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A new protorhyphid fly (Insecta: Diptera: Protorhyphidae) from the Lower Jurassic of the Perth Basin, Western Australia

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ABSTRACT

A new genus and species of protorhyphid fly, *Austrorhyphus moryi* gen. & sp. nov., is described from the Lower Jurassic (Sinemurian to Toarcian) Mintaja insect locality of the Perth Basin, Western Australia. This is the first dipteran to be formally described from this locality, the first dipteran described from the Jurassic of Australia and only the third dipteran described from the Jurassic of Gondwana.

KEY WORDS: Early Jurassic. Mintaja insect locality. Western Australia. Diptera. Protorhyphidae. New species.

INTRODUCTION

Historically, research on Jurassic insects has focussed predominantly on localities of the Northern Hemisphere, leading to a bias against Southern Hemisphere forms. Although isolated fossils have been discovered from a number of sites within the Southern Hemisphere, few specimen-rich assemblages have been identified, and of these none have undergone comprehensive taxonomic study (Schlüter 2003). As a result, the rediscovery of insect-rich fossil sediments within the Hill River region of Western Australia, now considered Sinemurian to Toarcian (Early Jurassic; ~192-175.6 Ma) in age, is of considerable interest. An overview of the geology of this site can be found elsewhere.

This area was originally noted as insect-bearing by Riek (1968) who described a small collection of insect fossils including a number of disarticulated elytra and a poorly preserved blattodean tegmen. Based on one elytron he described the beetle *Mesothoris westraliensis* Riek, 1968, comparing it to similar elytra found from the Late Triassic of Queensland. A more comprehensive study of this Western Australian insect assemblage was recently initiated by the current author, and is continuing; coleopterans and blattodeans are the most common insects discovered in the assemblage to date, with representatives of the orders Hemiptera, Grylloblattodea, Neuroptera, Mecoptera and Diptera also found.

This paper describes the only dipteran discovered so far from the Mintaja insect locality, a wing belonging to the small Mesozoic family Protorhyphidae. This single, small wing was recovered from a collection of 1320 insect fossils, including 477 wings. Thus, the occurrence of dipterans in the Mintaja assemblage is low when compared with some other Early Jurassic localities such as Grimmen, Germany (Ansorge 1996), although this paucity appears to be a function of site taphonomy, with the palaeoenvironment apparently favouring more robust elements, such as beetle elytra and cockroach tegmen. Despite this, the dipteran wing described here is complete and one of the best preserved fossils recovered from the locality.

Although a small number of specimens representing four dipteran families have been recovered from the Upper Triassic Mount Crosby Formation of Queensland (Krzeminski & Krzeminska 2003), no dipterans have yet been identified from the only other Jurassic insect-bearing locality of Australia, the Upper Jurassic Talbragar Fish Beds of New South Wales (*pers. obs.*); however, studies on this site are continuing. The only other Jurassic dipterans described from a southern continent to date are two species of rhagionid from the Lower Jurassic Kotá Formation of India (Mostovski & Jarzembowski 2000).

MATERIALS AND METHODS

The Mintaja insect locality is located in coastal central Western Australia, roughly 200 km north-northwest of the state capital, Perth, and within the Perth Basin (Fig. 1). The insect-bearing layer crops out on a private cattle property; details of the location of this site are held on file in the Department of Earth Sciences, Western Australian Museum.

The wing described in this paper was identified during the sorting of siltstone taken from the Mintaja insect locality. This material was collected in 1989 but remained unstudied until the current author initiated research on the locality in early 2005. Siltstone was treated by first sieving to remove fine sand and silt particles, with the remaining rock then washed to remove surface dust. Each fragment was then inspected using a Leica MZ8 microscope under low angle light to increase the visibility of the preserved impressions. Inspection under the microscope also helped

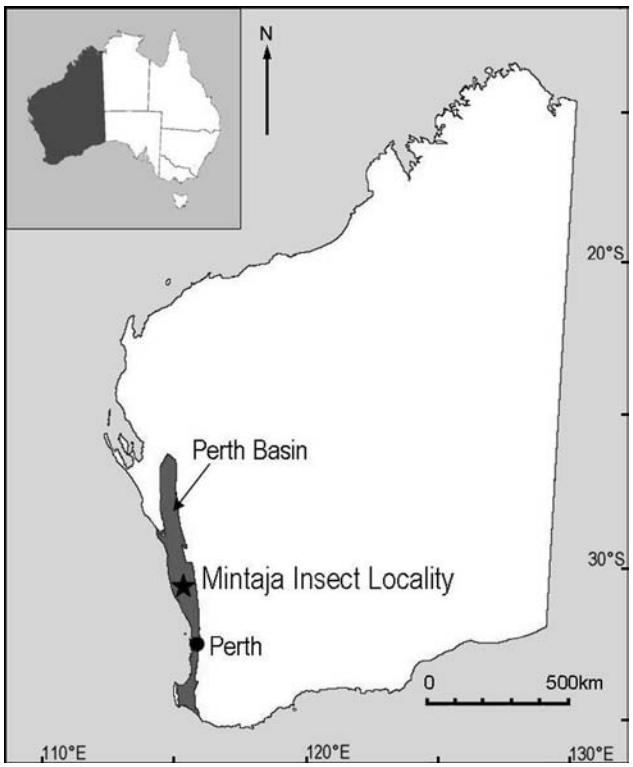

Figure 1. Map of Western Australia showing the general location of the Mintaja insect locality and the outline of the Perth Basin.

to reduce collection bias against very small insect elements. The wing, along with the rest of the Mintaja collection, is housed within the Invertebrate Palaeontology collection of the Western Australian Museum (WAM), Perth, Australia.

Photographs of the wing were taken using a Leica MZ16 Microscope with Leica DC500 digital camera (Terrestrial Environments department, Museum Victoria, Melbourne). Depth of field within the photomicrographs was enhanced by taking a number of photos as "slices" at differing focus depths, with all the resultant "slices" stitched together using photo merging software. Sketches were then made by tracing over the resultant photograph digitally using a pen tablet and photo-editing software.

Wing venation terminology based on Shcherbakov *et al.* (1995). Abbreviations used: Sc – subcosta; R – radius; Rs – radial sector; M – media; Cu – cubitus; CuA – cubitus anterior; CuP – cubitus posterior; iCu – intercalary or secondary cubital vein; *d* – discal cell; *r-m* – radial to medial cross-vein; *m-m* – medial to medial cross-vein; *m-cu* – medial to cubital cross-vein.

SYSTEMATIC PALAEONTOLOGY

Order: Diptera Linneaus, 1758
Suborder: Nematocera Latrielle, 1825
Superfamily: Anisopodoidea Knab, 1912
Family: Protorhyphidae Handlirsch, 1906

GENUS: ***Austrorhyphus*** gen. nov.

Type species: ***Austrorhyphus moryi*** Martin, sp. nov.

Etymology. From the Latin austro- 'southern' and –rhyphus, a common generic suffix for the Protorhyphidae. The name refers to the Australian (southern) occurrence of this genus.

Diagnosis. Sc gently curved, roughly 0.55x wing length. R1 curved distally, R2+3 converging with R1 at margin. R4 short, 0.45x length of R4+5 stem, 0.7x length of R5. Cross-vein *r-m* closer to base of R2+3 than R4. M stem faint; base M4 (above *m-cu*) roughly 0.25x *m-cu* length. Cross-vein *m-m* connects to M2 well distal of M1+2 fork, forming narrow, irregular *d*.

Remarks. *Austrorhyphus* differs from all other protorhyphids in the distally curved R_1 and the length of R_4, which is shorter than *Protorhyphus* Handlirsch, 1906, *Archirhyphus* Handlirsch, 1939 and *Vymrhyphus* Blago-

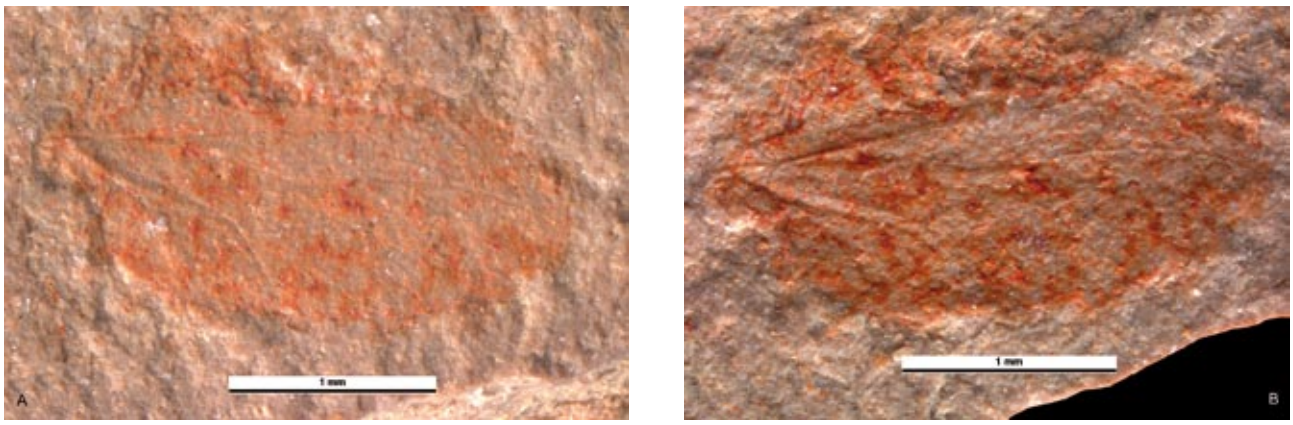

Figure 2. *Austrorhyphus moryi* gen. & sp. nov., holotype WAM 07.227, from the Early Jurassic Mintaja insect locality of Western Australia. A. Photomicrograph of wing part; B. Photomicrograph of wing counterpart, reversed to allow easier comparison with the part.

derov, 1995 (in Shcherbakov *et al.* 1995) and longer than *Brachyrhyphus* Blagoderov & Grimaldi, 2007. A dichotomous key separating the genera of the Protorhyphidae based on wing venation is provided below (Tab. 1). Other important differences not mentioned in this key include the well-developed basal cross-vein which is not seen in *Protorhyphus*, *Archirhyphus* or *Brachyrhyphus*; and in the position of *r-m* which in *Protorhyphus* and *Archirhyphus* is generally closer to R_4 than R_{2+3}, while in *Brachyrhyphus* *r-m* is closer to R_{2+3} than in *Austrorhyphus*.

Austrorhyphus moryi sp. nov.

Figures 2-3

Etymology. Named for Arthur Mory, the Geological Survey of Western Australia geologist who first discovered the Mintaja insect locality.

Holotype. WAM 07.227. Single disarticulated wing; no other specimens known.

Type locality and occurrence. Mintaja insect locality, Mintaja 1 outcrop, Lower Jurassic (Sinemurian to Toarcian) Cattamarra Coal Measures, Western Australia.

Diagnosis. As for genus.

Description. Wing length 2.5mm. Elongate ovate wing, maximum width 0.4x length, petiolate. Sc gently curved, roughly 0.55x wing length; R1 slightly flexed distally, intersecting costal margin roughly 0.8x wing length from base. Basal cross-vein links R1 with CuA. Rs joins R1 0.3x wing length from base, curving throughout length; R2+3 originating roughly 0.2x vein length from R1-Rs fork, converging slightly with, but not joining, R1 at margin. R4 curved, short, 0.45x length of R4+5 stem, 0.7x length of R5; R5 curves slightly at tip and intersects apex. Cross-vein *r-m* occurs closer to base of R2+3 than R4; r-m 0.25x length of R4+5 between R2+3 and *r-m*. M stem faintly preserved, apparently extending to basal cross-vein. M1 and M_2 long, forking apically of *r-m* at 0.5x wing length, reaching margin well below apex. M_{3+4} stem branching from M stem around 0.35x wing length from base. M_{3+4} stem short, roughly 0.6x length of *m-cu* cross-vein, M_3 and M_4 parallel to, and roughly equal in length to, M_1 and M_2. Apices of M_{1-4} almost evenly spaced at wing margin. Cross-vein *m-m* between M_2 and M_3 occurs close to M_2 base, forming small, irregular *d*, cross-vein *r-m* slightly beyond *d* mid-length. M_4 linked to CuA by *m-cu* cross-vein; base M_4 (above *m-cu*) roughly 0.25x *m-cu* length, towards base of *d*. CuA slightly angular, intersecting margin just under 0.45x wing length; iCu parallel to CuA, ending short of margin. CuP apparently merges with iCu close to base, curving to meet posterior margin 0.3x wing length from base.

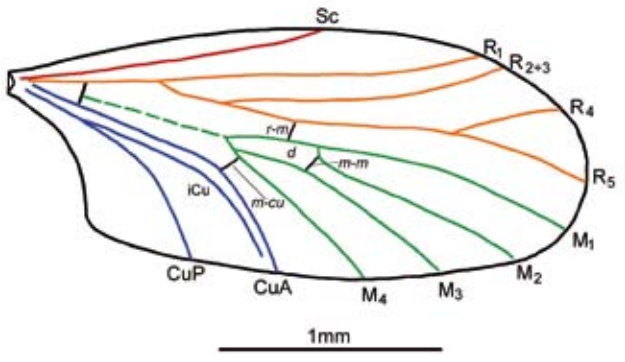

Figure 3. *Austrorhyphus moryi* gen. & sp. nov., holotype WAM 07.227, from the Early Jurassic Mintaja insect locality, Western Australia. Interpretative sketch made from photomicrographs in Figure 2. Abbreviations are as defined in the text.

Remarks. Indistinct preservation makes some features, particularly M and the costal margin, difficult to interpret.

DISCUSSION

Protorhyphidae is considered part of the superfamily Anisopodoidea along with the closely related taxa Crosaphidae and Anisopodidae; this superfamily is believed to be the sister group of the brachyceran flies (Woodley 1989, Oosterbroek & Courtney 1995, Shcherbakov *et al.* 1995, Blagoderov *et al.* 2007). The family currently contains around fifteen species in four genera: *Protorhyphus*, *Archirhyphus*, *Vymrhyphus* and *Brachyrhyphus*. In addition, the species *Vymrhyphus blagoderovi* Krzeminski & Krzeminska, 2003, was considered a possible separate genus within the Protorhyphidae by Blagoderov *et al.* (2007), although a new name was not proposed at the time. As a result, this species is recorded separately from *Vymrhyphus* in the provided taxonomic key. Other genera previously assigned to this family have been subsequently reviewed: *Acritorhyphus* Bode, 1953 was synonymised with the genus *Eoptychoptera* Handlirsch, 1906 by Lukashevich *et al.* (1998); *Heterorhyphus* Bode, 1953 was removed to its own family (Heterorhyphidae; Ansorge & Krzeminski 1995); and *Brachyopteryx* Hong, 1984 was considered by Zhang (2007) to fall outside the Protorhyphidae, although an alternate familial placement was not suggested.

Protorhyphids occur stratigraphically from the Middle Triassic through to the Latest Jurassic-Earliest Cretaceous, and are currently recorded from Germany, Russia (Siberia), France, Kyrgyzstan, Kazakhstan, China (Inner Mongolia) and the United States of America (Blagoderov *et al.* 2007); therefore, the wing described here is the first record of this family from a Gondwanan continent (Shcherbakov *et al.* 1995, Krzeminski & Krzeminska 2003, Blagoderov *et al.* 2007, Zhang 2007). Although there was previous mention of a protorhyphid from the Triassic of Australia (Krzeminski & Krzeminska 2003, p. 173), the only other member of the Anisopodoidea formally recorded from the Australian continent belongs to the related family Crosaphidae, with type species *Crosaphis anomala* Evans, 1971 described from the Upper Triassic Mt Crosby Formation of south-eastern Queensland (Kovalev 1983).

The short R4 of the Western Australian wing is unusual within the Protorhyphidae, previously occurring only in *Brachyrhyphus distortus* Blagoderov & Grimaldi, 2007 from the Upper Triassic (Carnian) Cow Branch Formation

1.	R_4 shorter than R_{4+5} stem..... 2
—	R_4 longer than R_{4+5} stem..... 3
2(1).	Sc <0.5x wing length. R_4 0.25x R_{4+5} stem. R_1 straight.....
	..... *Brachyrhyphus* Blagoderov & Grimaldi, 2007
—	Sc >0.5x wing length. R_4 0.45x R_{4+5} stem. R_1 curved..... *Austrorhyphus* sp. nov.
3(1).	Wing broad. Sc <0.5x wing length..... 4
—	Wing narrow. Sc >0.5x wing length..... 5
4(3).	M_{1+2} leaving *d* with common stem..... *Archirhyphus* Handlirsch, 1939
—	M_1 and M_2 leaving *d* independently..... *Protorhyphus* Handlirsch, 1906
5(3).	Branches of R equidistant at margin. *d* located in basal wing half. *r-m* basal of R_4 base.....
	..... *Vymrhyphus* Blagoderov, 1995
—	R_{2+3} converging with R_1 at margin. *d* located in distal wing half. *r-m* distal of R_4 base.....
	..... *'Vymrhyphus' blagoderovi* Krzemiński & Krzemińska, 2004

Table 1. Key to the genera of the dipteran family Protorhyphidae, based on wing venation.

of Virginia, USA. Other features which *B. distortus* and *A. moryi* share include having R2+3 converging with R1; *r-m* developed near the centre of discal cell; *m-m* connecting to M2 well distal of the M1+2 fork; and in having M1-4 roughly evenly spaced at the wing margin. Although these similarities suggest that *Austrorhyphus* is closely related to *Brachyrhyphus*, there are a number of important differences between these two species, including the broader and more rounded wing shape, longer Sc, well-developed basal cross-vein, curved R1, longer and curved R4, more distally placed *r-m* (further from R2+3), shorter *m-cu*, less evenly curved CuA, stronger iCu, and wider separation of CuA-CuP at the margin (1.0x M_4-CuA marginal width in *Austrorhyphus*, 2.0x in *Brachyrhyphus*). *Austrorhyphus* also shares some features with *Vymrhyphus*, particularly the long Sc and well-developed basal cross-vein, although *Vymrhyphus* differs distinctly in its narrow wing shape; in the branches of R, the apices of which are evenly spaced at the margin; and in *m-m* connecting at, or basally of, the M1+2 fork (Shcherbakov *et al.* 1995, Krzeminski & Krzeminska 2003, Blagoderov *et al.* 2007). Thus, the unique combination of features seen in the Western Australian protorhyphid suggests that this wing is best considered a separate genus.

Blagoderov *et al.* (2007) noted that there was a common trend among the Bibionomorpha to distally shift, reduce and eventually lose R4, and it was on the basis of this trend that *Brachyrhyphus,* with its severely reduced R4, was considered intermediate between the Protorhyphidae and its sister group Anisopodidae. Following this logic, Austrorhyphus, with its slightly longer but still reduced R4 (and longer Sc), appears to demonstrate closer ties to the Protorhyphidae (especially *Vymrhyphus*) than the Anisopodidae, when compared with *Brachyrhyphus*.

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