



EARTH SCIENCES

New species of *Myrmicium* Westwood (Pseudosiricidae = Myrmiciidae: Hymenoptera, Insecta) from the Early Cretaceous (Aptian) of the Araripe Basin, Brazil

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Abstract: This paper records the first occurrence of the genus *Myrmicium* Westwood, 1854 in the Cretaceous of Gondwana and describes it as a new species *Myrmicium araripterum* sp. nov, based on the most complete specimen of this genus yet known, which represents the largest specimen of the grade “Symphyta” ever found in the Crato Formation.

Key words: New taxa, *Myrmicium araripterum*, Siricoidea, Siricomorpha.

INTRODUCTION

Having the most complete continental record of the end of the rift phase of the Brazilian continental margin (Castro et al. 2006), the Araripe Sedimentary Basin has one of the most important Mesozoic *Konservat Lagerstätten* of Gondwana (Maisey 1991, Martill 1993, Kellner 2002). The Santana Group, which is one of the most famous fossil deposits in the world, based on both its diversity and the surprising preservation of fossil insects (Grimaldi 1990, Osten 2007, Heads et al. 2008, Barling et al. 2013).

With regard to the insects in the Araripe Basin, the vast majority are restricted to the Crato Formation. Only one insect record is reported for the Romualdo Formation (Freitas et al. 2016). Yet the entomofauna is badly underexplored, and there are still many families under analyses, represented by taxa yet unnamed within the Crato Formation (Bechly 2007, Barling et al. 2013).

Hymenoptera are one of the largest and most diverse insect orders. Their most common

classification encompass suborder Apocrita (=Vespina) and the grade “Symphyta” (=Siricina), even though the latter is characterized only by plesiomorphies (primarily by the absence of constriction in the first and second abdominal segments), and so represents a grade rather than a monophylum.

Among the Hymenoptera of the Mesozoic fossil records, Siricoidea appears as a comparatively diverse group more diverse than in the present fauna. In the Jurassic and Cretaceous, it is represented with highly diverse Anaxyelidae, moderately diverse Siricidae, less diverse Pseudosiricidae (Myrmiciidae) and Protosiricidae, as compared with the contemporary fauna encompassing only moderately diverse Siricidae and relictual, monotypical Anaxyelidae (Rasnitsyn 1980, Taeger et al. 2010, Schiff et al. 2012). Former siricoid families Xiphydriidae and Daohugoidae are currently either (the former) upgraded as a superfamily of its own (Sharkey 2007), or

downgraded as a subfamily of Xyelidae (Wang et al. 2019).

Only two species of the grade “Symphyta” are described to the Cretaceous of Brazil: *Prosyntexis gouleti* Darling & Sharkey (1990) assigned to the family Sepulcidae and *Cratoenigma articulata* Krogmann & Nel (2012) of debatable affinities (the third species, *Atefia rasnitsyni* Krogmann et al., described as a tenthredinoid sawfly of obscure relationships, cf. Krogmann et al. 2013, is in our opinion a caddisfly rather than a sawfly). It is noteworthy that the only place in Brazil with Cretaceous records of the grade “Symphyta” is the Crato Formation of the Araripe Sedimentary Basin (Martins-Neto 2006).

In view of the foregoing, the aim of the present work is to describe the first occurrence of a new species of Hymenoptera in the Lower Cretaceous of the Gondwana.

The horntails now attributed to the genus *Myrmicium* Westwood, 1854 are known under various names from the famous uppermost Jurassic lithographic shales of Solnhofen and Eichstätt in Germany since 1839 (for review see Handlirsch 1906-1908, Carpenter 1932, Maa 1949). Because of poor preservations of these numerous fossils we consider all of them as forming the only polymorphic species *M. schroeteri* (Germar 1839) until better preserved material is accumulated (Rasnitsyn 1969). *Myrmicium nanus* sensu Carpenter (1932) probably represents an exception, for contrary to the claim of Carpenter it considerably differs venationally from other Solnhofen material including the type series of *M. nanus* Handlirsch, 1906 whose photographs (type specimens 1985/11/1 and 1985/11/2, Naturhistorischen Museums in Wien) are studied courtesy of Alexander G. Ponomarenko (Moscow). Line drawings made by Carpenter are usually precise, and a separate species status of the Carnegie Museum specimen looks possible. Yet a direct study of the Carnegie Museum

specimen no. 5189 or of its good photograph is desirable for that, so we have to postpone this until another opportunity.

The only other described species of *Myrmicium* is its type species *M. heeri* Westwood, 1854 from the lowermost Cretaceous (Berriassian) of Purbeck in southern England (Rasnitsyn et al. 1998). The new species from the Aptian of Brazil differs clearly from its congeners (see below). It is the youngest and the best preserved species of *Myrmicium*.

The family Pseudosiricidae Handlirsch, 1906 (= Myrmiciidae, Maa 1949) has been proposed to cover several genera (Rasnitsyn 1969) with an explicit reservation of its catch-all nature (cf. Lutz 1986, 1990 for taxonomic position of some former Myrmiciidae), so currently we consider it as encompassing the type genus only. The family name Pseudosiricidae has unquestionable priority over Myrmiciidae, and yet Rasnitsyn (1969, 1980, 1988) followed Maa (1949) to consider Myrmiciidae as valid name and respectively Pseudosiricidae as its synonym. This erroneous usage (based evidently on synonymy of *Pseudosirex* Handlirsch, 1906 under *Myrmicium* Westwood, 1854) is abandoned. The family in question was variously treated as a full family (Handlirsch 1906-1908, Carpenter 1932, 1992, Rasnitsyn 1969, Taeger et al. 2010) or as a synonym of Siricidae (Rasnitsyn 1980, 1988): this dichotomy is postponed here until special study in expectation of a more rich and better preserved material primarily from the Crato deposits.

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MATERIALS AND METHODS

Area of Study

The Araripe Sedimentary Basin is situated in the interior of Brazilian Northeast (Fig. 01), in the border region between the states of Pernambuco, Ceará, and Piauí, between meridians 38° 30' and 40° 50' W longitude and parallels 7° 05' and 7° 50' in S latitude (Neumann 1999).

The tectono-sedimentary evolution of the basin encompasses four stages, with five tectono-stratigraphic phases (Assine 1992, 2007, Neumann 1999, Neumann & Cabrera 1999, Assine

et al. 2014, Fabin et al. 2018): Syncline phase (Silurian-Devonian); Pre-rift phase (Jurassic-Tithonian); Rift phase (Cretaceous-Berriasian-Hauterivian); Post-Rift I phase (Aptian-Albian) and Post-rift II phase (Albian-Cenomanian).

The fossil object of study in this work comes from the Crato Formation of the Santana Group (Post-Rift I phase) which is subdivided into the Crato, Ipubi, and Romualdo Formations (Neumann & Cabrera 1999) (Figs. 1 and 2).

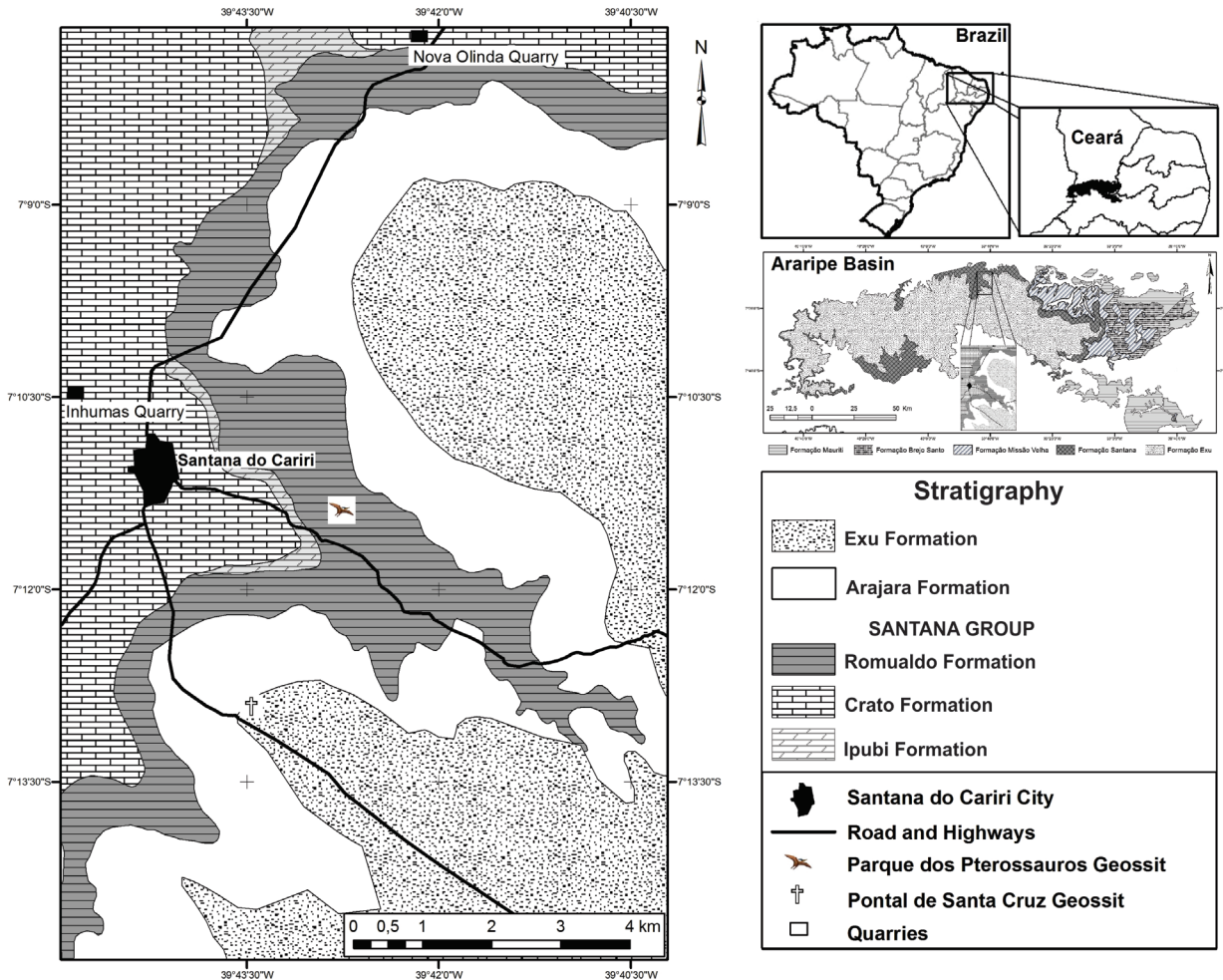


Figure 1. Map of geographical area and lithologic distribution in the Araripe Basin, with details of the region of Nova Olinda and Santana do Cariri.

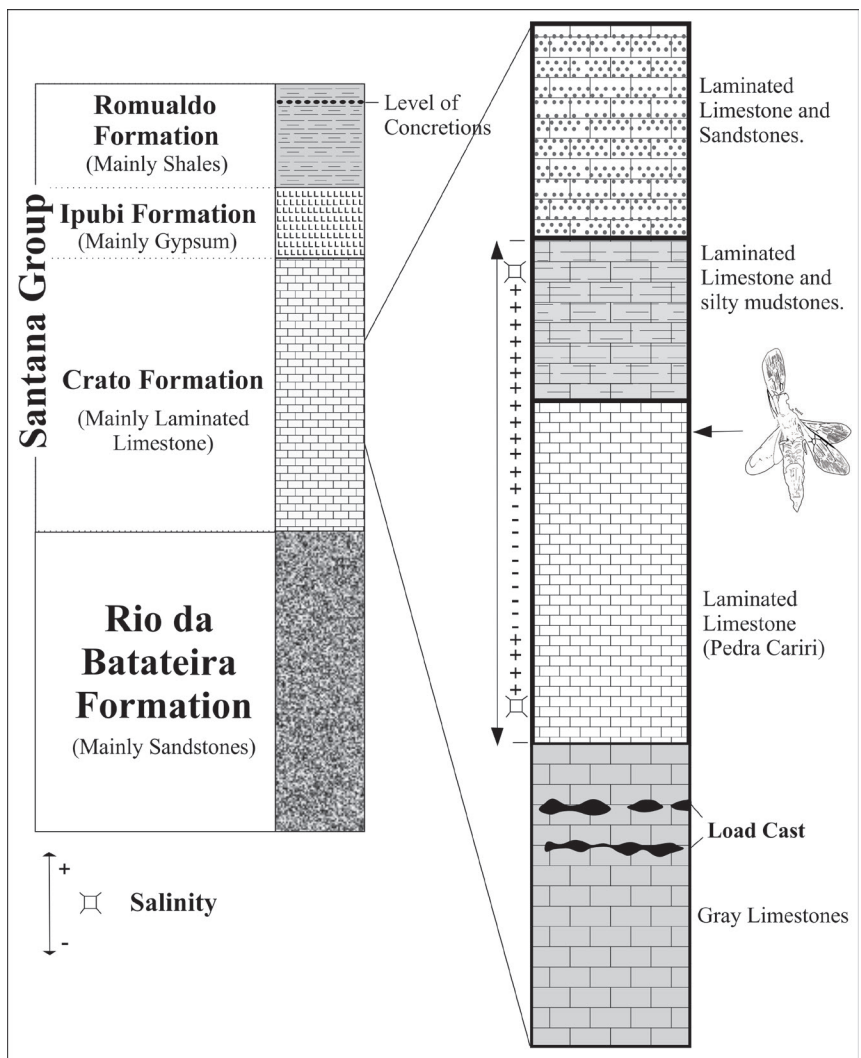


Figure 2. Sedimentary facies of the Crato Formation, Santana Group, Lower Cretaceous of the Araripe Basin, specifying the stratigraphic location of the fossil find.

Methods

The specimen was mechanically prepared under a stereomicroscope using brushes and needles, seeking more access to the diagnostic characters, especially wing venations.

For comparison with other fossil specimens already described, in addition to the visits (Laboratory of Paleontology of the Federal University of Ceará; Geological Survey of Brazil in Fortaleza; and Paleontology Museum of Santana do Cariri), an extensive bibliographic review was conducted.

As to the taxonomy of the Hymenoptera, the current keys, particularly at the level of species, use some features that are not

usual for the comparison and identification of fossil specimens, such as colors and other apomorphies that are not preserved in fossils. Due to these limitations, we relied only on morphological characters to identify the species in this study.

For the comparisons between families and superfamilies, the most morphologically representative specimens of their families were chosen. As a basis we used the keys and identifications in Benson (1951), Mason (1993), Rasnitsyn & Zhang (2004a, b), Zhang & Rasnitsyn (2006), and Vilhelmsen (2003). The wing venation nomenclature used is that of Rasnitsyn 1969 and Rasnitsyn 1980.

RESULTS

Systematic palaeontology

Order: Hymenoptera Linnaeus, 1758

Superfamily: Siricoidea Billbergh, 1820
(Latreille, 1802)

Family: Pseudosiricidae Handlirsch, 1906

Genus: *Myrmicium* Westwood, 1854

Species: *Myrmicium araripterum* sp. nov.

Derivation of name: *araripterum*, in reference to the type locality of the holotype, the Araripe Basin.

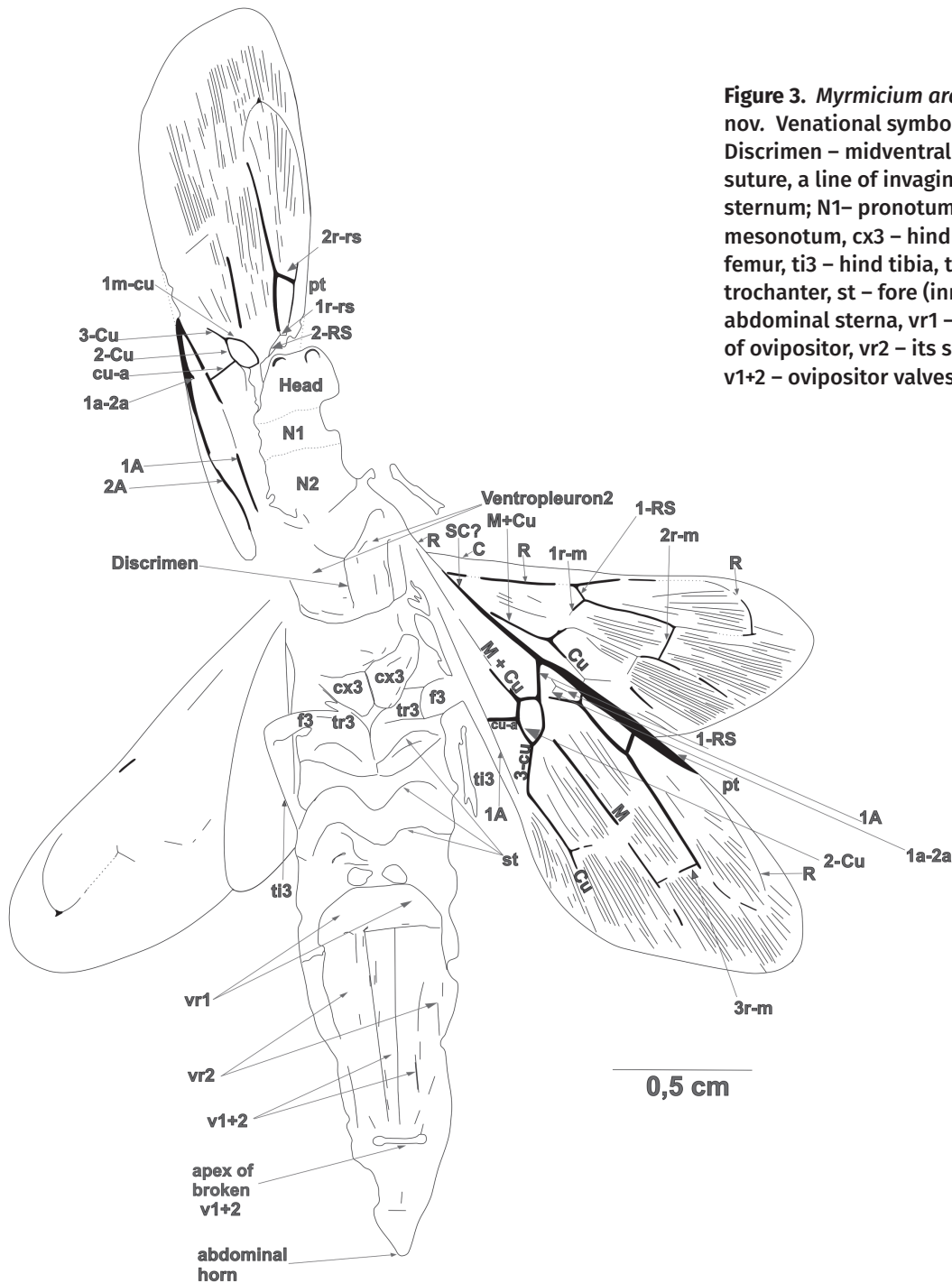


Figure 3. *Myrmicium araripterum*, sp. nov. Venational symbols standard: Discrimen – midventral thoracic suture, a line of invagination of sternum; N1– pronotum, N2 – mesonotum, cx3 – hind coxa, f3 – hind femur, ti3 – hind tibia, tr3 – hind trochanter, st – fore (inner) margin of abdominal sterna, vr1 – first valvifer of ovipositor, vr2 – its second valvifer, v1+2 – ovipositor valves.



Figure 4. *Myrmicium araripterum*, sp. nov.

Holotype: # SGBFO-PA045 in the collection of the Geological Survey of Brazil, in Fortaleza-CE; almost complete female with poorly preserved body, legs, and antennae; ovipositor lost (Figs. 3 and 4).

Non-type material: 3 specimens figured by Osten (2007: Pl. 15f-h) similar to the holotype in general appearance (except for sex dependent features in male, Pl. 15g, and preserved ovipositor in the female Pl. 15h) and in most venational characters when preserved.

Stratigraphy: Beige laminated limestones, rich in fossil remains of angiosperms, Crato Formation of the Santana Group, Lower Cretaceous of the Araripe Basin-Brazil.

Type locality: Inhumas, located 2.2 km from the municipal seat of Santana do Cariri – Ceará.

Diagnosis:

- 3r-m and 2cu-a weak but distinct
- RS+M absent (or almost absent)
- M + Cu not angular basal of fork
- 1mcu cell short, with cu-a at about 0.3-0.4 its lower side
- 1m-cu shorter than half of 3-Cu
- hind wing with cells r and rm closed and with 1r-m longer than 1-RS and 1-M
- Marginal cell (3r) closed away of wing margin in both wings, wider distal than rm cell(s)

Description

Female holotype. Body large (38 mm), subcylindrical, weakly tapering back, with details of structure little known because of incomplete preservations. Hind legs with femur short, rather thin, tibia and tarsus thin, much longer (better seen in non-type specimens). Abdominal apex acute triangular (analogue of abdominal horn of female Siricidae). Ovipositor starting at or slightly before abdomen midlength, extending behind abdomen apex for about half abdomen length (visible in non-type specimen Osten, Pl. 15h).

Forewing with outer membrane strongly corrugated, with corrugation extending basal at least up to 2r-rs, 2-RS (inner border of cell 2rm), 1m-cu and 2cu-a. Costal space comparatively wide, ribbon-like, possibly with longitudinal stalk of SC and strong, straight R. Pterostigma long, narrow, not distinctly tapering from 1r-rs to 2r-rs, with 2r-rs slightly distal of its midlength; cell 3r wide, particularly distal (wider than 3r-m length), closed far away of wing fore margin. 1-R proclival, almost aligned with 2-M and less than twice as long as 2-M; RS+M absent or very short. 2r-m absent; 3r-m distal of 2m-cu almost for

2m-cu length. M+Cu straight, with no angulation before fork. Cell 1m-cu small, with cu-a well distant from M+Cu apex, with 1m-cu shorter than half of 3-Cu. Anal cell narrow basal (basal loop of cell 1a lost), 1a-2a oblique, distal of cu-a.

Hind wing with complete venation as preserved (posterior wing part not seen sufficiently well) and with strong corrugation. space wide, SC absent; 1-RS short but distinct; cell r similar to 3r in forewing; 1r-m and 2r-m present, 1r-m longer than 1-R and 1-M and almost aligned with 1-M; cu-a near distal third of cell m-cu, 1a-2a well basal of cu-a.

Measurements (in mm): body length 38, forewing length 24, hind wing length 17.5, fore femur length 3.2, inner ovipositor structures (basal of ovipositor sheaths base) 12.

Non-type female Osten Pl. 15f: very similar to type in general appearance including lost ovipositor revealing acuminate abdominal apex, but with obscure wing venation and better preserved hind legs. Smaller in size (body 22 mm, forewing 17 mm). Hind tibia 6.6 mm long, hind tarsus 6.5 mm. Hind femur difficult to measure but relying on proportions derived from forewing length in holotype it should be some 2.3 mm, that is only 0.35x as long as either tibia or tarsus.

Non-type female Osten Pl. 15h: as preserved and available from the printed photo, similar with the type except its paradoxically small size (forewing length 12.4 mm if the scale provided is correct). It is important that this fossil preserves complete ovipositor with sheaths 0.4x as long as forewing (5 mm long as calculated based on the scale provided).

Non-type male Osten Pl. 15g: as available from the illustration, similar to females in wing venations and in very long hind tibia and tarsus and differs in expectable sex-depending characters (short abdomen with wide apex, long filiform antenna) as well as again unexpectedly

small size (forewing 10 mm as calculated based on the scale provided).

It is worth mentioning that a huge size variation, as shown in the samples described here, is characteristic of wood wasps as well as in other xylophagous insects (Benson 1943, Schiff et al. 2012).

Remarks: The new species differs from both *M. heeri* and *M. schroeteri* in having (i) RS+M absent or almost so (vs. distinct in the above ones), (ii) M+Cu almost straight (vs. angular before fork, at a place where a supernumerary cu-a arises in many Siricidae), (iii) 1m-cu cell short, tapering distal, and with cu-a at its midlength (vs. much longer, not or very slightly tapering and with cu-a well before its midlength), (iv) 3r-m and 2cu-a weak but distinct (vs. not found), cell 3r distal wider than space between R and M there. It differs from *M. schroeteri* also in having (v) pterostigma parallel-sided between 1r-rs and 2r-rs (vs. tapering distal); (vi) hind wing with 1r-m longer than 1-M (vs. much shorter; unknown in *M. heeri*), (vii) hind wing with cells r and rm closed (vs. open; unknown in *M. heeri*), (viii) ovipositor long (based on non-type female, Osten 2007, Pl. 15h) (vs. short in *M. schroeteri*; unknown in *heeri*).

DISCUSSION

The new material described herein adds much to morphology of the little known group of extinct woodwasps as well as to its distributions both in time and space. Known before only in vicinity of Jurassic-Cretaceous boundary in Europe, it is now recorded in an opposite point on the globe, in Brazil, and some 25-30 Ma later, in Aptian. In its general appearance as well as wing venation *Myrmicium* is close to Siricidae: it shares with various siricids, particularly with living ones, large body size; wings with deeply corrugated

membrane (with corrugation extending about as far basal as in *Ypresiosirex* Archibald & Rasnitsyn 2015); 3r cell very wide distal and closed far from the wing fore margin (*M. araripterum* only), and anal cell with basal portion (basal of loop) very narrow (hardly developed). Additional similarities are found in female sex: cylindrical body; short femora combined with long tibiae and tarsi; acuminate abdominal apex and stout, straight ovipositor. However, many important characters are unknown in *Myrmicium* yet including the crucial one, presence or absence of the transverse mesonotal suture which incorrect interpretations in the family Daohugoidae has resulted in its erroneous attribution to Siricoidea (Wang et al. 2019). That is why we prefer to postpone reconsideration of taxonomic position of Pseudosiricidae until more information is accumulated about thoracic morphology of *Myrmicium*.

The genus *Myrmicium* recorded in three fossil sites only, namely, the latest Jurassic Solnhofen, the earliest Cretaceous Purbeck, and the later Lower Cretaceous Santana, all placed at near-seashore environments: this might indicate its respective landscape preferences which needs further study of course.

This new species increases the diversity of the grade “Symphyta” for the Lower Cretaceous of Gondwana which is poorly known yet, with only two other species correctly referred to the group thus far (*Prosyntexis gouleti* Sharkey, 1990 [= *P. legitima* Martins-Neto et al. 2007 (teste Jattiot et al. 2011)] of Sepulcidae as confirmed by Kopylov & Rasnitsyn (2017) and *Cratoenigma articulata* Krogmann & Nel (2012) of debatable affinities), both of the Araripe Sedimentary Basin as well, and contributes to the evolving understanding of the Hymenoptera. There is a great potential to find other genera and families there that will open an unknown world of Mesozoic Gondwana grade “Symphyta”.

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Author contributions

Freitas, LCB prepared the specimen, made the figures and conducted the writing of the manuscript. Rasnitsyn, PA did the review, contributed to the diagnosis and made important contributions to the discussions of the manuscript. Moura, GJB and Mendes, M participated in the description of the specimen, mainly in the initial phase. All authors made critical reviews of the manuscript's content from the first version to the final version submitted for publication.

