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# A new parasitoid wasp (Hymenoptera: Chalcidoidea) from the Lower Cretaceous Crato Formation of Brazil: The first Mesozoic Pteromalidae

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ABSTRACT

A new genus and species of small (3.5 mm excluding ovipositor) parisitoid wasp is described from the Lower Cretaceous (Aptian) Crato Formation Lagerstätte of Brazil. *Parviformosus wohlrabeae* gen. et sp. nov. is known from a single female imago and is assigned to Pteromalidae. It is diagnosed by the robustness of the scutellum, the structure, size and positioning of the mesopleuron, the complexity of the propodeum–petiole junction and a posteriorly curved dorsal 'lip' on metasomal segment 4. At only 3.5 mm in length, *P. wohlrabeae* is the smallest fossil wasp from the Cretaceous of South America and the first Mesozoic representative of Pteromalidae.



## 1. Introduction

The Hymenoptera is one of the most diverse orders of insects. It is characterised by impoverished wing venation (most veins simple, excluding rare SC branching and RS forking (forewing), pterostigmal cell lost or thick, M fused with Cu sub-basally), the presence of hamuli on the hind wings, haplodiploid sex determination, and the presence of a protibial spur with velum (Rasnitsyn, 2002; Grimaldi and Engel, 2005). The hymenopteran fossil record is well-documented and data suggests that hymenopterans are a sister taxon to Panorpida and likely diverged during the Carboniferous (Beutel et al., 2011). Hymenoptera underwent a series of explosive adaptive radiations in the Jurassic, Cretaceous and Paleogene through which they attained their astonishing modern diversity (Riek, 1955; Rasnitsyn, 1969, 2002; Grimaldi and Engel, 2005; Michez et al., 2009). Their hyperdiversity is at least in part due to the evolution of microscopic parasitoid wasps, which constitute the vast majority of species in the order (Kristensen, 1981; Rasnitsyn, 2002; Grimaldi and Engel, 2005).

Here, we describe a new genus and species of tiny parasitoid wasp from the Lower Cretaceous (Aptian) Crato Formation, a heterolithic sequence of interbedded laminated limestones, sandstones, marls and clays within the Araripe Basin of north-east Brazil (Heimhofer and Martill, 2007; Heimhofer et al., 2010). At its base is the Nova Olinda Member, a fossil Konservat–Lagerstätte of Aptian age that is well known for the abundance and exceptional preservation of arthropods, vertebrates and flora (Grimaldi, 1990; Martill, 1993; Martill et al., 2007). This member crops out around the north-eastern to south-eastern edges of the Chapada do Araripe, a typical Brazilian tableland in the north-eastern state of Ceará. The outcrop between Nova Olinda, Santana do Cariri and Tatajuba is especially fossiliferous, yielding large numbers of insects (Martill, 1993; Heads et al., 2008).

## 2. Material and methods

*Material.* The specimen described here comprises a single adult female wasp preserved in right lateral aspect on a circular slab (diameter 32 mm, depth 10 mm) of fine-grained laminated limestone. It has been replaced by goethite, which may be a consequence of the weathering of an original iron sulphide replacing mineral (Menon and Martill, 2007). It is largely preserved in three-dimensions with only slight compactional damage, largely concentrated over the metathorax and propodeum. The specimen is deposited in the Staatliches Museum für Naturkunde, Stuttgart with accession number SMNS 70092.

*Methods.* The partially exposed insect was etched in 10% hydrochloric acid to reveal more anatomical detail but was not removed from the

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slab. It was then mounted on an aluminium stub and sputter coated first with carbon and later with gold. The acid etching exposed considerable detail but left the specimen in an extremely fragile condition. Scanning electron microscopy was performed using a JEOL JSM–6100 SEM and images captured and analysed using PC digitiser and 'SemAfore' software. Image manipulation and construction of illustrations was performed using CorelDRAW X5 and Corel PaintShop Photo Pro X3. The fossil sustained some damage after initial examination on the SEM, losing aspects of the head, wings and some metasomal sterna. The fossil has also acquired some contamination on the remaining metasomal sterna (excluding propodeum) by carbon putty. Some images reproduced here were taken prior to damage and have been rescaled (using the same image ratio) and digitally rotated to allow a complete image to be formed of the original specimen. Images of the wing articulations before damage are not included due to severe charging. Note that due to the lack of diagnostic characters in the fossil comparable with modern chalcidoids, the diagnosis is, of necessity, descriptive rather than comparative. For chalcidoid morphology the reader is referred to Gibson (1997).

## 3. Systematic palaeontology

Hymenoptera Linnaeus, 1758
Apocrita Gerstaecker, 1867
Chalcidoidea Latreille, 1817
Pteromalidae Dalman, 1820
Genus *Parviformosus* gen. nov.

*Derivation of name*. Parvi, L. small; formos, L. beauty.

*Diagnosis*. Small (5.1 mm (3.5 mm excluding ovipositor)) pteromalid wasp. Ovipositor elongate and ventrally curved. Mesosoma robust with particularly robust scutellum and mesopleuron. Mesopleuron large, elongate and ventrally positioned, overlapping ventral portions of petiole. Complex propodeum–petiole junction with petiole extending into mesosoma and hooking under propodeum. Metasoma with well-defined segmentation. Metasomal segment 4 with posteriorly curved dorsal 'lip' approximately 100 μm in length anteroposteriorly and 75 μm in depth extending dorsoventrally over metasomal segment 5.

*Remarks*. Familial placement for *P. wohlrabeae* is extremely difficult due to the lack of three key taxonomic structures; the legs, wings and antennae. However, the shape of the posterior end of the gaster and the morphology of the ovipositor suggest that *P. wohlrabeae* belongs within Pteromalidae (J.-Y. Rasplus, pers. comm. 2012). The length and shape of the ovipositor, height relative to width of the gaster, short pronotum, shortened head and an apically expanding ovipositor sheath suggest that *P. wohlrabeae* may even be resolved to the Sycophaginae (R. Burks and M. Yoder, pers. comm. 2013). However, the character set for Sycophaginae is relatively poor and these morphological similarities are not sufficient to confirm placement. *P. wohlrabeae* is therefore, tentatively placed within Pteromalidae subfamily incertae sedis.

*Parviformosus wohlrabeae* sp. nov.
Figs. 1–3

*Derivation of name*. After Judith Wohlrabe who discovered the holotype while studying Crato Formation fossils at the University of Portsmouth.
*Holotype*. SMNS 700902.
*Type locality*. Most likely from an area of active quarrying between Santana do Cariri, Nova Olinda and Tatajuba, flanks of the Chapada do Araripe, Ceará, Brazil (precise quarry unknown).
*Horizon*. Nova Olinda Member, Crato Formation, Araripe Group. Early Cretaceous, Aptian.
*Diagnosis*. As for the genus, by monotypy.

### 3.1. Description

Incomplete adult female imago preserved in right lateral aspect, comprising head, mesosoma, metasoma and ovipositor (Figs. 1 and 2); body length 3.5 mm, total length including ovipositor 5.1 mm.

*Head*. The head of the specimen was severely damaged during transport. Most of the posteroventral half of the head was lost, leaving only an area representing the vertex, part of the eye and the clypeus/frons(?) (Fig. 3B). Much of the cuticle on the right lateral surface of the head is absent. It is approximately circular in outline, but slightly dorsoventrally compressed in lateral view. The entire head measures 900 μm anteroposteriorly and ~700 μm dorsoventrally. The eye is preserved in outline as a deep cavity within the head. The eye is large (approximately 40–45% of the head), anteriorly positioned and kidney–shaped. It measures 440 μm dorsoventrally and approximately 375 μm anteroposteriorly, however it may have been larger in life. Antennae are not preserved, however, a notch is present on the anterior surface where the antennae originally articulated. This notch is located ~200 μm down the anterior surface of the head, but lies above the base of the eye. Ocelli are not preserved. Only fragments of the mouthparts are preserved and accurate identification of individual elements is not possible. A semicircular cavity with a diameter of ~250 μm is present on the ventral surface of the head and probably represents the former position of the mouthparts (Fig. 3B). In the central portion of this cavity a bulbous appendage with fine setae represents the left labial palpus. It has a maximum visible diameter of ~20 μm and length of ~70 μm and the setae are sparse with a length of 4–9 μm (Fig. 3C). Some are pointed, but others appear rod–like and are truncated with sub–parallel margins.

*Mesosoma*. The total anteroposterior length of the mesosoma is 1.14 mm and the greatest dorsoventral depth is 0.92 mm (Fig. 3A). The boundary between the prothorax and the mesothorax is clearly discernible. The prothorax appears simple and takes up approximately one fifth of the whole mesosoma, measuring 875 μm dorsoventrally and 275 μm anteroposteriorly. Only patches of the mesothorax are preserved uncrushed. The boundary between the mesothorax and propodeum is partially crushed, but visible in the dorsal and ventral areas. Crushed areas have been filled with matrix, making some segment boundaries in these areas difficult to define. A group of sclerites are visible slightly anterior to the centre of the mesosoma. The dorsal portion may represent a lobe of the scutellum, but the sutures of the ventral areas are ill defined. It is robust and is emphasised by high relief. The prepectus is not visible, and is probably internalised, as in many pteromalid subfamilies. There are fragments of sclerites that probably represent the tegula, and a marginal lobe of the mesopleuron. Three wing fragments are visible. A wing fragment on the right lateral surface of the mesosoma appears to represent a forewing articulation while the more dorsally located fragments may represent a segment of hind wing. A large (~680 μm anteroposterior, ~225 μm dorsoventral) structure preserved on the ventral edge of the mesosoma may represent one of two structures. It could be an enlarged coxa that has been taphonomically displaced along the side of the mesosoma or, alternatively, a mesopleuron that has shifted ventrally in its anterior portion, giving a 'semi–detached' appearance. Due to the positioning, size and apparent fusion to the mesothorax, we consider it more likely that this structure is a mesopleuron. If this structure should prove to represent an enlarged coxa then the other leg element identifications are incorrect. Only a single fragmentary leg remains. The trochanter and possible femur are preserved semi-articulated in a folded position and crushed over the lateral surface