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Cooperina (Productida, Brachiopoda) from the lower Permian of Japan

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Introduction

Cooperina is a minute, very distinctive productid brachiopod belonging to the Family Cooperinidae Pajaud, 1968. This genus was established by Termier *et al.* (1966) with *Cooperina inexpectata* Termier, Termier and Pajaud, 1966, from the Word Formation of the Glass Mountains, West Texas, USA, as type species. At that time, Termier *et al*. considered the genus as a possible ancestor of the Triassic–Recent thecideid brachiopods (Superfamily Thecideoidea Gray, 1840, Order Thecideida Elliott, 1958). Later, Cooper and Grant (1969, 1975) considered *Cooperina* as a genus of the Superfamily Aulostegacea Muir-Wood and Cooper, 1960, Suborder Productidina Waagen, 1883, based on well preserved material from the lower to middle Permian of West Texas. More recently, Waterhouse (2002) grouped *Cooperina* into the Superfamily Cooperinoidea Pajaud, 1968 within the Suborder Productidina.

Five species of *Cooperina* have thus far been described from the lower to middle Permian of the United States, Venezuela and Thailand: *Cooperina inexpectata*, from the Wordian of West Texas (Termier *et al*., 1966; Pajaud, 1968; Cooper and Grant, 1975) and from the Roadian to Wordian of Venezuela (Hoover, 1981); *Cooperina parva* Cooper and Grant, 1975, from the upper Wolfcampian to the uppermost Leonardian of West Texas (Cooper and Grant, 1975); *Cooperina subcuneata* Cooper and Grant, 1975, from the uppermost Leonardian of West Texas; *Cooperina triangulata* Cooper and Grant, 1975, from the lower Wolfcampian of West Texas; and *Cooperina polytreta* Grant, 1976, from the upper Kungurian–Roadian Ratburi Limestone of southern Thailand.

This paper presents the first description of *Cooperina* from Japan. The specimens, described here as *C. inexpectata* and *Cooperina nipponica* sp. nov., were collected by the second (Y. M.) and third (Y. O.) authors from the lower part of the Nabeyama Formation (*Parafusulina yabei* Zone, Kungurian) of Yamasuge (Loc. KY4 of Tazawa *et al*., 2012), Kuzu area, Ashio Mountains, central Japan (Fig. 1). The material was prepared by separating the silicified fossils from some limestone blocks by using formic acid (3–4%). The occurrence of *Cooperina* from the Kuzu area supports the Permian palaeogeography of the Yamasuge fauna as described by Tazawa *et al.* (2010, 2012), who suggested that the Nabeyama Formation was deposited in an equatorial region of Panthalassa during the early Permian (Kungurian), proximal to what is now West Texas.

All of the specimens described below are registered with the prefix KFM and housed in the Kuzu Fossil Museum, Kuzu, Sano City, Tochigi Prefecture, central Japan.

Systematic descriptions

Taxonomical classification above the generic level follows Waterhouse (2002).

Order Productida Sarytcheva and Sokolskaya, 1959
Suborder Productidina Waagen, 1883
Superfamily Cooperinoidea Pajaud, 1968
Family Cooperinidae Pajaud, 1968
Subfamily Cooperininae Pajaud, 1968
Genus ***Cooperina*** Termier, Termier and Pajaud, 1966

Type species.—*Cooperina inexpectata* Termier, Termier and Pajaud, 1966.

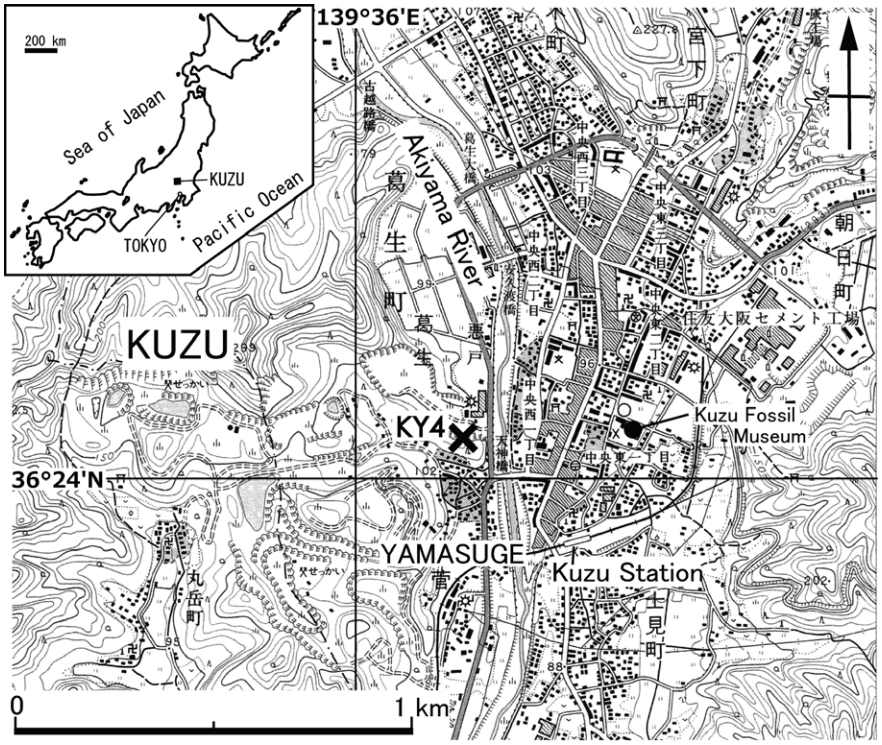

Figure 1. Index map showing the fossil locality KY4 in Kuzu, central Japan (using the 1:25,000 "Tanuma" sheet published by the Geospatial Information Authority of Japan).

Cooperina inexpectata Termier, Termier and Pajaud, 1966

Figures 2.1, 2.2

Cooperina inexpectata Termier, Termier and Pajaud, 1966, p. 332, fig. 1; Pajaud, 1968, fig. 2A; Cooper and Grant, 1975, p. 824, pl. 210, figs. 1–61, pl. 212, figs. 11–22; Hoover, 1981, p. 57, pl. 4, figs. 19–37.

Material.—Two specimens, both ventral valves, KFM1852, 1857.

Description.—Shell small size for genus, slightly elongate subrectangular in outline; sides moderately divergent; hinge shorter than greatest width occurring at about two-thirds length from umbo; length 2.4 mm, width 2.0 mm, hinge width 0.9 mm in the larger specimen (KFM1852). Ventral valve moderately and unevenly convex in lateral profile, with flattened umbonal region and subgeniculated anterior half; strongly convex in anterior profile, with nearly flat disk and steep lateral slopes; cicatrix of attachment large, occupying one-third to nearly a half of valve posteriorly; interarea high, triangular, measuring 0.5 mm long, 1.1 mm wide in the holotype; no delthyrium; ears small, flattened, forming approximately a right angle. External surface of ventral valve ornamented with strong, suberect spines, distant and scattered over valve except for area of attachment. Ventral interior not well preserved, neither muscle scars nor median ridge observed.

Remarks.—These specimens are referred to *Cooperina inexpectata* Termier, Termier and Pajaud, 1966, originally described by Termier *et al.* (1966) from the Word Formation of West Texas, on account of size, shape and external ornamentation of the ventral valve.

This species is closest to *Cooperina subcuneata* Cooper and Grant (1975, p. 826, pl. 209, figs. 38–59), from the Road Canyon Formation of West Texas, but the latter differs from *C. inexpectata* by its subcuneate outline and in having a narrower hinge.

Cooperina nipponica sp. nov.

Figures 2.3–2.7

Etymology.—Named after the country of the fossil locality, Nippon.

Material.—Eleven specimens: (1) one conjoined shell, KFM1856 (holotype); (2) six ventral valves, KFM1850, 1851, 1854, 1855, 1858, 1859; (3) four dorsal valves, KFM1853, 1860, 1861, 1862.

Diagnosis.—Small, slightly transverse *Cooperina*, with large bilobate cardinal process and high, long

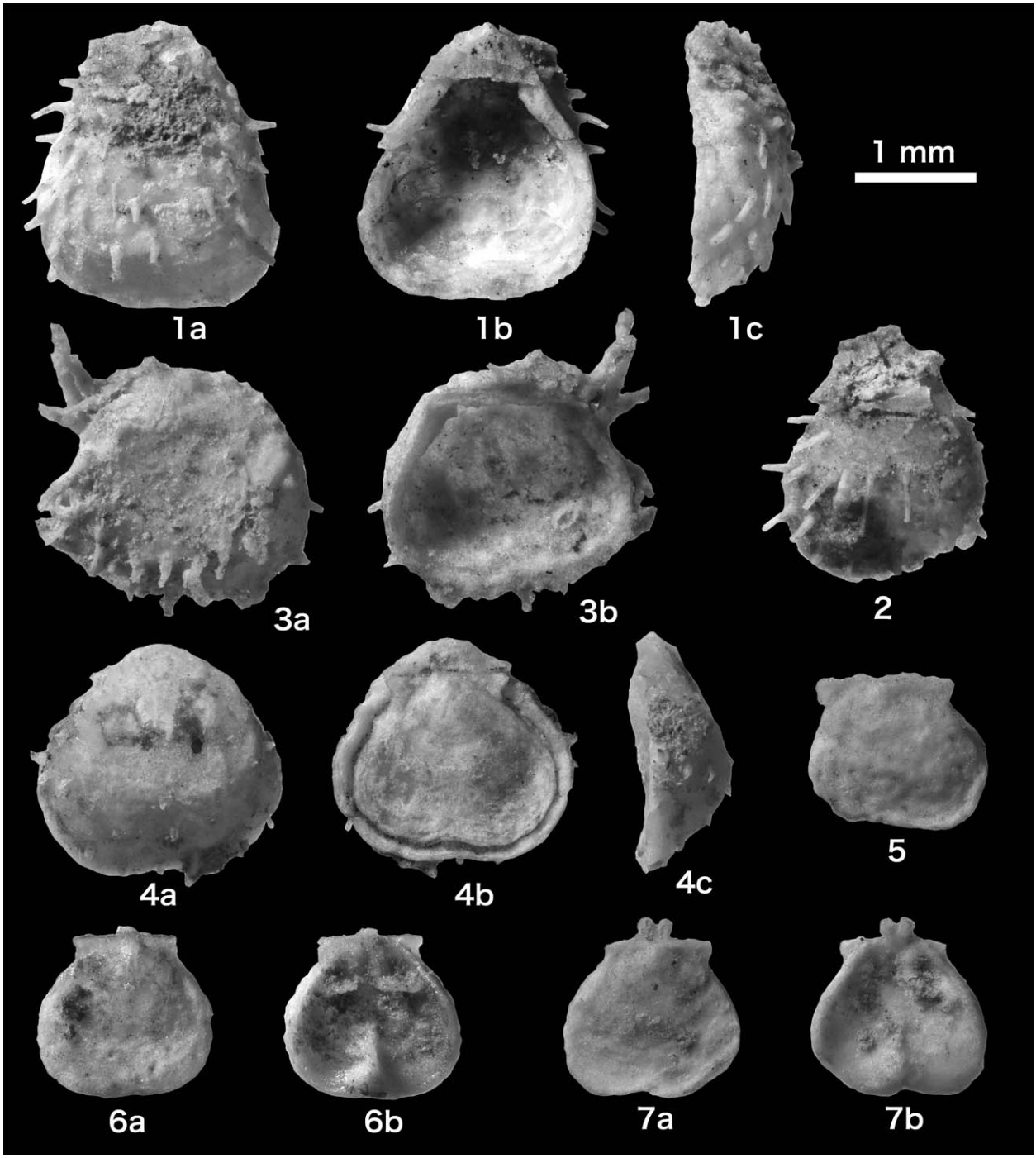

Figure 2. **1, 2,** *Cooperina inexpectata* Termier, Termier and Pajaud; 1a–c, ventral, interior and lateral views of ventral valve, KFM1852; 2, ventral view of ventral valve, KFM1857; **3–7,** *Cooperina nipponica* sp. nov.; 3a, 3b, ventral and interior views of ventral valve, KFM1855; 4a–c, ventral, dorsal and lateral views of conjoined shell, KFM1856 (holotype); 5, dorsal view of dorsal valve, KFM1862; 6a, 6b, dorsal and interior views of dorsal valve, KFM1853; 7a, 7b, dorsal and interior views of dorsal valve, KFM1861.

median ridge in dorsal valve.

Description.—Shell small size for genus, transversely wider, subtriangular to subcircular in outline, with greatest width at about midlength; length of ventral valve 1.9 mm, width of ventral valve 2.0 mm, length of dorsal valve 1.5 mm, width of dorsal valve 1.7 mm, hinge width

1.0 mm in the holotype (KFM1856). Ventral valve moderately and unevenly convex in lateral profile, almost flat in posterior half, subgeniculated, and followed by gently convex anterior half; cicatrix of attachment large, occupying about a posterior half of valve; interarea low. External surface of ventral valve ornamented with strong, distant and scattered spines except for smooth flat area of attachment. No internal structures observed in ventral valve. Dorsal valve flatly concave; ears flat, prominent, moderately acute. External surface of dorsal valve ornamented with a few, sporadically scattered, small pits on anterior one third of valve. Dorsal valve interior with a large bilobate cardinal process; median ridge long and high, extended to about midlength of valve; adductor platforms thin, fairly large, elevated anteriorly.

Remarks.—*Cooperina nipponica* sp. nov. is distinguished from the type species, *Cooperina inexpectata* Termier, Termier and Pajaud, 1966, by its transverse outline and wider hinge.

Both species, *Cooperina triangulata* Cooper and Grant (1975, p. 827, pl. 209, figs. 1–37), from the lower Wolfcampian of West Texas, and *Cooperina polytreta* Grant (1976, p. 87, pl. 19, figs. 1–24), from the Ratburi Limestone (upper Bolorian–Kubergandian) of Ko Muk, southern Thailand, are readily distinguished from the present new species by their smaller and more triangular shells.

Cooperina parva Cooper and Grant (1975, p. 826, pl. 208, figs. 13–38), from the upper Wolfcampian to Leonardian of West Texas, is also easily distinguished from *C. nipponica* by its small, squarish shell with smaller ears, and short, low median ridge and less strong cardinal process with four small lobes in the dorsal valve.

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