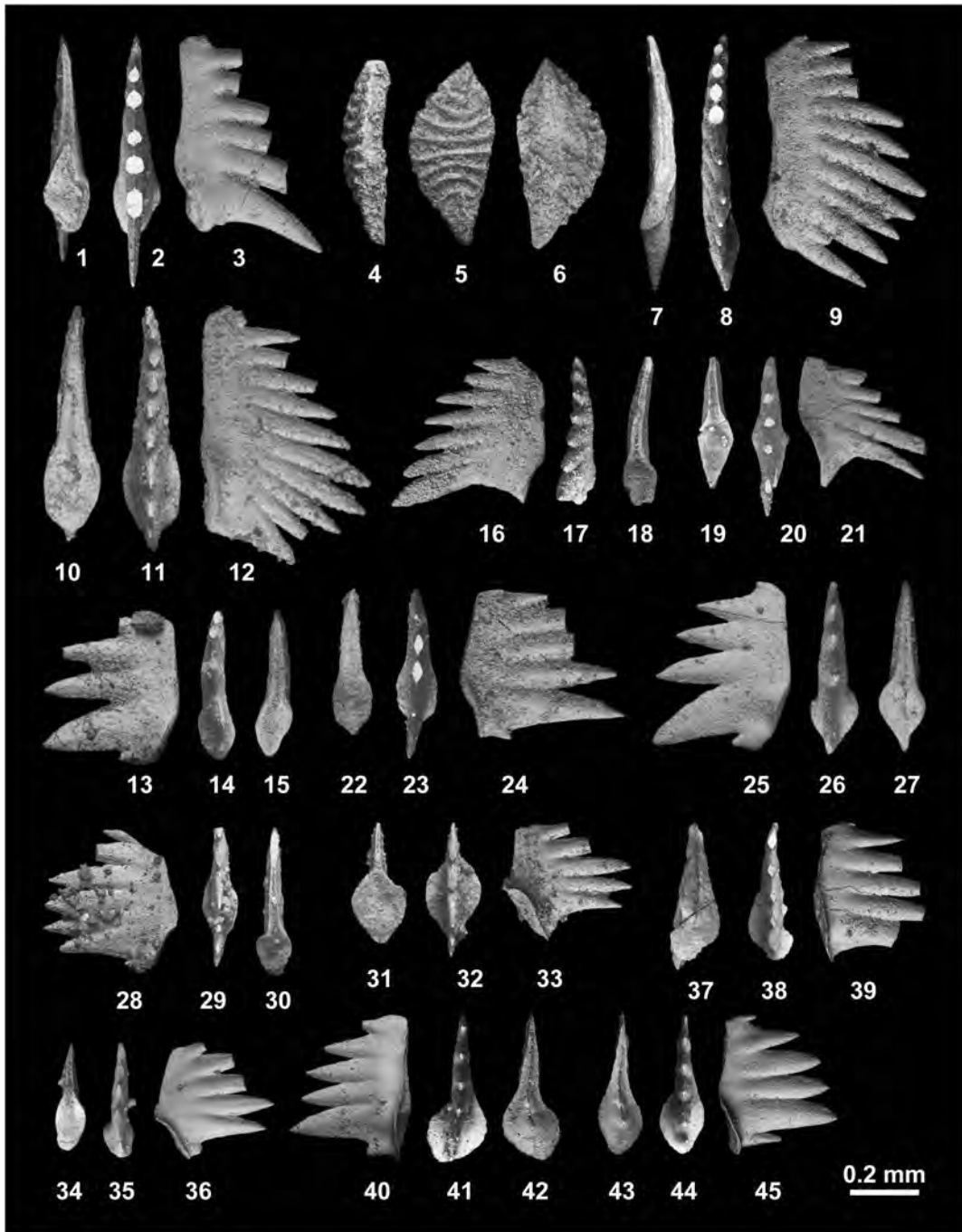


Fig. 161. 1–3, *Guangxidella* sp. indet. B, MPC25262, from KC01-11. 4–6, *Eurygnathodus costatus* Staesche, 1964, MPC25263, from BT01-03. 7–9, *Neospathodus* aff. *concaus* Zhao and Orchard, 2007, MPC25264, from BT01-07. 10–12, *Neospathodus cristagalli* (Huckriede, 1958), MPC25265, from BT01-04. 13–15, MPC25266, from BT01-04. 16–18, MPC25267, from BT01-07. 19–21, MPC25268, from BT01-07. 22–24, MPC25269, from BT02-02. 25–27, MPC25270, from KC01-01. 28–30, MPC25271, from KC01-13. 31–33, MPC25272, from KC01-13. 34–36, MPC25273, from KC01-13. 37–39, MPC25274, from KC02-02. 40–42, MPC25275, from KC02-02. 43–45, MPC25276, from KC02-02.

figs. 1–15; Igo, 2009, p. 183, figs. 152.23–152.24; Orchard, 2010, figs. 5.9, 5.10.

*Platyvillosus costatus* (Staesche, 1964). Goel, 1977, p. 1098, pl. 2, figs. 15–21; Wang and Cao, 1981, p. 371, pl. 2, figs. 1–4, 28, 29, 30, 33; Koike, 1982, p. 44, pl. 5, figs. 1–9; Tian *et al.*, 1983, p. 391, pl. 81, fig. 2; Matsuda, 1984, p. 128, pl. 6, figs. 6–10; Duan, 1987, pl. 3, fig. 4; Koike, 1988, pl. 1, figs. 1–57, pl. 2, figs. 1–37; Bui, 1989, p. 411, pl. 31, figs. 7–9; Beyers and Orchard, 1991, pl. 5, fig. 10; Cao and Wang, 1993, pl. 56, fig. 16; Wang and Zhong, 1994, p. 404, pl. 1, figs. 15, 23.

**Material examined:** One specimen, MPC25263, from BT01-03.

**Description:** Dextral segminiplanete element; outline of platform ellipsoidal with sharply pointed anterior and posterior ends; length 0.53 mm; width 0.25 mm; length to width ratio 2.1. Upper surface of the platform bears 10 transverse ridge-like denticles, denticle form straight in middle part and curved convexly toward center in middle to both anterior and posterior parts. Element exhibits slightly bowed lateral form. Basal cavity narrow, sub-rounded. Groove runs from basal pit to anterior end.

**Remarks:** Koike (1988) demonstrated morphological variation in the ornamentation of *Platyvillosus costatus* (Staesche, 1964) (= *Eurygnathodus costatus* Staesche, 1964) based on abundant specimens from the Taho limestone, Southwest Japan. He recognized four morphotypes (Central form, Morphotype  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\sigma$ ) and fifteen forms (A–O) based on the ornamentation on the platform. Central form (= Form A) is characterized by transverse ridges covering the entire width of the platform. This form is identical to the holotype of this species (Staesche, 1964, pl. 28, figs. 1–4). Morphotype  $\alpha$  has nodose denticles and is subdivided into three forms (Form B, C, D). Morphotype  $\beta$  exhibits a size increase of denticles in the axial region and includes three forms (Form E, F, G). Morphotype  $\gamma$  represents a tendency toward development of increasingly prominent nodose to ridge-like denticulation and consists of four forms (Form H, I, J, K).

Morphotype  $\sigma$  shows a tendency to decrease in oral ornamentation and includes four forms (Form L, M, N, O).

The described specimen has conspicuous ridge-like denticles, which extend the entire width of the platform. This feature matches well with Form A of Koike (1988). Bui (1989) described some specimens of *Eurygnathodus costatus* from the Bac Thuy Formation, one of which (Bui, 1989, pl. 31, fig. 7) is identical to Form A and a second type with weak ridge-like denticles (Bui, 1989, pl. 31, figs. 8, 9), is very similar to Form L of Morphotype  $\sigma$ .

**Occurrence:** Specimen from BT01-03 within the portion of the *Novispathodus* ex gr. *waageni* Zone in the *Flemingites rursiradiatus* beds (lowest Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, north-eastern Vietnam. This species also occurs in Lower Triassic formations in South Tirol (Staesche, 1964), Spiti, India (Goel, 1977; Orchard and Krystyn, 2007; Orchard, 2010), Kashmir, India (Matsuda, 1984), South China (Wang and Cao, 1981; Wang and Zhong, 1994), Malaysia (Koike, 1982), Southwest Japan (Koike, 1988), British Columbia, Canada (*Neogonlodella milleri* Zone, Beyers and Orchard, 1991), South Primorye, Russia (*Neospathodus dieneri*-Ns. *pakistanensis* Zone and *Neospathodus* ex gr. *waageni*-Ns. *novaehollandiae* Zone, Shigeta *et al.*, 2009). According to Orchard and Krystyn (2007) and Shigeta *et al.* (2009), this species ranges from the Upper Dienerian to the Smithian.

Genus *Neospathodus* Mosher, 1968

**Type species:** *Spathognathodus cristagalli* Huckriede, 1968.

*Neospathodus* aff. *concaus* Zhao and Orchard, 2007

Fig. 161.7–161.9

aff. *Neospathodus concaus* Zhao and Orchard, 2007, in Zhao *et al.*, 2007, p. 35, pl. 1, figs. 1A–C; Orchard and Krystyn, 2007, fig. 4; Igo, 2009, p. 184–185, fig.

154.13.

**Material examined:** One specimen, MPC25264, from BT01-07.

**Description:** Bowed segminate element 0.73 mm in length; 0.48 mm in height; length to height ratio 1.5. Pole-like pointed denticles total 12 in number. Lower part of element straight anteriorly and downturned at posterior margin. Non-expanded basal cavity convex to aboral surface. Groove extends to anterior end.

**Remarks:** The described specimen is similar to *Neospathodus concavus* Zhao and Orchard, 2007 in having a bowed element, but differs by a convex, non-expanded basal cavity. *Ns. concavus* has an arched blade, a concave, expanded and rounded basal cavity, and a prominent lateral rib.

**Occurrence:** Described specimen from BT01-07 within a portion of the *Novispathodus* ex gr. *waageni* Zone between the *Flemingites rursiradiatus* beds (lowest Middle Smithian = middle Lower Olenekian) and *Urlyceras tulongensis* beds (lower Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the Upper Dienerian (upper Upper Induan, *Neospathodus cristagalli* Zone with *Gyronites frequens* Zone) in the Mikin Formation at the Mud Section, Spiti, India (Orchard and Krystyn, 2007), in the Lower Smithian (lower Lower Olenekian) in Anhui Province, South China (*Neospathodus waageni eowaageni* Subzone to *Neospathodus waageni waageni* Subzone with *Flemingites-Euflemeingites* Zone, Zhao *et al.*, 2007) and South Primorye (*Neospathodus* ex gr. *waageni*-*Ns. novaehollandiae* Zone with *Clypeoceras timorense* Zone, Shigeta *et al.*, 2009).

***Neospathodus cristagalli* (Huckriede, 1958)**

Fig. 161.10–161.12

*Spathognathodus cristagalli* Huckriede, 1958, p. 161, pl. 10, fig. 14, 15.

*Neospathodus cristagalli* (Huckriede, 1958). Sweet, 1970a, p. 9, pl. 1, figs. 18, 21; Sweet, 1970b, p. 246, pl. 1, figs. 14, 15; Mosher, 1973, p. 170, pl. 20, fig. 4;

Matsuda, 1982, p. 92, pl. 3, figs. 1–12; Tian *et al.*, 1983, p. 375, pl. 80, figs. 2a, 2b; Orchard and Krystyn, 2007, pl. 1, fig. 5.

multielement apparatuses, *Neospathodus* cf. *cristagalli* (Huckriede, 1958). Orchard, 2005, p. 88, text-fig. 14.

**Material examined:** One specimen, MPC25265, from BT01-04

**Description:** Laterally compressed blade-like element 0.75 mm in length; 0.48 mm in height; length to height ratio 1.6, with arched upper edge. Basal margin straight anteriorly and slightly turned upward in the posterior one-third. Reclined broad denticles, 12 in number, lower part fused and upper part discrete, highest point situated in posterior one-third of element. Triangular shaped large process situated at posterior end. Basal cavity oblong, with deep pit, and groove extends from pit to anterior end.

**Remarks:** The described specimen has a terminal triangular denticle at the posterior end, which is a diagnostic feature of *Neospathodus cristagalli* (Huckriede, 1958). The lateral form of the element and the ratio of the fused part of the denticles of the described specimen are similar to those of the holotype (Huckriede, 1958, pl. 10, fig. 15) and specimens described by various authors (e.g. Sweet, 1970a, b; Matsuda, 1982; Tian *et al.*, 1983).

**Occurrence:** Described specimen from BT01-04 within the portion of the *Novispathodus* ex gr. *waageni* Zone in the *Flemingites rursiradiatus* beds (lowest Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also ranges from the Upper Dienerian (upper Upper Induan) to the Smithian (Lower Olenekian) in the Salt Range, Pakistan (Huckriede, 1958; Sweet, 1970a, b), British Columbia, Canada (*Vavilovites sverdrupi* Zone, Mosher, 1973), Kashmir, India (Matsuda, 1982), Tibet (Tian *et al.*, 1983), and the Mikin Formation at the Mud Section, Spiti, India (*Neospathodus cristagalli* Zone to *Neospathodus waageni sensu stricto* Zone with *Gyronites frequens*

Zone, *Meekophiceras? vercherei* beds, and *Rohillites rohilla* Zone, Krystyn *et al.*, 2007; Orchard, 2007b; Orchard and Krystyn, 2007).

***Neospathodus dieneri* Sweet, 1970a**

Figs. 161.13–161.45, 162, 163, 164.1–164.6

*Neospathodus dieneri* Sweet, 1970a, p. 9, pl. 1, fig. 17; Sweet, 1970b, p. 249, pl. 1, figs. 1, 4; McTavish, 1973, p. 293, pl. 2, figs. 3, 6; Birkenmajer and Trammer, 1975, pl. 1, fig. 4; Buryi, 1979, p. 52, pl. 7, fig. 7; Wang and Cao, 1981, pl. 2, figs. 24, 25; Matsuda, 1982, p. 90, pl. 2, figs. 1–11; Koike, 1982, p. 37, pl. 6, figs. 15–21, 25; Beyers and Orchard, 1991, pl. 5, fig. 4; Wang and Zhong, 1994, p. 400, pl. 1, figs. 18; Zhao and Orchard (in Zhao *et al.*, 2007), p. 35, pl. 1, figs. 12A, B, 9A, B, C, 11A, B, C; Orchard and Krystyn, 2007, figs. 3, 6, 7; Igo, 2009, p. 186, 188, figs. 151.6–151.16, 152.8, 152.9; Beranek *et al.*, 2010, figs. 6.20, 6.21.

**Material examined:** One specimen, MPC25266, from BT01-04, two specimens, MPC25267, 25268, from BT01-07, one specimen, MPC25269, from BT02-02, one specimen, MPC25270, from KC01-01, three specimens, MPC25271–25273, from KC01-11, forty specimens, MPC25274–25313, from KC02-02, and one specimen, MPC25314, from KC02-03.

**Description:** Sub-triangular or sub-square segminate elements 0.32–0.55 mm in length, average 0.41 mm; 0.32–0.55 mm in height, average 0.38 mm; length to height ratio 0.7–1.6, average 1.1 for forty-nine specimens. Denticles erect or slightly reclined posteriorly, and vary in number from 4 to 9, average 6. Cusp situated at posterior end. Some specimens have small posterior denticle. Lower margin of element straight and slightly upturned or concave anteriorly, and upturned posteriorly. Rounded or sub-rounded basal cavity extends one-fourth to one-half the length of the element and is slightly or strongly concave. Groove runs from basal pit to anterior end.

**Remarks:** Zhao *et al.* (2007) recognized three morphotypes in *Neospathodus dieneri* Sweet, 1970a. Morphotype 1 has the longest posterior terminal cusp, which is broader in

width than the other morphotypes. Morphotype 2 is characterized by a penultimate denticle as large as the terminal cusp. Morphotype 3 has an additional posterior denticle, which is broader in width and shorter in length than the other denticles. These morphotypes occur continuously in ascending order from the Upper Dienerian to the Smithian part of the Yinkeng Formation in the West Pingingshan Section, South China (Zhao *et al.*, 2007). Specimens from the Bac Thuy Formation include all morphotypes of Zhao *et al.* (2007), and their ranges are equal.

**Occurrence:** Described specimens from BT01-04, BT01-07, BT02-02, KC01-01, KC01-11, KC02-02 and KC02-03 within the portion of the *Novispathodus* ex gr. *waageni* Zone that includes the *Flemingites rursiradatus* beds (lowest Middle Smithian = middle Lower Olenekian), *Urduyceras tulongensis* beds (lower Middle Smithian = middle Lower Olenekian) and the *Leyeceras* and *Guodunites* horizons of the *Owenites koeneni* beds (middle to upper Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also ranges from the Dienerian (Upper Induan) to the Smithian (Lower Olenekian) in the Salt Range, West Pakistan (Zone 3 to middle part of Zone 7, Sweet, 1970a, b), Australia (McTavish, 1973), Svalbard (Birkenmajer and Trammer, 1975; Hatleberg and Clark, 1984), Spiti, India (Goel, 1977; Orchard and Krystyn, 2007), South Primorye, Russia (*Neospathodus dieneri*-*Ns. pakistanensis* Zone with *Clypeoceras spitiense* “bed” and lower part of *Paranorites varians* Zone, Shigeta *et al.*, 2009), South China (*Neospathodus dieneri* M1 Zone to lower part of *Neospathodus waageni waageni* Subzone with upper part of *Ophiceras-Lytophiceras* Zone, *Prionolobus-Gyronites* Zone, and lower part of *Flemingites-Euflemingites* Zone, Wang and Cao, 1981; Zhao *et al.*, 2007), Kashmir, India (Matsuda, 1982), Malaysia (Koike, 1982), and British Columbia, Canada (Beyers and Orchard, 1991; Beranek *et al.*, 2010). *Ns. dieneri*



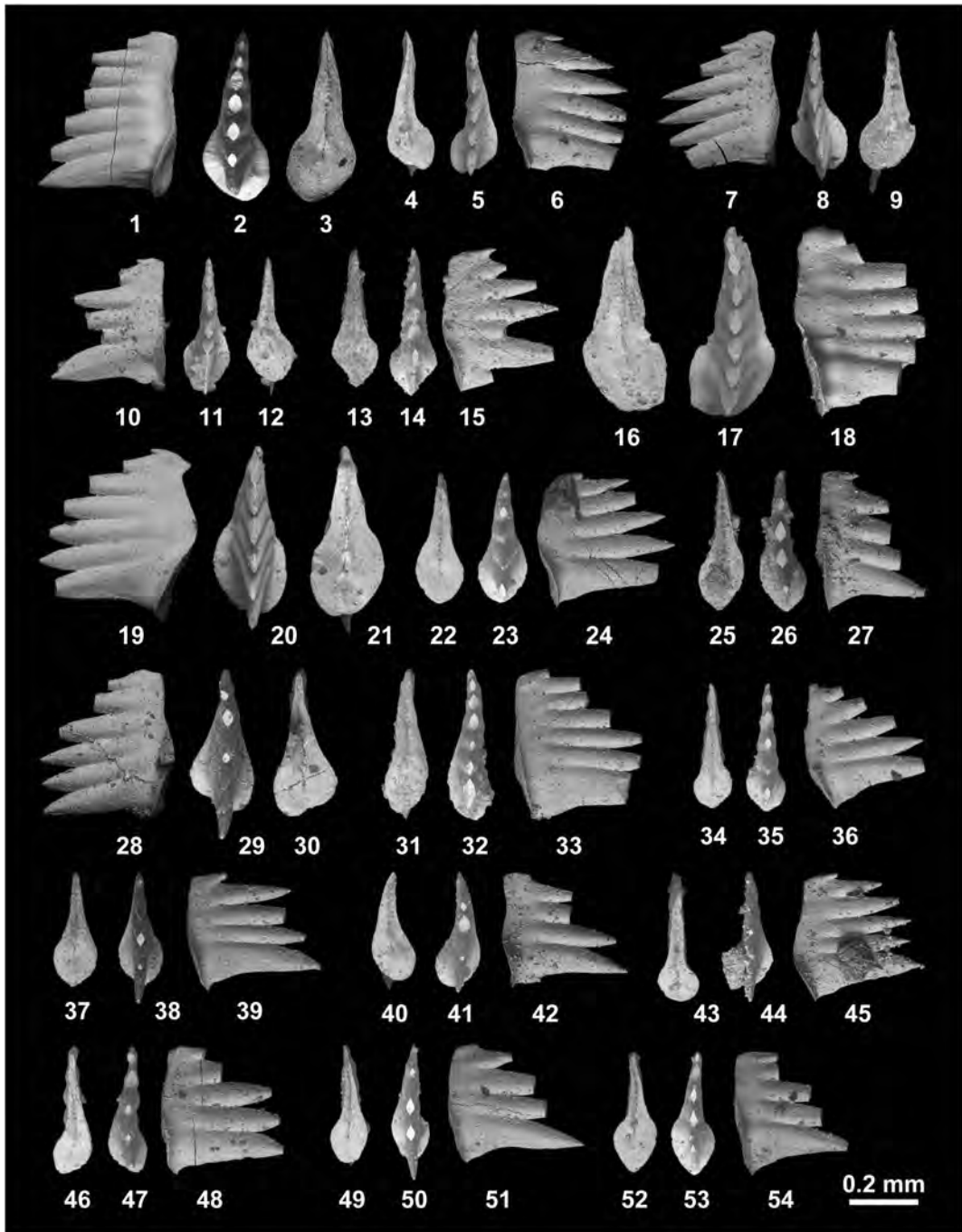


Fig. 162. *Neospathodus dieneri* Sweet, 1970a from KC02-02. 1–3, MPC25277. 4–6, MPC25278. 7–9, MPC25279. 10–12, MPC25280. 13–15, MPC25281. 16–18, MPC25282. 19–21, MPC25283. 22–24, MPC25284. 25–27, MPC25285. 28–30, MPC25286. 31–33, MPC25287. 34–36, MPC25288. 37–39, MPC25289. 40–42, MPC25290. 43–45, MPC25291. 46–48, MPC25292. 49–51, MPC25293. 52–54, MPC25294.

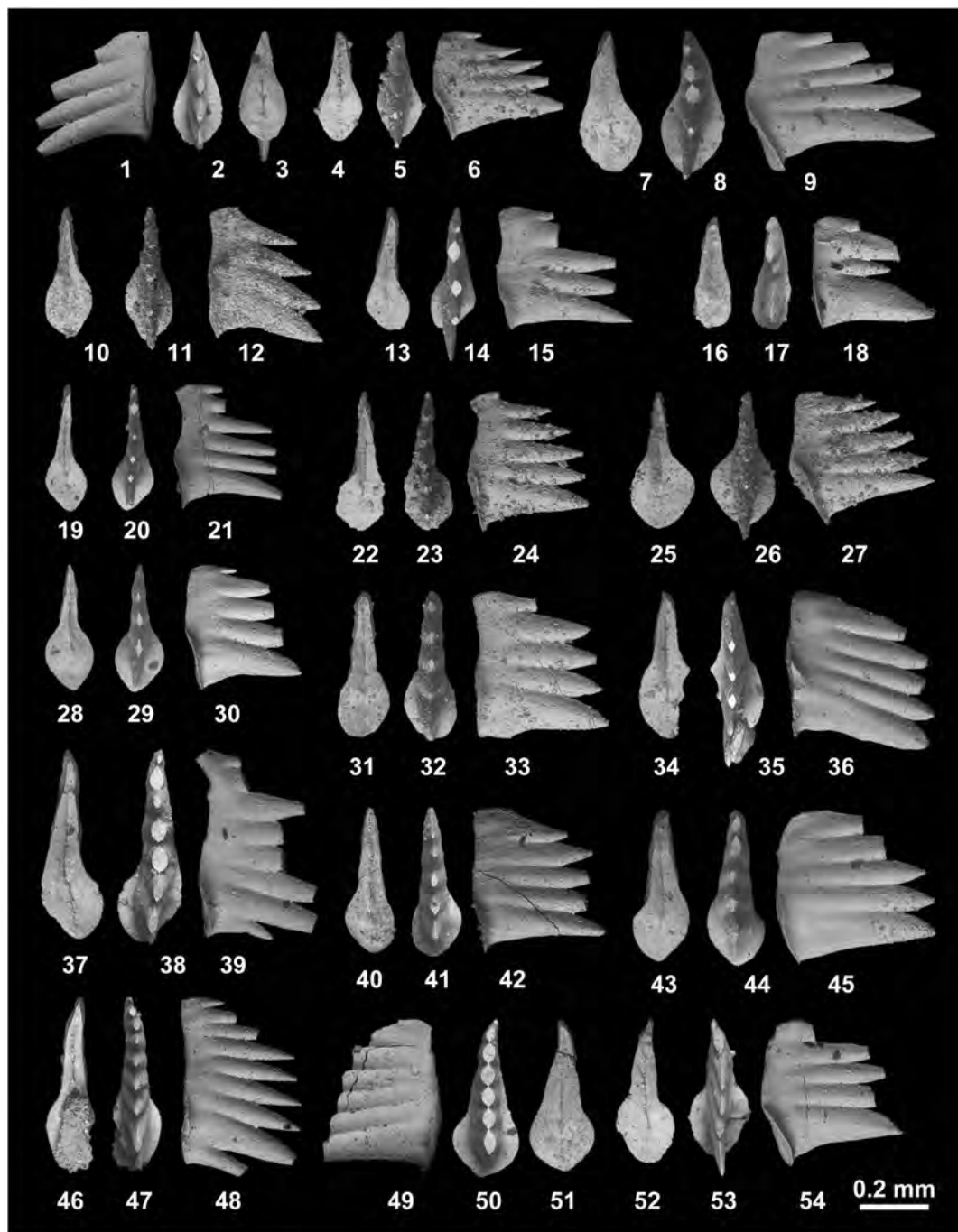


Fig. 163. *Neospathodus dieneri* Sweet, 1970a from KC02-02. 1–3, MPC25295. 4–6, MPC25296. 7–9, MPC25297. 10–12, MPC25298. 13–15, MPC25299. 16–18, MPC25300. 19–21, MPC25301. 22–24, MPC25302. 25–27, MPC25303. 28–30, MPC25304. 31–33, MPC25305. 34–36, MPC25306. 37–39, MPC25307. 40–42, MPC25308. 43–45, MPC25309. 46–48, MPC25310. 49–51, MPC25311. 52–54, MPC25312.

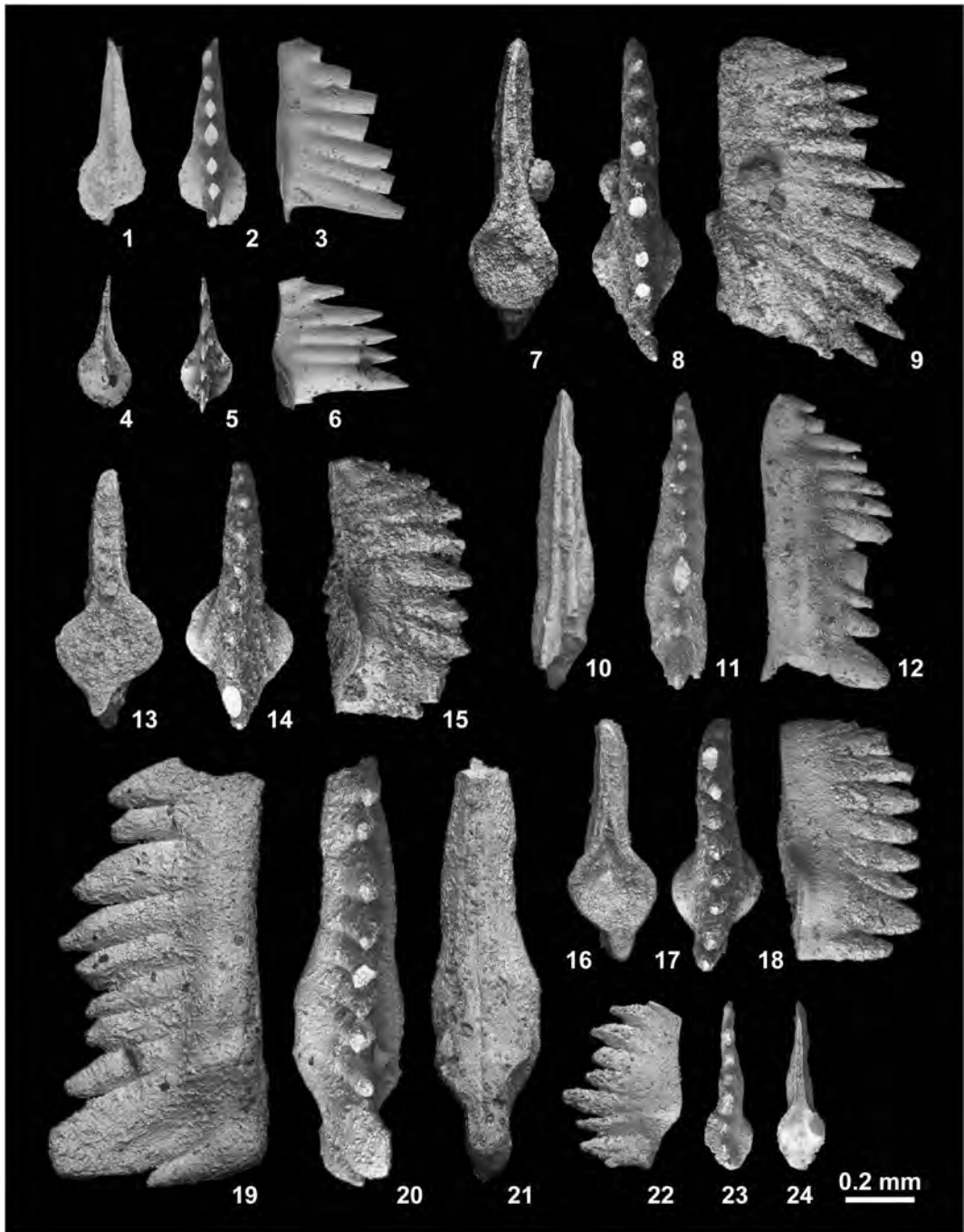


Fig. 164. 1–6, *Neospathodus dieneri* Sweet, 1970a. 1–3, MPC25313, from KC02-02. 4–6, MPC25314, from KC02-03. 7–24, *Neospathodus novaehollandiae* McTavish, 1973. 7–9, MPC25315, from BT01-03. 10–12, MPC25316, from BT01-07. 13–15, MPC25317, from BT01-10. 16–18, MPC25318, from BT01-10. 19–21, MPC25319, from BT01-10. 22–24, MPC25320, from BT01-10.

attains its maximum abundance at KC02-02 in the Bac Thuy Formation. A similar phenomenon is also reported from the *Ns. w. waageni* Subzone in the Yinkeng Formation, South China (Zhao *et al.*, 2007).

***Neospathodus novaehollandiae* McTavish, 1973**

Figs. 164.7–164.24, 165.1–165.3

*Neospathodus novaehollandiae* McTavish, 1973, p. 294, figs. 4, 5, 14, 16–23; Goel, 1977, p. 1091, pl. 1, figs. 1, 2; Beyers and Orchard, 1991, pl. 5, fig. 7; Orchard, 2007b, figs. 15–18, 27, 28; Igo, 2009, p. 188, 190, figs. 153.8–153.14, 154.7–154.11, 155.1–155.11.

**Material examined:** One specimen, MPC25315, from BT01-03, one specimen, MPC25316, from BT01-07, four specimens, MPC25317–25320, from BT01-10, and one specimen, MPC25321, from KC01-05.

**Description:** Blade-like large elements 0.49–1.25 mm in length, average 0.86 mm; 0.35–0.64 mm in height, average 0.48 mm; length to height ratio 1.4–2.0, average 1.8 for seven specimens. Robust, broad, pole-like and fused denticles vary in number from 8 to 12, average 10, sub-erect or reclined posteriorly. Upper edge forms arched or straight outline. Cusp, situated in nearby posterior end, bears one to three small posterior denticles. Some specimens have a cusp twice as long as other denticles. Prominent lateral rib at middle and lower parts of element. Lower margin straight in larger element, and straight anteriorly and upturned in posterior one-third in smaller specimen (MPC25320). Rounded basal cavity expanded in posterior one-third of element. Deep furrow extends from both anterior and posterior ends.

**Remarks:** The element of *Neospathodus novaehollandiae* McTavish, 1973 resembles that of *Ns. pakistanensis* Sweet, 1970b, but previous authors have already pointed out that *Ns. novaehollandiae* has a larger element, a stronger lateral rib, and a straighter lower margin than *Ns. pakistanensis*. These features enable us to distinguish the mentioned species.

**Occurrence:** Described specimens from BT01-03, BT01-10 and KC01-05 within the portion of the *Novispathodus* ex gr. *waageni* Zone that includes the *Flemingites rursiradatus* beds (lowest Middle Smithian = middle Lower Olenekian) and *Urduyceras tulongensis* beds (lower Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the Smithian (Lower Olenekian) in West Australia (McTavish, 1973), Spiti, India (Goel, 1977; Orchard, 2007b), British Columbia, Canada (Beyers and Orchard, 1991), and South Primorye, Russia (*Neospathodus* ex gr. *waageni*-*Ns. novaehollandiae* Zone with *Clypeoceras timorensis* Zone and *Radioprionites abrekensis* “bed”, Shigeta *et al.*, 2009).

***Neospathodus pakistanensis* Sweet, 1970b**

Fig. 165.4–165.24

*Neospathodus pakistanensis* Sweet, 1970b, p. 254, pl. 1, figs. 16, 17; McTavish, 1973, p. 295, pl. 1, figs. 1, 2; Buryi, 1979, p. 57, pl. 9, fig. 2; Wang and Cao, 1981, p. 367, pl. 2, fig. 27; Matsuda, 1983, p. 87, pl. 1, figs. 1–5; Tian *et al.*, 1983, p. 379, pl. 81, fig. 3; Hatleberg and Clark, 1984, pl. 1, fig. 5; Beyers and Orchard, 1991, pl. 5, fig. 2; Cao and Wang, 1993, pl. 56, fig. 14; Orchard, 2007b, figs. 19, 20, 23–26; Orchard and Krystyn, 2007, figs. 19, 20; Orchard, 2008, p. 407, figs. 8.11, 8.12; Igo, 2009, p. 190, 192, figs. 151.18–151.26, 152.1–152.7, 152.10–152.13, 152.20–152.21, 153.1–153.7, 154.1–154.6; Beranek *et al.*, 2010, figs. 6.31–6.33.

*Neospathodus homeri* (Bender, 1970). Bui, 1989, p. 402, pl. 31, fig. 16.

**Material examined:** Five specimens, MPC25322–25326, from BT01-03, one specimen, MPC25327, from BT01-04, and one specimen, MPC25328, from BT01-06.

**Description:** Blade-like elements 0.51–0.75 mm in length, average 0.60 mm; 0.36–0.47 mm in height, average 0.35 mm; length to height ratio 1.4–2.1, average 1.7 for seven specimens. Upper edge of element straight or arched, highest point located at posterior one-third, lower edge generally straight or upward at anterior end, posterior part of lower margin



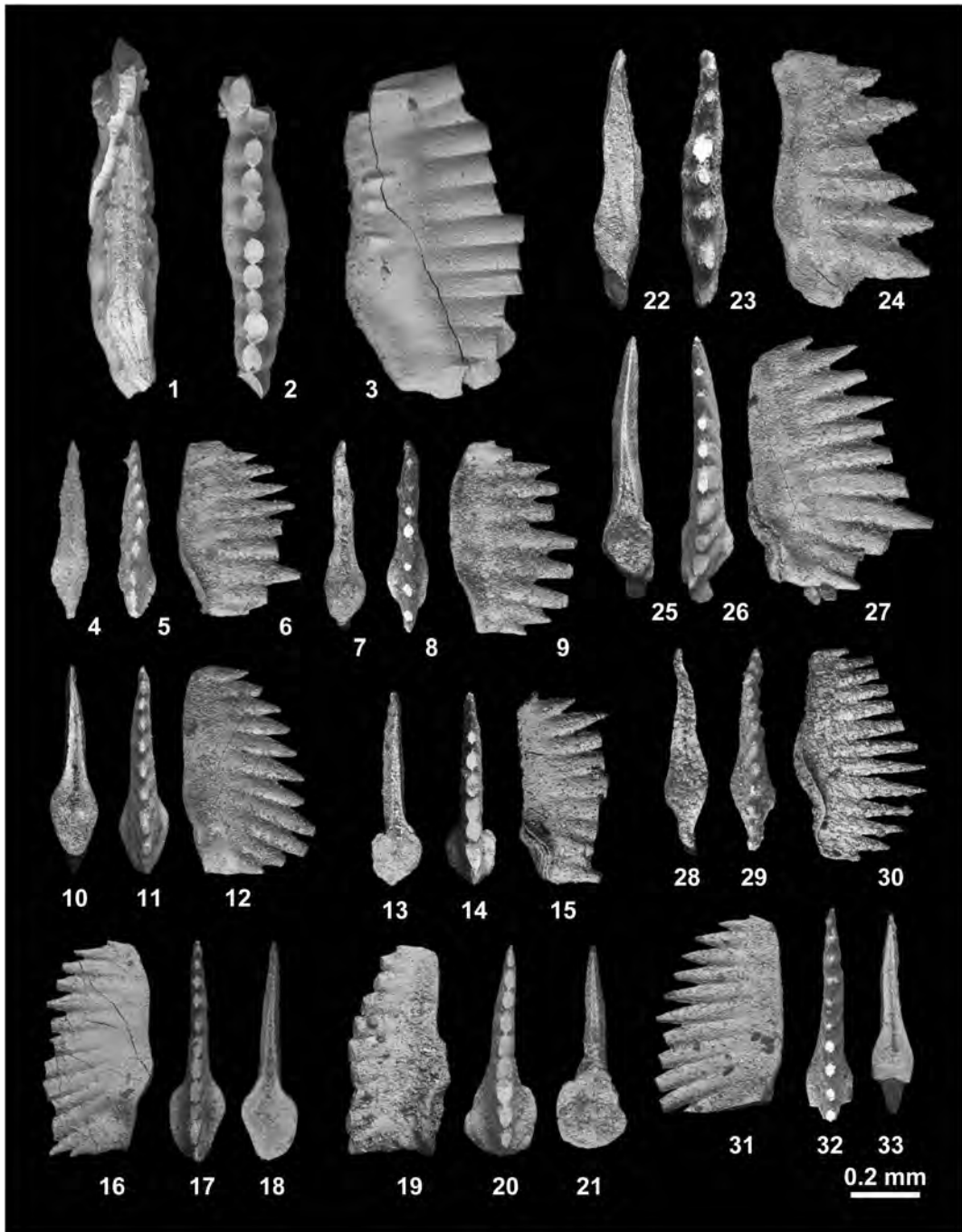


Fig. 165. 1–3, *Neospathodus novaehollandiae* McTavish, 1973, MPC25321, from KC01-05. 4–24, *Neospathodus pakistanensis* Sweet, 1970b. 4–6, MPC25322, from BT01-03. 7–9, MPC25323, from BT01-03. 10–12, MPC25324, from BT01-03. 13–15, MPC25325, from BT01-03. 16–18, MPC25326, from BT01-03. 19–21, MPC25327, from BT01-04. 22–24, MPC25328, from BT01-06. 25–33, *Neospathodus posterolongatus* Zhao and Orchard, 2007 from BT01-03. 25–27, MPC25329. 28–30, MPC25330. 31–33, MPC25331.

slightly deflected upward or slightly downturned posteriorly. Spine-like denticles vary in number from 9 to 13, average 10, erect or reclined posteriorly. Cusp bears two posterior small denticles. Rounded or sub-rounded basal cavity situated in posterior one-third. Groove extends from basal pit to anterior end.

*Remarks:* *Neospathodus pakistanensis* Sweet, 1970b is characterized by its blade-like element, sub-rounded basal cavity, several posterior small denticles, and a strongly downturned posterior lower margin. Although the described specimens have a slightly upturned lower posterior margin, they share many features with *Ns. pakistanensis*.

*Occurrence:* Described specimens from BT01-03, BT04 and BT01-06 within the portion of the *Novispathodus* ex gr. *waageni* Zone that includes the *Flemingites rursiradiatus* beds (lowest Middle Smithian=lower Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also ranges from the Upper Dienerian (upper Upper Induan) to Lower Smithian (lower Lower Olenekian) in the Salt Range, Pakistan (Zone 6, Sweet, 1970b), West Australia (McTavish, 1973), South Primorye (Buryi, 1979; *Neospathodus dieneri*-*Ns. pakistanensis* Zone and *Neospathodus* ex gr. *waageni*-*Ns. novaehollandiae* Zone with *Clypeoceras spitiense* "bed", *Paranorites varians* Zone, and *Clypeoceras timorense* Zone, Shigeta *et al.*, 2009), South China (Wang and Cao, 1981; Cao and Wang, 1993), Kashmir, India (Matsuda, 1983), Tibet (Tian *et al.*, 1983), and the Mikin Formation at the Mud Section, Spiti, India (Krystyn *et al.*, 2007; Orchard, 2007b; Orchard and Krystyn, 2007).

***Neospathodus posterolongatus* Zhao and Orchard, 2007**

Figs. 165.25–165.33, 166.1–166.18

*Neospathodus waageni* subsp. B Zhao, 2004, p. 42, fig. 2.  
*Neospathodus posterolongatus* Zhao and Orchard, in Zhao *et al.*, 2007, p. 36, pl. 1, figs. 2A, B, C; Orchard, 2007b, figs. 1–6; Orchard, 2008, p. 407, figs. 8.3, 8.4;

Beranek *et al.*, 2010, figs. 6.24, 6.25.

*Material examined:* Four specimens, MPC25329–25332, from BT01-03, three specimens, MPC25333–25335, from BT01-04, and two specimens, MPC25336, 25337, from KC01-01.

*Description:* Blade-like elements 0.53–0.78 mm in length, average 0.64 mm; 0.35–0.54 mm in height, average 0.43 mm; length to height ratio 1.3–1.9, average 1.5 for nine specimens. Arched upper edge bears needle-like denticles that vary in number from 10 to 13, average 12, discrete in upper half, reclined anteriorly in anterior part, erect or inclined posteriorly in center and posterior parts, denticle size decreases both anteriorly and posteriorly. Cusp situated in posterior one-third. Lower edge straight and slightly upturned in anterior end. Ellipsoidal basal cavity extended to posterior with shallow pit. Groove runs from basal pit to anterior end.

*Remarks:* *Neospathodus posterolongatus* Zhao and Orchard, 2007 is distinguishable from the typical *Ns. waageni* Sweet, 1970b by the posterior elongation of the basal cavity and the presence of small secondary posterior denticles (Zhao and Orchard, 2007).

*Occurrence:* Described specimens from BT01-03, BT01-4, and KC01-01 within the portion of the *Novispathodus* ex gr. *waageni* Zone that includes the *Flemingites rursiradiatus* beds (lowest Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

The first appearance datum (FAD) of *Neospathodus posterolongatus* in the Yingkeng Formation at the West Pingdingshan Section, South China is situated 3 cm below the FAD of the ammonoids *Flemingites* and *Euflemingites*, which indicates the Induan/Olenekian Boundary (IOB) of this formation. This evidence suggests that *Ns. posterolongatus* may have age diagnostic potential for the IOB (Zhao *et al.*, 2007). In addition, this species co-occurs with *Ns. ex gr. waageni* Morphotype 1, whose

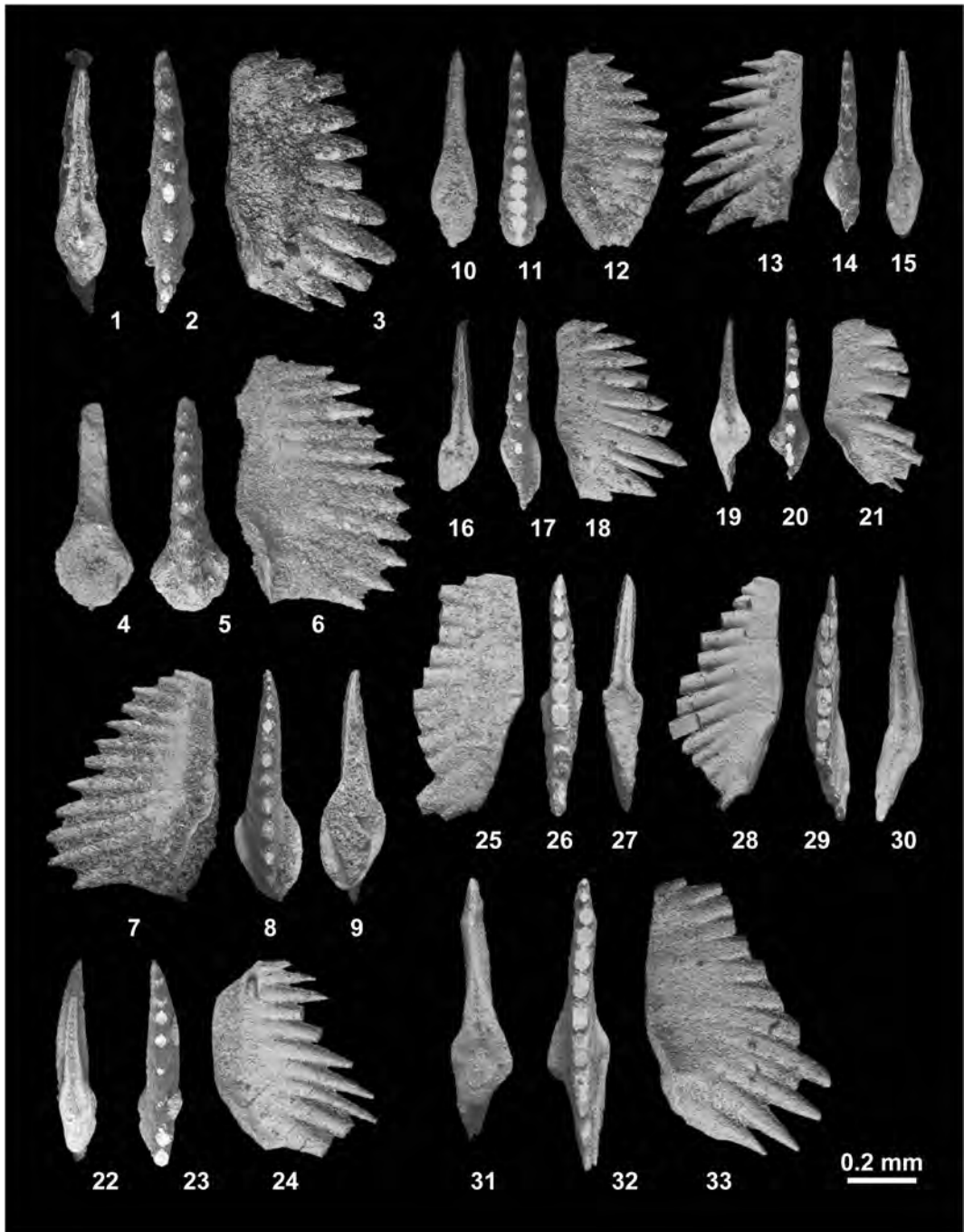


Fig. 166. 1–18, *Neospathodus posterolongatus* Zhao and Orchard, 2007. 1–3, MPC25332, from BT01-03. 4–6, MPC25333, from BT01-04. 7–9, MPC25334, from BT01-04. 10–12, MPC25335, from BT01-04. 13–15, MPC25336, from KC01-01. 16–18, MPC25337, from KC01-01. 19–33, *Neospathodus spitiensis* Goel, 1977. 19–21, MPC25338, from BT01-03. 22–24, MPC25339, from BT01-03. 25–27, MPC25340, from BT01-03. 28–30, MPC25341, from BT01-03. 31–33, MPC25342, from BT01-04.

FAD defines the IOB in the Mianwali Formation of Spiti, India (Krystyn *et al.*, 2007; Orchard and Krystyn, 2007).

This species also ranges from the Upper Dienerian (upper Upper Induan) to Lower Smithian (lower Lower Olenekian) in the Yingkeng Formation, South China (*Neospathodus waageni eowaageni* Subzone and lower part of *Neospathodus waageni waageni* Subzone with uppermost part of *Prionolobus-Gyronites* Zone and lower part of *Flemingites-Euflemingites* Zone, Zhao *et al.*, 2007), the Mikin Formation in the Mud section, Spiti, India (*Neospathodus waageni sensu lato* Zone and *Neospathodus waageni sensu stricto* Zone with *Rohillites rohilla* Zone, Krystyn *et al.*, 2007; Orchard, 2007b), in British Columbia, Canada (Beranek *et al.*, 2010), and the Canadian Arctic (*Euflemingites romunderi* Zone, Orchard, 2008).

***Neospathodus spitiensis* Goel, 1977**

Figs. 166.19–166.33, 167–169, 170.1–170.6

*Neospathodus spitiensis* Goel, 1977, p. 1094, pl. 1, figs. 14–18; Duan, 1987, pl. 2, fig. 19; Orchard and Krystyn, 2007, figs. 23, 24; Igo, 2009, p. 194, figs. 156.1–156.6, 156.21–156.22.

*Neospathodus homeri* (Bender, 1970). Bui, 1989, p. 402, pl. 31, fig. 15.

**Material examined:** Four specimens, MPC25338–25341, from BT01-03, two specimens, MPC25342, 25343, from BT01-04, nineteen specimens, MPC25344–25362, from BT01-07, five specimens, MPC25363–25367, from BT01-10, two specimens, MPC25368, 25369, from BT01-12, one specimen, MPC25370, from BT02-01, one specimen, MPC25371, from KC01-01, three specimens, MPC25372–25374, from KC01-04, two specimens, MPC25375, 25376, from KC01-05, and one specimen, MPC25377, from KC01-06.

**Description:** Laterally compressed segminate elements 0.38–0.81 mm in length, average 0.60 mm; 0.35–0.60 mm in height, average 0.45 mm; length to height ratio 0.9–2.2, average 1.3 for forty specimens. Upper part of ele-

ment arched and consists of laterally compressed, fairly discrete denticles. Denticles vary in number from 8 to 13, average 10, sub-erect or reclined anteriorly, gradually inclined to posterior end. Cusp situated in posterior one-third with 2 to 4 small posterior denticles. Some specimens have a large triangular shaped process at posterior end. Basal margin straight or almost upturned in anterior part, and upturned 10–40 degrees in posterior part. Anterior part occupies more than half of element. Sub-triangular or sub-rounded basal cavity unexpanded in general, and gradually narrows toward posterior end. Groove extends from anterior end to posterior end.

**Remarks:** *Neospathodus spitiensis* Goel, 1977 is characterized by its arched element with mostly discrete denticles, upturned basal margin of posterior one-third to half, and narrow triangular shaped basal cavity, which extends posteriorly (Goel, 1977; Orchard and Krystyn, 2007). Igo (2009) reported that some specimens of this species have a posteriorly extended elliptical basal cavity. The described specimens exhibit a wide range of intraspecific variation in basal cavity form and denticulation, but they also include similar forms reported by previous authors. Some specimens have a large triangular process, which has never been reported.

**Occurrence:** Described specimens from BT01-03, BT01-04, BT01-07, BT01-10, BT01-12, BT02-01, KC01-01, KC01-04, KC01-05 and KC01-06 within the portion of the *Novispathodus ex gr. waageni* Zone that includes the *Flemingites rursiradiatus* beds (lowest Middle Smithian = middle Lower Olenekian) and *Urdoceras tulongensis* beds (lower Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the Lower Smithian (lower Lower Olenekian) in Spiti, India (Goel, 1977; Krystyn *et al.*, 2007; Orchard and Krystyn, 2007), South China (Duan, 1987; Zhao *et al.*, 2007), and South Primorye, Russia (Igo, 2009).



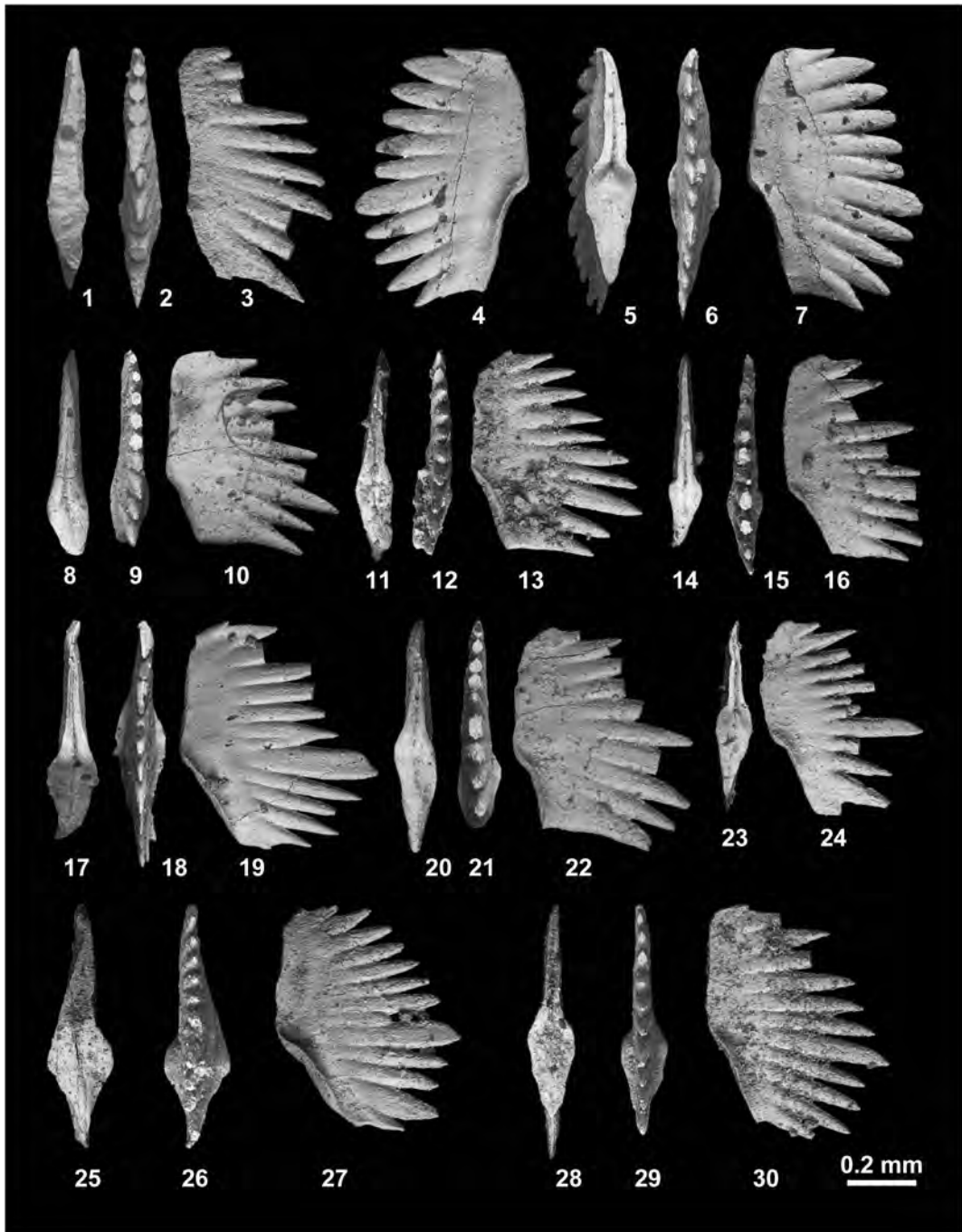


Fig. 167. *Neospathodus spitiensis* Goel, 1977. 1–3, MPC25343, from BT01-04. 4–7, MPC25344, from BT01-07. 8–10, MPC25345, from BT01-07. 11–13, MPC25346, from BT01-07. 14–16, MPC25347, from BT01-07. 17–19, MPC25348, from BT01-07. 20–22, MPC25349, from BT01-07. 23–24, MPC25350, from BT01-07. 25–27, MPC25351, from BT01-07. 28–30, MPC25352, from BT01-07.

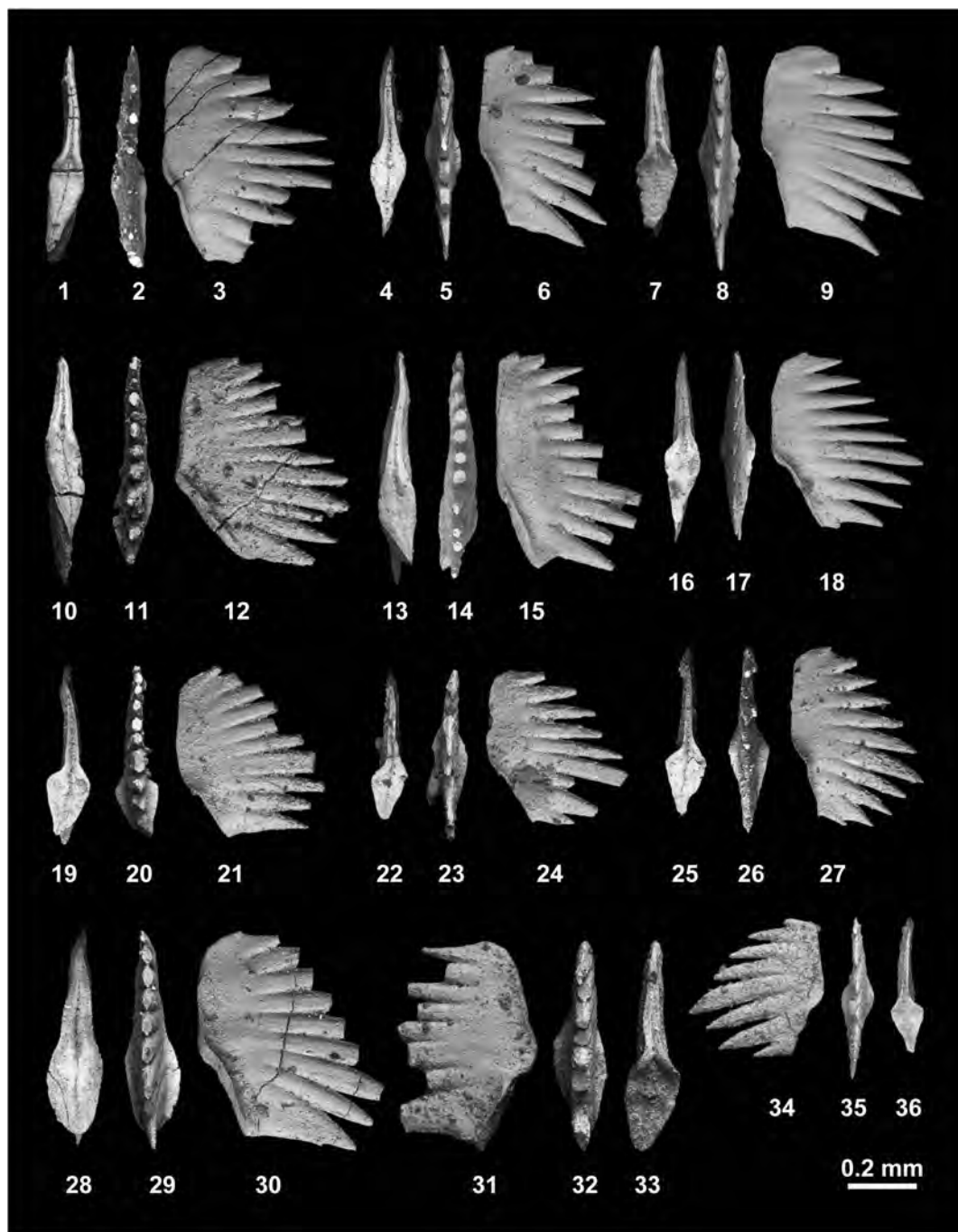


Fig. 168. *Neospathodus spitiensis* Goel, 1977. 1–3, MPC25353, from BT01-07. 4–6, MPC25354, from BT01-07. 7–9, MPC25355, from BT01-07. 10–12, MPC25356, from BT01-07. 13–15, MPC25357, from BT01-07. 16–18, MPC25358, from BT01-07. 19–21, MPC25359, from BT01-07. 22–24, MPC25360, from BT01-07. 25–27, MPC25361, from BT01-07. 28–30, MPC25362, from BT01-07. 31–33, MPC25363, from BT01-10. 34–36, MPC25364, from BT01-10.

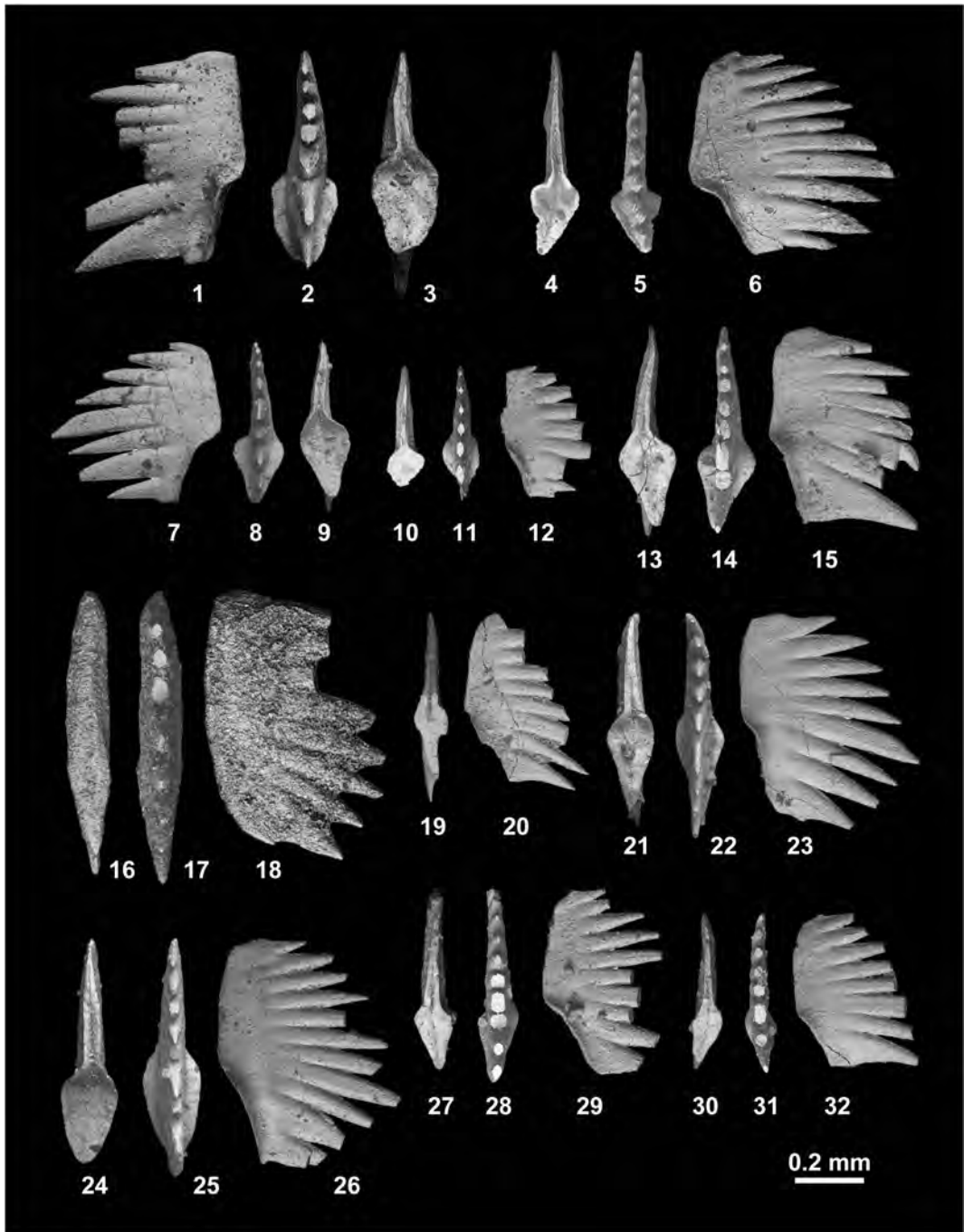


Fig. 169. *Neospathodus spitiensis* Goel, 1977. 1–3, MPC25365, from BT01-10. 4–6, MPC25366, from BT01-10. 7–9, MPC25367, from BT01-10. 10–12, MPC25368, from BT01-12. 13–15, MPC25369, from BT01-12. 16–18, MPC25370, from BT02-01. 19–20, MPC25371, from KC01-01. 21–23, MPC25372, from KC01-04. 24–26, MPC25373, from KC01-04. 27–29, MPC25374, from KC01-04. 30–32, MPC25375, from KC01-05.

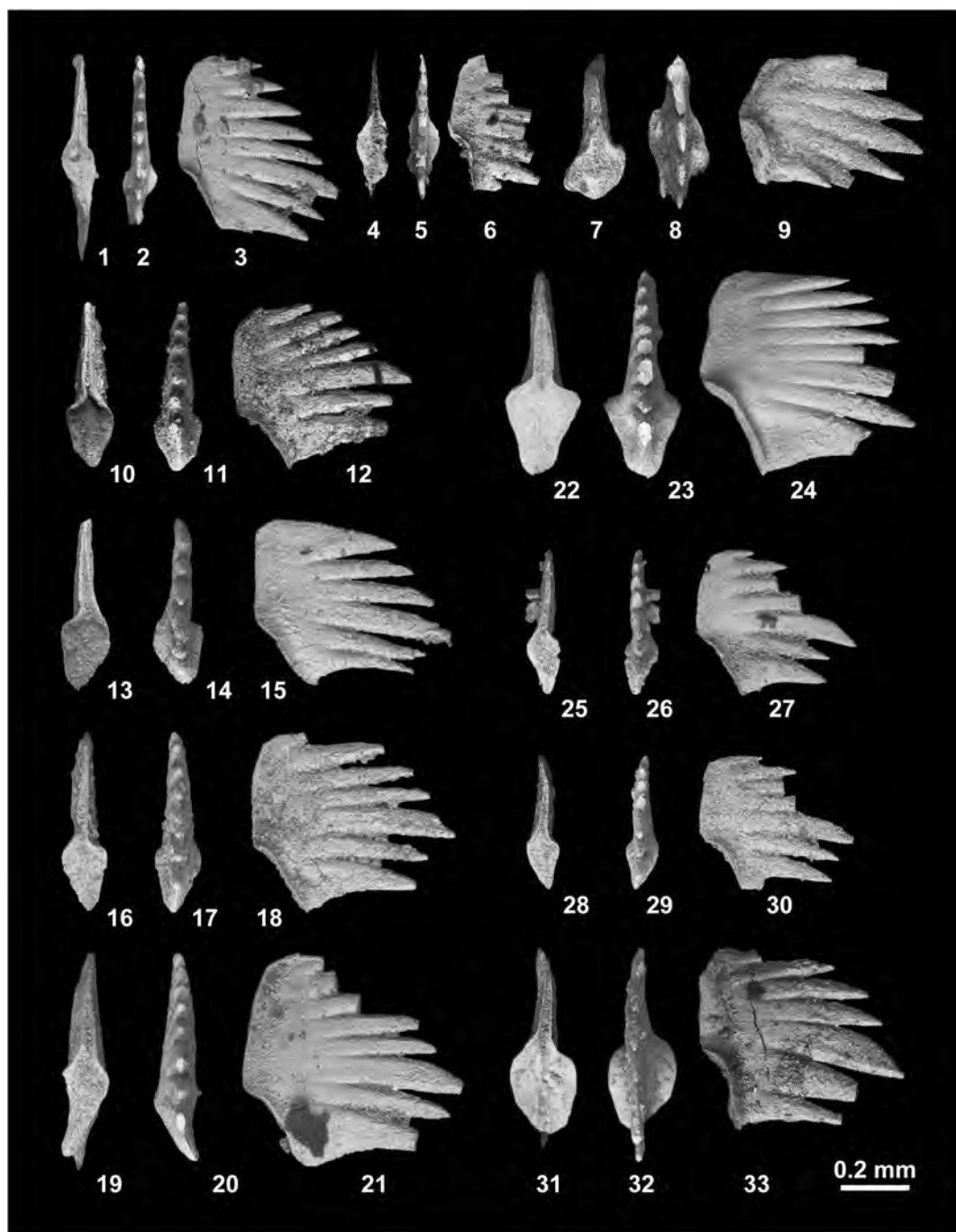


Fig. 170. 1–6, *Neospathodus spitiensis* Goel, 1977. 1–3, MPC25376, from KC01-05. 4–6, MPC25377, from KC01-06. 7–33, *Neospathodus* sp. indet. A. 7–9, MPC25378, from BT01-03. 10–12, MPC25379, from BT01-06. 13–15, MPC25380, from BT01-10. 16–18, MPC25381, from BT01-10. 19–21, MPC25382, from BT01-12. 22–24, MPC25383, from BT01-12. 25–27, MPC25384, from BT01-12. 28–30, MPC25385, from BT01-14. 31–33, MPC25386, from KC01-13.



The first appearance datum of this species is located in bed 15 of the Muth section in Spiti (Orchard and Krystyn, 2007; Krystyn *et al.*, 2007) and bed 26 of the West Pingdingshang section in Anhui Province, South China (Zhao *et al.*, 2007), both of which correspond to the *Flemingites-Euflemingites* Zone of the Smithian (Orchard and Krystyn, 2007; Orchard, 2010).

*Neospathodus* sp. indet. A

Fig. 170.7–170.33

*Material examined:* One specimen, MPC25378, from BT01-03, one specimen, MPC25379, from BT01-06, two specimens, MPC25380, 25381, from BT01-10, three specimens, MPC25382–25384, from BT01-12, one specimen, MPC25385, from BT01-14, and one specimen, MPC25286, from KC01-13.

*Description:* Segminate elements 0.39–0.62 mm in length, average 0.50 mm; 0.45–0.65 mm in height, average 0.56 mm; length to height ratio 0.7–0.9, average 0.9 for nine specimens. Lateral profile of elements exhibits chevron-like form, with arched upper edge. Reclined slender denticles vary in number from 6 to 9, average 7. Cusp situated in center of element, size twice as large as other denticles. Large terminal process exhibits a triangular shape. Lower edge straight or almost upturned in anterior half, and upturned 15–40 degrees in posterior half. Outline of expanded basal cavity triangular. Anterior furrow extends to basal pit.

*Remarks:* The described specimen is very close to *Neospathodus spitiensis* Goel, 1977 in having a triangular terminal process at the posterior end and a triangular basal cavity, whose height is greater than its length, but differs by its vertical long element and a slightly fewer number of denticles.

*Occurrence:* Described specimens from BT01-03, BT01-06, BT01-10, BT01-12, BT01-14 and KC01-13 within the portion of the *Novispathodus* ex gr. *waageni* Zone that

includes the *Flemingites rursiradiatus* beds (lowest Middle Smithian = middle Lower Olenekian), *Urdoceras tulongensis* beds (lower Middle Smithian = middle Lower Olenekian) and *Leyceceras* horizon of the *Owenites koenei* beds (middle Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

*Neospathodus* sp. indet. B

Fig. 171.1–171.3

*Material examined:* One specimen, MPC25387, from BT01-04.

*Description:* Blade-like segminate element 0.77 mm in length; 0.48 mm in height; length to height ratio 1.6. Lateral form of element rectangular with arched upper edge and slightly bowed lower edge. Pointed slender denticles total 10 in number, discrete in upper half and fused in lower half, gradually reclined posteriorly. Large-sized terminal cusp triangular in shape. Elliptical basal cavity situated at posterior end. Narrow groove extends to anterior end.

*Remarks:* The described specimen is very close to *Neospathodus pakistanensis* Sweet, 1970b in having a rectangular lateral shape and elliptical basal cavity, but differs by its triangular shaped terminal cusp.

*Occurrence:* Described specimen from BT01-04 within the portion of the *Novispathodus* ex gr. *waageni* Zone represented by the *Flemingites rursiradiatus* beds (lowest Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

*Neospathodus* sp. indet. C

Fig. 171.4–171.6

*Material examined:* One specimen, MPC25388, from KC01-11.

*Remarks:* The specimen is characterized by its strongly reclined, laterally compressed denticles, which are discrete in the upper two-thirds. The form in lower view is slightly sigmoidal, and the width of the element is longer

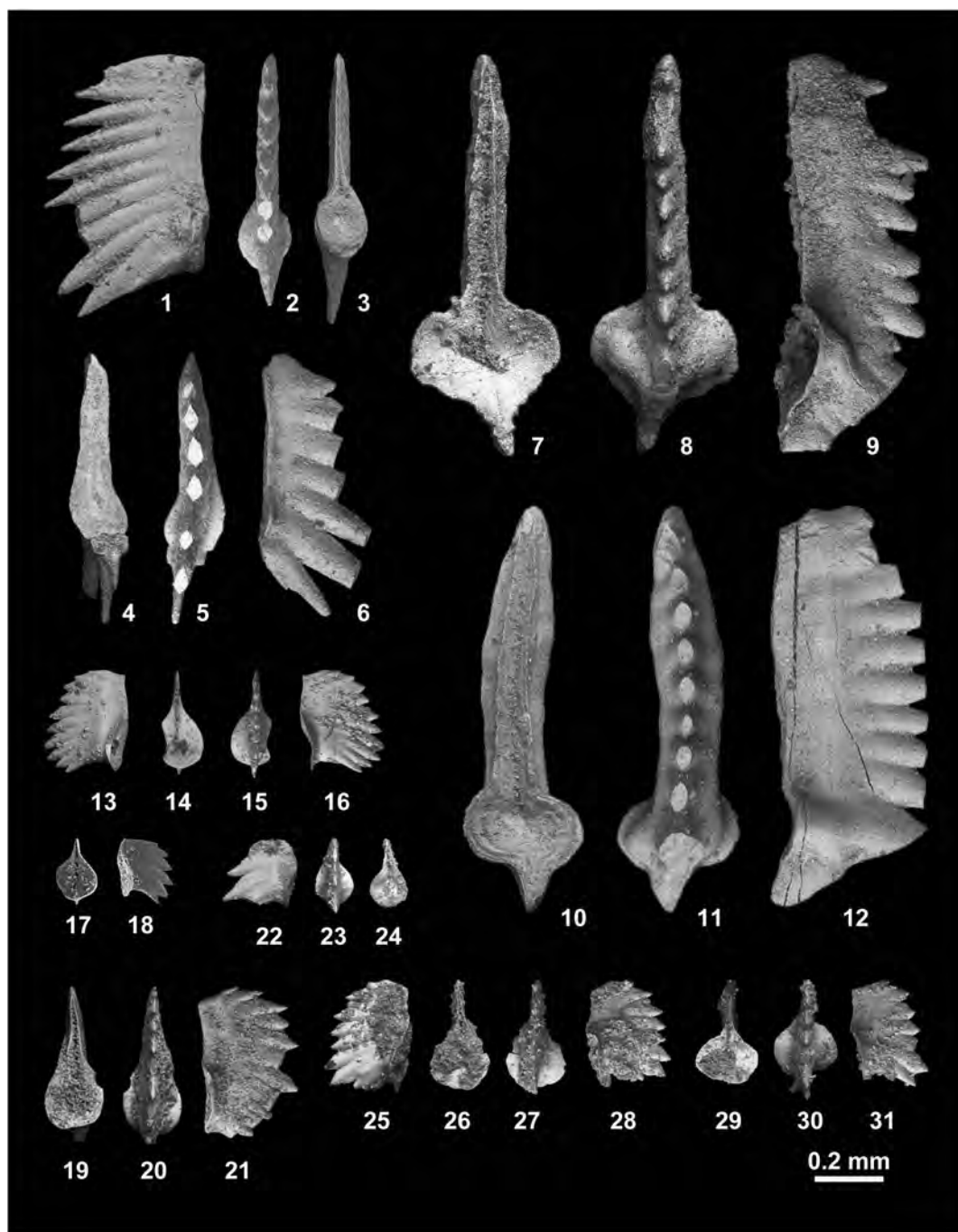


Fig. 171. 1–3, *Neospathodus* sp. indet. B, MPC25387, from BT01-04. 4–6, *Neospathodus* sp. indet. C, MPC25388, from KC01-11. 7–12, *Smithodus longiusculus* (Buryi, 1979). 7–9, MPC25389, from BT01-07. 10–12, MPC25390, from KC01-01. 13–31, *Novispathodus pingdingshanensis* (Zhao and Orchard, 2007). 13–16, MPC25391, from KC02-08. 17–18, MPC25392, from KC02-10. 19–21, MPC25393, from KC02-12. 22–24, MPC25394, from KC01-17. 25–28, MPC25395, from NT01-07. 29–31, MPC25396, from NT01-07.

than other species of *Neospathodus*. It is close to *Ns. sp. nov. S* by Orchard (2008), but differs by its lack of the terminal largest cusp and the rhomboidal outline of its basal cavity.

**Occurrence:** Described specimen from KC01-11 within the portion of the *Novispathodus* ex gr. *waageni* Zone represented by the *Leyceceras* horizon of the *Owenites koeneni* beds (middle Middle Smithian = middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Genus *Smithodus* Budurov, Buryi and Sudar, 1988

**Type species:** *Neospathodus longiusculus* Buryi, 1979.

***Smithodus longiusculus*** (Buryi, 1979)

Fig. 171.7–171.12

*Anchignathodus* sp. A, Mosher, 1973, p. 152, pl. 17, fig. 1.  
*Neospathodus longiusculus* Buryi, 1979, p. 58, pl. 12, fig. 1, pl. 13, fig. 1, pl. 14, fig. 1.

*Smithodus longiusculus* (Buryi, 1979). Buryi, 1997, pl. 1, figs. 1, 2; Orchard, 2007a, fig. 2.

**Material examined:** One specimen, MPC25389, from BT01-07, and one specimen, MPC25390, from KC01-01.

**Description:** Two rectangular blade-like elements 1.16–1.17 mm in length; 0.45–0.46 mm in height; length to height ratio 2.5–2.6. Long, straight, and thin blade bears short node-like denticles totaling 12 and 15 in number, erect or reclined posteriorly. Cusp situated near posterior end. Basal margin straight, slightly upturned in anterior end, downturned in posterior one-fourth. Specimen (MPC25390) has prominent lateral rib. Wide, large, sub-rounded basal cavity situated below cusp, extends to posterior end, strongly concave. Deep broad furrow extends from anterior end to posterior end.

**Occurrence:** Described specimens collected from BT01-07 and KC01-01 within the *Novispathodus* ex gr. *waageni* Zone in the Bac Thuy Formation, northeastern Vietnam. BT01-

07 is located between the *Flemingites rursiradiatus* beds (lowest Middle Smithian = middle Lower Olenekian) and *Urdyceras tulongensis* beds (lower Middle Smithian = middle Lower Olenekian). KC01-01 is located beneath the *Owenites koeneni* beds (middle Middle Smithian = middle Lower Olenekian). Mosher (1973) reported the occurrence of *Smithodus longiusculus* in the *Euflemingites romunderi* Zone (Middle Smithian) in Canada, and Buryi (1979) described the species from the *Anasibirites nevolini* Zone (Upper Smithian). Thus, this species ranges from the middle to Upper Smithian.

Subfamily Novispathodinae Orchard, 2005

Genus *Novispathodus* Orchard, 2005

**Type species:** *Novispathodus abruptus* (Orchard, 1995).

***Novispathodus pingdingshanensis*** (Zhao and Orchard, 2007)

Fig. 171.13–171.31

*Neospathodus pingdingshanensis* Zhao and Orchard, 2007, in Zhao *et al.*, 2007, p. 36, pl. 1, figs. 4A, B, C; Ji *et al.*, 2011, figs. 4.7–4.9; Liang *et al.*, 2011, figs. 1–3.

multielement apparatuses, *Novispathodus pingdingshanensis* (Zhao and Orchard, 2007). Goudemand and Orchard (in Goudemand *et al.*, 2012), p. 1030, figs. 2B, F, I, J, M, Q, AD, 3T, U, 6.

**Material examined:** One specimen, MPC25391, from KC02-08, one specimen, 25392, from KC02-10, one specimen, MPC25393, from KC02-12, one specimen, MPC25394, from KC02-17, and two specimens, MPC25395, 25396, from NT01-07.

**Description:** Small segminate elements 0.19–0.44 mm in length, average 0.30 mm; 0.17–0.29 mm in height, average 0.24 mm; length to height ratio 1.1–1.5, average 1.2 for six specimens. Arched upper edge bears mostly fused, triangular-shaped denticles, varying in number from 4 to 12, average 8, reclined posteriorly. Cusp situated in posterior one-

third with a few small posterior denticles. Basal margin straight or upturned in anterior. Large broadly expanded oval or sub-rounded basal cavity upturned on inner margin, flat to downturned on outer margin, and occupying more than half of basal margin with deep pit. Groove extends to anterior end.

**Remarks:** The described specimens include the juveniles (MPC25392, MPC25394), whose sizes are one-half of the others. However, the feature whereby the large basal cavity exceeds more than half of the length of element is common in all specimens.

**Occurrence:** Described specimens from KC02-08, KC02-10 and NT01-07 within the portion of the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian), and those from KC02-12 and KC02-17 within the portion of the *Triassospathodus symmetricus* Zone that includes the *Tirolites* cf. *cassianus* beds (lowest Lower Spathian=lowest Upper Olenekian) and *Tirolites* sp. nov. beds (Lower Spathian=lower Upper Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in South China (Zhao *et al.*, 2007; Ji *et al.*, 2011; Liang *et al.*, 2011; Goudemand *et al.*, 2012).

Zhao and Orchard (in Zhao *et al.*, 2007) originally described this species as *Neospathodus* from Chaohu, Anhui Province, South China and defined the *Ns. pingdingshanensis* (= *Novispathodus pingdingshanensis*) Zone in the Yinkeng Formation (Zhao *et al.*, 2007). The zone extends from just above the *Ns. waageni* Zone to the base of the *Ns. homeri* Zone. Previous authors (Zhao *et al.*, 2007; Liang *et al.*, 2011) have suggested that *Nv. pingdingshanensis* is a zonal-index taxon for the lowermost Lower Spathian based on the evidence that ammonoids defining the base of the Spathian co-occur with this species. However, the species also occurs with *Xenoceltites variocostatus*, which is an index ammonoid for the Upper Smithian (Goudemand *et al.*,

2012 and this study) in South China and north-eastern Vietnam. This fact suggests that the FAD of *Nv. pingdingshanensis* occurs in the Upper Smithian.

### *Novispathodus triangularis* (Bender, 1970)

Figs. 172, 173, 174.1–174.30

*Neospathodus cristagalli* (Huckriede, 1958). Mosher, 1968, p. 930, pl. 115, fig. 2.

*Spathognathodus triangularis* Bender, 1970, p. 530, pl. 5, figs. 22a, b.

*Neospathodus biangularis* Z. H. Wang and Cao, 1981, p. 367, pl. 2, figs. 22, 23; Wang and Cao, 1993, pl. 56, fig. 15.

*Neospathodus triangularis* (Bender, 1970). Sweet, 1970b, p. 253, pl. 1, figs. 7, 8; Goel, 1977, p. 1097, pl. 2, figs. 12, 13; Solien, 1979, p. 304, pl. 3, fig. 7; Koike, 1981, pl. 1, fig. 6; Duan *et al.*, 1983, p. 380, pl. 97, figs. 3a, b; Matsuda, 1983, pp. 93–94, pl. 3, figs. 5–9; Wang and Zhong, 1994, pl. 1, figs. 1, 2, 6, 10; Orchard, 1995, p. 116, 118, figs. 3.–3.4; Lucas and Orchard, 2007, figs. 10–12; Ji *et al.*, 2011, figs. 3.7, 3.11.

*Neospathodus curtatus* Orchard, 1995, p. 119, figs. 3.8–3.13.

**Material examined:** One specimen, MPC25397, from KC02-14, and thirty-four specimens, MPC25398–25431, from KC02-15.

**Description:** P<sub>1</sub> element: Trapezoidal-shaped, small segminate elements 0.37–0.57 mm in length, average 0.45 mm; 0.27–0.38 mm in height, average 0.33 mm; 0.16–0.35 mm, average 0.22 mm in width; length to height ratio 1.2–1.7, average 1.4 for thirty-three specimens. Arched upper edge bears erect or radial, small, fused, spine-like denticles varying in number from 10 to 14, average 12. Cusp situated from center to posterior of element. Denticle size gradually decreases from cusp to both anterior and posterior ends. Lower edge consists of straight or concave anterior part and strongly downturned posterior margin. Sub-triangular or sub-quadrangular, strongly concave basal cavity occupies posterior one-third to one-half length of element. Groove extends from basal pit to anterior end.



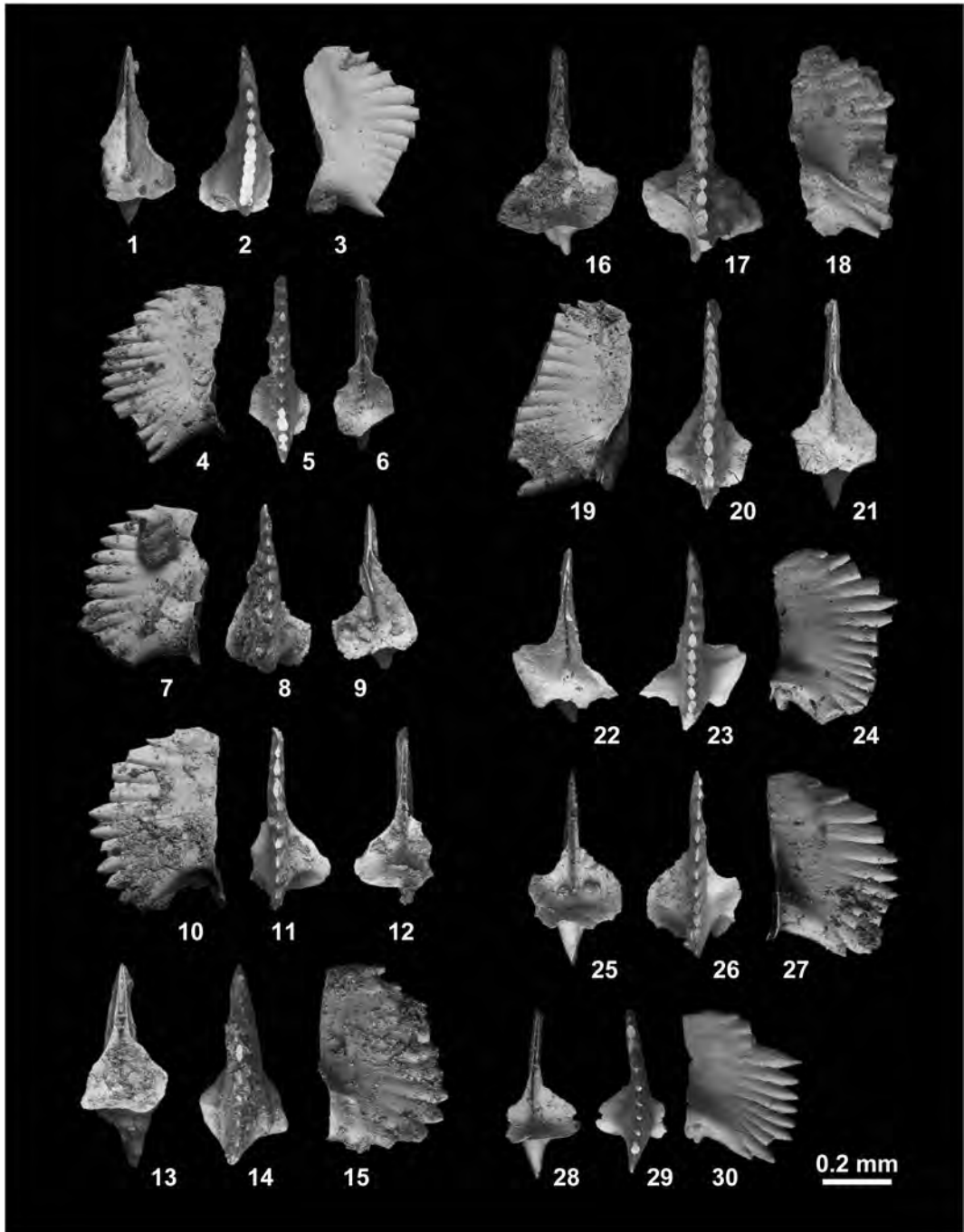


Fig. 172. *Novispathodus triangularis* (Bender, 1970), P<sub>1</sub> element. 1–3, MPC25397, from KC02-14. 4–6, MPC25398, from KC02-15. 7–9, MPC25399, from KC02-15. 10–12, MPC25400, from KC02-15. 13–15, MPC25401, from KC02-15. 16–18, MPC25402, from KC02-15. 19–21, MPC25403, from KC02-15. 22–24, MPC25404, from KC02-15. 25–27, MPC25405, from KC02-15. 28–30, MPC25406, from KC02-15.

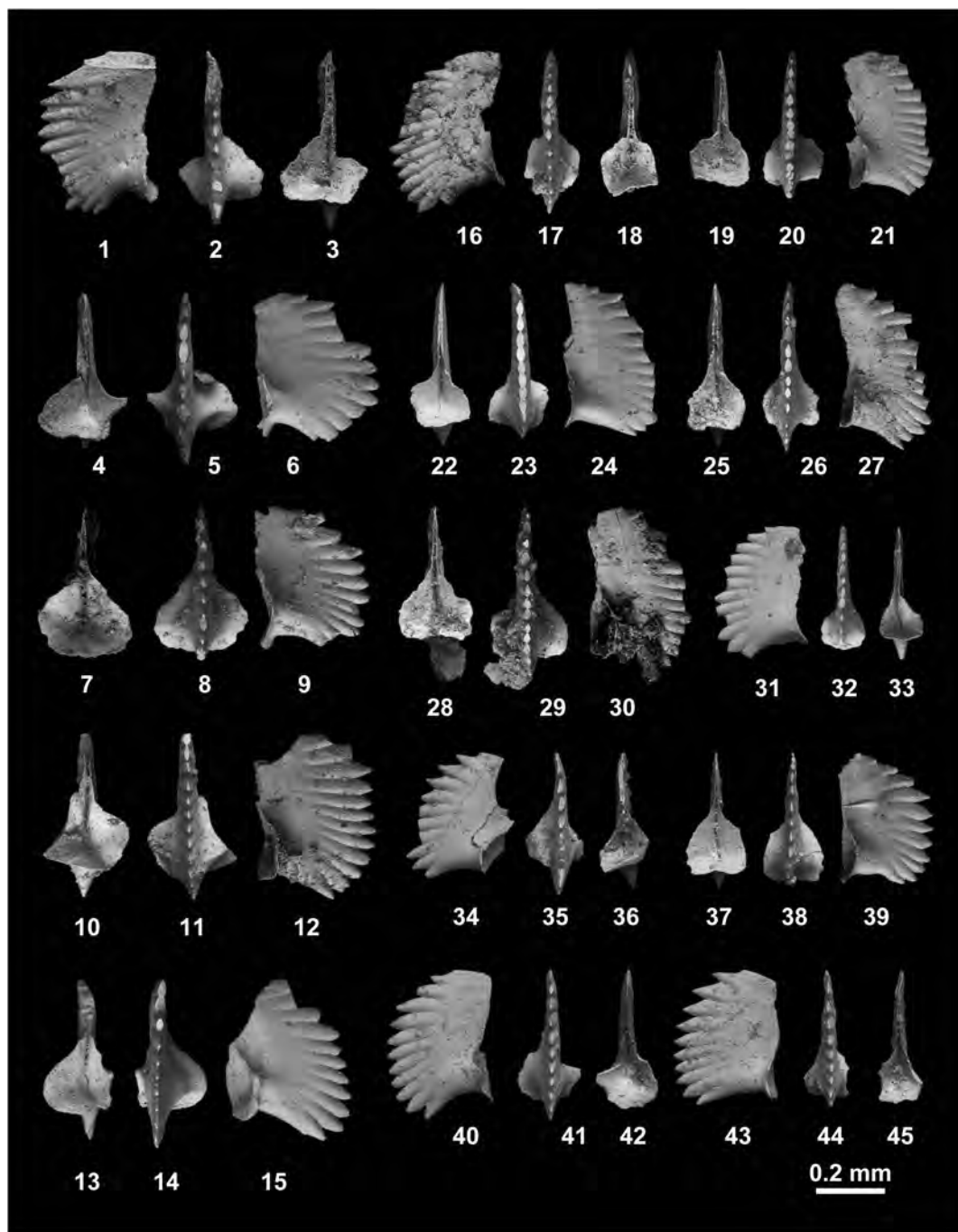


Fig. 173. *Novispathodus triangularis* (Bender, 1970), P<sub>1</sub> element, from KC02-15. 1–3, MPC25407. 4–6, MPC25408. 7–9, MPC25409. 10–12, MPC25410. 13–15, MPC25411. 16–18, MPC25412. 19–21, MPC25413. 22–24, MPC25414. 25–27, MPC25415. 28–30, MPC25416. 31–33, MPC25417. 34–36, MPC25418. 37–39, MPC25419. 40–42, MPC25420. 43–45, MPC25421.

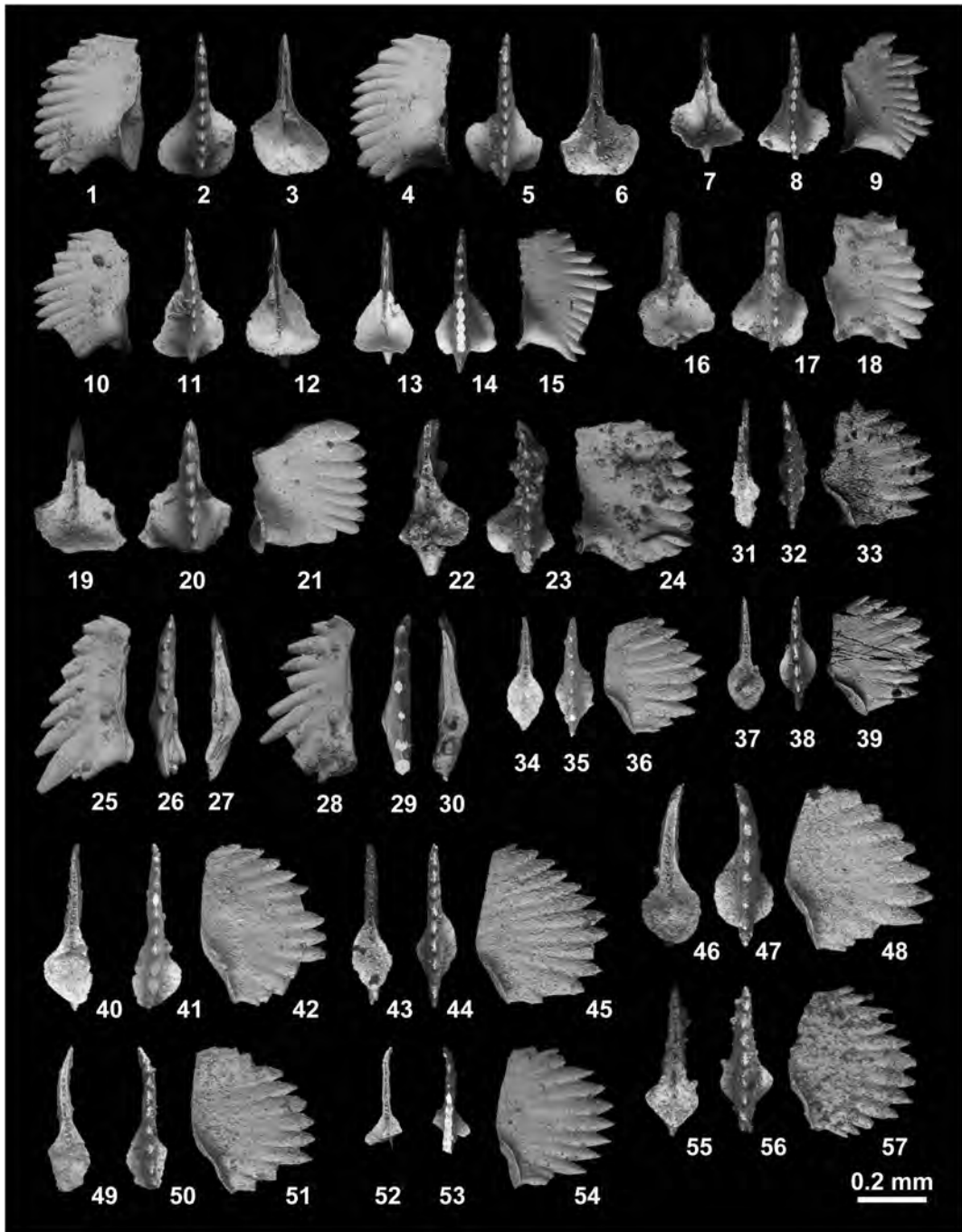


Fig. 174. 1–30, *Novispathodus triangularis* (Bender, 1970) from KC02-15. 1–3,  $P_1$  element, MPC25422. 4–6,  $P_1$  element, MPC25423. 7–9,  $P_1$  element, MPC25424. 10–12,  $P_1$  element, MPC25425. 13–15,  $P_1$  element, MPC25426. 16–18,  $P_1$  element, MPC25427. 19–21,  $P_1$  element, MPC25428. 22–24,  $P_1$  element, MPC25429. 25–27,  $P_2$  element, MPC25430. 28–30,  $P_2$  element, MPC25431. 31–57, *Novispathodus* ex gr. *waageni* (Sweet, 1970b) from BT01-03. 31–33, MPC25432. 34–36, MPC25433. 37–39, MPC25434. 40–42, MPC25435. 43–45, MPC25436. 46–48, MPC25437. 49–51, MPC25438. 52–54, MPC25439. 55–57, MPC25440.

$P_2$  element: Two laterally compressed, triangular-shaped segminate elements 0.49–0.52 mm in length; 0.29 mm in height; length to height ratio 1.7–1.8. Broad denticles total 10 in number. Size and inclination of denticles gradually increase toward posterior end. Posterior terminal cusp bears 1 or 2 small denticles. Basal margin of element bowed. Aboral surface concave, and slightly expanded around basal pit. Groove extends from anterior end to posterior end.

*Remarks:* Some of the described specimens (MPC25398, 25407, 25414, etc.) have 2 to 4 small posterior processes, and hence, are close to *Neospathodus curtatus* Orchard, 1995, which is probably one of the morphological variants of *Novispathodus triangularis* (Bender, 1970). The  $P_2$  elements of the described specimens show that the denticulation gradually increases in size and inclination. They are close to the  $P_2$  elements of *Nv. abruptus* Orchard (2005), but the number of denticles is fewer.

*Occurrence:* Described specimens from KC02-14 and KC02-15 within the portion of the *Triassospathodus symmetricus* Zone represented by the *Tirolites* sp. nov. beds (Lower Spathian=lower Upper Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species occurs in the lowermost Lower Spathian in the Salt Range (Sweet, 1970b) and western USA (Sweet *et al.*, 1971), and its range extends to the uppermost Spathian (Orchard, 2010). This species is also known from Nevada (Mosher, 1968; Lucas and Orchard, 2007), Chios, Greek (Bender, 1970), Spiti, India (Goel, 1977), Southwest Japan (Koike, 1981), South China (Wang and Cao, 1981; Wang and Zhong, 1994), and Oman (Orchard, 1995).

*Novispathodus* ex gr. *waageni* (Sweet, 1970b)

Figs. 174.31–174.57, 175–180, 181.1–181.31

*Neospathodus waageni* Sweet, 1970b, p. 260, pl. 1, figs. 11, 12; McTavish, 1973, p. 300, pl. 2, figs. 11, 22, 25–28; Mosher, 1973, p. 172, pl. 20, fig. 5; Goel,

1977, p. 1094, pl. 2, figs. 1–4; Solien, 1979, p. 304, pl. 3, fig. 9; Buryi, 1979, p. 56, pl. 7, figs. 8, 9; Wang and Cao, 1981, pl. 2, fig. 26; Koike, 1982, p. 39, pl. 6, figs. 24–27; Matsuda, 1983, p. 88, pl. 1, figs. 6–10, pl. 2, figs. 1–7; Duan, 1987, pl. 2, figs. 7; Cao and Wang, 1993, p. 261, pl. 56, figs. 5, 11; Wang and Zhong, 1994, p. 402, pl. 1, figs. 12, 13; Nakrem *et al.*, 2008, figs. 5.7, 5.8, 5.11, 5.14; Orchard, 2008, p. 40, figs. 8.1, 8.2, 8.8, 8.9; Beranek *et al.*, 2010, figs. 6.22, 6.23.

*Neospathodus waageni waageni* Sweet, 1970b. Zhao and Orchard (in Zhao *et al.*, 2007), p. 36, pl. 1, figs. 10A, B.

*Neospathodus waageni eowaageni* Zhao and Orchard, 2007, in Zhao *et al.*, 2007, p. 36, pl. 1, figs. 5A, B.

*Neospathodus* ex gr. *waageni* (Sweet, 1970b). Orchard and Krystyn, 2007, figs. 8–18; Igo, 2009, p. 194, figs. 152.14–152.19, 156.7–156.19.

*Novispathodus waageni* (Sweet, 1970b). Goudemand and Orchard (in Goudemand *et al.*, 2012), p. 1031, figs. 3D, E, H, N, S, T.

*Material examined:* Twenty-three specimens, MPC25432–25454, from BT01-03, nine specimens, MPC25455–25463, from BT01-04, seven specimens, MPC25464–25470, from BT01-06, six specimens, MPC25471–25476, from BT01-07, eighteen specimens, MPC25477–25494, from BT01-10, eight specimens, MPC25495–25502, from BT01-12, six specimens, MPC25503–25508, from BT02-01, two specimens, MPC25509, 25510, from BT02-02, three specimens, MPC25511–25513, from KC01-01, nine specimens, MPC25514–25522, from KC01-04, one specimen, MPC25523, from KC01-05, four specimens, MPC25524–25527, from KC01-06, two specimens, MPC25528, 25529, from KC01-08, two specimens, MPC25530, 25531, from KC01-11, two specimens, MPC25532, 25533, from KC01-12, two specimens, MPC25534, 25535, from KC01-13, and one specimen, MPC25536, from KC02-08.

*Description:* Laterally compressed arched elements 0.30–0.78 mm in length, average 0.49 mm; 0.27–0.60 mm in height, average 0.41 mm; length to height ratio 0.9–1.8, average 1.2 for one hundred-five specimens. Arched upper edge bears sharp pointed denti-



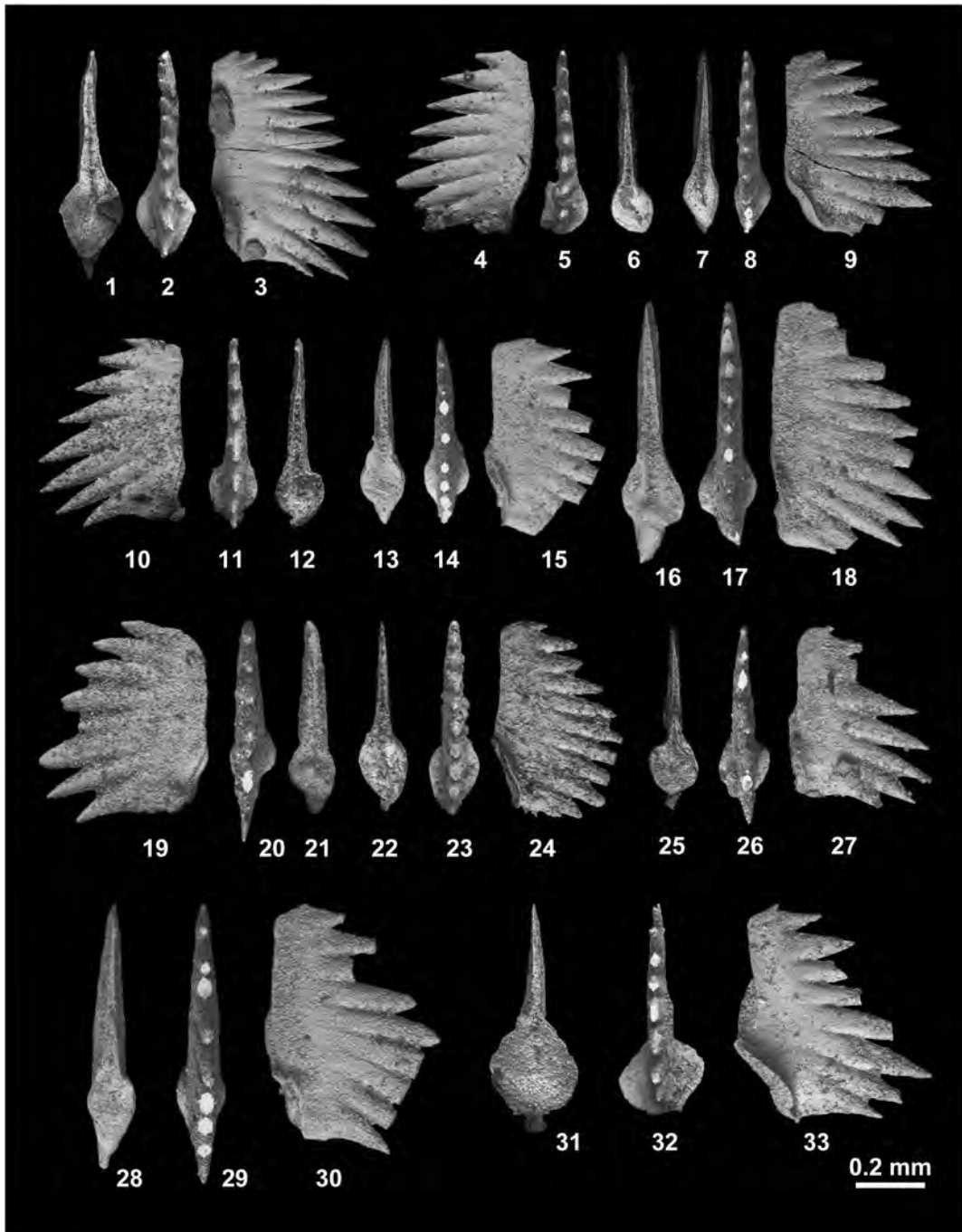


Fig. 175. *Novispathodus ex gr. waageni* (Sweet, 1970b) from BT01-03. 1–3, MPC25441. 4–6, MPC25442. 7–9, MPC25443. 10–12, MPC25444. 13–15, MPC25445. 16–18, MPC25446. 19–21, MPC25447. 22–24, MPC25448. 25–27, MPC25449. 28–30, MPC25450. 31–33, MPC25451.

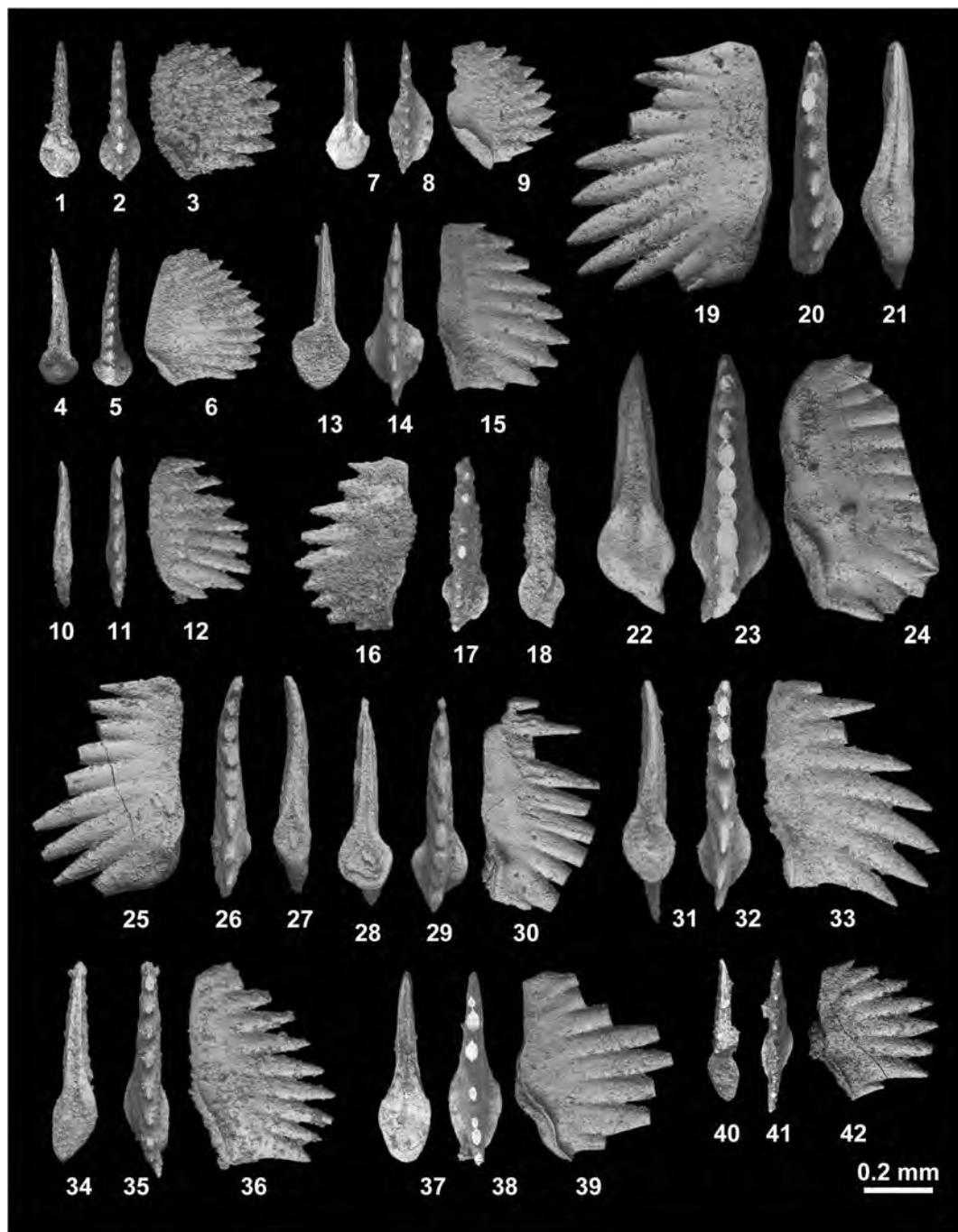


Fig. 176. *Novispathodus* ex gr. *waageni* (Sweet, 1970b). 1–3, MPC25452, from BT01-03. 4–6, MPC25453, from BT01-03. 7–9, MPC25454, from BT01-03. 10–12, MPC25455, from BT01-04. 13–15, MPC25456, from BT01-04. 16–18, MPC25457, from BT01-04. 19–21, MPC25458, from BT01-04. 22–24, MPC25459, from BT01-04. 25–27, MPC25460, from BT01-04. 28–30, MPC25461, from BT01-04. 31–33, MPC25462, from BT01-04. 34–36, MPC25463, from BT01-04. 37–39, MPC25464, from BT01-06. 40–42, MPC25465, from BT01-06.

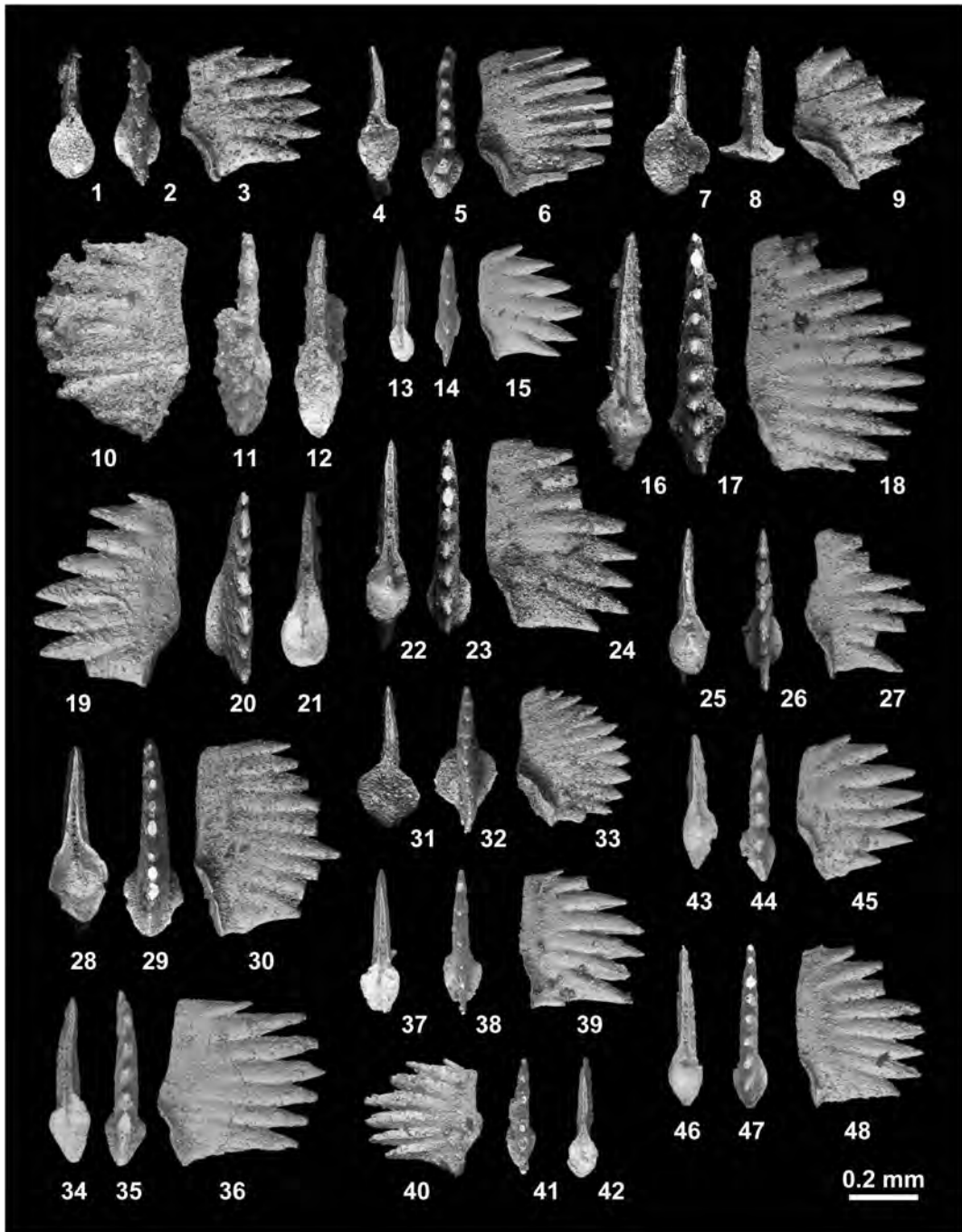


Fig. 177. *Novispathodus ex gr. waageni* (Sweet, 1970b). 1–3, MPC25466, from BT01-06. 4–6, MPC25467, from BT01-06. 7–9, MPC25468, from BT01-06. 10–12, MPC25469, from BT01-06. 13–15, MPC25470, from BT01-06. 16–18, MPC25471, from BT01-07. 19–21, MPC25472, from BT01-07. 22–24, MPC25473, from BT01-07. 25–27, MPC25474, from BT01-07. 28–30, MPC25475, from BT01-07. 31–33, MPC25476, from BT01-07. 34–36, MPC25477, from BT01-10. 37–39, MPC25478, from BT01-10. 40–42, MPC25479, from BT01-10. 43–45, MPC25480, from BT01-10. 46–48, MPC25481, from BT01-10.



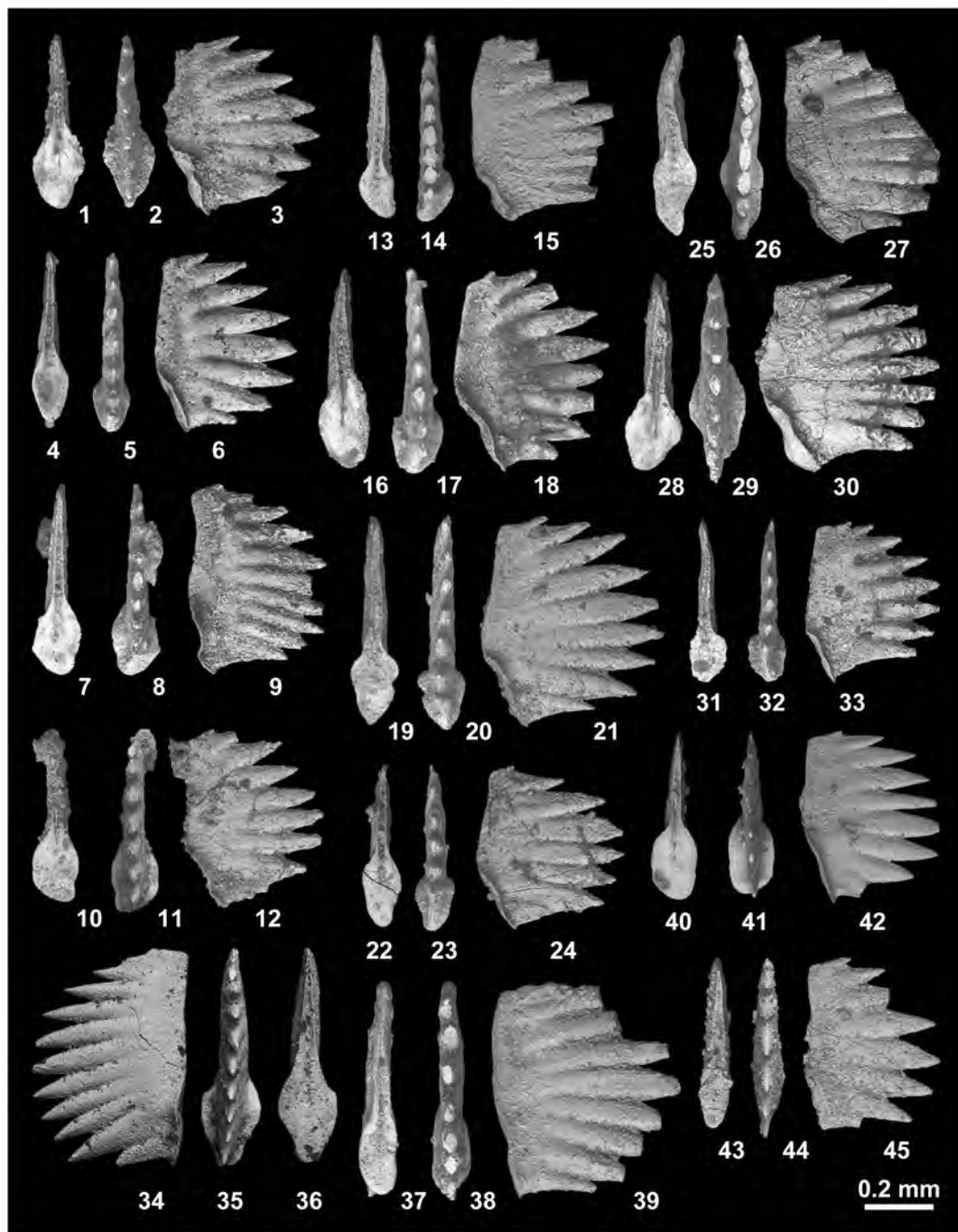


Fig. 178. *Novispathodus ex gr. waageni* (Sweet, 1970b). 1–3, MPC25482, from BT01-10. 4–6, MPC25483, from BT01-10. 7–9, MPC25484, from BT01-10. 10–12, MPC25485, from BT01-10. 13–15, MPC25486, from BT01-10. 16–18, MPC25487, from BT01-10. 19–21, MPC25488, from BT01-10. 22–24, MPC25489, from BT01-10. 25–27, MPC25490, from BT01-10. 28–30, MPC25491, from BT01-10. 31–33, MPC25492, from BT01-10. 34–36, MPC25493, from BT01-10. 37–39, MPC25494, from BT01-10. 40–42, MPC25495, from BT01-12. 43–45, MPC25496, from BT01-12.



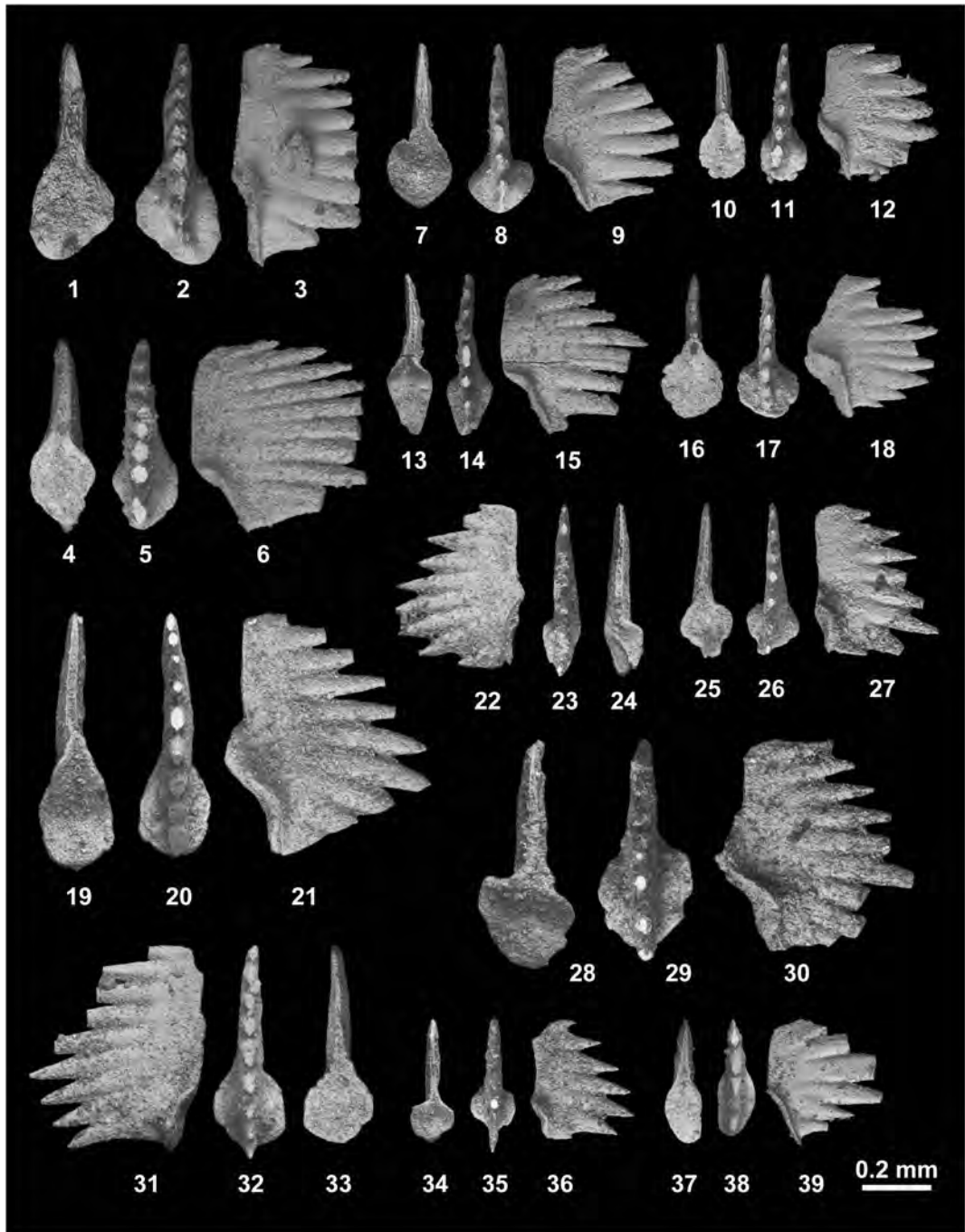


Fig. 179. *Novispathodus ex gr. waageni* (Sweet, 1970b). 1–3, MPC25497, from BT01-12. 4–6, MPC25498, from BT01-12. 7–9, MPC25499, from BT01-12. 10–12, MPC25500, from BT01-12. 13–15, MPC25501, from BT01-12. 16–18, MPC25502, from BT01-12. 19–21, MPC25503, from BT02-01. 22–24, MPC25504, from BT02-01. 25–27, MPC25505, from BT02-01. 28–30, MPC25506, from BT02-01. 31–33, MPC25507, from BT02-01. 34–36, MPC25508, from BT02-01. 37–39, MPC25509, from BT02-02.

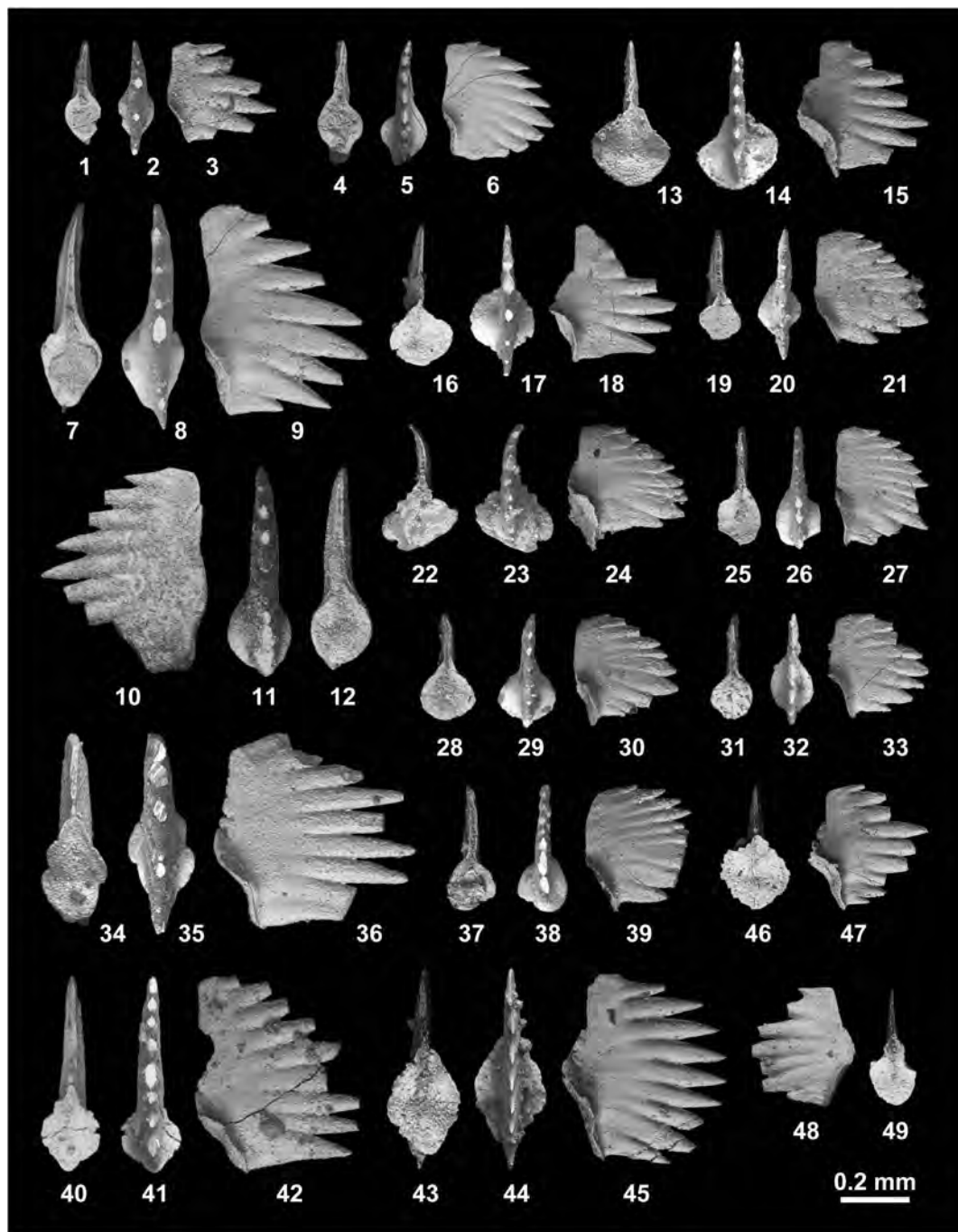


Fig. 180. *Novispathodus* ex gr. *waageni* (Sweet, 1970b). 1–3, MPC25510, from BT02-02. 4–6, MPC25511, from KC01-01. 7–9, MPC25512, from KC01-01. 10–12, MPC25513, from KC01-01. 13–15, MPC25514, from KC01-04. 16–18, MPC25515, from KC01-04. 19–21, MPC25516, from KC01-04. 22–24, MPC25517, from KC01-04. 25–27, MPC25518, from KC01-04. 28–30, MPC25519, from KC01-04. 31–33, MPC25520, from KC01-04. 34–36, MPC25521, from KC01-04. 37–39, MPC25522, from KC01-04. 40–42, MPC25523, from KC01-05. 43–45, MPC25524, from KC01-06. 46–47, MPC25525, from KC01-06. 48–49, MPC25526, from KC01-06.

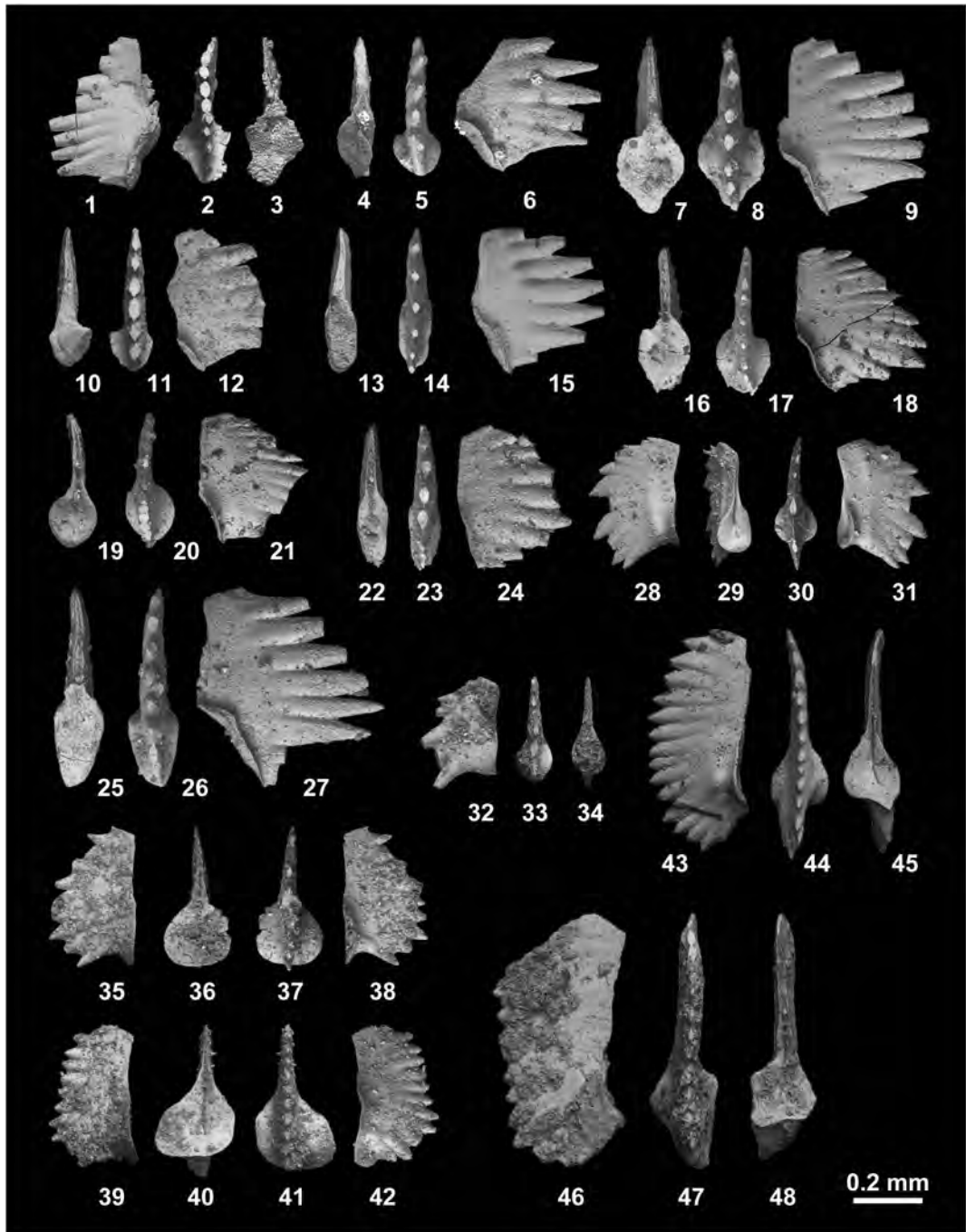


Fig. 181. 1–31, *Novispathodus* ex gr. *waageni* (Sweet, 1970b). 1–3, MPC25527, from KC01-06. 4–6, MPC25528, from KC01-08. 7–9, MPC25529, from KC01-08. 10–12, MPC25530, from KC01-11. 13–15, MPC25531, from KC01-11. 16–18, MPC25532, from KC01-12. 19–21, MPC25533, from KC01-12. 22–24, MPC25534, from KC01-13. 25–27, MPC25535, from KC01-13. 28–31, MPC25536, from KC02-08. 32–38, *Novispathodus* sp. nov. A Goudemand and Orchard, 2012. 32–34, MPC25537, from KC02-08. 35–38, MPC25538, from NT01-07. 39–42, *Novispathodus* sp. indet. A, MPC25539, from NT01-07. 43–48, *Triassospathodus homeri* (Bender, 1970) from KC02-15. 43–45, MPC25540. 46–48, MPC25541.

cles, varying in number from 6 to 13, average 9, discrete in upper one-third to one-half, sub-erect or reclined posteriorly, some specimens have 1 to 3 small posterior denticles. Lower edge straight or curved slightly upward anteriorly, posterior margin upturned about 5–40 degrees. Rounded or sub-rounded basal cavity expanded at posterior end, occupies one-fourth to one-half of length of element, and is slightly concave. Groove extends from basal pit to anterior end.

*Remarks:* Following Sweet's (1970b) first description of *Novispathodus waageni* from the Salt Range as *Neospathodus waageni*, Zhao *et al.* (2007) subdivided it into three subspecies: *Ns. waageni waageni*, *Ns. w. eowaageni*, and *Ns. posterolongatus*, based on many specimens collected from the West Pingdingshan section. Furthermore, Orchard and Krystyn (2007) recognized six morphotypes including two subspecies (*Ns. w. waageni* and *Ns. w. eowaageni*), based on specimens found at Spiti, India. Morphotype 1 is characterized by the developed platform flange in the lateral side of the element. Morphotype 2 is the same as the holotype (= *Ns. w. waageni*). Morphotype 3 is relatively small with a length to height ratio of about 1.1 and is the same as *Ns. w. eowaageni*. Morphotype 4 has a few small denticles at the posterior end of the element. Morphotype 5 has a large triangular shaped terminal cusp. Morphotype 6 has denticles spreading in a radial fashion from the base.

The described specimens contain Morphotypes 2, 3, 4, 5 and 6, with Morphotypes 4 and 5 being relatively abundant. Specimen (MPC25536) from KC02-08 within the *Nv. pingdingshanensis* Zone is smaller than the others and has an undulating basal margin. The size of basal cavity is smaller than that of *Nv. pingdingshanensis* (Zhao and Orchard, 2007).

*Occurrence:* Described specimens from BT01-03, BT01-04, BT01-06, BT01-07, BT01-10, BT01-12, BT02-01, BT02-02, KC01-01, KC01-04, KC01-05, KC01-06,

KC01-08, KC01-11, KC01-12 and KC01-13 within the portion of the *Novispathodus ex gr. waageni* Zone that includes the *Flemingites rursiradiatus* beds, *Urdoceras tulongensis* beds and *Owenites koeneni* beds (lowest to middle Middle Smithian = middle Lower Olenekian), and KC02-08 within the portion of the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian = upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

*Novispathodus waageni* is a well-known Smithian species throughout the world, and its FAD defines the IOB (Orchard, 2007a, b; Orchard and Krystyn, 2007; Zhao *et al.*, 2007; Shigeta *et al.*, 2009; Orchard, 2010). According to Zhao *et al.* (2007) and Goudemand *et al.* (2012), *Nv. waageni* occurs in the uppermost Smithian with *Nv. pingdingshanensis*. Therefore, *Nv. waageni* ranges throughout the entire Smithian.

*Novispathodus* sp. nov. A Goudemand and Orchard, 2012

Fig. 181.32–181.38

*Novispathodus* sp. nov. A Goudemand and Orchard, in Goudemand *et al.*, 2012, p.1031 figs. 2A, R, Z.

*Material examined:* One specimen, MPC25537, from KC02-08, and one specimen, MPC25538, from NT01-07.

*Description:* Segminate elements 0.34–0.41 mm in length; 0.24–0.25 mm in height; length to height ratio 1.4–1.6 for two specimens, with arched upper edge. Highest point situated near posterior end. Lower margin of element almost straight. Mostly fused and pointed denticles total 7 and 10 in number, sub-erect or reclined posteriorly. Large basal cavity rounded and slightly concave. Groove extends from basal pit to anterior end.

*Remarks:* The described specimens including juvenile (MPC25537) are characterized by a straight lower margin and mostly fused and pointed denticles, which are reclined posteri-



orly. The basal cavity is smaller than that of *Novispathodus pingdingshanensis* (Zhao and Orchard, 2007). These features match well with specimens of *Nv.* sp. nov. A described by Goudemand and Orchard (in Goudemand *et al.*, 2012) from South China.

**Occurrence:** Described specimens from KC02-08 and NT01-07 within the portion of the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the lowest Spathian part of the Tsoteng section, Guangxi, South China (Goudemand *et al.*, 2012).

***Novispathodus* sp. indet. A**

Fig. 181.39–181.42

**Material examined:** One specimen, MPC25539, from NT01-07.

**Description:** Small segminate element 0.41 mm in length; 0.25 mm in height; length to height ratio 1.6, with arched upper edge. Node-like short denticles total 12 in number, sub-erect or reclined posteriorly. Smallest terminal process strongly reclined posteriorly. Highest point situated above basal cavity. Lower margin of element slightly bowed. Asymmetrical sub-triangular basal cavity occupies posterior half of element. Thin furrow extends from basal pit to anterior end.

**Remarks:** The described segminate element has a few small posterior denticles, which are straight or reclined posteriorly and a large basal cavity. These distinctive features enable it to be assigned with reasonable confidence to the genus *Novispathodus*. The lateral view resembles *Icriospathodus? crassatus* (Orchard, 1995) and *I.? zaksi* (Buryi, 1979), but these species have a more robust denticulation and an expanded lateral rib.

**Occurrence:** Described specimen from NT01-07 within the portion of the *Novispathodus pingdingshanensis* Zone in the *Xenocelt-*

*ites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Genus ***Triassospathodus*** Kozur, 1998

**Type species:** *Spathognathodus homeri* Bender, 1970.

***Triassospathodus homeri*** (Bender, 1970)

Fig. 181.43–181.48

*Spathognathodus homeri* Bender, 1970, p. 528, pl. 5, figs. 16a, b, c.

*Neospathodus homeri* (Bender, 1970). Sweet, 1970b, p. 245, pl. 1, figs. 2, 3, 9, 10; Matsuda, 1983, p. 94, pl. 5, figs. 2a, b; Wang and Zhong, 1994, p. 400–401, pl. 1, fig. 27; Orchard, 1995, p. 115, figs. 2.1–2.3, 2.7–2.9, 2.14–2.17, 2.20, 2.21.

multielement apparatuses, *Triassospathodus homeri* (Bender, 1970). Orchard, 2005, p. 93, text-fig. 19.

*Triassospathodus* ex gr. *homeri* (Bender, 1970). Lucas and Orchard, 2007, figs. 7.8, 7.9; Orchard *et al.*, 2007a, figs. 5.5, 5.6; Orchard *et al.*, 2007b, figs. 6.10–6.12; Orchard, 2010, figs. 7.15, 7.16.

**Material examined:** Two specimens, MPC25540, 25541, from KC02-15.

**Description:** Two slender blade-like elements 0.64–0.74 mm in length; 0.30–0.39 mm in height; length to height ratio 1.9–2.1. Arched upper edge bears triangular-shaped fused denticles totaling 11 and 16 in number, including 3 or 4 posterior small terminal processes, gradually reclined posteriorly. Cusp situated in middle part of element. Basal margin straight in anterior two-thirds, downturned in posterior one-third. Sub-rounded basal cavity elongated and curved laterally at terminal end. Narrow groove extends from basal pit to anterior end.

**Remarks:** *Triassospathodus homeri* (Bender, 1970) is one of the well-known characteristic species of the Spathian. According to Orchard (1995), the diagnostic features of the taxon include the posteriorly elongated elliptical basal cavity and the presence of several small posterior processes. In contrast, *T. symmetricus* (Orchard, 1995) lacks small posterior

denticles and the asymmetrical basal cavity, which is slightly elongated posteriorly. In the Bac Thuy Formation, the FAD of *T. homeri* at KC02-15 occurs above the FAD of *T. symmetricus* at KC02-12. This evidence suggests that *T. homeri* evolved from *T. symmetricus* during earliest Spathian time.

**Occurrence:** Described specimens from KC02-15 within the portion of the *Triassospathodus symmetricus* Zone represented by the *Tirolites* sp. nov. beds (Lower Spathian=lower Upper Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the Spathian (Upper Olenekian) in Chios (Bender, 1970), Desli Caira, North Dobrogea, Romania (Orchard *et al.*, 2007a), the Salt Range, Pakistan (Sweet, 1970), Kashmir, India (Matsuda, 1983), Jabal Safra, Oman (Orchard, 1995), Southern Jiangsu, China (Duan, 1987), and Guizhou, South China (Orchard *et al.*, 2007b).

***Triassospathodus symmetricus* (Orchard, 1995)**

Figs. 182–185, 186.1–186.3

*Neospathodus cristagalli* (Huckriede, 1958). Mosher, 1968, p. 930, pl. 115, fig. 1

*Neospathodus triangularis* (Bender, 1970). Sweet, 1970b, pp. 253–254, pl. 1, figs. 7, 8; Perri and Andraghetti, 1987, p. 311, pl. 33, figs. 5a, b, c.

*Neospathodus homeri* (Bender, 1970). Mosher, 1973, p. 171, pl. 20, fig. 14; Goel, 1977, p. 1097, pl. 2, figs. 10, 11; Duan, 1987, pl. 2, figs. 8, 9; Cao and Wang, 1993, pl. 56, figs. 1, 2; Ji *et al.*, 2011, p. 220, figs. 3.9a, b, c.

*Neospathodus ex gr. homeri* (Bender, 1970). Orchard, 1994, pl. 1, figs. 11, 15–18.

*Neospathodus symmetricus* Orchard, 1995, p. 120, figs. 2.6, 2.10–2.13, 2.18; Koike, 2004, p. 137, figs. 6.34–6.38; Ji *et al.*, 2011, figs. 3.5a, b, c.

**Material examined:** Two specimens, MPC25542, 25543, from KC02-12, three specimens, MPC25544–25546, from KC02-14, and forty-three specimens, MPC25547–25589, from KC02-15.

**Description:** Laterally compressed blade-like elements 0.41–0.87 mm in length, average 0.61 mm; 0.22–0.41 mm in height, average

0.33 mm; length to height ratio 1.6–2.7, average 1.9 for forty-eight specimens. Straight or arcuate upper edge bears sub-triangular, pointed and fused denticles varying in number from 10 to 18, average 13, erect and gradually reclined posteriorly. Basal margin slightly or strongly bowed. Some specimens have posterior small denticles above terminal basal cavity. Several elements have a well-developed lateral rib in middle part of element. Basal cavity concave, and exhibits various shapes: circular, elliptical, sub-triangular, square, cordiform. Narrow furrow extends to anterior end.

**Remarks:** The described specimens from KC02-15 display a wide range of intraspecific variation in the form of their denticulation, basal cavities, and basal margins.

**Occurrence:** Described specimens from KC02-12, KC02-14 and KC02-15 within the portion of the *Triassospathodus symmetricus* Zone that includes the *Tirolites* cf. *cassianus* beds (lowest Lower Spathian=lowest Upper Olenekian) and *Tirolites* sp. nov. beds (Lower Spathian=lower Upper Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

This species also occurs in the Spathian in the Salt Range, Pakistan (Zone 9, Sweet, 1970b), the Werfen Formation, southern Alps, Italy (Perri and Andraghetti, 1987), British Columbia, Canada (*Keyserlingites subrobustus* Zone, Mosher, 1973 and Orchard, 1994), Spiti, India (Goel, 1977), the Prida Formation, Nevada (*Subcolumbites* beds and *Neopopanoceras hangi* Zone, Orchard, 1994), the Luolou Formation, Qingyan Section, Guizhou, South China (*Neospathodus homeri* Zone, Ji *et al.*, 2011), and the Tahoe limestone, Southwest Japan (Koike, 2004).

The FAD of *Triassospathodus symmetricus* occurs in the lowest Spathian, but its last appearance datum (LAD) is unknown. The exact range of this taxon must be clarified with respect to its occurrence in other Spathian aged formations and detailed descriptions of co-occurring species must be included.

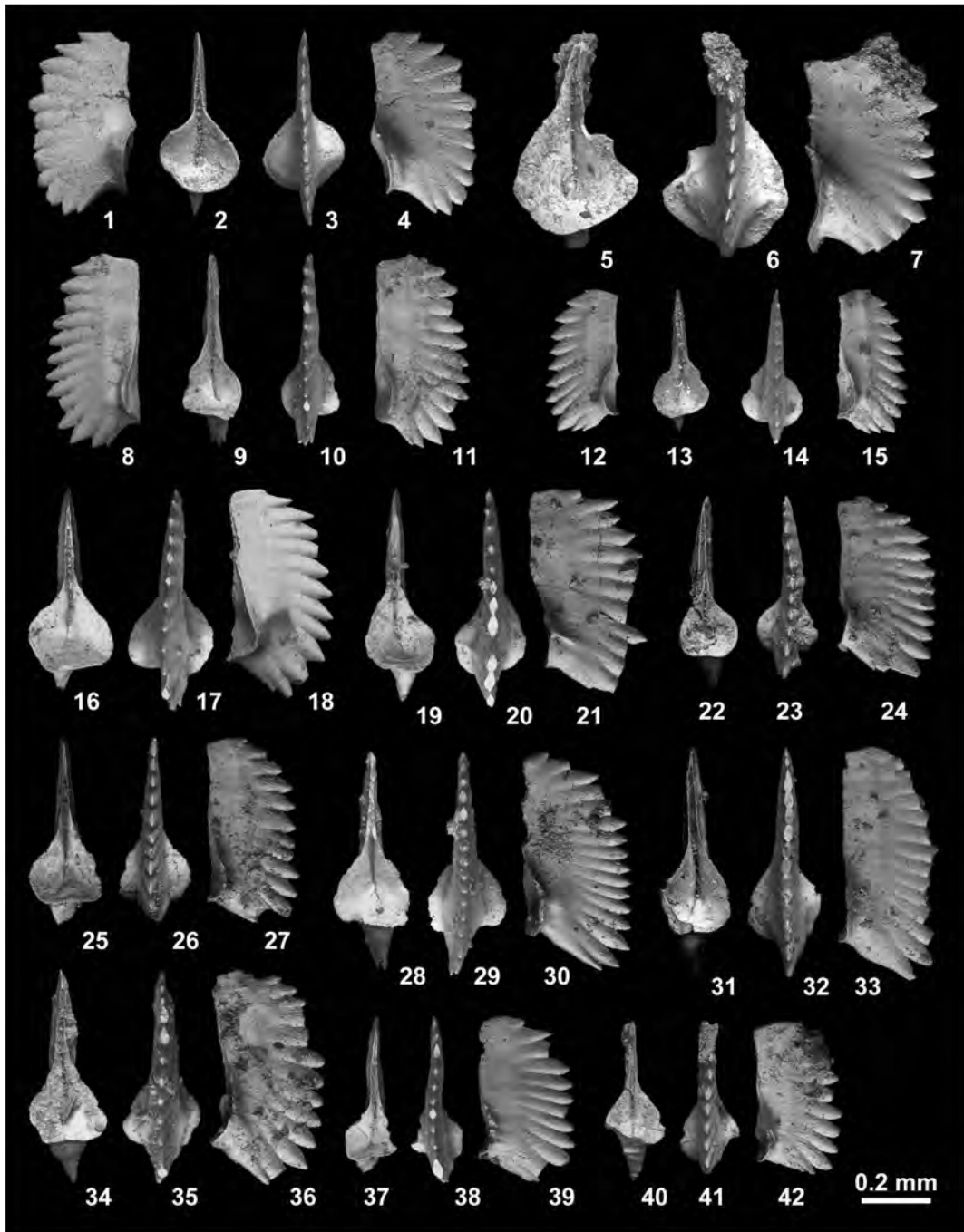


Fig. 182. *Triassospathodus symmetricus* (Orchard, 1995). 1–4, MPC25542, from KC02-12. 5–7, MPC25543, from KC02-12. 8–11, MPC25544, from KC02-14. 12–15, MPC25545, from KC02-14. 16–18, MPC25546, from KC02-14. 19–21, MPC25547, from KC02-15. 22–24, MPC25548, from KC02-15. 25–27, MPC25549, from KC02-15. 28–30, MPC25550, from KC02-15. 31–33, MPC25551, from KC02-15. 34–36, MPC25552, from KC02-15. 37–39, MPC25553, from KC02-15. 40–42, MPC25554, from KC02-15.

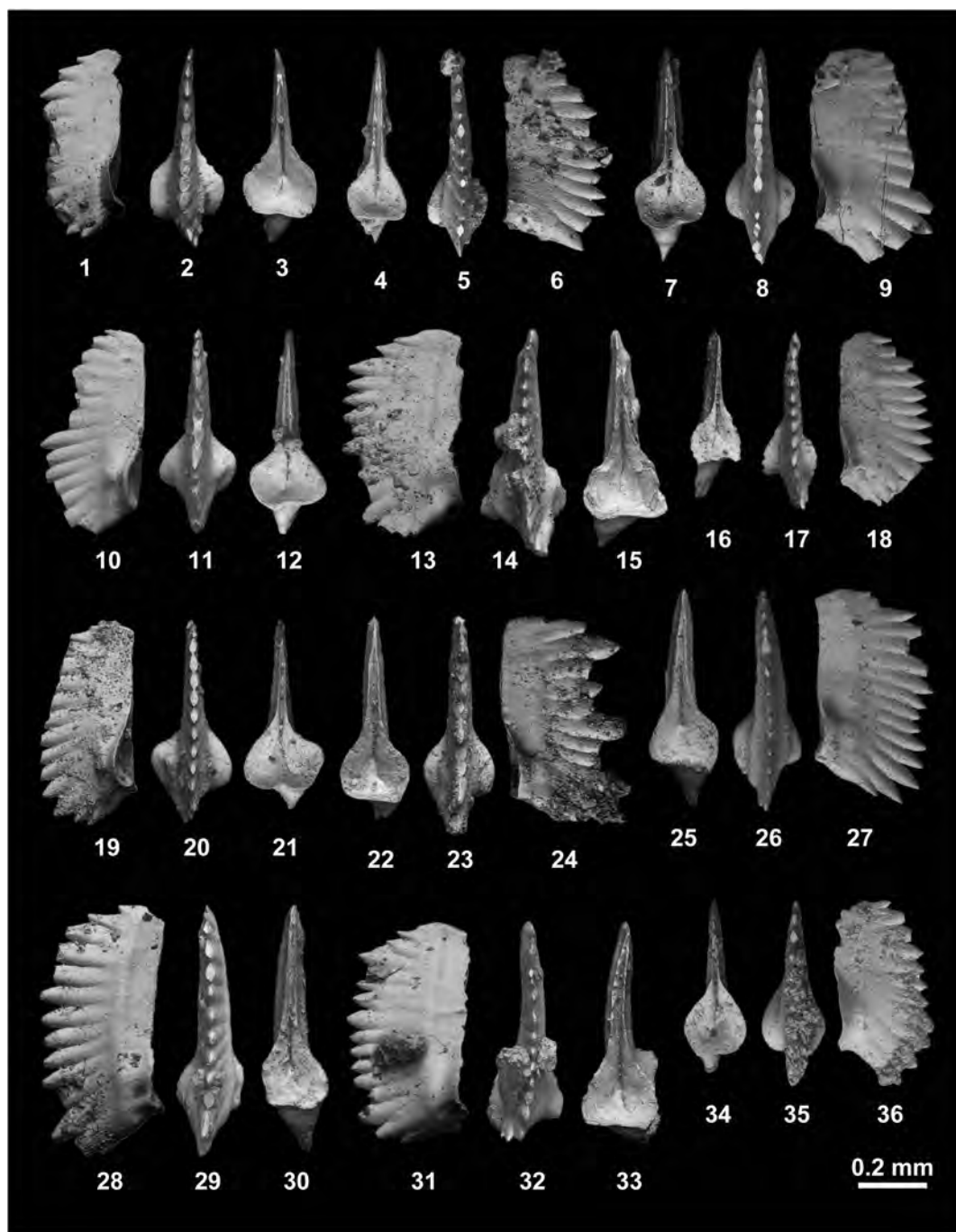


Fig. 183. *Triassospathodus symmetricus* (Orchard, 1995) from KC02-15. 1–3, MPC25555. 4–6, MPC25556. 7–9, MPC25557. 10–12, MPC25558. 13–15, MPC25559. 16–18, MPC25560. 19–21, MPC25561. 22–24, MPC25562. 25–27, MPC25563. 28–30, MPC25564. 31–33, MPC25565. 34–36, MPC25566.



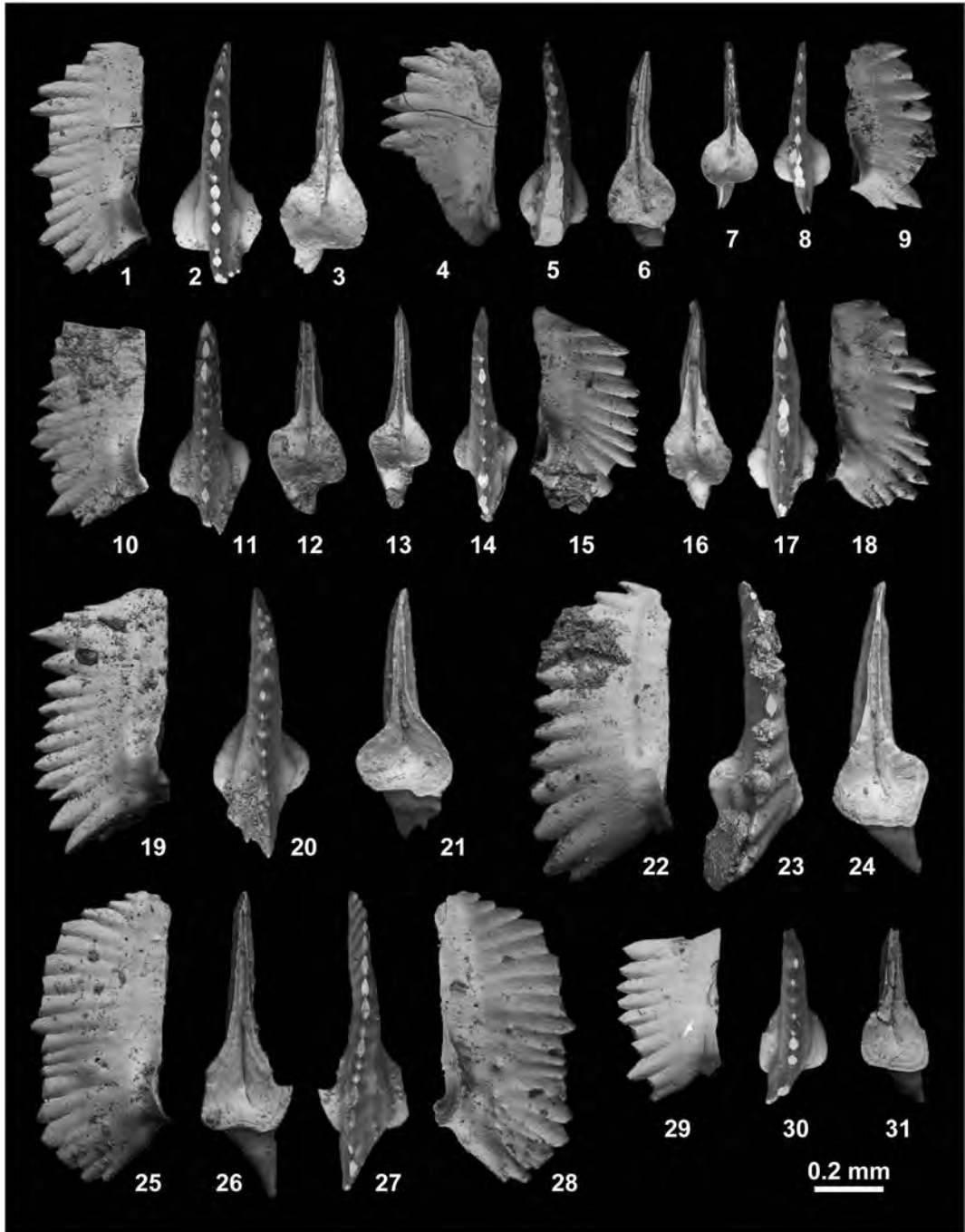


Fig. 184. *Triassospathodus symmetricus* (Orchard, 1995) from KC02-15. 1–3, MPC25567. 4–6, MPC25568. 7–9, MPC25569. 10–12, MPC25570. 13–15, MPC25571. 16–18, MPC25572. 19–21, MPC25573. 22–24, MPC25574. 25–28, MPC25575. 29–31, MPC25576.

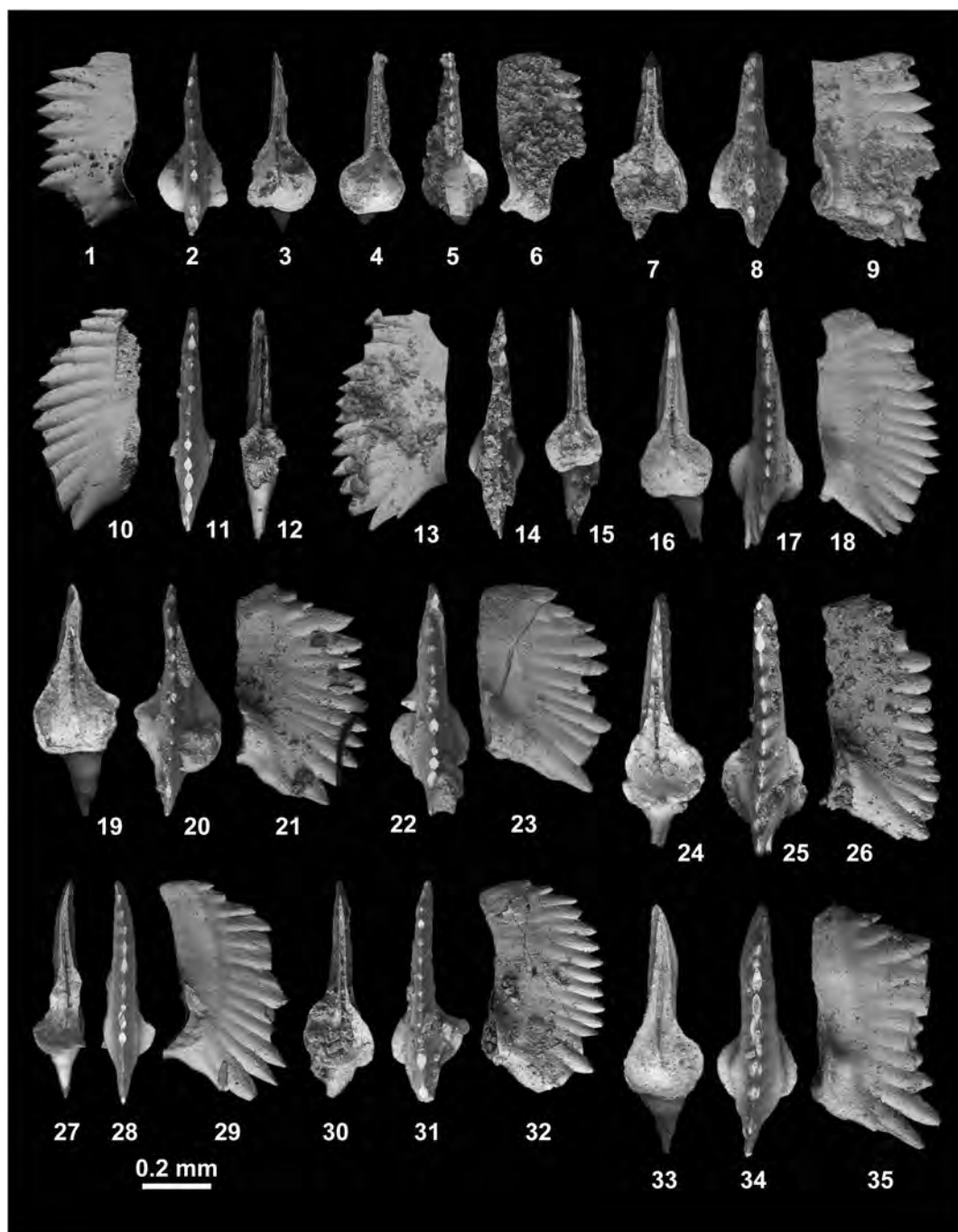


Fig. 185. *Triassospathodus symmetricus* (Orchard, 1995) from KC02-15. 1–3, MPC25577. 4–6, MPC25578. 7–9, MPC25579. 10–12, MPC25580. 13–15, MPC25581. 16–18, MPC25582. 19–21, MPC25583. 22–23, MPC25584. 24–26, MPC25585. 27–29, MPC25586. 30–32, MPC25587. 33–35, MPC25588.

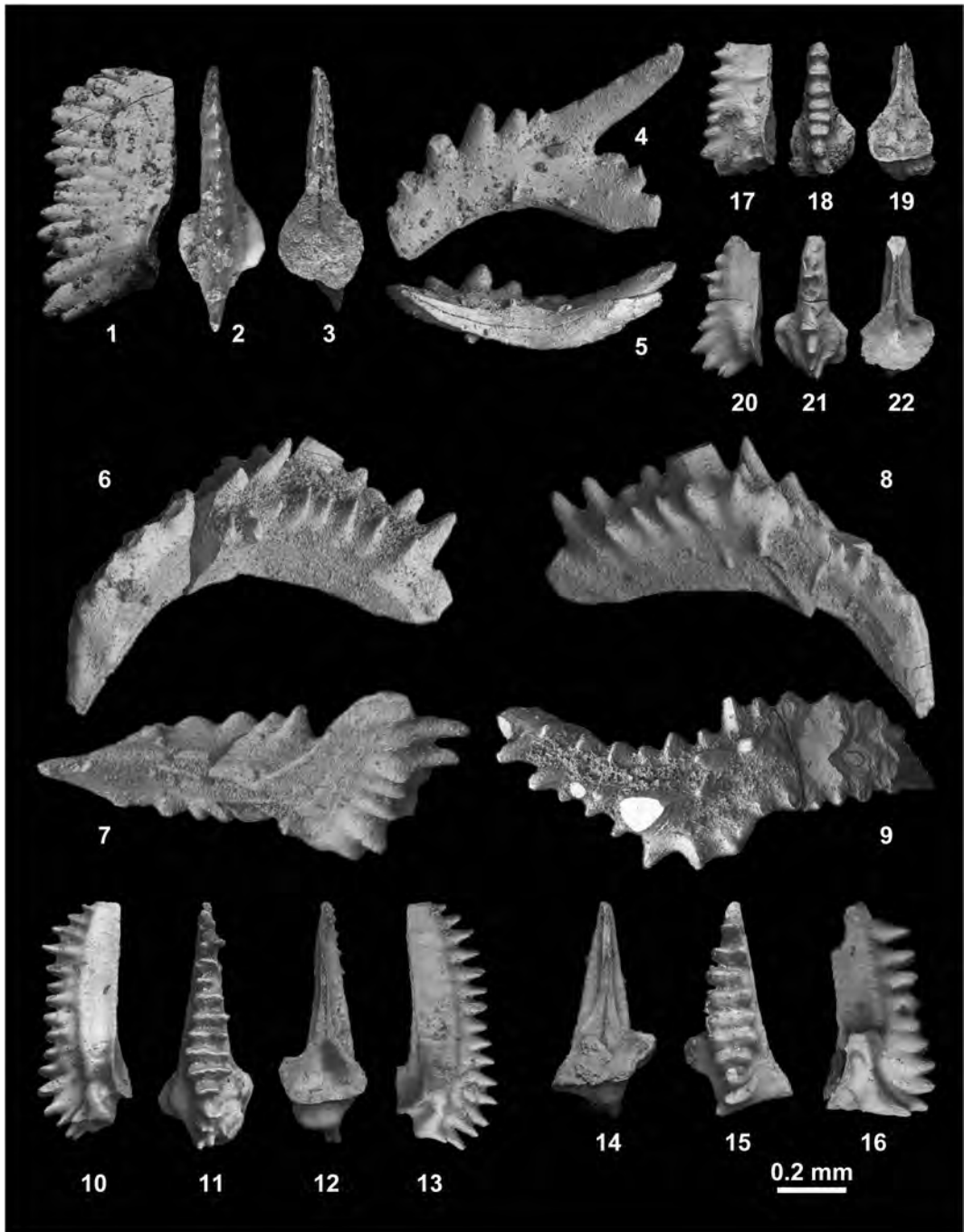


Fig. 186. 1–3, *Triassospathodus symmetricus* (Orchard, 1995), MPC25589, from KC02-15. 4–5, *Hadrodontina?* sp. indet. A, MPC25590, from BT01-07. 6–9, *Hadrodontina?* sp. indet. B, MPC25591, from BT02-02. 10–22, *Icriospathodus collinsoni* (Solien, 1979). 10–13, MPC25592, from KC02-14. 14–16, MPC25593, from KC02-14. 17–19, MPC25594, from KC02-15. 20–22, MPC25595, from KC02-15.

## Subfamily Uncertain

Genus *Icriospathodus* Krahl, Kauffmann,  
Kozur, Richter, Foerster and Heinritzi, 1983

*Type species: Neospathodus collinsoni* Solien, 1979.

***Icriospathodus collinsoni* (Solien, 1979)**

Figs. 186.10–186.22, 187–191, 192.1–192.6

*Icriodus*. Clark *et al.*, 1964, pl. 60, figs. 1a, b.

*Neospathodus* sp. G. Sweet *et al.*, 1971, pl. 1, fig. 13;

Buryi, 1979, p. 49, pl. 9, figs. 3a–c, pl. 18, figs. 4a, b.

*Neospathodus collinsoni* Solien, 1979, p. 302, pl. 3, figs.

10, 12–20.; Clark *et al.*, 1979, pl. 1, figs. 11, 12;

Duan, 1987, pl. 2, figs. 1–6; Cao and Wang, 1993, pl. 55, figs. 12, 13.

*Neospathodus? collinsoni* Solien, 1979. Koike, 1981, pl. 1, figs. 42–44.

*Spathoicriodus collinsoni* Budurov, Sudar and Gupta, 1987, p. 175.

*Spathoicriodus collinsoni* (Solien, 1979). Koike, 1992, p. 357–361, figs. 12.1–12.42, 12.44, 12.47–12.50, 13.8–13.37.

*Icriospathodus collinsoni* (Solien, 1979). Orchard, 1995, p. 113, figs. 2.22–2.24; Nakazawa *et al.*, 1994, pl. 1, fig. 30; Lucas and Orchard, 2007, figs. 7.4–7.7, 7.13–7.15; Ji *et al.*, 2011, figs. 4.5a–c.

multielement apparatuses, *Icriospathodus collinsoni* (Solien, 1979). Orchard, 2005, p. 96, text-fig. 22.

*Material examined:* Two specimens, MPC25592, 25593, from KC02-14, and fifty-four specimens, MPC25594–25647, from KC02-15.

*Description:* Blade-like robust elements 0.50–0.92 mm in length, average 0.64 mm; 0.20–0.36 mm in height, average 0.27 mm; length to height ratio 1.4–2.9, average 2.0 for fifty-six specimens, with rectangular general profile. Upper part of element consists of pointed node-like and ridge-like denticles. Prominent strong rib extended to posterior end in the middle part of element, flanged laterally above basal cavity. Lower margin straight or bowed at both anterior and posterior ends, downturned prominently. Denticles, varying in number from 10 to 18, average 12, change to spine or node-like form at both anterior and posterior ends, and exhibit biserial ribs or sin-

gle ridge across platform. Line of denticulation straight, or slightly or strongly curved to sinistral or dextral sides of element at posterior end. Some specimens have small pointed denticles extended along the posterior margin. Denticles show some variation in size and form. Ridge-like denticles widest in middle or slightly posterior part of element, gradually decreasing to both anterior and posterior ends, highest point situated in posterior one-fourth, and lowest in anterior end. Strongly concave basal cavity exhibits various shapes: sub-round, triangular, square, parallelogram, pentagon. Some posterior margins branched or remarkably elongated to lateral side at posterior end. Deep furrow extends from basal pit to anterior end.

*Remarks:* Koike (1992) demonstrated a wide range of intraspecific variation in the platform morphology and denticulation of *Spathoicriodus collinsoni* (Solien, 1979) (= *Icriospathodus collinsoni* [Solien, 1979]) from the Taho limestone, Southwest Japan, and consequently divided into three forms ( $\alpha$ ,  $\beta$ ,  $\gamma$ ) on the basis of the degree of development of its ridge-like denticles. Form  $\alpha$  is marked by having transverse ridge-like denticles on the entire platform. Form  $\beta$  has narrow uniserial or a few biserial denticles on the middle portion of the platform. Form  $\gamma$  has laterally compressed or laterally rounded and tipped denticles (lacking ridge-like denticles or paired platform nodes) on the entire platform. Form  $\gamma$  and other forms co-occur in Oman, Southwest Japan, and Idaho, Form  $\gamma$  occurs by itself in the Spathian of California (Orchard, 1995). Orchard (1995) separated Form  $\gamma$  from the other forms based on their differences in denticulation and FAD (Form  $\gamma$  occurs earlier than the other forms), and proposed a new species, *Neospathodus crassatus* Orchard, 1995 (= *I. crassatus* [Orchard, 1995]).

*Occurrence:* Described specimens from KC02-14 and KC02-15 within the portion of the *Triassospathodus symmetricus* Zone represented by the *Tirolites* sp. nov. beds (Lower



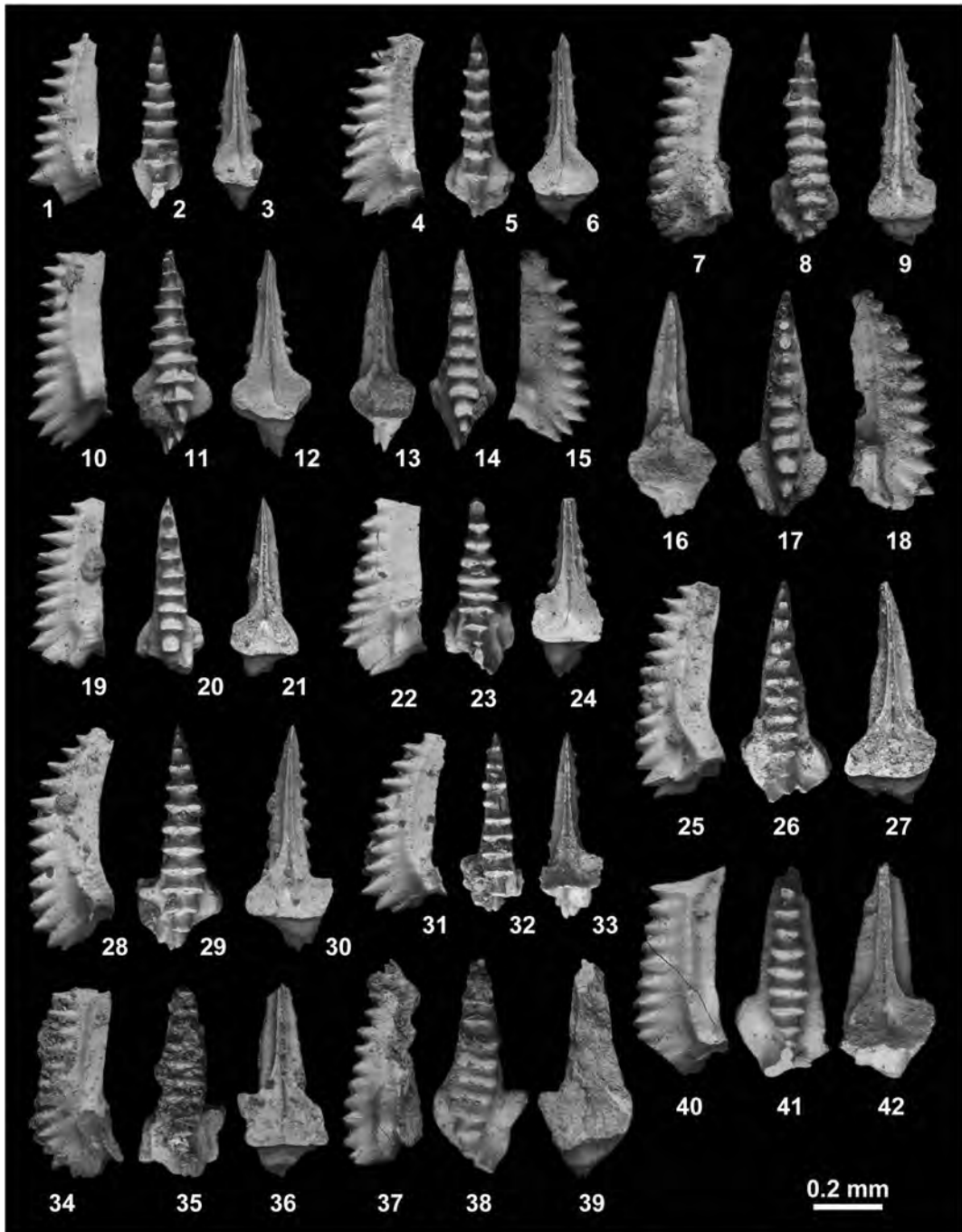


Fig. 187. *Ichriospathodus collinsoni* (Solien, 1979) from KC02-15. 1–3, MPC25596. 4–6, MPC25597. 7–9, MPC25598. 10–12, MPC25599. 13–15, MPC25600. 16–18, MPC25601. 19–21, MPC25602. 22–24, MPC25603. 25–27, MPC25604. 28–30, MPC25605. 31–33, MPC25606. 34–36, MPC25607. 37–39, MPC25608. 40–42, MPC25609.

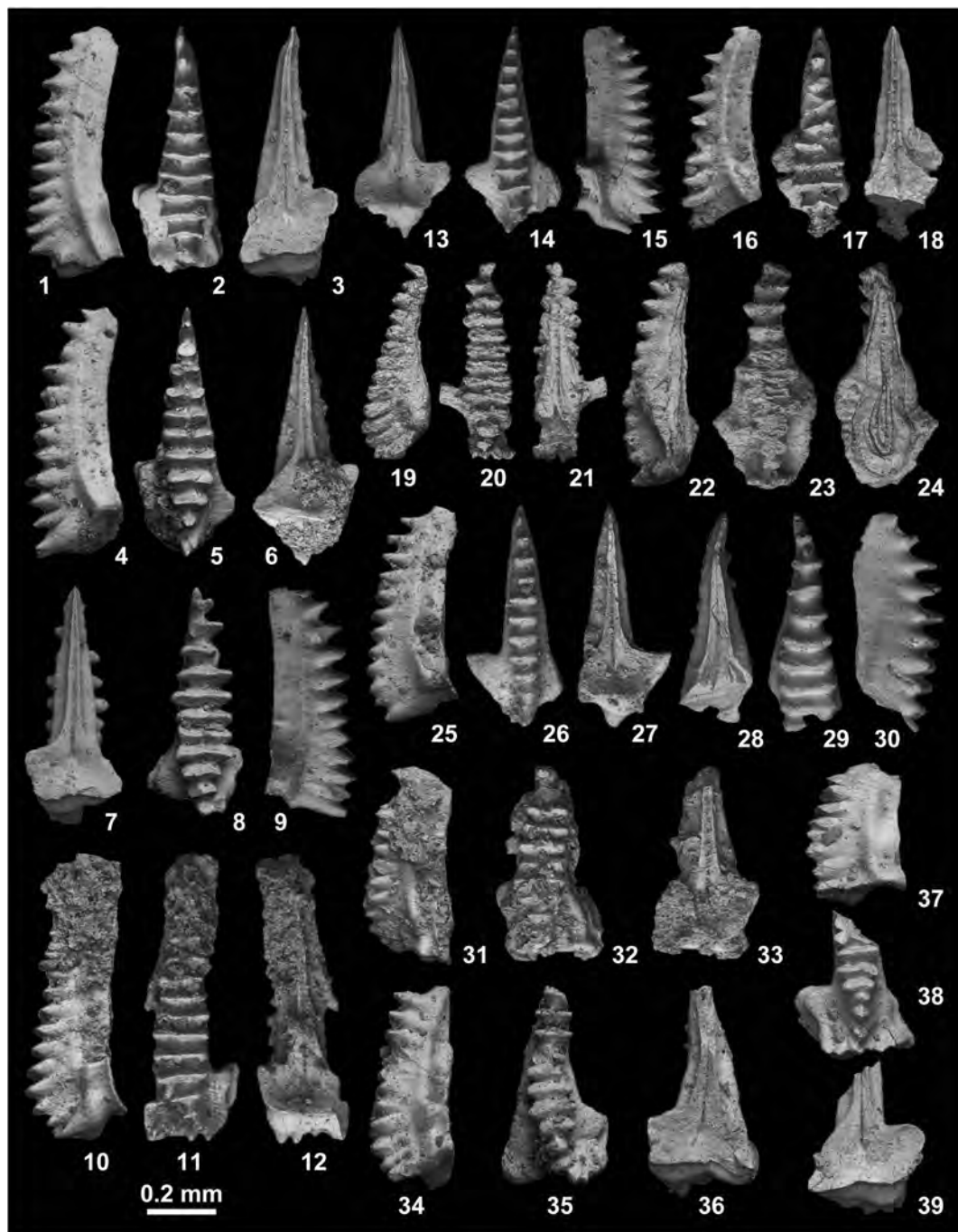


Fig. 188. *Icriospathodus collinsoni* (Solien, 1979) from KC02-15. 1–3, MPC25610. 4–6, MPC25611. 7–9, MPC25612. 10–12, MPC25613. 13–15, MPC25614. 16–18, MPC25615. 19–21, MPC25616. 22–24, MPC25617. 25–27, MPC25618. 28–30, MPC25619. 31–33, MPC25620. 34–36, MPC25621. 37–39, MPC25622.

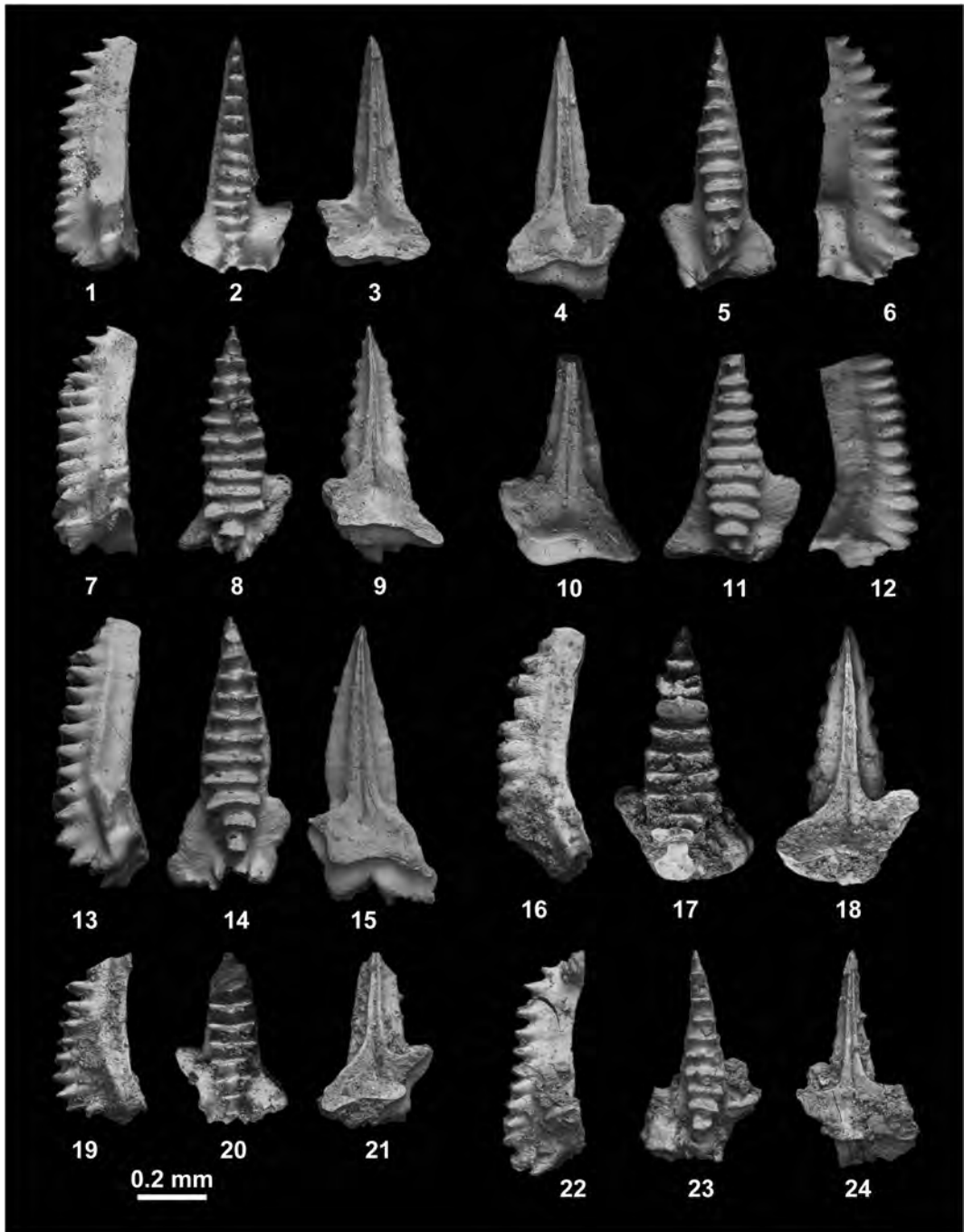


Fig. 189. *Ichriospathodus collinsoni* (Solien, 1979) from KC02-15. 1–3, MPC25623. 4–6, MPC25624. 7–9, MPC25625. 10–12, MPC25626. 13–15, MPC25627. 16–18, MPC25628. 19–21, MPC25629. 22–24, MPC25630.

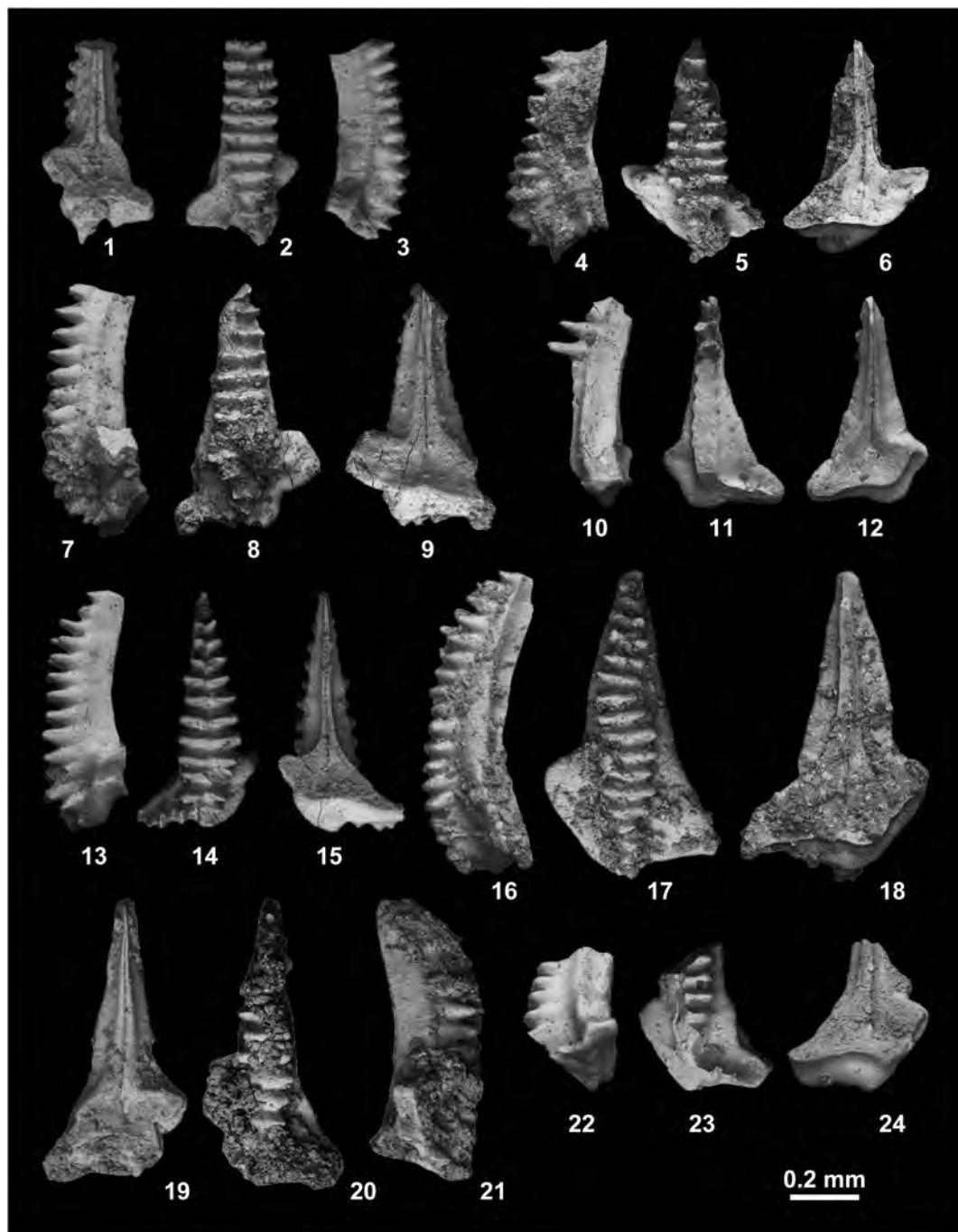


Fig. 190. *Icriospathodus collinsoni* (Solien, 1979) from KC02-15. 1–3, MPC25631. 4–6, MPC25632. 7–9, MPC25633. 10–12, MPC25634. 13–15, MPC25635. 16–18, MPC25636. 19–21, MPC25637. 22–24, MPC25638.



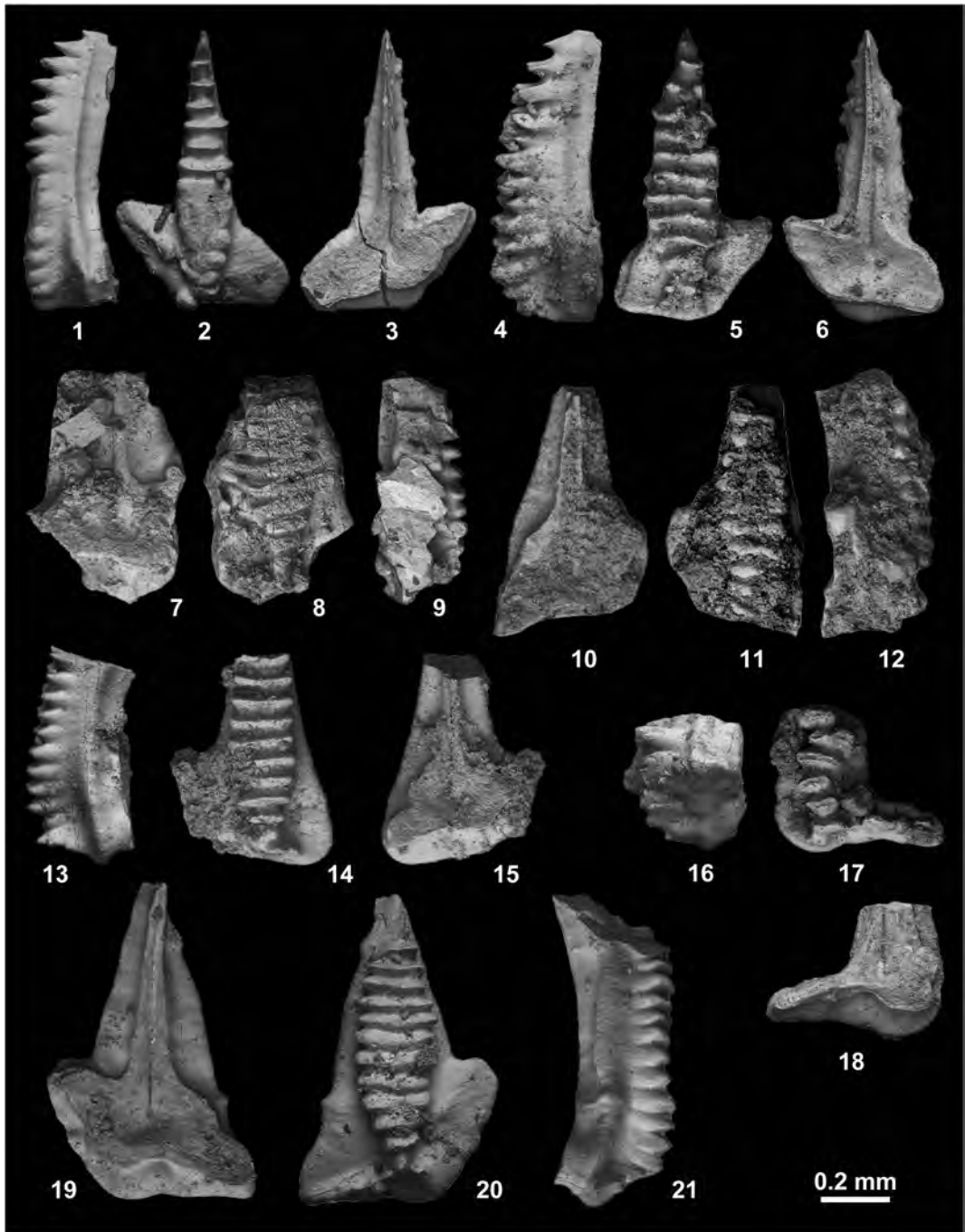


Fig. 191. *Icriospathodus collinsoni* (Solien, 1979) from KC02-15. 1–3, MPC25639. 4–6, MPC25640. 7–9, MPC25641. 10–12, MPC25642. 13–15, MPC25643. 16–18, MPC25644. 19–21, MPC25645.

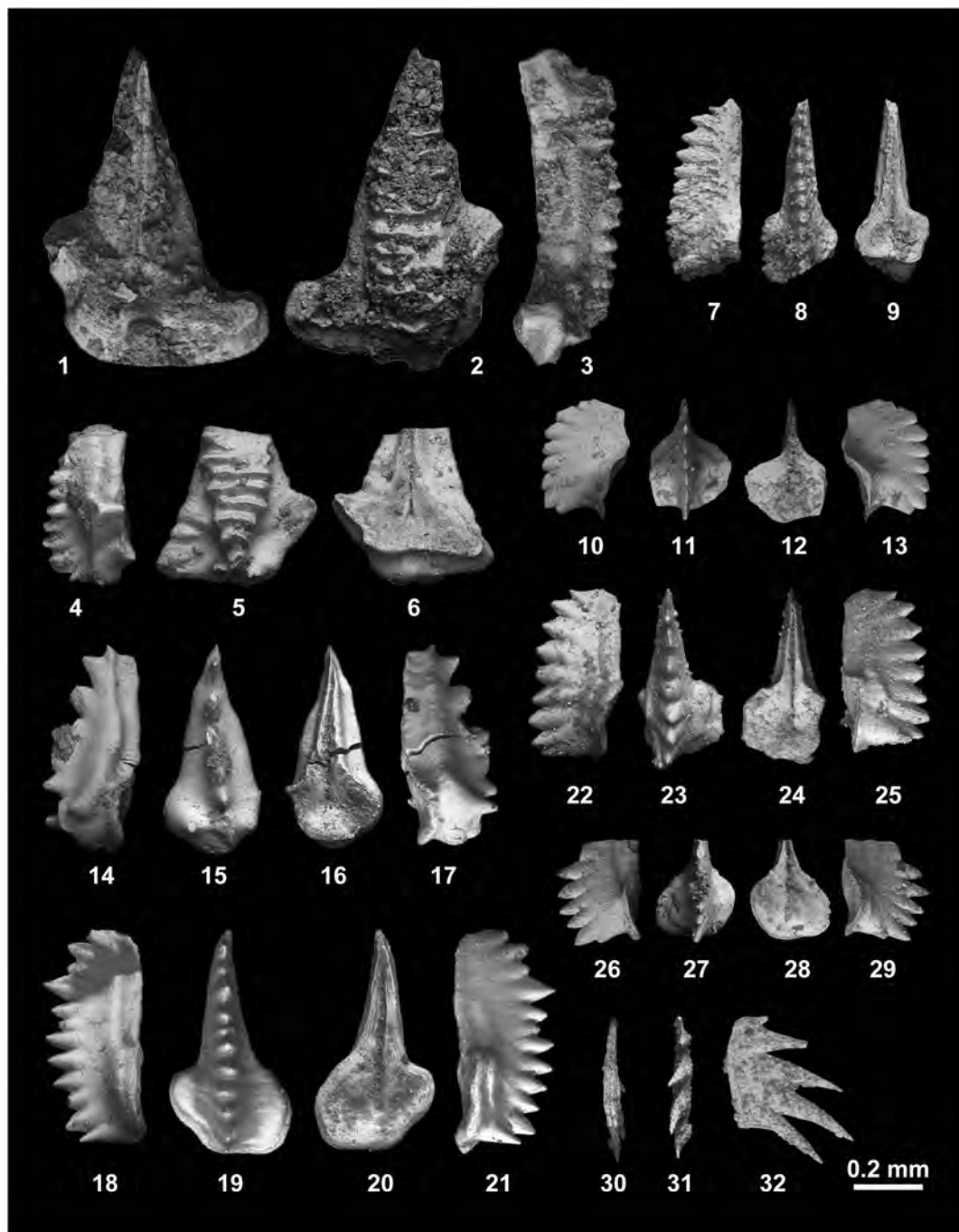


Fig. 192. 1–6, *Icriospathodus collinsoni* (Solien, 1979) from KC02-15. 1–3, MPC25646. 4–6, MPC25647. 7–9, *Icriospathodus? crassatus* (Orchard, 1995), MPC25648, from KC02-15. 10–13, *Icriospathodus? zaksi* (Buryi, 1979). 10–13, MPC25649, from KC02-08. 14–17, MPC25650, from KC02-10. 18–21, MPC25651, from KC02-10. 22–25, MPC25652, from NT01-07. 26–29, MPC25653, from NT01-09. 30–32, Genus gen. indet. A, MPC25654, from BT01-03.

Spathian=lower Upper Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the Lower Spathian in Idaho (upper part of Zone 10 and Zone 11, Sweet *et al.*, 1971), the Thaynes Formation, Utah (middle and upper part of *Platyvillosus* Zone and *Neospathodus collinsoni* Zone, Solien, 1979), Nevada (Clark *et al.*, 1964; Lucas and Orchard, 2007), South Primorye (*Tirolites cassianus* Zone, Buryi, 1979), the Tahoe limestone, Southwest Japan (Koike, 1981, 1992), South China (Duan, 1987; Ji *et al.*, 2011), and Svalbard (Hatleberg and Clark, 1984).

According to Sweet *et al.* (1971), Solien (1979), and Lucas and Orchard (2007), in North America, *I. collinsoni* occurs in the *Columbites* beds and its FAD is placed slightly above the Smithian/Spathian boundary (SSB), which is indicated by the FAD of *Platyvillosus asperatus* Clark, Sincavage and Stone. *P. asperatus* has been reported only from the western part of Panthalassa and it co-occurs with *Ns. homeri* (Bender, 1970) (= *Triassospathodus homeri* [Bender, 1970]) and *Ns. triangularis* (Bender, 1970) (= *Novispathodus triangularis* [Bender, 1970]). In the Bac Thuy Formation, *I. collinsoni* (KC02-14) co-occurs with *Columbites* sp. indet. and its FAD is placed slightly above the FAD of *Tirolites* cf. *cassianus* (KC02-11), the ammonoid that marks the SSB. This fact agrees with other reports.

#### *Icriospathodus?* *crassatus* (Orchard, 1995)

Fig. 192.7–192.9

*Spathoicriodus collinsoni* (Solien, 1979). Koike, 1992, p. 357, figs. 12.1–12.12, 12.43, 12.45–12.46, 12.51–12.53, 13.1–13.7.

*Neospathodus crassatus* Orchard, 1995, p. 120, figs. 2.19, 2.25–2.57, Ji *et al.*, 2011, figs. 4.2a–c.

*Icriospathodus?* *crassatus* (Orchard, 1995). Orchard, 2007a, p. 60, fig. 2.

**Material examined:** One specimen, MPC25648, from KC02-15.

**Description:** Robust rectangular-shaped segminate element 0.52 mm in length;

0.22 mm in height; 0.23 mm in width; length to height ratio 2.4; length to width ratio 2.3, with rectangular lateral profile. Node-like denticles total 11 in number, and contain one small posterior process. Cusp situated near posterior end. Lower edge straight, slightly undulated below cusp. Square basal cavity expanded at posterior end with a deep pit. Furrow extends from pit to anterior end

**Remarks:** The described specimen closely resembles *Icriospathodus collinsoni* (Solien, 1979) in its lateral and lower views, but it lacks the ridge-like denticles on its platform. It also resembles *I.?* *zaksi* (Buryi, 1979), but the width of the element is smaller.

**Occurrence:** Described specimen from KC02-15 within the portion of the *Triassospathodus symmetricus* Zone represented by the *Tirolites* sp. nov. beds (Lower Spathian=lower Upper Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the Lower Spathian in Southwest Japan (Koike, 1992), Oman, Idaho and California (Orchard, 1995), and South China (Ji *et al.*, 2011).

#### *Icriospathodus?* *zaksi* (Buryi, 1979)

Fig. 192.10–192.29

*Neospathodus zaksi* Buryi, 1979, p. 60, pl. 18, figs. 3a, b.

*Neospathodus triangularis* (Bender, 1970). Perri and Andraghetti, 1987, p. 311, pl. 33, figs. 1–4.

*Icriospathodus?* *zaksi* (Buryi, 1979). Orchard, 2007a, p. 105, fig. 2.

**Material examined:** One specimen, MPC25469, from KC02-08, two specimens, MPC25450, 25451, from KC02-10, one specimen, MPC25452, from NT01-07, and one specimen, MPC25453, from NT01-09.

**Description:** Robust segminate elements 0.35–0.65 mm in length, average 0.48 mm; 0.25–0.30 mm in height, average 0.28 mm; 0.23–0.36 mm in width, average 0.27 mm; length to height ratio 1.3–2.1, average 1.7; length to width ratio 1.5–2.1, average 1.9 for five specimens, with rectangular lateral pro-

file. Short, robust, triangular-shaped denticles vary in number from 7 to 12, average 9, gradually becomes smaller towards both anterior and posterior ends, extremely small at posterior end. Terminal processes in some specimens turn to the sinistral side. Cusp situated in posterior one-third, except for MPC25651. Specimen (MPC25650) has terminal processes along the posterior margin of element. In lateral view, prominent lateral rib developed in middle part of element, becoming strong posteriorly. Lower margin straight or curved slightly upward in anterior-most part, down-curved or slightly deflected upward in posterior part. Sub-rounded or rectangular asymmetrical basal cavity strongly concave. Deep furrow extends from the basal pit to anterior end.

*Remarks:* The described specimens, which include a juvenile (MPC25649), show a broad morphological variation in the platform. Specifically, one specimen (MPC25650) has a laterally expanded element and terminal process at the posterior end. Koike (1992) reported similar morphological variations in *Icriospathodus collinsoni* (Solien, 1979) and *I.?* *crassatus* (Orchard, 1995).

*Occurrence:* Described specimens from KC02-08, KC02-10, NT01-07 and NT01-09 within the portion of the *Novispathodus pingdingshanensis* Zone that represents the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also ranges from the Upper Smithian (upper Lower Olenekian) to the Lower Spathian (lower Upper Olenekian) in South Primorye, Russia (upper part of *Anasibirites nevolini* Zone and lower part of *Tirolites cassianus* Zone, Buryi, 1979), and the Werfen Formation, southern Alps, Italy (Perri and Andraghetti, 1987).

Order Prioniodinida Sweet, 1988  
Family Ellisoniidae, Clark, 1972  
Genus *Hadrodontina* Staesche, 1964

*Type species: Hadrodontina anceps* Staesche, 1964.

*Hadrodontina?* sp. indet. A

Fig. 186.4, 186.5

*Material examined:* one specimen, MPC25590, from BT01-07.

*Remarks:* The specimen is characterized by an arcuatiform element with robust denticles that are reclined posteriorly, and a cusp that is longer and larger than the other denticles. Assignment of this specimen to *Hadrodontina* is uncertain, but its arched form with strongly inclined pole-like processes and non-expanded basal cavity suggest that this element belongs to the family Ellisoniidae.

*Occurrence:* Described specimen from BT01-07 in the portion of the *Novispathodus* ex gr. *waageni* Zone between the *Flemingites rursiradiatus* beds (lowest Middle Smithian=middle Lower Olenekian) and *Urdoceras tulongensis* beds (lower Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

*Hadrodontina?* sp. indet. B

Fig. 186.6–186.9

*Material examined:* One specimen, MPC25591, from BT02-02.

*Description:* Angulate-like arcuatiform element 1.13 mm in length; 0.82 mm in height. Platform strongly bowed in lateral view, sigmoidal in upper view and V-shaped in lower view. Node-like denticles arranged in three rows: 13 on each side, with 6 in the center, inclination and size gradually increase posteriorly. Largest process situated in middle part of element, four times larger than other denticles.

*Remarks:* The assignment of this specimen to *Hadrodontina* is uncertain, but it is somewhat similar to the specimen of *Hadrodontina*



*anceps* Staesche, 1964 described by Perri and Andraghetti (1987, pl. 33, fig. 1a), in having three rows of denticles on the platform, but differs by its pole-like denticles arranged in a radial fashion on the symmetrical platform.

*Occurrence:* Described specimen from BT02-02 within the portion of the *Novispathodus* ex gr. *waageni* Zone represented by the *Urdoceras tulongensis* beds (lower Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Incertae sedis

**Genus** gen. indet. A

Fig. 192.30–192.32

*Material examined:* One specimen, MPC25654, from BT01-03

*Remarks:* The completely discrete denticles, which total 5 in number, and the lack of an expanded basal cavity, indicate that this element belongs to the P<sub>2</sub> element of an uncertain species.

*Occurrence:* Described specimen from BT01-03 within the portion of the *Novispathodus* ex gr. *waageni* Zone that represents the *Flemingites rursiradiatus* beds (lowest Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

**Genus** gen. indet. B

Fig. 193.1–193.4

*Material examined:* One specimen, MPC25655, from BT01-06

*Remarks:* This specimen is similar to *Furnishius triserratus* Clark, 1959 in its branched anterior part, but the latter has double lines of denticles on both anterior branches. The lateral form of this specimen is close to species of the genus *Neospathodus*, but such an assignment would be uncertain based on only one specimen.

*Occurrence:* Described specimen from BT01-06 within the portion of the *Novispathodus* ex gr. *waageni* Zone between the *Flemingites rursiradiatus* beds (lowest Middle Smithian=middle Lower Olenekian) and *Urdoceras tulongensis* beds (lower Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

an=middle Lower Olenekian) and *Urdoceras tulongensis* beds (lower Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

**Genus** gen. indet. C

Fig. 193.5–193.7

*Material examined:* One specimen, MPC25656, from BT01-06

*Remarks:* This specimen is similar to *Discretella* in having discrete denticles and a rounded basal cavity, but the more robust and strongly laterally curved posterior part of the element makes it difficult to determine an assignment.

*Occurrence:* Described specimen from BT01-06 within the portion of the *Novispathodus* ex gr. *waageni* Zone between the *Flemingites rursiradiatus* beds (lowest Middle Smithian=middle Lower Olenekian) and *Urdoceras tulongensis* beds (lower Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

**Genus** gen. indet. D

Fig. 193.8–193.12

*Material examined:* One specimen, MPC25657, from BT01-07, and one specimen, MPC25658, from PK01-02.

*Remarks:* The specimens have a large reclined cusp on a relatively short platform. Specimen MPC25658 has several processes on both the anterior and posterior sides of the cusp and a strongly expanded platform, when compared with specimen MPC25657. These elements probably exhibit different growth stages.

*Occurrence:* Described specimen from BT01-07 within the portion of the *Novispathodus* ex gr. *waageni* Zone between the *Flemingites rursiradiatus* beds (lowest Middle Smithian=middle Lower Olenekian) and *Urdoceras tulongensis* beds (lower Middle Smithian=middle Lower Olenekian), and from PK01-02 within the portion of the *Novispatho-*

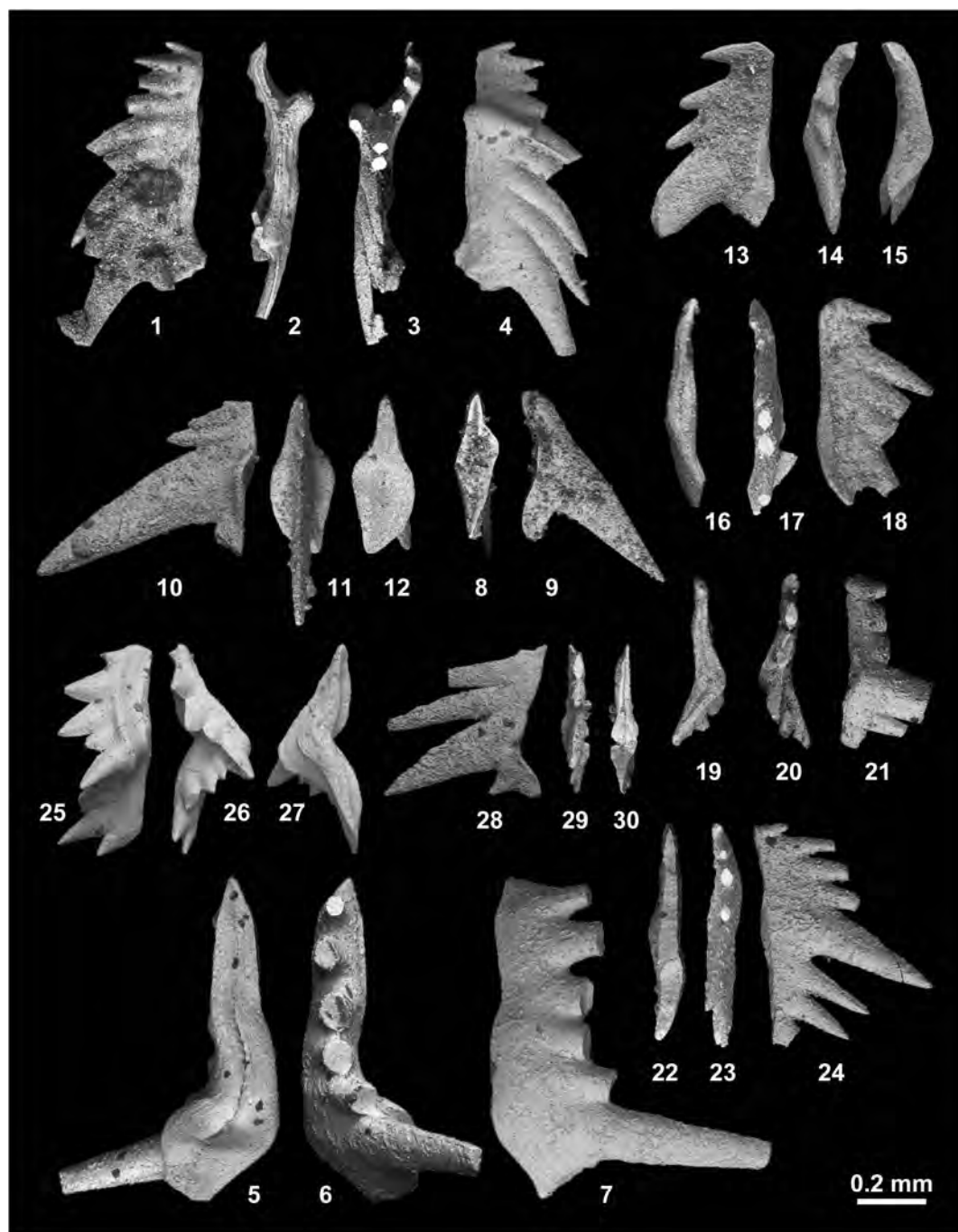


Fig. 193. 1–4, Genus gen. indet. B, MPC25655, from BT01-06. 5–7, Genus gen. indet. C, MPC25656, from BT01-06. 8–12, Genus gen. indet. D. 8–9, MPC25657, from BT01-07. 10–12, MPC25658, from PK01-02. 13–21, Genus gen. indet. E. 13–15, MPC25659, from BT02-01. 16–18, MPC25660, from BT02-01. 19–21, MPC25661, from BT03-01. 22–24, Genus gen. indet. F, MPC25662, from BT02-03. 25–27, Genus gen. indet. G, MPC25663, from KC01-05. 28–30, Genus gen. indet. H, MPC25664, from PK01-02.

*us ex gr. waageni* Zone represented by the *Owenites koeneni* beds (middle Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

**Genus gen. indet. E**

Fig. 193.13–193.21

*Material examined:* Two specimens, MPC25659, 25660, from BT02-01, and one specimen, MPC25661, from BT03-01.

*Remarks:* The specimens are characterized by a laterally curved element with strongly reclined denticles and a large cusp situated in the posterior one-third. These features indicate that the specimens probably belong to the P<sub>2</sub> element of the family Gondolellidea.

*Occurrence:* Described specimens collected from BT02-01 within the portion of the *Novispathodus ex gr. waageni* Zone represented by the *Flemingites rursiradiatus* beds (lowest Middle Smithian=middle Lower Olenekian), and from BT03-01 within the portion of the *Novispathodus ex gr. waageni* Zone represented by the *Owenites koeneni* beds (middle Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

**Genus gen. indet. F**

Fig. 193.22–193.24

*Material examined:* One specimen, MPC25662, from BT02-03.

*Remarks:* The specimen lacks a part of its lower side, but discrete needle-like denticles on the upper side are similar to those of the P<sub>2</sub> element of species in the subfamily Mulleninae.

*Occurrence:* Described specimen from BT02-03 within the portion of the *Novispathodus ex gr. waageni* Zone represented by the *Leyceras* horizon of the *Owenites koeneni* beds (middle Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

**Genus gen. indet. G**

Fig. 193.25–193.27

*Material examined:* One specimen, MPC25663, from KC01-05.

*Remarks:* This specimen exhibits a “V” shaped platform with laterally compressed short denticles in the upper view. An affiliation assignment of this element is not possible.

*Occurrence:* Described specimen from KC01-05 within the portion of the *Novispathodus ex gr. waageni* Zone below the *Owenites koeneni* beds (middle Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

**Genus gen. indet. H**

Fig. 193.28–193.30

*Material examined:* One specimen, MPC25664, from PK01-02.

*Remarks:* This bowed specimen lacks the anterior part of element. Discrete long processes and a slightly expanded basal cavity demonstrate that this element belongs to the P<sub>2</sub> element of species in the family Gondolellidea.

*Occurrence:* Described specimen from PK01-02 within the portion of the *Novispathodus ex gr. waageni* Zone represented by the *Owenites koeneni* beds (middle Middle Smithian=middle Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

**Ostracods** (by G. Tanaka, T. Komatsu and T. Maekawa)

Most of the ostracod specimens recovered by acid treatment of limestone samples have consisted of incomplete, fragmented, or crushed valves or carapaces, but six species belonging two genera have been recognized and several well-preserved specimens are described in this paper. The morphological terms used are based on the work of Moore (1961).

*Abbreviations:* L=length, H=height, W=width, LV=left valve, RV=right valve, C=carapace.

*Institution abbreviation:* MPC=Micro-paleontology Collection, National Museum of Nature and Science, Tsukuba.

Phylum Arthropoda Latreille, 1829  
 Subphylum Crustacea Brünnich, 1772  
 Class Ostracoda Latreille, 1802  
 Order Podocopida Sars, 1866  
 Suborder Cypridocopina Jones, 1901  
 Superfamily Cypridoidea Baird, 1845  
 Family Candonidae Kaufmann, 1900  
 Genus *Paracypris* Sars, 1866

*Type species: Paracypris polita* Sars, 1866.

*Paracypris vietnamensis*

Tanaka and Komatsu sp. nov.

Figs. 194, 195

*Type specimens:* Holotype, MPC25845; paratypes, seven specimens, MPC25846–25852. Type specimens were collected from BR01-04.

*Diagnosis:* LV larger than RV, overlapping along anterior to posterior margin via dorsal margin. Posterior margin protruded with small curvature and protruding toward postero-ventral direction.

*Etymology:* After Vietnam, where the type specimens are from.

*Description:* Valve sub-trapezoidal in lateral view and anterior end higher than posterior end (Figs. 194.1, 195.1). LV larger than RV, overlapping along anterior to posterior margin via dorsal margin (Fig. 195.3). Anterior cardinal angle obtuse at about 150 degrees, posterior cardinal angle obtuse at about 140 degrees. In lateral view, lower half of anterior margin acutely rounded and protruded antero-ventrally; dorsal margin straight, inclined toward posterior; ventral margin sinuate and concave at middle; one-third of lower posterior margin protruded, with small curvature and protruding in a postero-ventral direction, and two-thirds of upper posterior margin broadly arched in RV (Fig. 195.3), broadly arched postero-dorsally in LV (Fig. 195.1). Surface of C finely

reticulated (Figs. 194.3, 195.4), probably shrinking after diagenesis or acid-treatment. Reticulation probably due to shrinkage of the chitinous membrane, because same reticulation is observed on internal surface of the valve (Figs. 194.7, 194.8, 195.7). Extremely thin valve (1.5–5.0  $\mu\text{m}$ ) (Figs. 194.5, 194.7, 194.8, 195.2, 195.5, 195.7). Normal pore canals (Fig. 194.3) are sporadically distributed, and diameter of each is about 1.5  $\mu\text{m}$ . In dorsal view, bullet-shaped carapace, LV larger than RV, anterior end protruding more than posterior end. In internal view, straight hinge line (Fig. 194.6) runs parallel to dorsal margin (Fig. 194.6) in LV. Sulcus of RV (Fig. 195.6) fit straight hinge bar of RV. Adont hinge. Duplicature developed in antero-dorsal to postero-dorsal areas along ventral area, broadly in antero-ventral and postero-ventral areas (Figs. 194.6, 194.7, 195.6, 195.7). Adductor muscle scars not observed. Sexual dimorphism unknown.

*Discussion:* *Paracypris vietnamensis* sp. nov. is similar to *Paracypris jinyaensis* Crasquin-Soleau, 2006 (in Crasquin-Soleau *et al.*, 2006) from the Early Triassic (Olenekian) strata of the Fengshan area, Guangxi Province, South China, but differs from it in terms of its postero-ventrally bended caudal process, its more rounded lateral outline, and its slightly sinuated ventral margin. *Paracypris vietnamensis* sp. nov. resembles *Paracypris* sp. reported by Wei (1981) from the Middle Triassic Leikoupo Formation of Weiyuan of Sichuan, South China, but can be distinguished from *Paracypris* sp. by its small carapace and by its widely arched posterior margin and more rounded lateral outline in the RV. The new species is similar to *Paracypris? scalaris* Wei, 1981 from the Early Triassic Jialingjiang Formation of Sichuan, South China, but differs from the latter in terms of its more acute posterior margin, the tendency for its dorsal margin to be inclined toward the posterior, and its more blunt anterior and posterior cardinal angles.



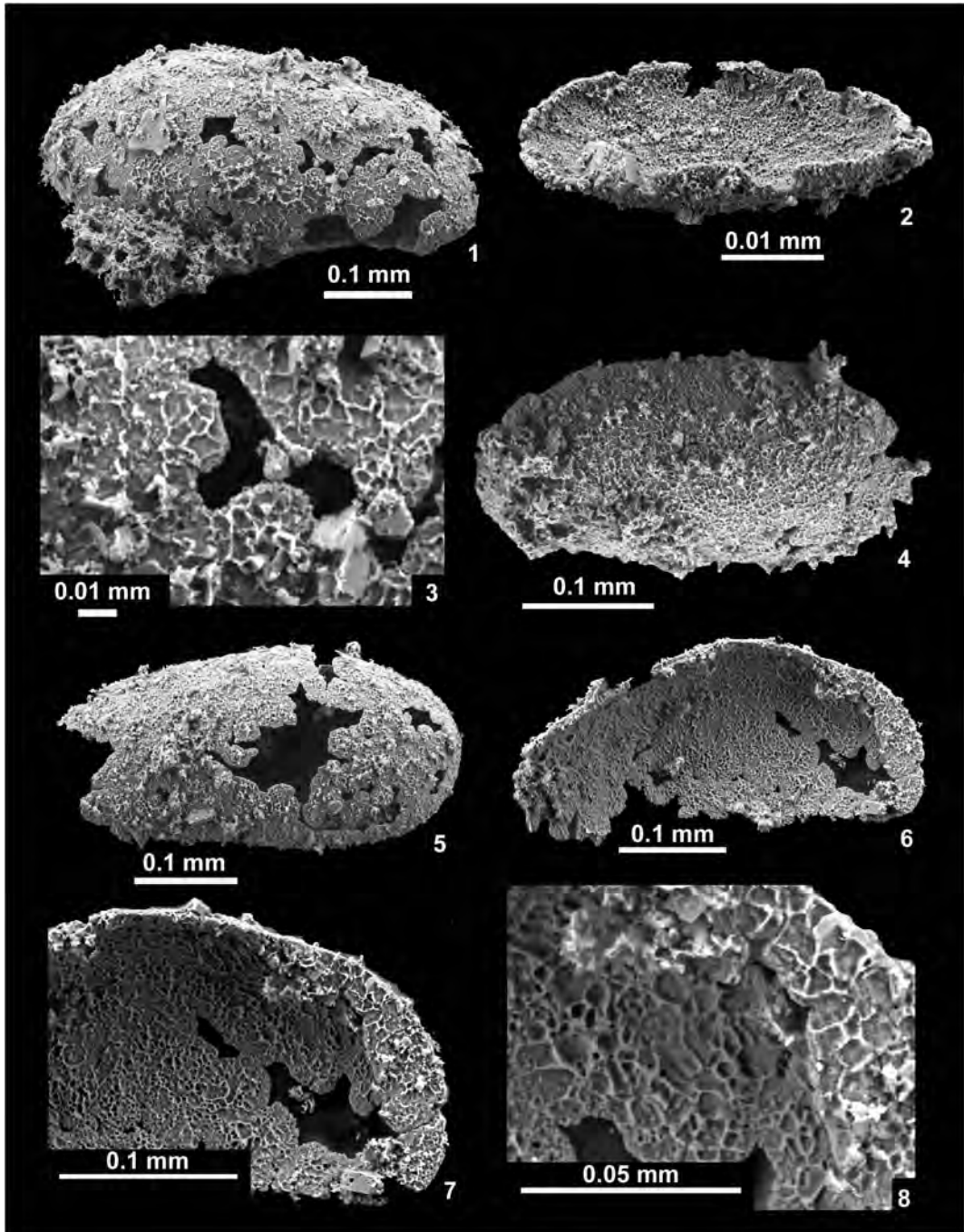


Fig. 194. *Paracypris vietnamensis* Tanaka and Komatsu sp. nov., from BR01-04. 1, 3, MPC25848, paratype. 1, Left lateral view of C. 3, Enlargement of mid-posterior area. 2, MPC25849, paratype, ventral view of internal valve of RV. 4, MPC25850, paratype, lateral view of RV. 5, MPC25851, paratype, lateral view of RV. 6–8, MPC25852, paratype. 6, Internal view of LV. 7, Enlargement of anterior area. 8, Magnified antero-dorsal margin.

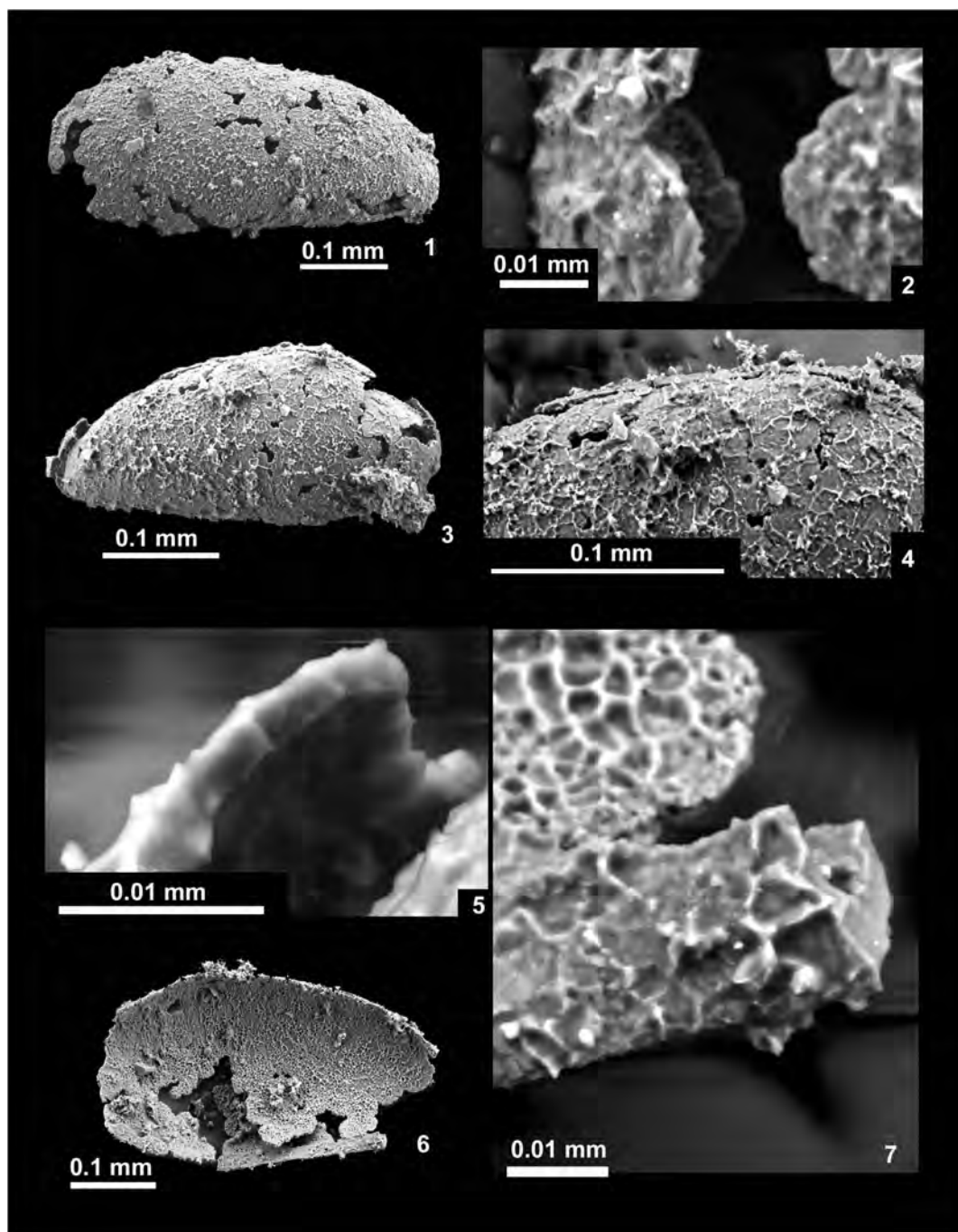


Fig. 195. *Paracypris vietnamensis* Tanaka and Komatsu sp. nov., from BR01-04. 1–2, MPC25846, paratype. 1, External view of LV. 2, Enlargement of antero-ventral area. 3–5, MPC25845, holotype. 3, Right lateral view of C. 4, Enlargement of mid-dorsal area. 5, Magnification of dorso-posterior area. 6–7, MPC25847, paratype. 6, Internal view of partly broken RV. 7, Enlargement of postro-ventral area.

*Occurrence:* Described specimens from BR01-04 within the *Novispathodus pingdingshanensis* Zone below the *Xenoceltites vario-costatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, north-eastern Vietnam.

***Paracypris* sp. indet. A**

Figs. 196.1–196.5, 197.3–197.5, 197.7, 197.8

*Material examined:* Five specimens, MPC25853–25857, from BR01-04.

*Discussion:* This species is similar to *P. jinyaensis* Crasquin-Soleau, 2006 (in Crasquin-Soleau *et al.*, 2006) from the Early Triassic (Olenekian) strata of the Fengshan area, Guangxi Province, South China, but differs from it in the straight upper half of its anterior margin, its more acute caudal process, and its lack of an evenly rounded anterior margin. *Paracypris* sp. indet. A resembles *Paracypris* sp. reported by Wei (1981) from the Middle Triassic Leikoupo Formation of Weiyuan in Sichuan, South China, but it can be distinguished from *P. sp.* by its small carapace, ventrally arched anterior margin, and more rounded posterior margin. This species is similar to *Paracypris badongensis* Guan, 1985 from the Middle Triassic Baotahe Formation, Hubei Province, South China, but differs from it in that it has a more protruded caudal process, a straight dorsal margin, and a more inflated carapace from the dorsal view.

*Occurrence:* Described specimens from BR01-04 within the *Novispathodus pingdingshanensis* Zone below the *Xenoceltites vario-costatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, north-eastern Vietnam.

***Paracypris* sp. indet. B**

Figs. 196.6, 196.7, 197.6

*Material examined:* Two specimens, MPC25858–25859, from BR01-04.

*Discussion:* This species is similar to *Paracypris* sp. Wei, 1981 from the Middle Tri-

assic Leikoupo Formation, Sichuan Province, South China, but differs from it in that it has a broadly arched anterior margin, higher lateral outline, and sinuated ventral margin.

*Occurrence:* Described specimens from BR01-04 within the *Novispathodus pingdingshanensis* Zone below the *Xenoceltites vario-costatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, north-eastern Vietnam.

***Paracypris* sp. indet. C**

Fig. 197.1, 197.2

*Material examined:* One specimen, MPC25860, from BR01-04.

*Discussion:* This species is similar to *Paracypris? scalaris* Wei, 1981 from the Early Triassic Jialingjiang Formation, Sichuan Province, South China, but it differs from the latter in terms of its broadly arched dorsal margin, evenly arched anterior margin, and higher lateral outline.

*Occurrence:* Described specimens from BR01-04 within the *Novispathodus pingdingshanensis* Zone below the *Xenoceltites vario-costatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, north-eastern Vietnam.

Superfamily Bairdiacea Sars, 1887

Family Bairdiidae Sars, 1887

Genus *Bairdia* McCoy, 1844

*Type species: Bairdia curia* McCoy, 1844.

***Bairdia* sp. indet. A**

Fig. 198.3–198.5

*Material examined:* One specimen, MPC25862, from NT01-08.

*Discussion:* This species is similar to *Bairdia wailiensis* Crasquin-Soleau, 2006 (in Crasquin-Soleau *et al.*, 2006) from the Early Triassic (Olenekian) strata of the Jinya/Waili section, Guangxi Province, South China, but differs from it in the more steeply inclined



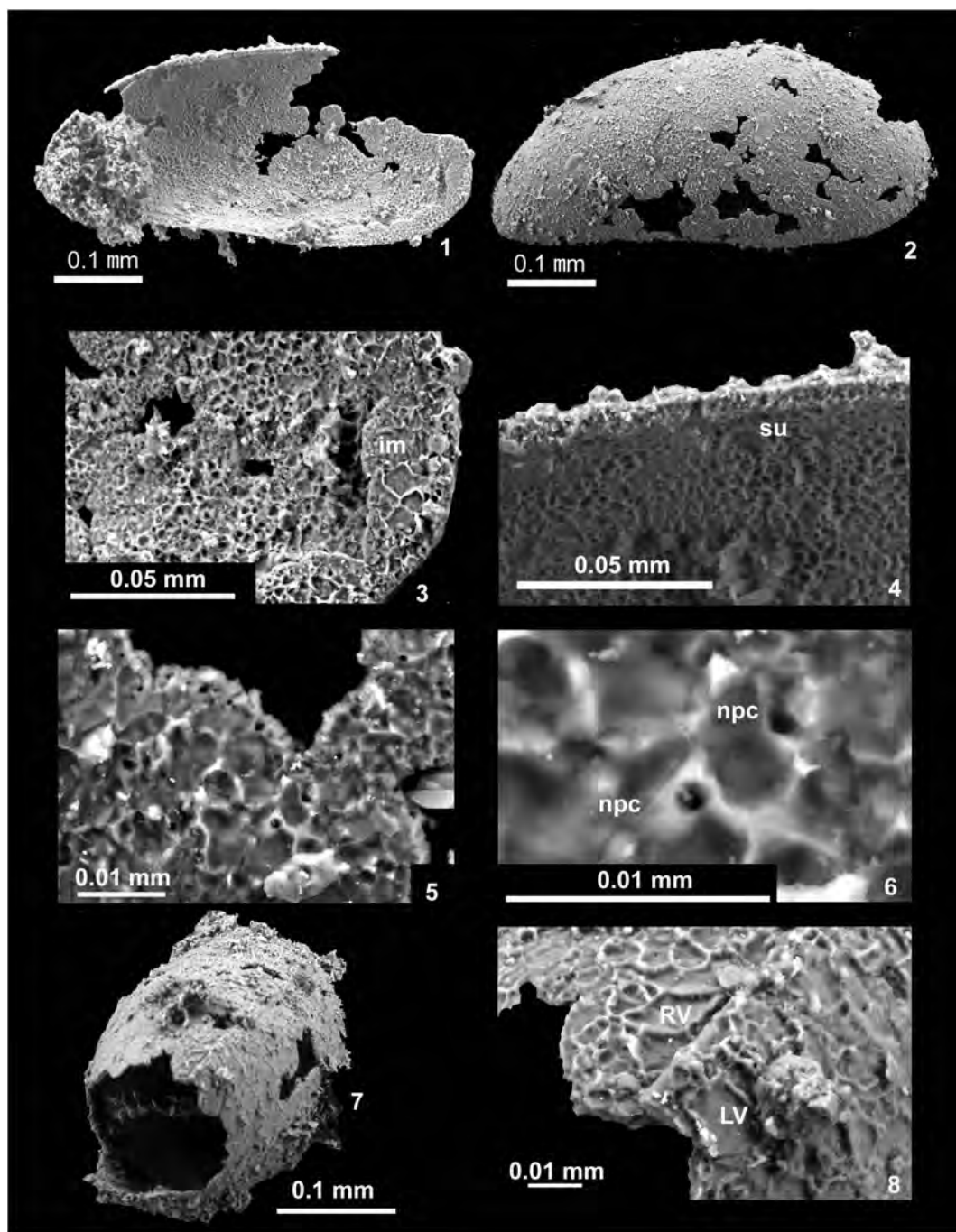


Fig. 196. 1–5, *Paracypris* sp. indet. A from BR01-04. 1, 2, MPC25853. 1, External view of LV. 2, Enlargement of broken part of anterior area, showing outer and inner shells. 3–5, MPC25854. 3, Right lateral view of C. 4, Enlargement of dorsal margin. 5, Magnified broken area of postero-dorsal margin. 6, 7, *Paracypris* sp. indet. B, MPC25858 from BR01-04. 6, Fragment of internal view of RV. 7, Enlargement of postero-ventral area, showing duplicature.



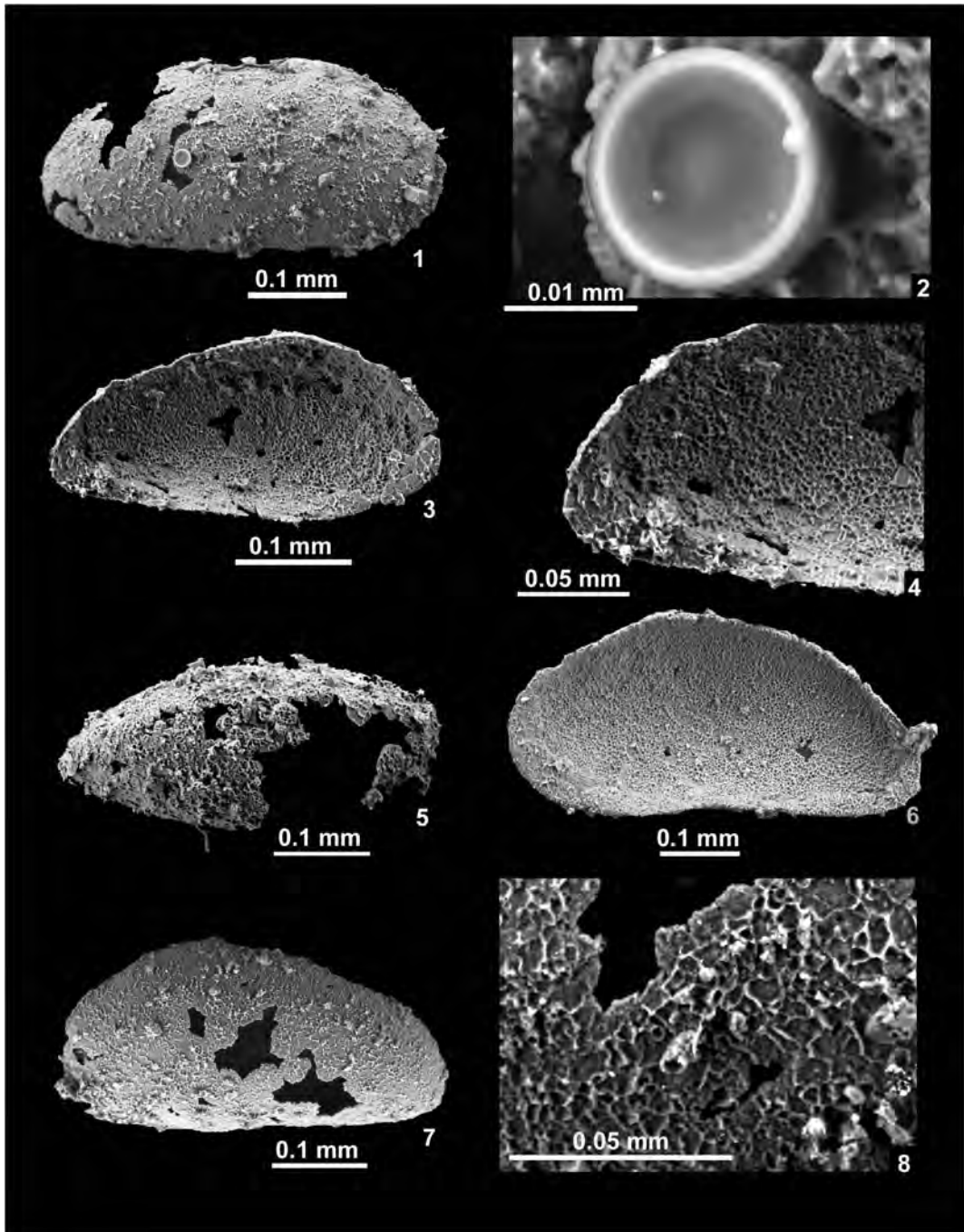


Fig. 197. 1, 2, *Paracypris* sp. indet. C, MPC25860 from BR01-04. 1, External view of RV. 2, Enlargement of central area showing attached diatom-like organism. 3–5, 7, 8, *Paracypris* sp. indet. A from BR01-04. 3, 4, MPC25855. 3, Internal view of LV. 4, Close-up of postero-ventral area. 5, MPC25856, dorsal view of C. 7–8, MPC25857. 7, External view of LV. 8, Enlargement of mid-ventral area, showing tube-like structure (center of image). 6, *Paracypris* sp. indet. B, MPC25859, from BR01-04, internal view of RV. im: inner margin, LV: left valve, npc: normal pore canal, RV: right valve, su: sulcus.

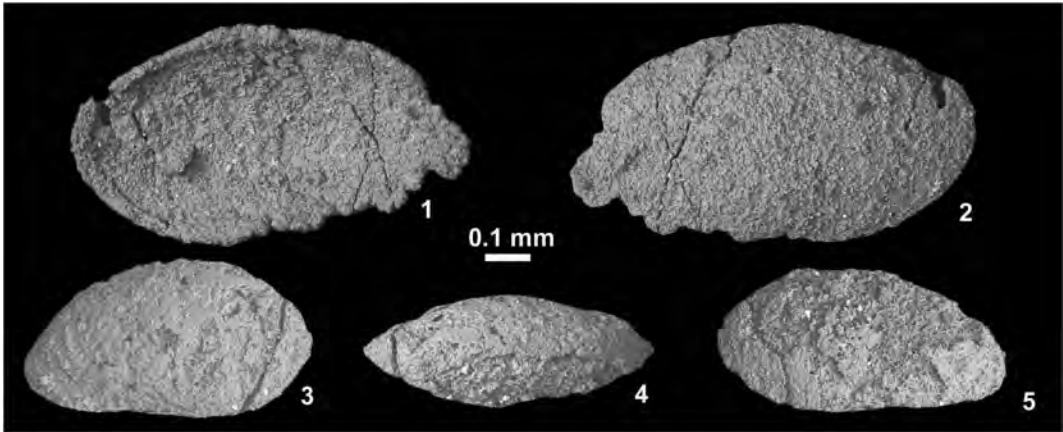


Fig. 198. 1, 2, *Bairdia* sp. indet. B, MPC25861, from NT01-09. 1, Internal view of RV. 2, External view. 3–5, *Bairdia* sp. indet. A, MPC25862, from NT01-08. 3, Right lateral view of C. 4, Dorsal view of C. 5, Left lateral view of C.

upper half of the posterior margin, more broadly arched dorsal margin, and sinuated ventral margin.

**Occurrence:** Described specimens from NT01-08 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

***Bairdia* sp. indet. B**

Fig. 198.1, 198.2

**Material examined:** One specimen, MPC25861, from NT01-09.

**Discussion:** This specimen is juvenile because of the presence of a weakly developed inner margin. This species is similar to *Bairdia* sp. Wei, 1981 from the Early Triassic Jialingjiang Formation, Sichuan Province, South China, but differs from the latter in that it has a longer upper half of anterior margin, broadly arched anterior margin, and longer dorsal margin.

**Occurrence:** Described specimen from NT01-09 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy For-

mation, northeastern Vietnam.

**Radiolarians** (by O. Takahashi and Y. Miyake)

Systematic descriptions are basically following the classification by De Wever *et al.* (2001).

**Institution abbreviations:** TGU=Tokyo Gakugei University.

Subclass Radiolaria Müller, 1858

Superorder Polycystina Ehrenberg, 1838,  
emend Riedel, 1967

Order Entactinaria Kozur and Mostler, 1982

Family Tetretractiniidae Kozur and Mostler,  
1979

Genus *Multisphaera* Nazarov and Afanasieva,  
2000, emend Dumitrica, 2011

**Type species:** *Multisphaera imperseptata* Nazarov and Afanasieva, 2000.

**Remarks:** The genus *Multisphaera* was first described by Nazarov and Afanasieva in Afanasieva (2000) from the Lower Permian Russian Platform. According to the emended description by Dumitrica (2011), *Multisphaera* possesses four or five concentric lattice spheres, which originated from an eccentric

four-rayed initial spicule, consisting of a double medullary shell, a single cortical shell, and one or two intermediary shells. The initial spicule has a very short median bar and four spines arranged tetrahedrally. Based on its morphological features, especially the tetrahedral arrangement of the initial spicule, Dumitrica (2011) transferred the genus to the family Tetretractiniidae.

***Multisphaera triassorobusta*** Takahashi, sp. nov.

Fig. 199

*Material examined:* Holotype, TGU 8717 (Fig. 199.1), from KC02-10. Seven specimens, TGU 8604, 8626, 8705, 8714, 8715, 8717, 8718, from KC02-10, seven specimens, TGU 9001, 9010, 9013, 9207, 9209, 9210, 9216, from NT01-05, and three specimens, TGU 8907, 8911, 8913, from NT01-07.

*Diagnosis:* Large robust concentric shell, comprising two medullary, one intermediary, and one cortical shells with up to about 15 three-bladed radial spines. Radial spines proximally cylindrical become three-bladed outside second medullary shell and increase their breadth distally up to the cortical shell.

*Etymology:* According to its occurrence in Triassic beds and the Latin noun robustus (robust) indicating its robust form.

*Description:* Fully grown specimens possess four concentric spheres comprising two medullary shells, one intermediary shell, and one cortical shell with up to about 15 three-bladed radial spines of uniform size and distribution. Inner medullary (1st) shell spherical and with small regularly arranged simple pores, approximately 20 on the half sphere. Outer medullary (2nd) shell also spherical and composed of an irregular network of very thin delicate anastomosing bars that sometimes has a sponge-like appearance. Between first and second medullary shell the radial spines are cylindrical. They become three-bladed outside second medullary shell and increase their breadth distally up to the cortical shell. Out-

side it they have not been observed because all of them are broken off. Numerous thorns or cylindrical thin short spines arise from the surface of the outer medullary shell. They may stop inside the space of the intermediary shell or may touch the wall of the latter when well preserved. Intermediary (3rd) shell composed of an irregular, delicate, anastomosing lace-like network of very thin bars; an almost identical texture is observed on the outer medullary shell. Cortical (4th) shell large, robust, rough-surfaced and composed of a very irregular loose spongy framework.

*Measurements* (3–5 specimens): Diameter of cortical shell 311–353  $\mu\text{m}$  (mean = 329.7  $\mu\text{m}$ ); diameter of intermediary shell 207–225  $\mu\text{m}$  (mean = 216.0  $\mu\text{m}$ ); diameter of outer medullary shell 92–116  $\mu\text{m}$  (mean = 105.8  $\mu\text{m}$ ); and diameter of inner medullary shell 27–35  $\mu\text{m}$  (mean = 31.2  $\mu\text{m}$ ).

*Remarks:* The observed specimens of this species were generally broken. Although the tetrahedral initial spicule allowed emendation of the diagnosis of the genus (Dumitrica, 2011) was not visible because of poor preservation, the set of several fragmentary images of this species shows all the other diagnostic features of the genus *Multisphaera* such as: double medullary shell, connected to the intermediary and cortical shells through about 15 three-bladed radial spines, which are thin and cylindrical between first and second medullary shells and three-bladed outside it. Also the structure of the intermediary shell resembles that of the type species of the genus *Multisphaera*. *Multisphaera triassorobusta* sp. nov. differs from *Multisphaera impersepta* Nazarov and Afanasieva, 2000 in having fewer radial spines and robust cortical shell.

*Discussion:* The genus *Multisphaera* has been represented until present only by its type species (*M. impersepta*) and considered to occur only in the Lower Permian. *M. triassorobusta* sp. nov., found in the Lower Triassic (upper Smithian), would prove that the genus *Multisphaera* crossed the P–T crisis. Although



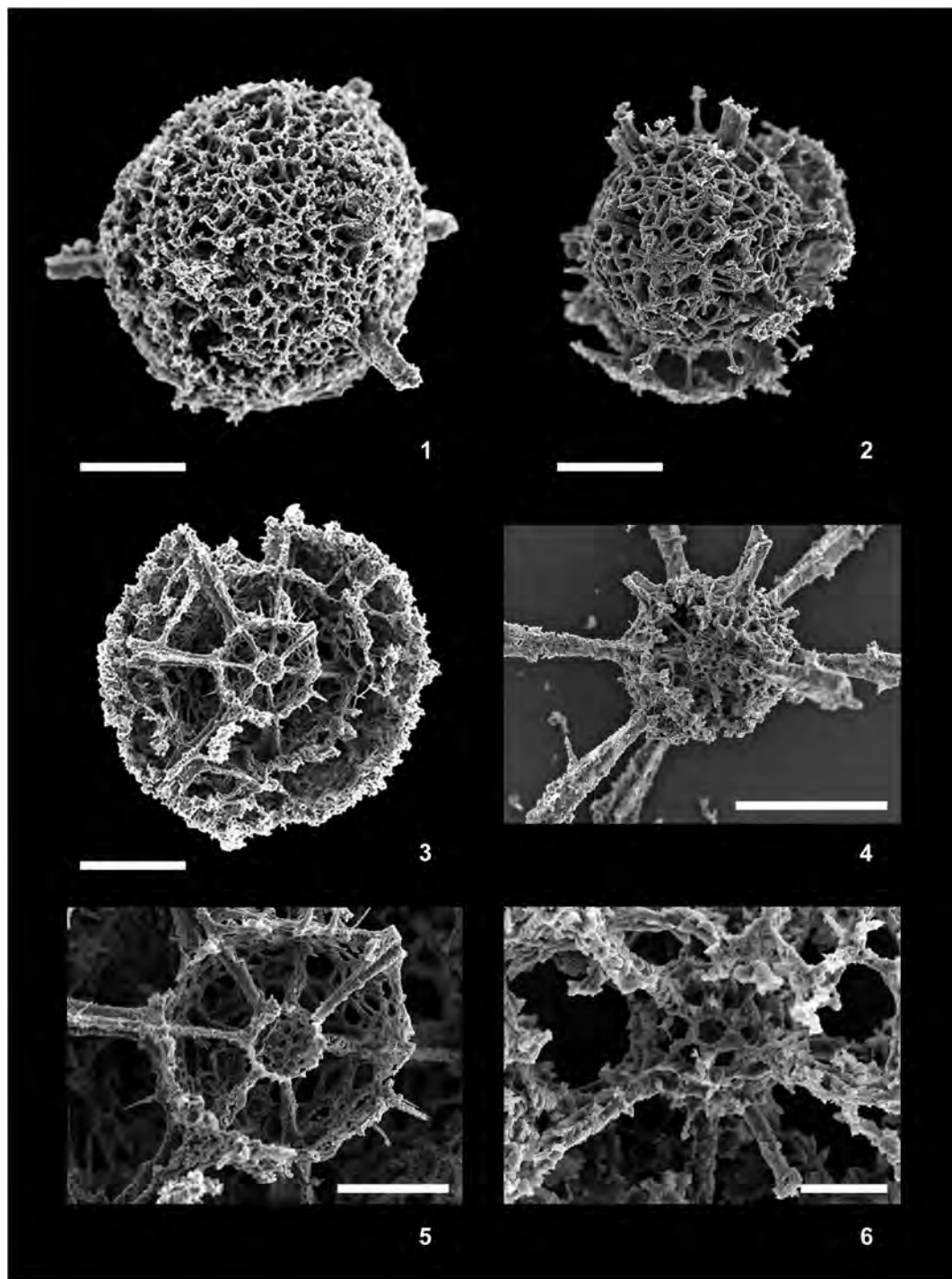


Fig 199. *Multisphaera triassorobusta* Takahashi, sp. nov. 1, TGU 8717, holotype, from KC02-10. 2, TGU 8714, from KC02-10. 3, 5, TGU 8705, from KC02-10. 4, TGU 9210, from NT01-05. 6, TGU 8626, from KC02-10. Scale bars = 100 $\mu$ m (1–4), 50 $\mu$ m (5), 20 $\mu$ m (6).



the family Tetrentactiniidae lineage has been suggested to have a long gap between the Lower Permian (Afanasieva, 2000) and Upper Jurassic (Dumitrica and Zügel, 2000; Dumitrica, 2011), *M. triassorobusta* sp. nov. probably fills partly the gap between the Permian and Jurassic genera of this family. It might suggest that the radiolarians bearing tetrahedrally arranged initial spicule represent a single family during this period at least, although Dumitrica (2013) erected a new family for the Jurassic genera with tetrahedral spicule.

**Occurrence:** Described specimens from NT01-05, NT01-07 and KC02-10 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Family Spongentactiniidae Nazarov, 1975

(syn: Retentactiniinae Won, 1997)

Genus *Retentactinia* Won, 1997

**Type species:** *Retentactinia repleta* Won, 1997.

**Remarks:** According to Won (1997), the most characteristic feature of the genus *Retentactinia* is having a network frame (N-frame) structure. This structure appears as an inner shell and is clearly separated from the spongy tissue of the outer shell. The N-frame is connected directly to the inner surface of the outer shell by six rays of the initial spicule. This genus differs from the genus *Spongentactinia* Nazarov, 1975 in having the N-frame structure.

*Retentactinia?* *kycungensis* Takahashi, sp. nov.

Fig. 200

**Material examined:** Holotype, TGU 9118 (Fig. 200.1), from NT01-05. Eight specimens, TGU 8606, 8627, 8632, 8702, 8703, 8712, 8805, 8808, from KC02-10, and eight specimens, TGU 9015, 9020, 9021, 9108, 9113, 9118, 9208, 9212, from NT01-05.

**Diagnosis:** Moderately sized, loose spongy spinulate shell with six long, proximally three-bladed but distally cylindrical radial spines. Apophyses forming an N-frame structure.

**Etymology:** The species is named after the Ky Cung River, where the uppermost part of the Bac Thuy Formation is exposed and from where the radiolarian-bearing limestone samples come.

**Description:** Test spherical, consisting of thin uniform spongy tissue. Surface of the shell consisting of an irregular and loose spongy framework with numerous microthorns. Six long, straight, proximally three-bladed but distally cylindrical radial spines asymmetrically arranged. They are unequal in length, one or two being slightly longer. Spines directly connected to the six rays of the initial spicule that has a short median bar. Apophyses of the species forming an N-frame structure.

**Measurements** (8 specimens): Diameter of shell 116–156  $\mu\text{m}$  (mean = 138.0  $\mu\text{m}$ ); length of apical spine 100–156  $\mu\text{m}$  (mean = 131.1  $\mu\text{m}$ ); length of other spines 95–116  $\mu\text{m}$  (mean = 101.8  $\mu\text{m}$ ).

**Remarks:** The shell texture and the frame of the internal network of *Retentactinia?* *kycungensis* sp. nov. resemble those of *Retentactinia repleta* Won, 1997, the type species of the genus. However, our species differs from *R. repleta* in having six cylindrical long spines connected to the N-frame.

**Occurrence:** Described specimens from NT01-05 and KC02-10 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

*Retentactinia?* *parvisphaera* Takahashi, sp. nov.

Fig. 201

**Material examined:** Holotype, TGU 9116 (Fig. 201.1), from NT01-05. Three specimens,

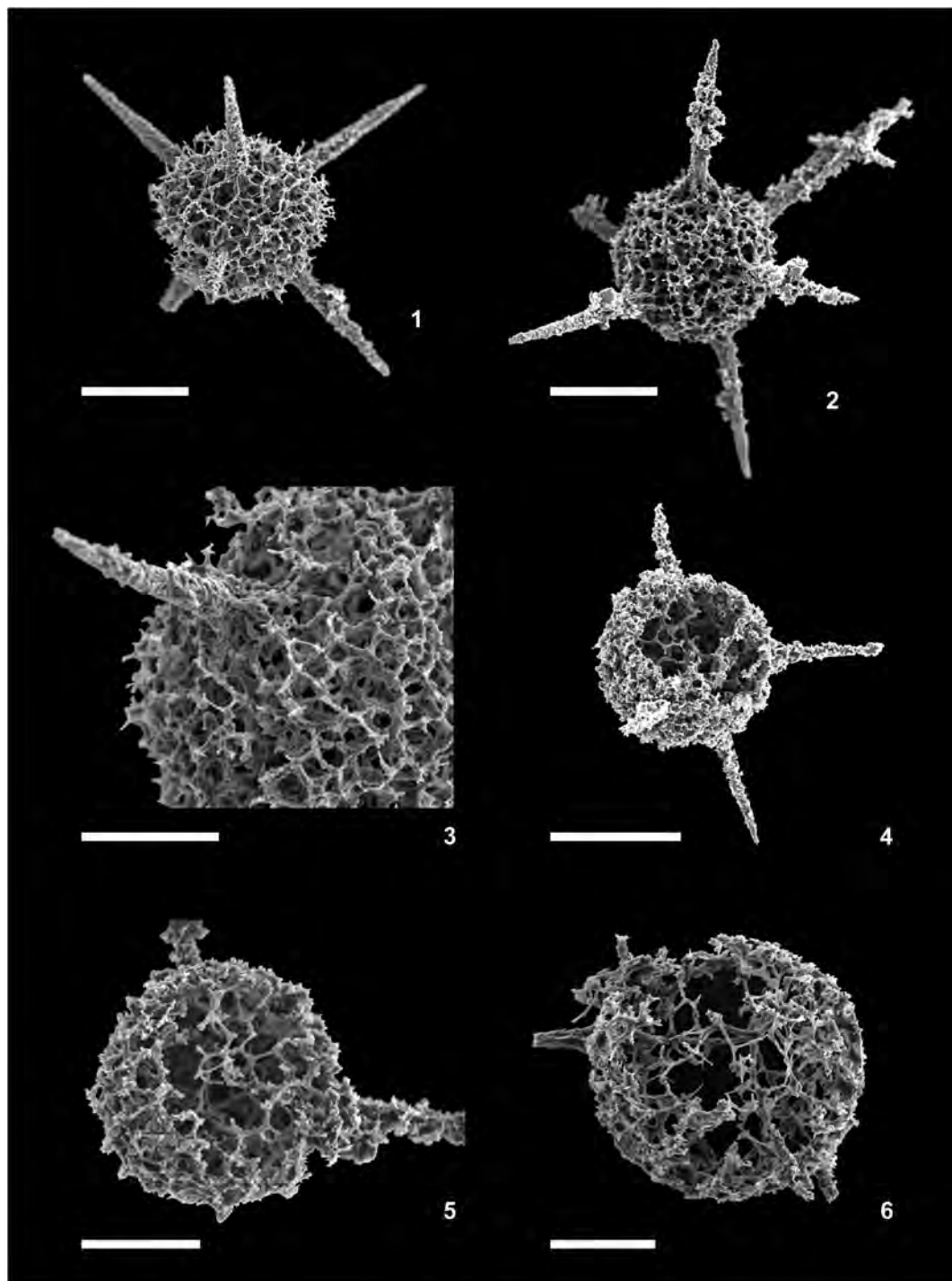


Fig. 200. *Retentactinia? kycungensis* Takahashi, sp. nov. 1, TGU 9118, holotype, from NT01-05. 2, TGU 8808, from KC02-10. 3, TGU 9021, from NT01-05. 4, TGU 8606, from KC02-10. 5, TGU 9020, from NT01-05. 6, TGU 8627, from KC02-10. Scale bars = 100 μm (1, 2, 4), 50 μm (3, 5, 6).

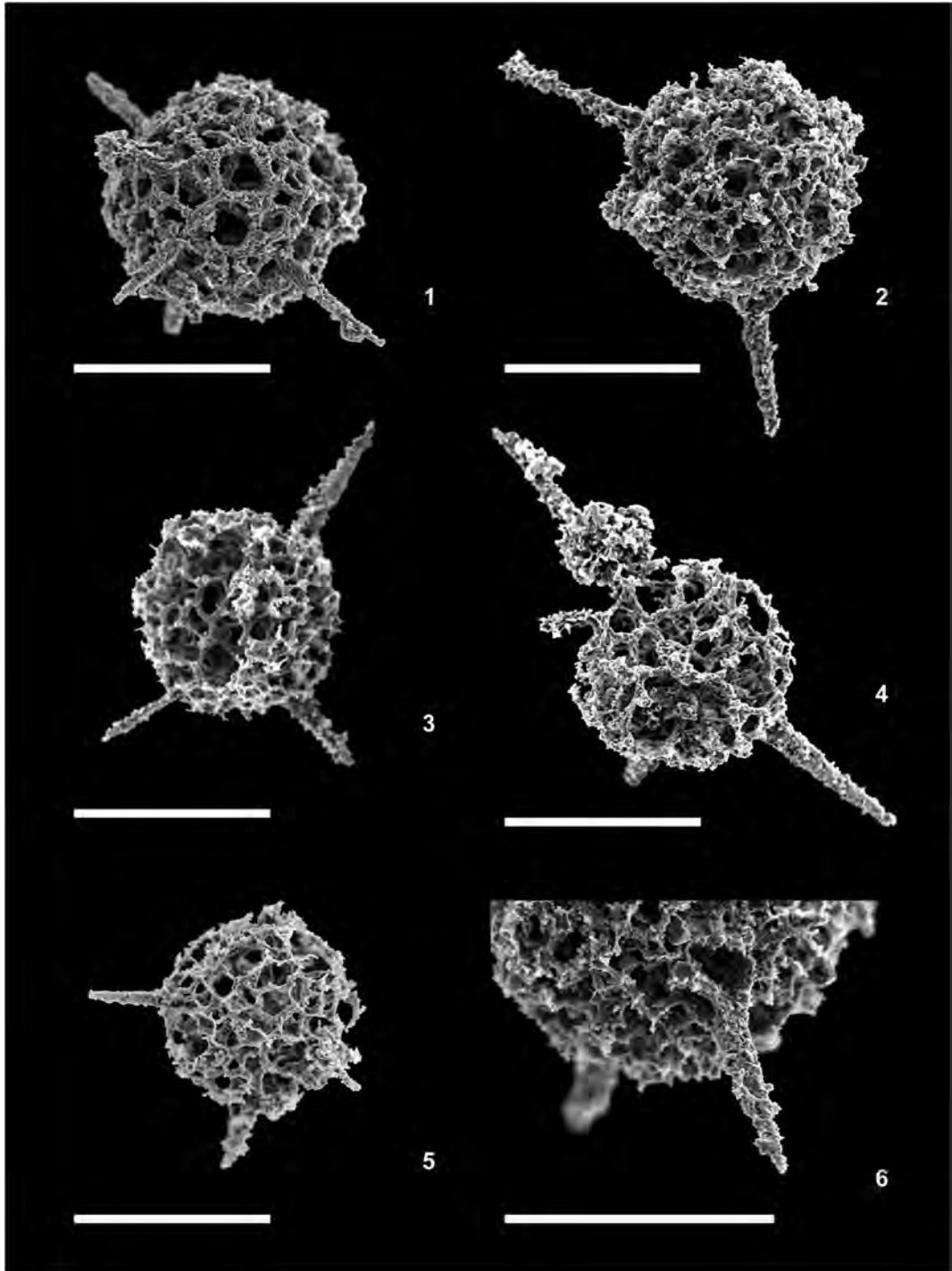


Fig. 201. *Retentactinia? parvisphaera* Takahashi, sp. nov. 1, TGU 9116, holotype, from NT01-05. 2, TGU 8607, from KC02-10. 3, TGU 8816, from KC02-10. 4, TGU 8819, from KC02-10. 5, TGU 9213, from NT01-05. 6, TGU 9101 from NT01-05. Scale bars = 100 $\mu$ m.

TGU 8607, 8616, 8819, from KC02-10, ten specimens, TGU 9007, 9014, 9101, 9114, 9116, 9117, 9202–9204, 9213, from NT01-05, and five specimens, TGU 8903, 8908–8910, 8912, from NT01-07.

*Diagnosis:* Small spherical shell, consisting of a coarse fragile meshwork with six short conical spines. Spines robust, connected to initial spicule with very short median bar. Apophyses forming an N-frame structure.

*Etymology:* The Latin adjective parvus (small) and the noun sphaera (sphere), indicating its small size and spherical form.

*Description:* Test small and spherical, consisting of a coarse or middle coarse meshwork and six spines. In some specimens, a fine spongy tissue covers partly the coarse meshwork. Spines are robust and arranged asymmetrically. They are conical but slightly three-bladed proximally and connected to the six thick rays of the initial spicule that has a very short median bar. The four thick, straight, longer rays of the initial spicule arise from near the midpoint of the shell; two short rays also arise from the N-framed inner structure of the shell.

*Measurements* (8 specimens): Diameter of shell 87–126  $\mu\text{m}$  (mean = 111.0  $\mu\text{m}$ ); length of spines 58–97  $\mu\text{m}$  (mean = 74.2  $\mu\text{m}$ ).

*Remarks:* The genus *Retentactinia* has a spongy shell with weakly developed spines, except for *Retentactinia interreticulata* Won, 1997, which possesses robust three-bladed radial spines. *Retentactinia? parvisphaera* sp. nov. differs from other *Retentactinia* species in having a very coarse and fragile meshwork on the shell surface and small, straight, but robust spines.

*Occurrence:* Described specimens from NT01-05, NT01-07 and KC02-10 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian = upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Genus *Plenoentactinia* Won, 1997

*Type species:* *Plenoentactinia sexangula* Won, 1997.

*Plenoentactinia? terespongia* Takahashi, sp. nov.

Fig. 202

*Material examined:* Holotype, TGU 8719 (Fig. 202.2), from KC02-10. Four specimens, TGU 8620, 8621, 8701, 8706, from KC02-10, nine specimens, TGU 9003, 9004, 9006, 9017–9019, 9104, 9105, 9107, from NT01-05, and one specimen, TGU 8904, from NT01-07.

*Diagnosis:* Moderately sized, thick non-layered spongy shell with eight long, cylindrical slender spines. A six-rayed initial spicule with a short median bar.

*Etymology:* The Latin adjective teres (fine, smooth) and the noun spongia (sponge) indicate its compact spongy tissues of the shell.

*Description:* Test spherical, spongy, and non-layered with eight slender, cylindrical radial spines. Size of the test relatively variable; however, the inner and superficial structure of the shell and the arrangement of the main spines have a similar development within the species. Single unlayered shell consisting of very compact, thick spongy tissue and with eight long radial spines of uniform length and shape. Pores on the inner surface of the shell characteristically larger and more irregular in shape than those on the outer surface. A six-rayed initial spicule with a short median bar was observed in some specimens. This means that some spines are not prolongation of the spicule rays.

*Measurements* (5 specimens): Diameter of shell 139–170  $\mu\text{m}$  (mean = 153.7  $\mu\text{m}$ ); length of spines 108–164  $\mu\text{m}$  (mean = 140.8  $\mu\text{m}$ ).

*Remarks:* *Plenoentactinia? terespongia* sp. nov. differs from the species Won (1997) assigned unquestionably to this genus in having the spines circular in cross section and may be compared only with *Plenoentactinia? abstrusa* (Aitchison, 1993) (Won, 1997).

*Occurrence:* Described specimens from



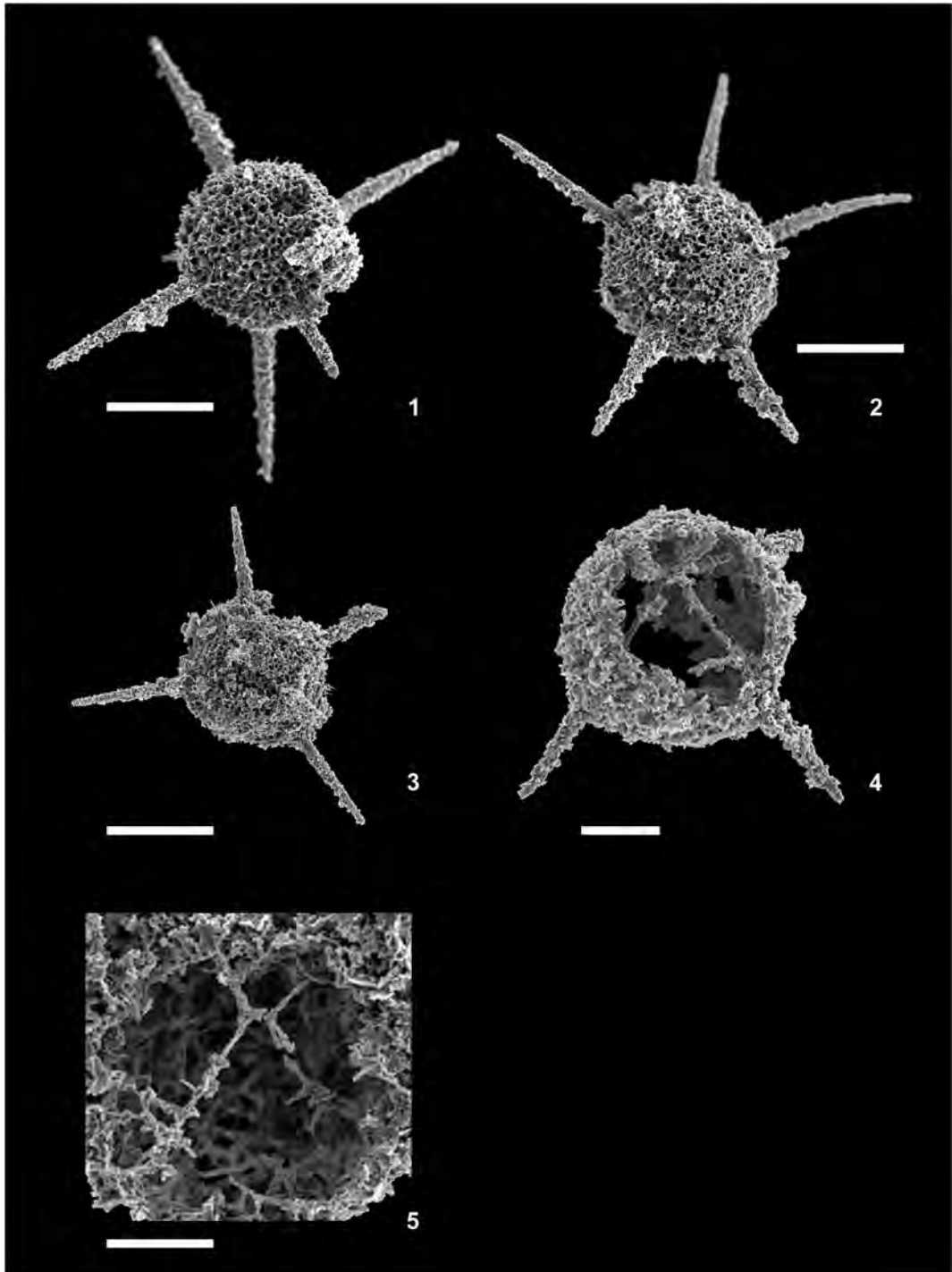


Fig. 202. *Plenoentactinia? terespongia* Takahashi, sp. nov. 1, TGU 8701, from KC02-10. 2, TGU 8719, holotype, from KC02-10. 3, TGU 8621, from KC02-10. 4, TGU 8620, from KC02-10. 5, TGU 8904, from NT01-07. Scale bars = 100  $\mu$ m (1–3), 50  $\mu$ m (4, 5).

NT01-05, NT01-07 and KC02-10 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Genus *Spongentactinia* Nazarov, 1975

*Type species: Spongentactinia fungosa* Nazarov, 1975.

*Spongentactinia?* sp. indet.

Fig. 203.1–203.4

*Material examined:* One specimen, TGU 9111, from NT01-05, and three specimens, TGU 8609, 8616, 8623, from KC02-10.

*Remarks:* We recovered only very poorly preserved and fragmental specimens of this species. The specimens have thin, fragile, spherical spongy shell with four or five, possibly six long, slender needle-like spines. Spongy shell has rather loose meshes, very thin and irregular bars and seems to be disposed in concentric layer and traversed by a series of thin radial bars. Spicule center is not visible due to the poor preservation.

*Occurrence:* Described specimens from NT01-05 and KC02-10 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Family Palaeoscenediidae Riedel, 1967,  
emend Furutani, 1983

(syn: Parentactiniidae Kozur and Mostler, 1981;  
Protoentactiniidae Kozur, Mostler and  
Repetski, 1996)

Genus *Parentactinia* Dumitrica, 1978

*Type species: Parentactinia pugnax* Dumitrica, 1978.

*Parentactinia nakatsugawaensis* Sashida,  
1983

Fig. 204.1–204.3

*Parentactinia nakatsugawaensis* Sashida, 1983, p. 172, pl. 37, figs. 1–9; Sashida, 1991, p. 687, figs. 5.15, 5.16, 6.1, 6.3–6.6; Sugiyama, 1992, p. 1212, 1213, figs. 14.7–14.10; Sugiyama, 1997, p. 184, figs. 27.2, 27.3; Sashida *et al.*, 2000a, p. 801, fig. 8.24; Sashida *et al.*, 2000b, p. 86, figs. 7.1–7.7.

*Material examined:* Two specimens, TGU 9115, 9211, from NT01-05, and two specimens, TGU 8902, 8905, from NT01-07.

*Remarks:* *Parentactinia nakatsugawaensis*, especially when poorly preserved, resembles the spiculate nassellarian species *Tandarnia recoarensis* Dumitrica, 1982, as suggested by Sashida (1983). However, both are distinguishable by the presence of a latticed shell and/or branching pattern of the spines. *P. nakatsugawaensis* has a loose hemispheric latticed shell, among the four basal spines; the basal spines are rather straight and are longer than those of *T. recoarensis*. Furthermore, *P. nakatsugawaensis* has no apical verticil.

*Occurrence:* Described specimens from NT01-05 and NT01-07 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species also occurs in the Lower Triassic (Spathian?) chert beds of central Japan (Sashida, 1983, 1991; Sugiyama, 1992, 1997) and the Spathian chert beds of the southern and northern Thailand (Sashida *et al.*, 2000a, b).

*Parentactinia* cf. *pugnax* Dumitrica, 1978

Fig. 203.5

cf. *Parentactinia pugnax* Dumitrica, 1978, p. 50, pl. 4, figs. 4?, 5, pl. 5, figs. 1–3; Kozur and Mostler, 1994, p. 45, pl. 1, figs. 11, 12.

*Material examined:* One specimen, TGU 9215, from NT01-05.

*Remarks:* From this species we found only the fragment illustrated. It has a globular shell

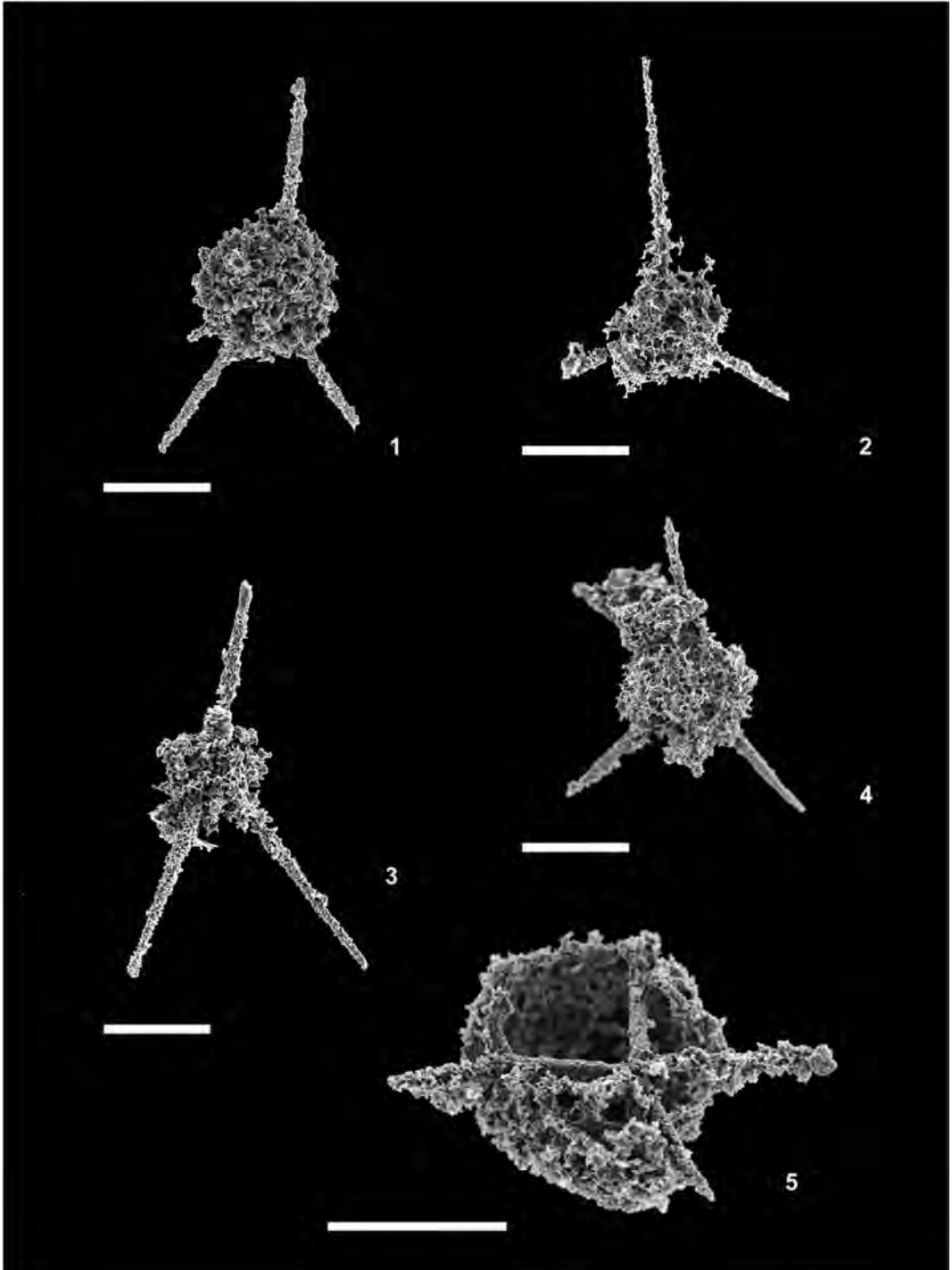


Fig. 203. 1–4, *Spongontactinia?* sp. indet. 1, TGU 8623, from KC02-10. 2, TGU 8616, from KC02-10. 3, TGU 8609, from KC02-10. 4, TGU 9111, from NT01-05. 5, *Parentactinia* cf. *pugnax* Dumitrica, 1978, TGU 9215, from NT01-05. Scale bars = 100  $\mu$ m.

and an eccentric and robust initial spicule with an extremely short median bar, four basal spines and probably three apical spines of which only two are preserved. Basal spines are longer than the apical ones, relatively straight and arranged under different angles relative to the axis of shell. They are prolonged outside the shell as relatively long spines. Test is also robust with pores of irregular shape, size and arrangement. Our specimen resembles very much the late Illyrian or early Fassanian specimen questionably assigned to *Parentactinia pugnax* Dumitrica, 1978. This specimen has also three apical spines and a globular shell that includes in it also the medial bar.

*Occurrence:* Described specimens from NT01-05 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian = upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. *Parentactinia pugnax* occurs fairly rare in the upper Illyrian (= uppermost Anisian) or lower Fassanian (lowest Ladinian) at Recoaro, northern Italy (Dumitrica, 1978) and Balaton Highland, western Hungary (Kozur and Mostler, 1994).

Family Pentactinocarpidae Dumitrica, 1978

Genus *Pentactinocarpus* Dumitrica, 1978

*Type species:* *Pentactinocarpus fusiformis* Dumitrica, 1978.

***Pentactinocarpus?* aff. *acanthicus***

Dumitrica, 1978

Fig. 204.4–204.7

aff. *Pentactinocarpus acanthicus* Dumitrica, 1978, p. 44, pl. 3, fig. 3; Kozur and Mostler, 1994, p. 46, pl. 2, figs. 3, 5.

*Material examined:* Four specimens, TGU 8614, 8618, 8625, 8806, from KC02-10, and four specimens, TGU 9008, 9112, 9120, 9214, from NT01-05.

*Remarks:* Our specimens have a large sub-spherical shell with long conical apical and antapical spines. Five or more basal spines ex-

tend laterally downward or slightly upward. Pores are elliptical or sub-circular and irregularly arranged. Although our specimens are poorly preserved, the characteristic features are similar to those of *Pentactinocarpus acanthicus* described from the uppermost Anisian to lowest Ladinian of Recoaro, Italy by Dumitrica (1978). However, our specimens differ from the type species in having more than four basal spines in some specimens, no primary ring around the spicule center and no intercalary spines between the four basal spines. Until present this genus was not yet recorded at stratigraphic levels older than late Anisian.

*Occurrence:* Described specimens from NT01-05 and KC02-10 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian = upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Family Thalassothamnidae Haecker, 1906  
Genus *Triassothamnus* Kozur and Mostler, 1981  
(syn: *Archaeothamnulus* Dumitrica, 1982)

*Type species:* *Palacantholithus? verticillatus* Dumitrica, 1978.

***Triassothamnus verticillatus*** (Dumitrica, 1978)

Fig. 205

*Palacantholithus? verticillatus* Dumitrica, 1978, p. 42, pl. 1, fig. 1, pl. 2, fig. 5.

*Archaeothamnulus verticillatus* (Dumitrica, 1978). Dumitrica, 1982, p. 418, pl. 5, figs. 3, 4, pl. 7, fig. 4.

*Material examined:* Three specimens, TGU 8615, 8802, 8803, from KC02-10, one specimen, TGU 9011, from NT01-05, and one specimen, TGU 8906, from NT01-07.

*Remarks:* Our specimens have a long, straight, needle-like axial spine and four slightly curved basal spines arising from the spicule center. The apical spine has sometimes an apical verticil of three short and thin spinules, whereas the basal spines have generally a verticil of three or four spinules. The lengths of spinules vary from very short to moderately



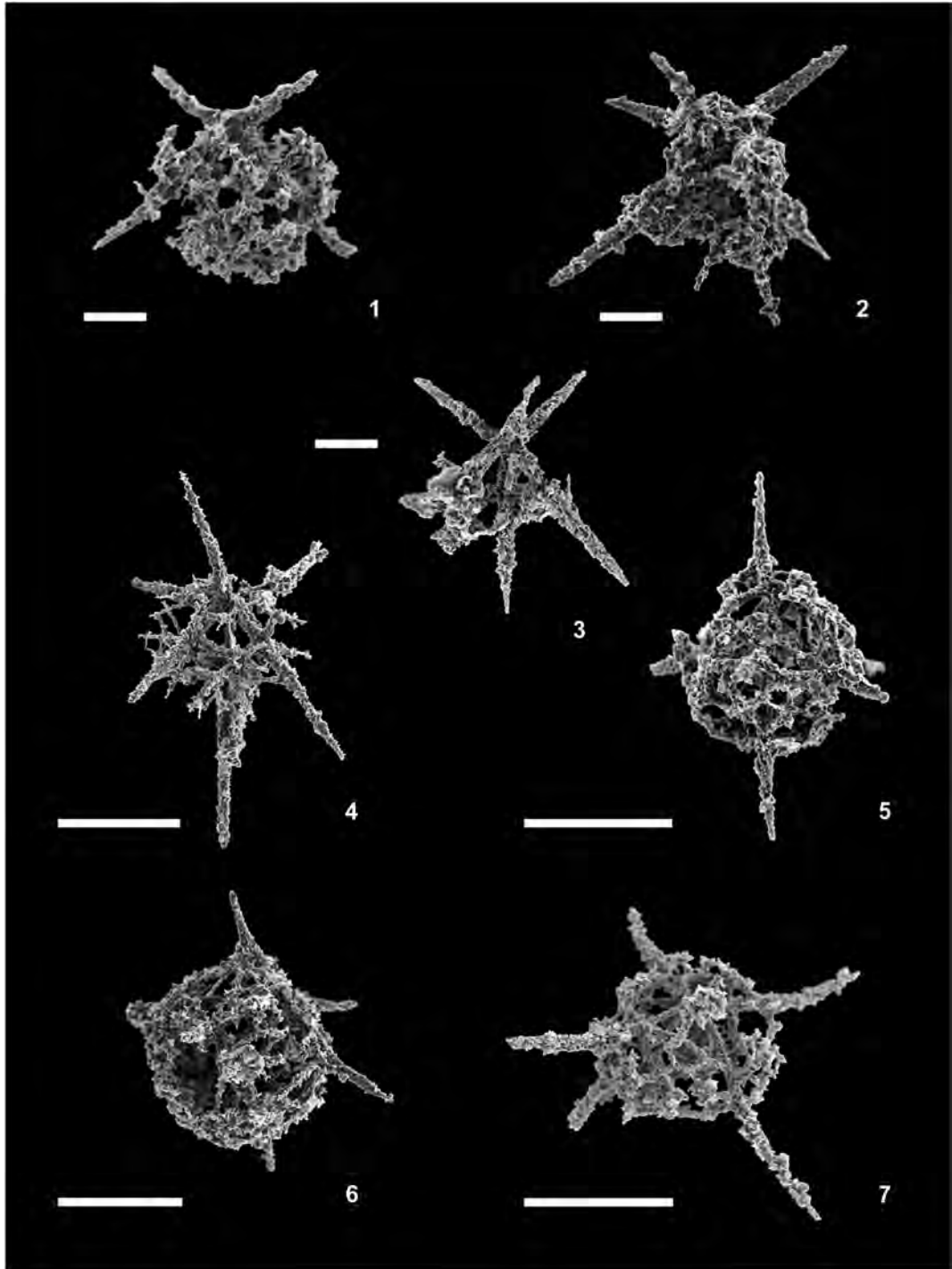


Fig. 204. 1–3, *Parentactinia nakatsugawaensis* Sashida, 1983. 1, TGU 8902, from NT01-07. 2, TGU 9115, from NT01-05. 3, TGU 9211, from NT01-05. 4–7, *Pentactinocarpus?* aff. *acanthicus* Dumitrica, 1978. 4, TGU 8618, from KC02-10. 5, TGU 9112, from NT01-05. 6, TGU 8614, from KC02-10. 7, TGU 8806, from KC02-10. Scale bars = 50  $\mu$ m (1–3), 100  $\mu$ m (4–7).

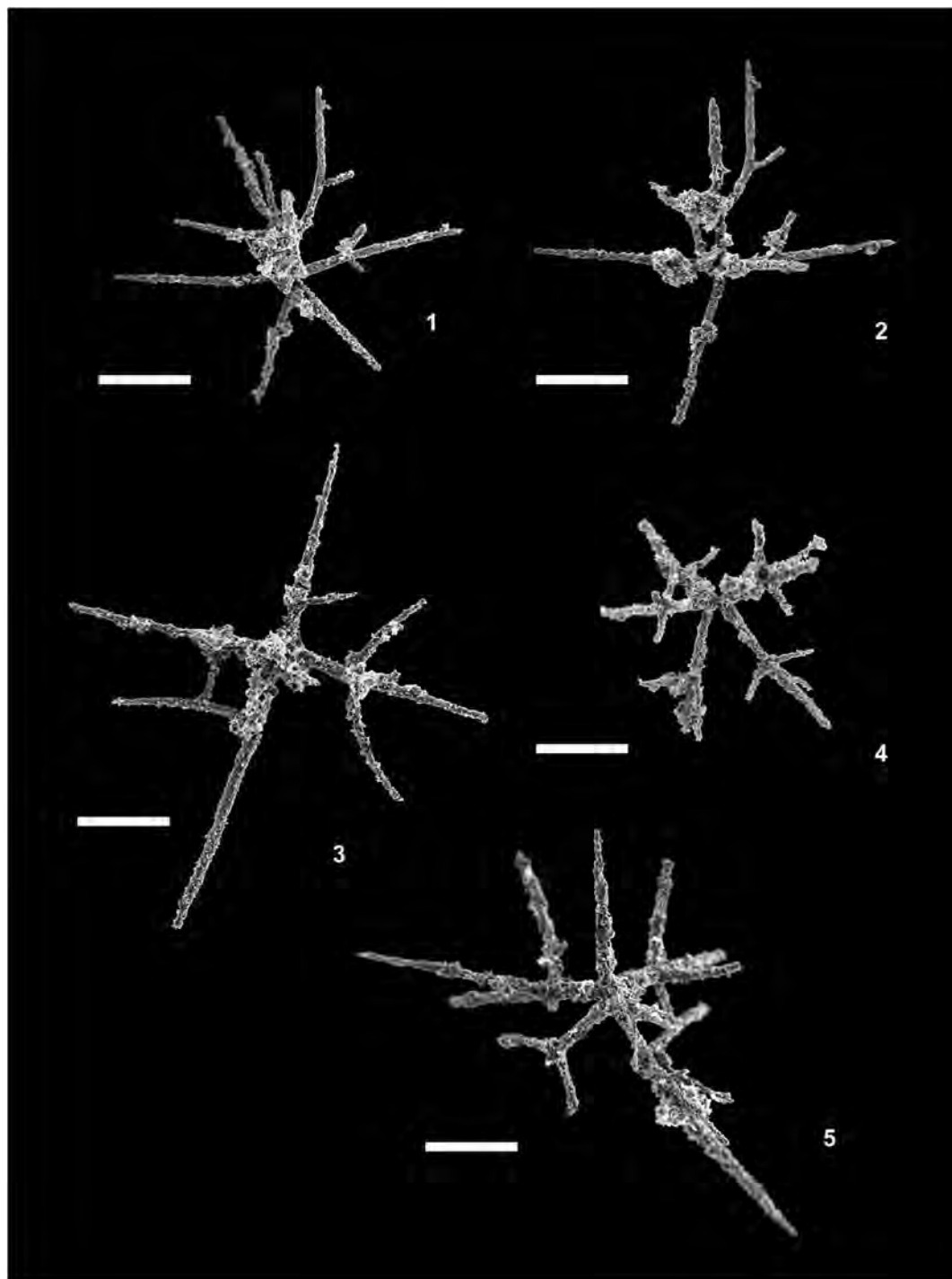


Fig. 205. *Triassothamnus verticillatus* (Dumitrica, 1978). 1, TGU 8802, from KC02-10. 2, TGU 8803, from KC02-10. 3, TGU 8615, from KC02-10. 4, TGU 8906, from NT01-07. 5, TGU 9011, from NT01-05. Scale bars = 100  $\mu$ m.

long. As already suggested by Dumitrica (1982), we recognized also two morphotypes within the species, one without an apical verticil (Fig. 205.5) and the other with an apical verticil consisting of three spinules (Fig. 205.1–205.4).

*Occurrence:* Described specimens from NT01-05, NT01-07 and KC02-10 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species rarely occurs in the lower Fassanian (lowest Ladinian) at Recoaro, northern Italy (Dumitrica 1978, 1982).

Family Entactiniidae Riedel, 1967

Genus *Entactinosphaera* Foreman, 1963

*Type species: Entactinosphaera esostrongyla* Foreman, 1963.

*Entactinosphaera* sp. indet.

Fig. 206.1–206.2

*Material examined:* Two specimens, TGU 9103, 9110, from NT01-05.

*Remarks:* The test consists of two thin spherical shells interconnected through seemingly six, three-bladed radial beams prolonged outside cortical shell into long and gently tapering three-bladed radial spines. Radial beams and spines not disposed in the three isometric axes. The wall of both shells perforated by small, polygonally-framed pores. Due to the poor preservation we could not see if inside the inner shell there is another shell or a spicule.

*Occurrence:* Described specimens from NT01-05 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

Order Nassellaria Ehrenberg, 1875

Family Archaeosemantidae Kozur and Mostler, 1981, emend De Wever *et al.*, 2001

Genus *Tandarnia* Dumitrica, 1982, emend Dumitrica, 2004

*Type species: Tandarnia recoarensis* Dumitrica, 1982.

*Remarks:* The genus *Tandarnia* is a Triassic spiculate genus with spicules very similar in arrangement to those of the entactinarian *Parentactinia* Dumitrica, 1978, but bearing no latticed shell as in *Parentactinia*. They are therefore easily distinguished by their general shape and, if possible, preserved ornamentation. Furthermore, the genus *Tandarnia* has typical disposition of spines as nassellarians; i.e., it has two homologous spines of apical and ventral, that are commonly longer than the other four lateral basal spines, and the arrangement is verticil, which is a system of branches disposed around the same point from the spicule center.

*Tandarnia recoarensis* Dumitrica, 1982

Fig. 206.3–206.5

*Tandarnia recoarensis* Dumitrica, 1982, p. 415, pl. 3, figs. 6–10; Goričan and Buser, 1990, p. 159, pl. 7, fig. 4.

*Tandarnia recoaroense* Dumitrica, 1982. Kozur *et al.*, 1996b, p. 219, pl. 11, figs. 1, 2, 4–7.

*Tandarnia recoarensis* Dumitrica, 1982. Sugiyama, 1997, p. 187, fig. 48.10; Dumitrica, 2004, p. 221, pl. 5, fig. 3, pl. 10, figs. 4–6.

*Material examined:* Three specimens, TGU 8613, 8709, 8713, from KC02-10.

*Remarks:* *Tandarnia recoarensis* resembles the entactinarian species of *Parentactinia nakatsugawaensis* Sashida, 1983. However, *T. recoarensis* differs from *P. nakatsugawaensis* in having two homologous apical and vertical spines, and four lateral upward-curved basal spines, and the arrangement of the all spines is verticil with three or four simple spinules. In addition, *T. recoarensis* has many short branching intricately crossed spinules.

*Occurrence:* Described specimens from

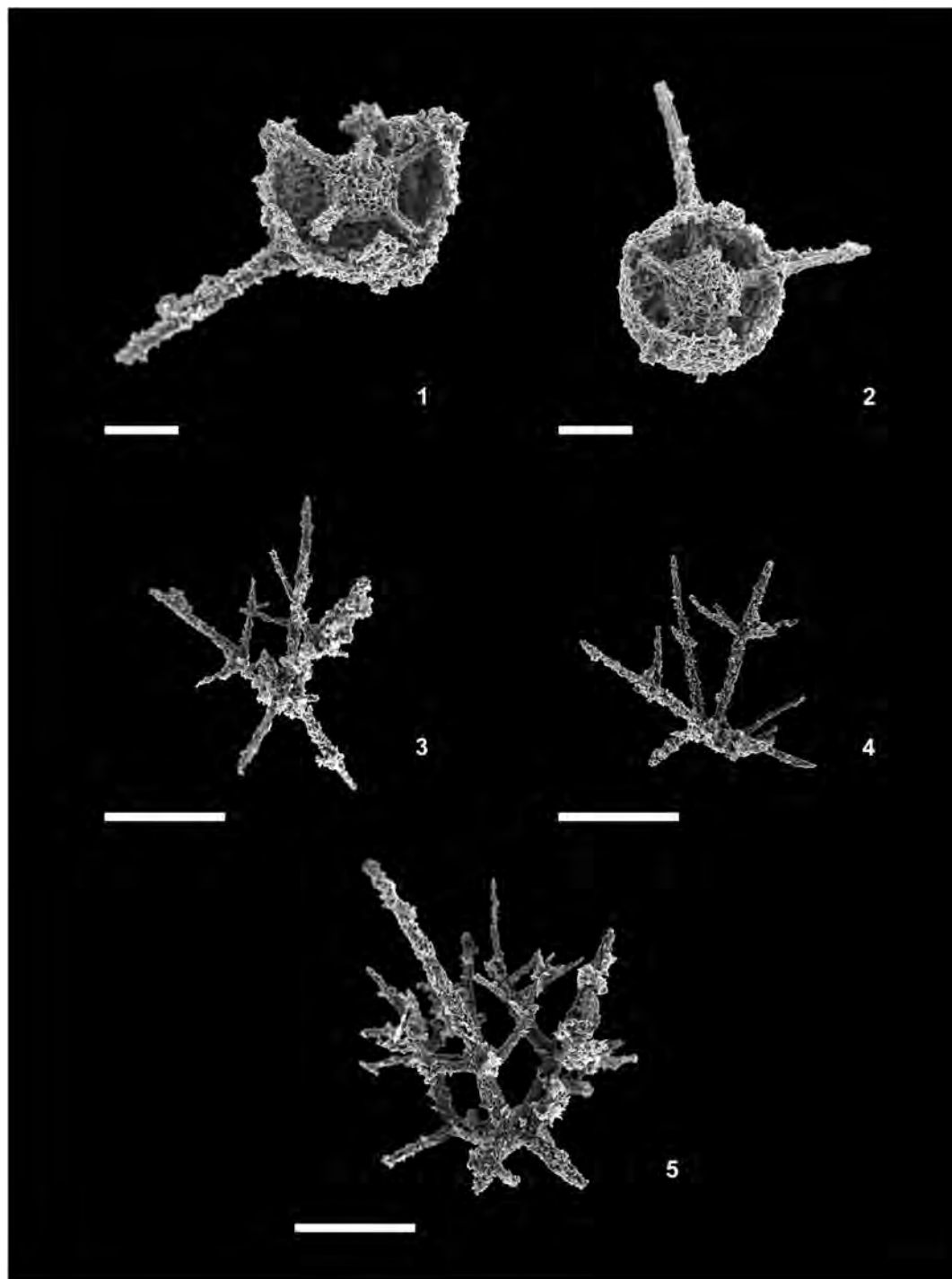


Fig. 206. 1–2, *Entactinosphaera* sp. indet. 1, TGU 9103, from NT01-05. 2, TGU 9110, from NT01-05. 3–5, *Tandarnia recoarensis* Dumitrica, 1982. 3, TGU 8709, from KC02-10. 4, TGU 8613, from KC02-10. 5, TGU 8713, from KC02-10. Scale bars = 100  $\mu$ m.



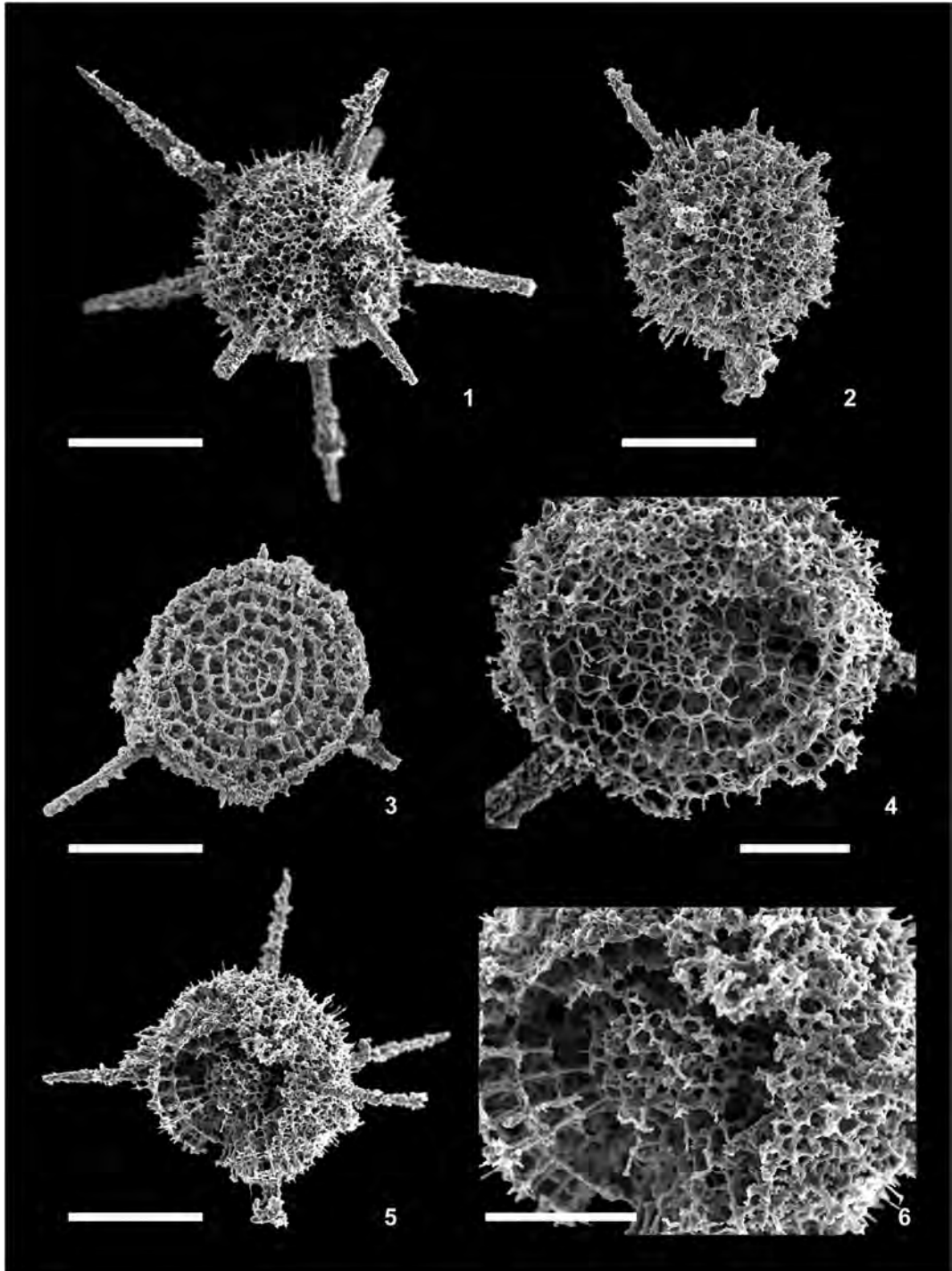


Fig. 207. *Paroertlispongia spinorientalis* Takahashi, sp. nov. 1, TGU 8809, holotype, from KC02-10. 2, TGU 8631, from KC02-10. 3, TGU 8914, from NT01-07. 4, TGU 8811, from KC02-10. 5–6, TGU 8708, from KC02-10. Scale bars = 100  $\mu\text{m}$  (1–3, 5), 50  $\mu\text{m}$  (4, 6).

KC02-10 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam. This species occurs in the upper Illyrian (=uppermost Anisian) to lower Fassanian (lowest Ladinian) at Recoaro, northern Italy (Dumitrica, 1982, 2004), the Slovenian Carbonate Platform, Slovenia (Goričan and Buser, 1990), and the Loibl Formation, Austria (Kozur *et al.*, 1996b). It also occurs in lower Anisian chert beds of central Japan (Sugiyama, 1997).

Order Spumellaria Ehrenberg, 1875, emend  
De Wever *et al.*, 2001

Family Oertlispongidae Kozur and Mostler, 1980  
emend Kozur and Mostler, 1981

Genus *Paroertlispongus* Kozur and Mostler, 1981

*Type species: Paroertlispongus multispinosus* Kozur and Mostler, 1981.

*Remarks:* We use this genus in the wider sense used already by Feng *et al.* (2006) who included in it species with many spines.

### *Paroertlispongus spinorientalis*

Takahashi, sp. nov.

Fig. 207

*Material examined:* Holotype, TGU 8809 (Fig. 207.1), from KC02-10. Five specimens, TGU 8502, 8631, 8708, 8811, 8815, from KC02-10, three specimens, TGU 9009, 9012, 9119, from NT01-05, and one specimen, TGU 8914, from NT01-07.

*Diagnosis:* Five to seven concentric spherical shells, consisting of an irregular, loose spongy framework with numerous thorns and nine long, slender, cylindrical spines. A three-dimensionally patterned framework of spongy tissues developed on each shell except in the innermost one.

*Etymology:* The Latin adjectives spinosus (thorny) and Orientalis (Oriental) indicate its morphology and the occurrence in the eastern Asia.

*Description:* Test composed of five to seven shells and nine long, slender radial spines. Spines straight and cylindrical with uniform length and shape. Innermost shell composed of a lattice with loose polygonal meshes. All other shells have a meshwork similar to that of the innermost shell; however, a three-dimensionally patterned framework of spongy tissues is developed on each shell except in the innermost shell. Surface of the outermost shell has an irregular, loose spongy framework and numerous thorns or cylindrical short by-spines.

*Measurements* (7 specimens): Diameter of shell 149–171  $\mu\text{m}$  (mean = 158.6  $\mu\text{m}$ ); length of spines 148–154  $\mu\text{m}$  (mean = 151.1  $\mu\text{m}$ ).

*Remarks:* The inner shell structure of the species was not possible to see because of the looseness and complexity of the shell meshwork. The general outline of the test of our specimens resembles those of the genus *Paroertlispongus*. This species resembles some multi-spiny species illustrated by Feng *et al.* (2006) from the latest Permian of South China.

*Occurrence:* Described specimens from NT0-05, NT01-07 and KC02-10 within the *Novispathodus pingdingshanensis* Zone represented by the *Xenoceltites variocostatus* beds (Upper Smithian=upper Lower Olenekian) in the Bac Thuy Formation, northeastern Vietnam.

### Concluding Remarks

(by Y. Shigeta, T. Komatsu, T. Maekawa  
and H. T. Dang)

Our Japanese-Vietnamese Joint field investigation has described in detail the stratigraphy and faunal succession of the Lower Triassic in northeastern Vietnam. These studies have not only resulted in the reconstruction of depositional environments and the establishment of a biostratigraphic framework, but they also have contributed significantly to a better understanding of the global environmental change and dynamics of the biotic recovery

following the Permian-Triassic mass extinction. However, a considerable amount of work remains to be accomplished. Planned studies include stable isotope stratigraphy, magnetostratigraphy, biomarker analysis, spore analysis and the study of fish and shark teeth. Therefore, the future efforts of the joint research team will result in even greater contributions and will significantly broaden our knowledge of the Early Triassic.

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