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FIRST ROVE BEETLES FROM THE JURASSIC TALBRAGAR FISH BED OF AUSTRALIA (COLEOPTERA, STAPHYLINIDAE)

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Abstract—The first two rove beetle fossils discovered from the Late Jurassic Talbragar Fish Bed in New South Wales, Australia are described and illustrated. *Juroglypholoma talbragarense* n. sp. is the second fossil record for one of the smallest and latest recognized staphylinid subfamily Glypholomatinae. The other staphylinid, *Protachinus minor* n. gen. n. sp., is an unusual member of extant subfamily Tachyporinae (tribe Tachyporini). It significantly retains several distinct features, including entire epistomal suture, and abdominal tergites III–VI each with a pair of basolateral ridges. The discovery of a new glypholomatine in Australia, together with recently reported one from the Middle Jurassic Daohugou biota of China, suggests the subfamily Glypholomatinae was probably much more widespread in the Jurassic than previously thought.

INTRODUCTION

With more than 58,500 described species grouped into one extinct and 32 extant subfamilies, Staphylinidae is now one of the most diverse families of Animalia (Grebennikov and Newton, 2009; Newton, unpublished data). It is distributed on all continents and major islands except Antarctica, as well as numerous Pacific and sub-Antarctic islands (Thayer, 2005). The rove beetle subfamily Glypholomatinae Jeannel, 1962, with only eight extant species within two genera, is a small group endemic to the southern hemisphere, including South America and southeastern Australia (Thayer, 1997). Recently, the first fossil Glypholomatinae has been reported from the Middle Jurassic Daohugou biota (ca. 165 Ma), Inner Mongolia, northeastern China, providing direct evidence that Glypholomatinae had already originated by the Middle Jurassic (Cai et al., 2012). The subfamily Tachyporinae MacLeay, 1825 has been long known as one of the groups of Staphylinidae that can be traced back at least to the Late Jurassic (Tikhomirova, 1968; Tikhomirova, 1973). Six species and three genera of Jurassic tachyporines are known from the Late Jurassic Karatau in Kazakhstan (Tikhomirova, 1968). In addition, another species from the Middle Jurassic Jiulongshan Formation in northern Hebei province, China, originally misidentified as the omaliine-like *Protostaphylinus mirus* Lin, definitely belongs to Tachyporinae (Cai and Huang, 2010; Hong, 1983). Cretaceous tachyporines appear to be more diverse than Jurassic ones, with three monotypic genera from Russia, two genera from China, and one from New Jersey amber (Cai et al., 2011; Gusarov, 2000; Ryvkin, 1990; Yue et al., 2009; Zhang et al., 1992). Our new discovery of two rove beetles belonging to Glypholomatinae and Tachyporinae from the Late Jurassic Talbragar Fish Bed of Australia suggests that the two subfamilies were more widespread in the Jurassic than previously thought.

The Talbragar Fish Bed is characterized by beautifully preserved fish and conifers which occur in great profusion (Bean, 2006; White, 1981). A substantial number of varied insect fossils have been collected since 2006 (Beattie and Avery, 2012), but most remain undescribed, with the exception of a petaltail dragonfly (Beattie and Nel, 2012), a nemonychid weevil (Oberprieler and Oberprieler, 2012), and an archisargid fly (Oberprieler and Yeates, 2012). The entomofauna, mainly consisting of protopsyllids and beetles but including aquatic and terrestrial Heteroptera, plant hoppers, crickets, scorpionflies, brachyceran flies, midges, lacewings, dragonflies, wasps, a snakefly, and stoneflies, is associated with a rich assemblage of early teleost and palaeoniscid fish, fish coprolites, bivalves and gastropods, as well as coniferous plants, seed ferns and true ferns. The Talbragar Fish Bed is considered to be Late Jurassic (Kimmeridgian) in age (Bean, 2006; Dulhunty and Eadie, 1969).

MATERIAL AND METHODS

The specimens studied here were collected from the northeastern side of Farrs Hill, located 30 km northeast of Gulgong, New South Wales, Australia. The specimens are both split through the beetle body. Thus, one mainly displays dorsal structures and the other shows the ventral structure of the same beetle. The holotypes are housed in the Australian Museum. Observations and photographs were made using Zeiss Discovery V20 microscope. Line drawings are made under a binocular Olympus SZX7 using a camera lucida.

SYSTEMATIC PALEONTOLOGY

Order Coleoptera Linnaeus 1758
Family Staphylinidae Latreille 1802
Subfamily Glypholomatinae Jeannel 1962
Genus Juroglypholoma Cai et al., 2012

Type species.—*Juroglypholoma antiquum* Cai et al., 2012.

Juroglypholoma talbragarense new species
Figures 1, 2

Diagnosis.—Recognized from other glypholomatines and other Staphylinidae by the combination of: relatively large body (4.3 mm long); antenna slightly clubbed, with antennomeres 8–10 each slightly longer than wide; epistomal suture distinctly present, nearly straight, without median stem (not like the Y-shaped epistomal suture found in the some modern glypholomatines *G. pustuliferum*, *G. rotundulum*, and *G. Chepuense*; for details see Thayer, 1997); elytra relatively short for Glypholomatinae, exposing four abdominal segments.

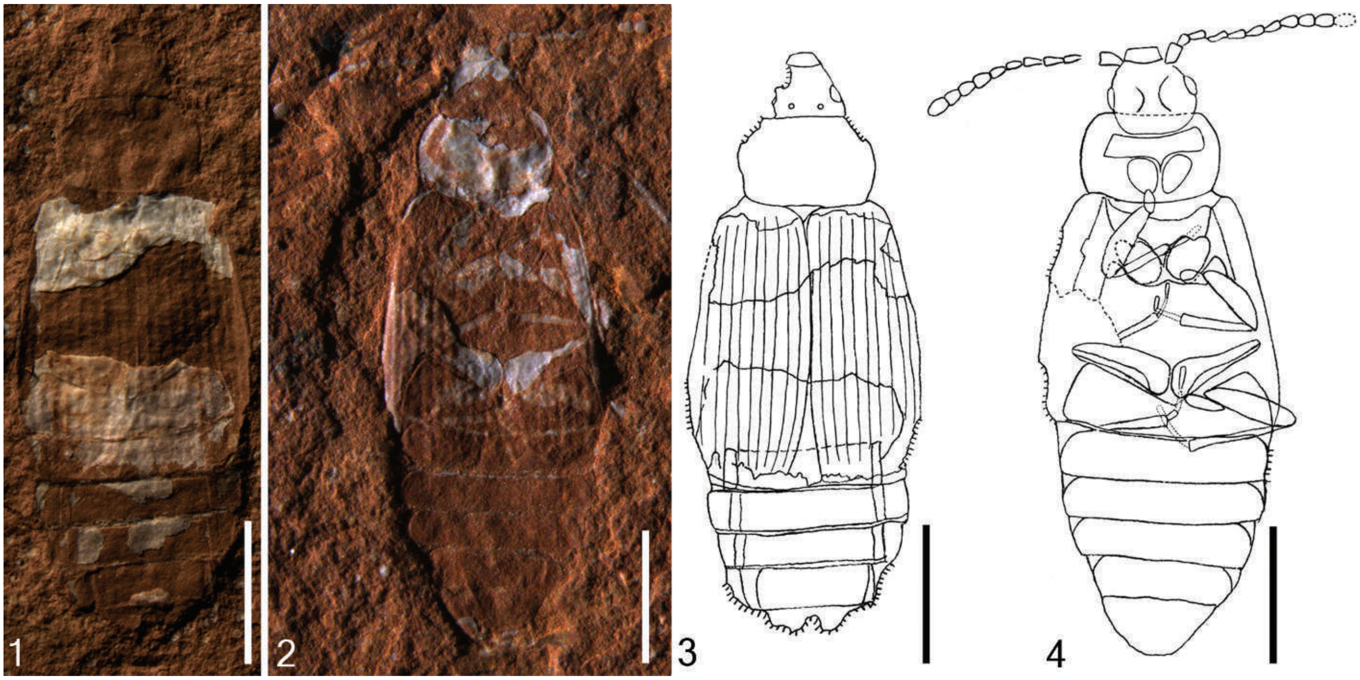

FIGURE *1*—*Juroglypholoma talbragarense* n. sp., habitus of holotype. *1*, F.110534, part; *2*, F.110535, counterpart; *3*, line drawing of part; *4*, line drawing of counterpart. Scale bars=1 mm.

Description.—Body fusiform in shape, relatively large for Glypholomatinae, 4.3 mm long. Dorsal surface glabrous.

Head relatively small, partly concealed under pronotum; widest across eyes, 0.61 mm wide, distinctly narrower than pronotum. Paired ocelli present, located at the inner margin of eye. Epistomal suture present and complete. Antenna relatively long, slightly longer than head and pronotum combined, apical four antennomeres slightly clavate, antennomere 1 elongate and broad, 0.17 mm long, antennomere 2 narrower and shorter, 0.13 mm long, antennomeres 3–7 elongate, narrower than antennomeres 8–11, apical one largest. Gular sutures distinctly separated, curved anteriorly and posteriorly (clearly visible when moistened with alcohol). Labrum and mandibles not preserved.

Pronotum slightly transverse, 0.98 mm wide and 0.65 mm long, widest just behind middle. Prosternum short, prosternal process present. Procoxae contiguous. Intercoxal process of mesoventrite narrow and triangular. Metaventrite slightly convex anteriorly. Mesocoxae relatively large, sub-contiguous. Metacoxae contiguous, broad and excavate to receive the short metafemora. Femora of all legs robust; hind femur relatively short, about as the same as hind coxal width. Tibiae dilated to apex. Tarsi faintly preserved; apical mesotarsomere long. Scutellar shield small, subtriangular.

Elytra relatively long, 2.0 mm long, each 0.81 mm wide; combined elytra wider than pronotum. Both sides slightly widened to posterior fourth then narrowed apically; surface punctuate, each with 9 longitudinal rows of punctures.

Abdomen broad, gradually tapering from base to obtuse apex; with six visible abdominal segments, each with one pair of wide paratergites. A pair of curved ridges present on anterolateral margins of sternites III–VII. Abdominal sternite III longest, IV–VII shorter, almost in same length.

Etymology.—The species name refers to the type locality.

Types.—Holotype, F.110534 (part), F.110535 (counterpart).

Occurrence.—Late Jurassic (Kimmeridgian); the northeastern slopes of Farrs Hill, northeast of Gulgong, New South Wales, Australia (S 32°10′031″, E 149°41′071″).

Remarks.—As indicated in a comprehensive cladistic study of the Omaliine group by Newton and Thayer (1995), the Glypholomatinae are characterized by the following synapomorphies: corporotentorium fused, metacoxa excavate to receive retractile femur, and abdomen with more than four first well-sclerotized tergites. The new species is placed in the subfamily Glypholomatinae on the basis of the following combination of features: elytra relatively long, each with nine distinct rows of punctures; presence of a pair of ocelli; anterolateral margins of sternites III–VII each with a pair of curved ridges; and metacoxae excavate to receive the short metafemora (synapomorphy of Glypholomatinae). In addition, the following characters can serve to certify this assignment: all coxae contiguous; hind femur relatively short, about as long as hind coxal width; epistomal suture present and complete; gular suture widely separated; antenna moderately long, slightly clavate (Newton, 1975; Thayer, 1997; Thayer and Newton, 1979). Only one fossil glypholomatine, *Juroglypholoma antiquum* Cai et al., has been known to date (Cai et al., 2012). The newly described species can be assigned to extinct genus *Juroglypholoma* as evidenced by the fusiform body shape, antenna with basal two antennomeres normal, and distal antennomeres slightly dilated to form a weak club; epistomal suture nearly straight, without stem; elytra relatively short (for the subfamily), exposing four abdominal segments (tergites V–VIII); and metafemur relatively short. Compared to *J. antiquum*, the new species *J. talbragarense* exhibits more characters than those of the type species, including the presence of paired ocelli, elytra each with nine rows of punctures. The new species can be readily separated from *J. antiquum* by possessing a larger body (4.3 mm long versus 3.65 mm in *J. antiquum*); antenna with antennomeres 8–10 each slightly longer than wide (nearly quadrate in *J. antiquum*).

FAMILY STAPHYLINIDAE Latreille

Subfamily TACHYPORINAE MacLeay
Tribe TACHYPORINI MacLeay
Genus PROTACHINUS new genus

Type species.—*Protachinus minor* new species designated herein.

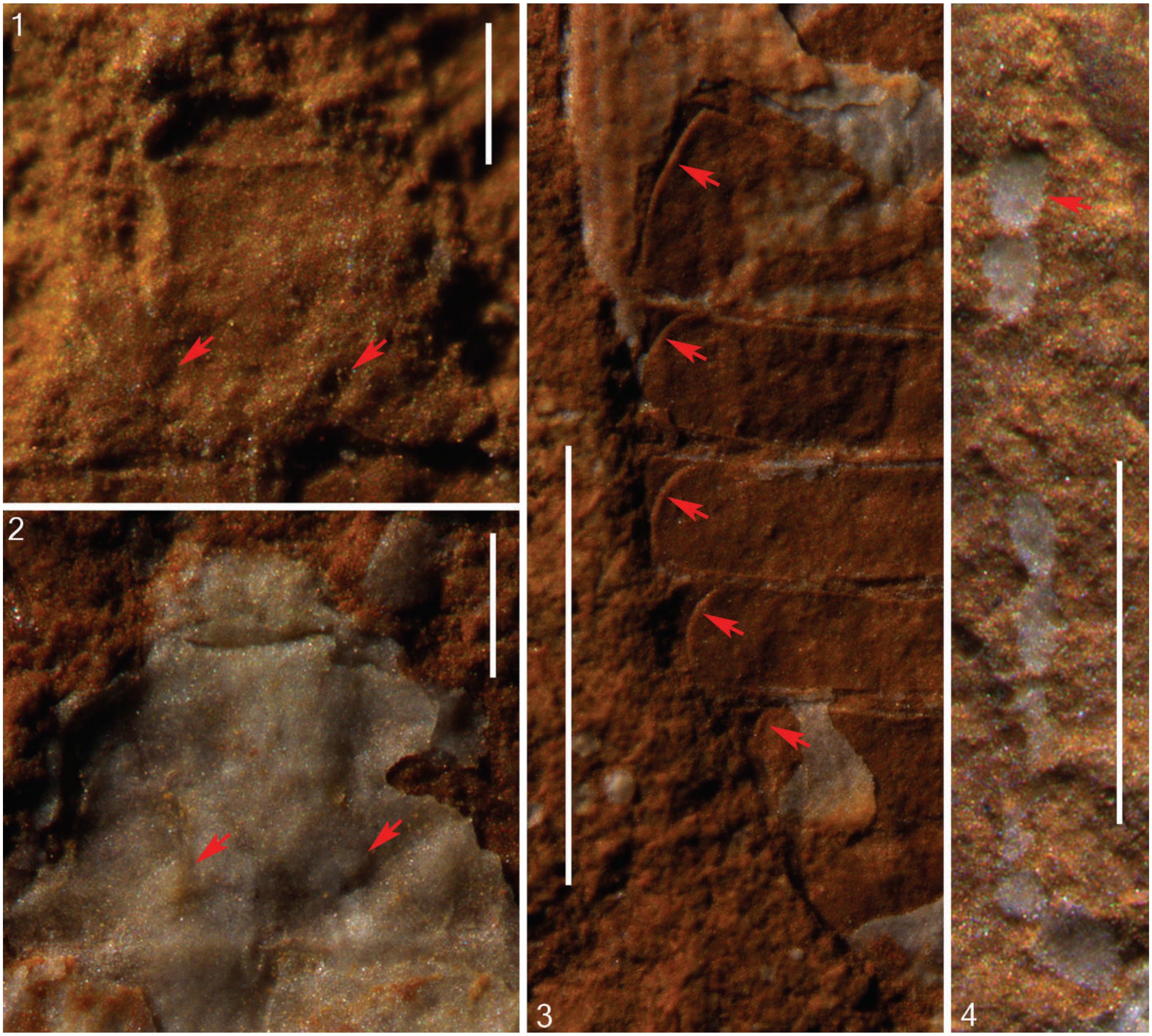

FIGURE 2—Enlargements of *J. talbragarense*, showing critical features for taxonomic placement. *1*, head, showing the nearly straight epistomal suture and paired ocelli (epistomal suture displayed as upraised line and ocelli as depressed pits in part, F.110534, with red arrows indicated); *2*, head with epistomal suture displayed as depressed groove and ocelli as upraised pustule in counterpart, F.110535, with red arrows indicated; *3*, partial abdomen of the counterpart with curved ridges on sternites III–VII indicated; *4*, right antenna of counterpart, with antennomere 10 indicated. Scale bars=200 µm in *1*, *2*; 1 mm in *3*; 500 µm in *4*.

Etymology.—A combination of the Greek *pro*-, meaning before, and the genus name *Tachinus*, a common extant tachyporine genus.

PROTACHINUS MINOR new species
Figures 3, 4

Diagnosis.—Body relatively small; epistomal suture entire and straight; elytra relatively long, covering half of abdominal tergite III; Each elytron apparently with 8 rows of punctures; abdominal tergites III–VII each with a pair of basolateral ridges; and tergite VIII and sternite VIII not emarginate apically.

Description.—Relatively small, 4.1 mm in length, limuloid, glabrous.

Head subtriangular, 0.69 mm wide and 0.67 mm long, without neck constriction; infraorbital ridge not visible. Eye located at the lateral side of head. Mandible faintly preserved, protruding. Ocelli absent. Gular suture moderately separated, diverging anteriorly and posteriorly. Left antenna (of specimen F.109735) partly preserved, antennomeres 4–7 each slightly longer than wide, antennomeres 8–10 approximately quadrate, antennomere 11 largest. Labrum transverse. Epistomal suture present.

Pronotum transverse, 1.31 mm wide and 0.67 mm long; anterior margin broadly concave, posterior margin slightly convex, side margins arcuate, widest just behind middle. Pronotal surface glabrous. Mesocoxae contiguous. Scutellar shield relatively large, subtriangular, 0.21 mm long and 0.28 mm wide.

Elytra relatively long, 1.19 mm long, each elytron 0.74 mm wide, covering half of abdominal tergite III, about 1.8 times as long as pronotum at midline, 1.7 times as long as its width; sides slightly widened approaching apex. Elytral disc punctuate, each

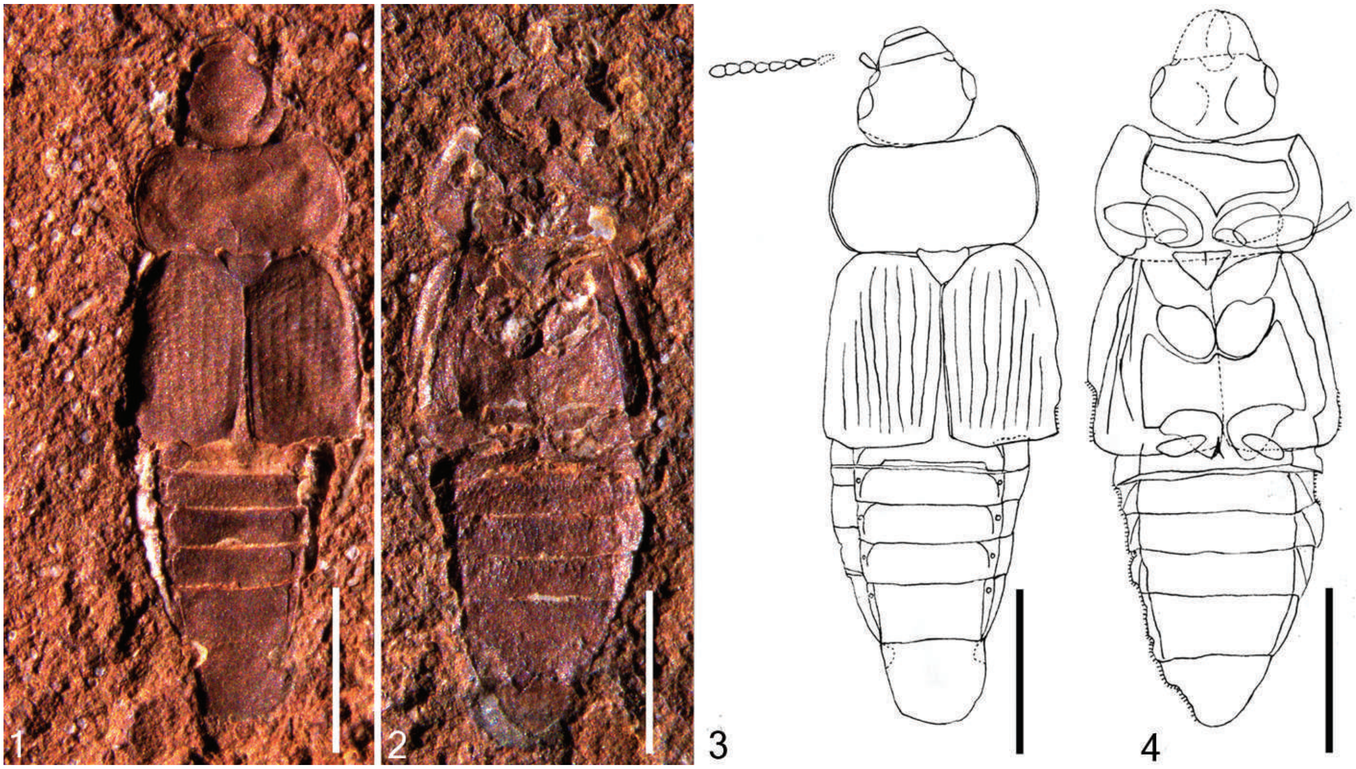

FIGURE 3—*Protachinus minor* n. gen. n. sp. *1*, F. 109735, part; *2*, F. 109737, counterpart; *3*, line drawing of part; *4*, line drawing of counterpart. Scale bars=1 mm.

elytron apparently with 8 rows of punctures. Elytra with epipleural keel.

Abdomen broad at base, gradually tapering towards apex, densely punctuate, with six visible complete sternites. Abdominal segment III–VII each with one pair of paratergites. Sternite III with an elevated median longitudinal carina. Tergites III–VI each with a pair of curved basolateral ridges. Tergites IV–VI almost in same length; tergite VII 1.5 times as long as VI. Tergite VIII and sternite VIII not emarginate apically.

Etymology.—The Latinized name *minor* refers to the type species is relatively small compared to extant *Tachinus* species.

Types.—Holotype, F.109735 (part), F.109737 (counterpart).

Occurrence.—Late Jurassic (Kimmeridgian); the northeastern slopes of Farrs Hill, northeast of Gulgong, New South Wales, Australia (S 32°10′031″, E 149°41′071″).

Remarks.—Even though the subfamily Tachyporinae cannot be demonstrated to be a monophyletic group based on both larval and adult characteristics (Ashe and Newton, 1993; Ashe, 2005), the the new rove beetle can be placed in Tachyporinae as supported by a combination of following characters: more or less limuloid body, with broad pronotum and tapered abdomen; antenna located before the anterior margin of eye, apparently monoliform; neck absent, head retractile into prothorax; elytron with epipleural keel; abdomen with six visible sternites (Newton et al., 2000). Moreover, the new genus *Protachinus* is comparable to several members belonging to the extant tribe Tachyporini. Specifically, *Protachinus* shows a number of resemblances to modern common genus *Tachinus* Gravenhorst in superficial appearance, including the general body shape, small triangular head, transverse pronotum, truncate elytra and tapered abdomen. *Protachinus* differs, however, from the latter in lacking an emarginate abdominal segment VIII. Notably, several Recent *Tachinus* species, e.g., *T. fimbriatus* and *T. longicornis*, possess striate elytra, and this feature is extremely rare for *Tachinus*, and even for the extant Tachyporinae. Therefore, we here tentatively assign *Protachinus* to the extant tribe Tachyporini. It is noteworthy that both tribe Tachyporini and *Tachinus* are evidently not monophyletic groups based on larval characteristics (Ashe and Newton, 1993). A detailed phylogenetic study focused on the tribe Tachyporini and the genus *Tachinus* is needed to address these problems. In addition to the striate elytra and non-emarginate abdominal segment VIII, *Protachinus* can be easily recognized from modern tachyporines by bearing medially carinate abdominal sternite III and abdominal tergites III–VI each with a pair of curved basolateral ridges. Among fossil tachyporines, *Protachinus* resembles the *Mesotachinus* Tichomirova from the Late Jurassic Karabastau Formation of Karatau in southern Kazakstan (Tichomirova, 1968). They share the same general body shape, a small triangular head, transverse pronotum, contiguous pro- and mesocoxae, truncate elytra, and tapered abdomen. However, the new genus could be separated from it by having distinct striate elytra and abdominal tergites III–VI each with a pair of basolateral ridges.

DISCUSSION

The discovery of two new rove beetles in the Talbragar Fish Bed provides new clues for understanding the early evolution of Staphylinidae. The most impressive feature identified in both species is the presence of distinct rows of punctures. In modern Staphylnidae, the presence of distinct punctuate striae is scattered in several groups: Dasycerinae, Glypholomatinae, Neophoninae, Trigonurinae, several genera of the omaliine tribe Anthophagini (e.g., *Deinopteroloma* Jansson, *Tanyrhinus* Farran, and *Trigonodemus* LeConte) and certain *Tachinus* species as mentioned above (Newton and Thayer, 1995). In addition, this character can be traced in several other staphylinid groups based on abundant materials from the Middle Jurassic Daohugou biota of northern China, including Olisthaerinae,

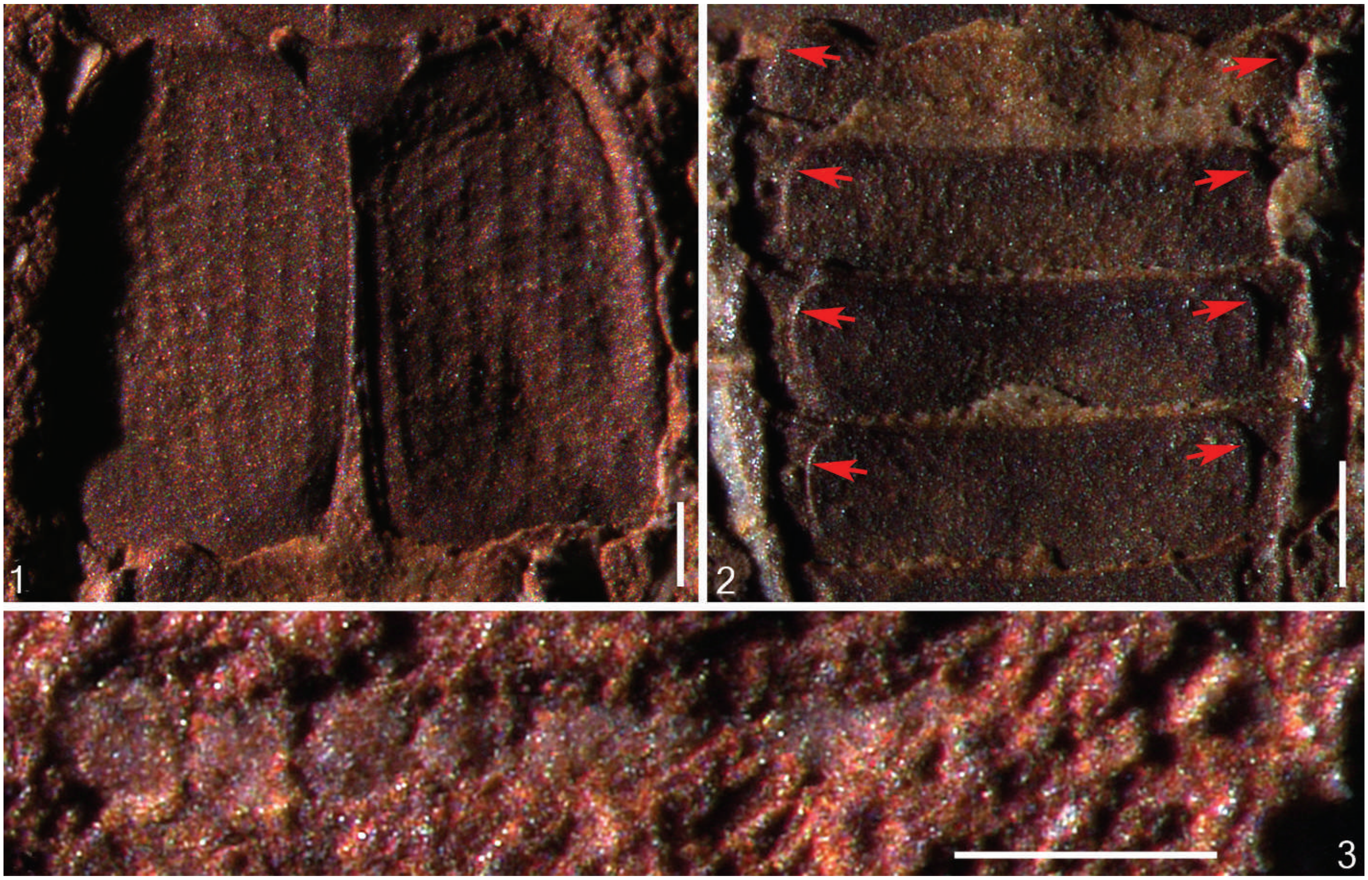

FIGURE 4—Enlargements of *P. minor*. *1*, elytra of the part, displaying 8 rows of punctures on each elytron; *2*, partial abdomen of part, showing the basolateral ridges on tergites III–VI; *3*, left antenna of part. All scale bars=200 μm.

Trigonurinae, a large number of Tachyporinae (others with nine rows of setae on each elytron; still others with elytra glabrous), and an unusual genus *Mesapatetica* (Cai, unpublished data). Therefore, the presence of punctate striae on elytron may be ancestral for the whole family Staphylinidae.

In addition, the presence of ocelli (or one ocellus) is found in different groups of beetles, including the polyphagan families Agyrtidae, Dermestidae, Derodontidae Hydraenidae, Leiodidae, Staphylinidae, and a proposed archostematan family Jurodidae (Leschen and Beutel, 2004). In Staphylinidae, a pair of ocelli occurs in Glypholomatinae, Microsilphinae, Neophoninae, Omaliinae (although absent in several genera), and a species of Scydmaeninae (*Nesuthia fijii* Franz); a single median ocellus is present in the genus *Metopsia* of Proteininae. Besides, Naomi (1987) mentioned an individual of *Lesteva* species (Omaiinae) from Japan possessing three ocelli, like those found in the extant Jurodidae. Among all Mesozoic beetles, only one agyrtid genus *Mesecanus* has been known with two ocelli to date (Ponomarenko, 1977). Interestingly, Beattie and Avery (2012) also mentioned a very unusual species of Ommatidae from the Jurassic Talbragar Fish Bed. As shown in the original publication (fig. 6F), the beetle bears a pair of distinct ocelli, which are present between the compound eyes towards the back of the head and relatively close to compound eyes. Even though this beetle is probably not an ommatid (due to the absence of window punctures on the elytra, paired ocelli present, metanepisternum very narrow), the presence of paired ocelli is of great interest for further study. The presence of ocelli is probably a character of the ground plan of insects, and they can be found on the dorsal surface or frontal surface of the head of many insects, such as Diptera (flies), Hymenoptera (bees, ants, wasps), Odonata (dragonflies, damselflies) and Orthoptera (grasshoppers, locusts). As to Coleoptera, the presence of ocelli is never found in the supposed basal group of beetles, such as Archostemata (excluding the problematic family Jurodidae). Furthermore, the ocelli are truly absent in either Mesozoic or Recent archostematan beetles. Thus, the new finding documenting another example of paired ocelli in fossil beetles has potential phylogenetic significance. Again, the presence of a pair of ocelli in the Jurassic glypholomatine genus *Juroglypholoma* probably suggests that this character state is plesiomorphic for Glypholomatinae.

Another intriguing feature for a member of Staphylinidae is the presence of a pair of basolateral ridges on the abdominal tergite. The feature has been known from different modern staphylinid subfamilies, including Megalopsidiinae, Oxyporinae, Oxytelinae, Piestinae, Pseudopsinae and Phloeocharinae. It is also found in an early Cretaceous oxyteline genus *Sinoxytelus* (Yue et al., 2010). Nevertheless, it is the first time this trait is found in subfamily Tachyporinae. Thus, the presence of a pair of basolateral ridges on tergite is possibly plesiomorphic for Tachyporiane.

So far our knowledge of Jurassic insects is mainly limited to the deposits of the Northern Hemisphere, particularly Karatau of Kazakhstan, Russian Siberia, and northeastern China (Grimaldi and Engel, 2005). The new finds of two different new rove beetles opens a unique window to this time period from the Gondwanan southern hemisphere. Even though several

Cretaceous rove beetles have been reported from the Southern Hemisphere, including Australia and Brazil (Jell and Duncan, 1986; Schomann and Solodovnikov, 2012), these are the first specimens of Jurassic staphylinids found in the southern hemisphere. The discovery of *Juroglypholoma talbragarense*, together with the recent find of *J. antiquum* from the Middle Jurassic of China, has considerable implications for the distribution of the small, Recent Southern-Hemisphere-endemic subfamily Glypholomatinae. It indicates that the subfamily was more widespread, occurring as far south as Australia, and suggests that Glypholomatinae were also present in other Gondwanan continents such as South America, where modern Glypholomatinae also live.

The discovery of two well-preserved rove beetles from the Late Jurassic of Australia also provides direct evidence for a possible regional stratigraphic correlation among the Australian Late Jurassic Talbragar Fish Bed, Late Jurassic Karatau of southern Kazakhstan, and the Middle Jurassic Daohugou biota of northeastern China. The Glypholomatinae from the Talbragar Fish Bed corresponds well with the genus *Juroglypholoma* from Daohugou. Again, the Tachyporinae, with distinct rows of punctures on each elytron, from the Talbragar Fish Bed is comparable to some members from Daohugou whereas all of the three tachyporine genera from Karatau lack the puncture rows on elytron (Tikhomirova, 1968). Another example is that Oberprieler and Yeates (2012) reported an archisargid fly from the Talbragar Fish Bed. The fly is placed in an extinct genus *Calosargus* Mostovski, which can be found in both Daohugou and Karatau (Mostovski, 1997; Zhang et al., 2007). Given the discussion above, we here suggest that the Talbragar Fish Bed comprises an insect assemblage containing elements from both Daohugou and Karatau. Compared to Karatau, the Talbragar Fish Bed is probably more comparable to the Middle Jurassic Daohugou biota.

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