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Short communication

Symphylella patrickmuelleri sp. nov. (Myriapoda: Symphyla): The oldest known Symphyla and first fossil record of Scolopendrellidae from Cretaceous Burmese amber

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ABSTRACT

Symphyla are one of the least known of the four classes of the Myriapoda. While Symphyla are dated to have split from the other myriapods at about 430–593 Ma, there are no fossil specimens known aside from seven specimens of the family Scutigerellidae preserved in Dominican and Baltic amber, with a maximum age of ca. 54 Ma. Here we describe the first fossil representative of the second Symphyla family, the Scolopendrellidae, *Symphylella patrickmuelleri* sp. nov., from Burmese amber (ca. 99 Ma). Utilizing micro-computed tomography (μCT) technology, as well as light microscopy and multi-layer photography, our specimen, despite being juvenile, can be assigned to the genus *Symphylella* Silvestri, 1902, a species-rich Recent genus that has an almost worldwide distribution. The specimen is preserved after ejecting long threads of silk from its large spinnerets. Our findings show that the recent genera and families of the Symphyla diverged already before the end of the Mesozoic.

1. Introduction

First thought to be the missing link connecting Insecta and Myriapoda (Ryder, 1880), the myriapod class Symphyla, belonging to the Progoneata (Gai et al., 2008; Edgecombe and Minelli, 2011), is the least diverse and least known class of the Myriapoda (Dominguez-Camacho, 2010; Salazar-Moncada et al., 2015). The correct placement of the Symphyla among the Myriapoda is still not resolved. Most recent studies retrieve the Symphyla as the sister-group of the Dignatha (Edgecombe, 2004; Regier et al., 2005), but several conflicting hypothesis exist (for an overview see Regier and Shulz, 2001). The Symphyla comprise about 195 described species, arranged in two families, the Scolopendrellidae with 6 genera, and the Scutigerellidae with 8 genera (Dunger, 1993; Szucsich and Scheller, 2011). Within the family Scolopendrellidae, the most diverse genus (and the second most diverse within the class) is *Symphylella* Silvestri, 1902, with 41 described species (Szucsich and Scheller, 2011). These unpigmented soft-bodied myriapods have a body consisting of an eyeless head, which carries the only pair of tracheal openings, and 14 segments with 12 leg-pairs. The number of dorsal scuta or tergites does not correspond to the number of ventral segments. The legs show coxal sacs and basal styli. The last segment possesses prominent spinnerets and trichobothria (Szucsich and Scheller, 2011). The few studied species feed on algae, bacteria, fungi and decomposed dead plant and animal remains (Dunger, 1993; Szucsich and Scheller, 2011). Symphyla are distributed worldwide and are usually restricted to moist soil. In humid environments, some representatives can also be found in the leaf litter (Scheller, 1982) and under the bark of trees, to where they migrate during flooding (Scheller and Adis, 1984).

The estimated divergence time of the Symphyla from the other Myriapoda varies between the Silurian (ca. 430 Ma), based on a morphological Myriapoda phylogeny (Edgecombe, 2004), Cambrian to Ordovician (520–470 Ma), according to a molecular study of Fernández et al. (2016), and early Precambrian (593.42 Ma) to late early Ordovician (484.39 Ma) based on molecular data by Miyazawa et al. (2014). Miyazawa et al. estimated the divergence of the two symphylan families Scutigerellidae and Scolopendrellidae between the early Ordovician (481.54 Ma) and the late Permian (248.44 Ma). Despite these early estimated appearances of the Symphyla, their fossil record is very poor, with no fossils being known from the Palaeozoic and Mesozoic (Shear and Edgecombe, 2010; Szucsich and Scheller, 2011). The whole fossil record of the group is restricted to seven specimens, all placed in the family Scutigerellidae and attributable to Recent genera. A single fossil species of Symphyla is known from Dominican amber (Poinar and

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Edwards, 1995) for which estimates of the age range between 15 Ma (Iturralde-Vinent and MacPhee, 1996) and 40 Ma (Eberle et al., 1980; Poinar, 1992). The oldest known Symphyla fossils come from the Eocene Baltic amber, from which six specimens belonging to two named species are known (Bachofen-Echt, 1942, 1949; Kosmowska-Ceranowicz and Mierzejewski, 1978; Weitschat and Wichard, 1998; Scheller and Wunderlich, 2004), dating back to a maximum of 54 Ma (Ritzkowski, 1997; Weitschat, 2002). The first fossil representative of the Symphyla was mentioned (but not named) by Bachofen-Echt (1942, 1949) and was erroneously assigned to the genus *Scolopendrella* Gervais, 1839, family Scolopendrellidae, which was later correctly placed in the family Scutigerellidae (Szucsich and Scheller, 2011).

Here we describe the oldest known and first Mesozoic fossil Symphyla and the first fossil of the family Scolopendrellidae from Cretaceous Burmese amber, utilizing classical light-microscopy. Burmese amber is dated back to the earliest Cenomanian (ca. 99 Ma), based on U–Pb dating of zircons (Shi et al., 2012). Therefore, our specimen is nearly twice as old as any previously known fossil Symphyla and represents the first record from the Mesozoic. For a detailed review of the history and geology of Burmese amber deposits see the pertinent literature (Zherikhin and Ross, 2000; Grimaldi et al., 2002; Cruickshank and Ko, 2003).

2. Material and methods

2.1. Measurements and preparation

The specimen (ZFMK MYR 6369) came into our possession from the private collection of Patrick Müller (Käshofen, Germany), who has the largest collection of zoological specimens preserved in Burmese amber in Europe. The piece was received as a donation and is stored in the collection of the Zoological Research Museum A. Koenig (ZFMK). All necessary legal exportation permits from Myanmar were procured and are available from the corresponding author upon request.

The size of the amber piece was measured using a digital caliper. The specimen was measured utilizing the 3D data obtained from the CT scan (see below).

The specimen is embedded in a small piece of amber, 4.2 mm long, 4.0 mm wide, and 1.6 mm high. It does not include any syninclusion but was cut from a larger piece, which contains one Polyzoniida (Diplopoda), one Archaeognatha and one dance fly (Diptera: Hybotidae) of the extinct genus *Alavesia* Waters & Arillo, 1999. The original piece was cut by Patrick Müller with a 0.3 mm diamond cutting disc using a Dremel 3000 (Dremel Europe). The piece was sanded using abrasive paper with mesh sizes of 200, 600, 1000, 3000 and 5000. The sanded surface was polished with polish for metals (Sidol, Henkel AG).

2.2. Photographs and drawings

The specimen BUB1171 from the collection of Patrick Müller was studied and drawn using an Olympus BX51 stereo-light-microscope with a mounted camera lucida. Photographs were obtained using a Canon EOS 7D camera with a magnifier lens mounted on it to obtain images at different focus levels. Image stacking was performed in Zerene Systems Stacker (Version 1.04). All images were modified in Adobe Photoshop CS2 (Adobe Systems Incorporated, San Jose, USA).

2.3. Micro-CT scan and processing

For measurements of the specimens μCT-data was obtained using a SKYSCAN 1272 (Bruker microCT, Kontich, Belgium) and the accompanying Control Software 1.1.7 (Bruker microCT, Kontich, Belgium), with following settings: source voltage = 30 kV, source current = 212 mA, 180° rotation, angular step size = 0.1°, exposure time = 3800 ms, no binning, no filter, averaging = 6, no random movement = 15, 1878 projections, 11 reference scans, pixel size = 1.000395 μm. Thermal-drift correction and digital section reconstruction was done in NRecon 1.7 (Bruker microCT, Kontich, Belgium). Data size was reduced by extracting a Volume of Interest (VOI) with DataViewer Version 1.5.2.4 (Bruker microCT, Kontich, Belgium), and by reducing the images to 8 bit Grayscale in Fiji/Image J 1.51f (Schindelin et al., 2012). The data was converted via DrishtiImport Version 2.6.3 (Limaye, 2012), volume rendering and measurements were performed in Drishti Version 2.6.3 (Limaye, 2012). Unfortunately, a visualization failed based on the thin cuticle of the specimen. Only morphometric data could be collected. Original μCT scans of the species will be deposited as cybertypes at MorphoBank (O'Leary and Kaufman, 2012) under project number 2783 (http://morphobank.org/permalink/?P2783). The publication has been registered on ZooBank under LSID zoobank.org:pub:B50D8DD9-1CC9-4417-8E5E-86FFB801B733.

2.4. Determination

To assign the specimen to the correct family and genus the keys by Edwards (1959) and Dominguez-Camacho (2010) were used.

3. Systematic paleontology

Class Symphyla Ryder, 1880
Order Symphylida Ryder, 1880
Family Scolopendrellidae Bagnall, 1913

Remarks: Our specimen fits into the family based on the following characters: Antennae with fewer than 20 articles, scuta with triangular lobes, reduced styli at base of legs. Arrangement of head median suture and its median branches correspond to Scolopendrellidae.

Genus *Symphylella* Silvestri, 1902

Remarks: Our specimen was placed in the genus based on the following combination of characters: 17 tergites, first reduced in size. All tergites (scuta) except first and last with triangular lobes. Head is longer than broad. Spinnerets large, covered by numerous setae. First leg-pair vestigial. Coxal sacs present on base of legs 3–9. Arrangement of head sutures corresponds to state described for *Symphylella* (see Dominguez-Camacho, 2010, fig. 10C). In congruence with the descriptions in the literature, the species can be assigned to the genus *Symphylella* (Edwards, 1959; Szucsich and Scheller, 2011; Dominguez-Camacho and VandenSpiegel, 2012).

Type species: *Symphylella isabellae* (Grassi, 1886)

Species included: 41 Recent species.
Distribution: Worldwide (Dunger, 1993; Szucsich and Sheller, 2011)

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Figs. 1–3

Material examined: Holotype: Juvenile (6th instar) (ZFMK MYR 6269), Myanmar, Kachin State, Hukawng Valley, Noije Bum amber mine.
Derivation of name: Adjective. Honors Mr. Patrick Müller, owner of a large collection of zoological objects in Burmese amber, who generously donated this valuable specimen to the collections of the