



First Occurrence and Paleo-Ecological Implications of Insects (Orthoptera: Ensifera Gryllidae) in the Romualdo Member of the Santana Formation, Eo-Cretaceous of the Araripe Basin

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ABSTRACT

The Romualdo Member of the Santana Formation, a lithostatigraphic unit attributed to a marine intrusion, is famous for its preserved fossils in calcareous concretions, which stand out for their diversity and excellent preservation levels. This paper aims to record the first occurrence of the Class Insecta in the Romualdo Member of the Santana Formation of the Araripe Basin, as well as to describe and discuss the paleo-ecological implications of such finding. The first occurrence of the order Orthoptera (family Gryllidae) is presented for this unit. This new species is attributed to the genus *Araripegryllus*, that lasted throughout the deposition of the Crato Member, which is under the Romualdo Member. In reference to its stratigraphic origin, the specimens was named *Araripegryllus romualdoi* sp. nov.

Key words: *Araripegryllus*, Grylloidea, Calcareous concretions, *Araripegryllus romualdoi*.

INTRODUCTION

The Romualdo Member, the upper unit in the Santana Formation, stands out for the quality and tridimensional preservation of its fossils in calcareous concretions, belonging to different taxonomic groups, such as Gymnosperms and Angiosperms leaves and trunks (Saraiva et al. 2003, Lima et al. 2012); Gastropods (Beurlen 1964); Crustaceans (Martins Neto 1987 and Pinheiro et al. 2013); Conchostracans (Carvalho and Viana 1993); Ostracods (Carmo et al. 2004)

and, especially, vertebrates: Chondrichthyes Actinopterygii (Agassiz 1841, Brito and Ferreira 1989); Testudines (Hirayama 1998, Oliveira and Kellner 2005); Dinosauria (Kellner 1999, Kellner and Campos 1996, Martill et al. 1996, Naish et al. 2004); Pterosauria (Kellner 1984, Wellnhofer 1985, Kellner and Tomida 2000, Witton 2009, Bantim et al. 2014); and Crocodilia (Price 1959, Kellner 1987) and no insect has yet been attributed to this unit in the literature, which limits paleo-ecological inferences, since insects (especially Orthoptera) are excellent bioindicators of paleoenvironments (Martins Neto 2006).

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Orthopteran constitutes the most diverse group of Polyneoptera, containing around 22.5 thousand species (both extant and fossils) (Grimaldi and Engel 2005, Heads and Martins Neto 2007).

Until 2005, 61 orthopteran fossil species (Ensifera + Caelifera + Phasmatoptera) had been described for Brazil (22% of the Brazilian paleoentomofauna), all for the Crato Member of the Santana Formation (Martins Neto 2005). Since then, no other Ensifera specimen has been described for the Santana Formation.

In view of the foregoing, this paper aims to record the first occurrence of the Class Insecta in the Romualdo Member of the Santana Formation of the Araripe Basin, as well as to describe and discuss the paleo-ecological implications of such finding.

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MATERIALS AND METHODS

The material under study comes from controlled excavations in the surroundings of the geological site known as *Parque dos Pterossauros* (Pterosaurs' Park), in the Araripe Geopark (24M 0420 696 NO UTM 9205 958) (Figure 1), where the greenish calciferous shale of the Romualdo Member of the Santana Formation of the Araripe sedimentary basin (Northeastern Brazil). Such Aptian-Albian shales are rich in ostracods where there is an abundance of calcareous concretions (Figure 2),

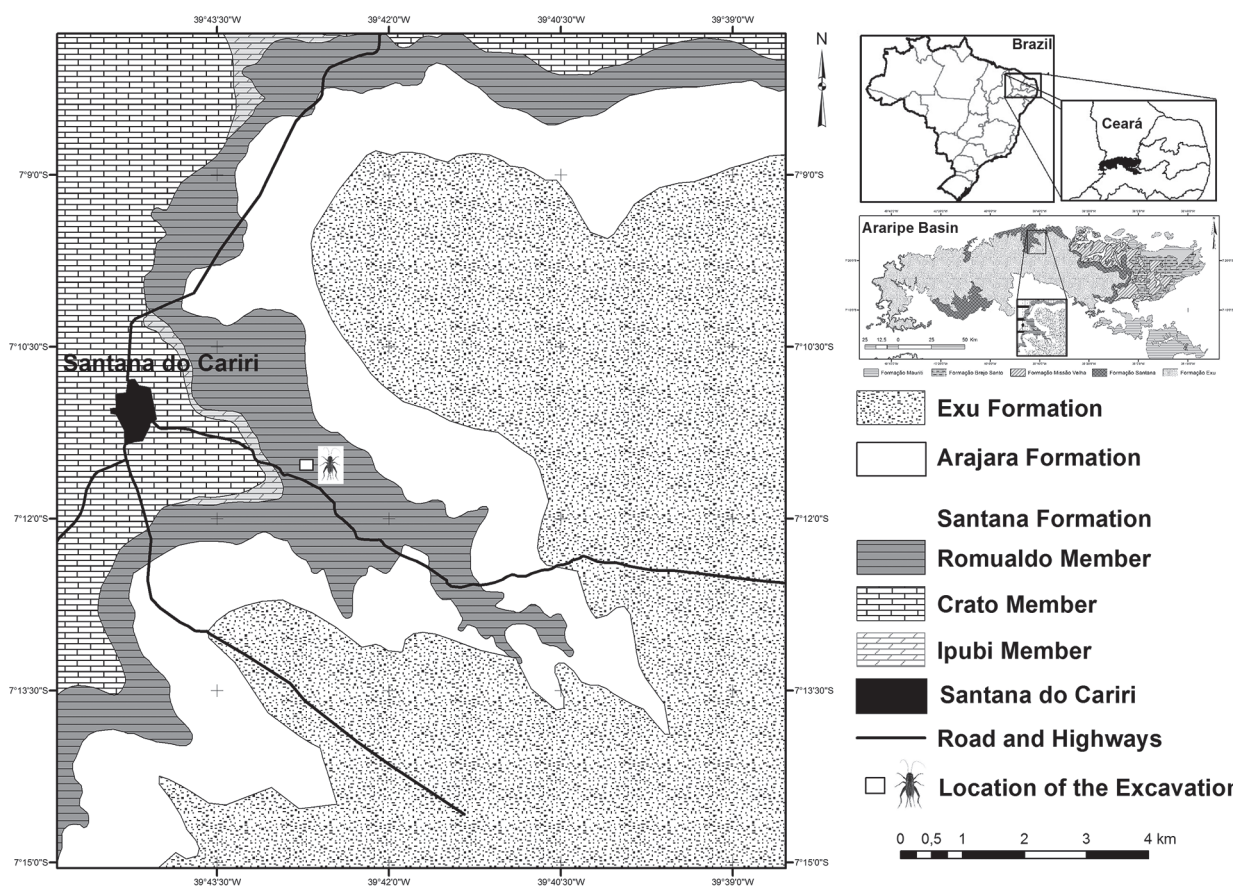


Figure 1 - Map of the location of the Santana do Cariri region within the Araripe sedimentary basin, highlighting the Romualdo Member and the location of the excavations. (Road and Highways – Location of the Excavation).

often fossiliferous (Assine 1992, Saraiva et al. 2007, Fara et al. 2005, Vila Nova et al. 2011) and is internationally renowned for the tridimensional preservation of its fossils (Kellner 2002, Pinheiro et al. 2013).

The Santana Formation, of middle-upper Albian age (Maisey 1991, Berthou 1994, Boss and Veiga 2011) is currently outcropping, surrounding a large part of the geomorphological profile of the Araripe Plateau.

In order to study and compare the fossil samples, a comprehensive bibliographical review was carried out about the paleontomofauna of the Santana Formation, using, for that, publications in indexed journals and classical literature relevant to the paleontology of this geological unit.

The material being studied is represented by a sample of calcareous concretion containing a fossil. The specimen was observed and photographed with binocular lenses and is kept at the paleontology

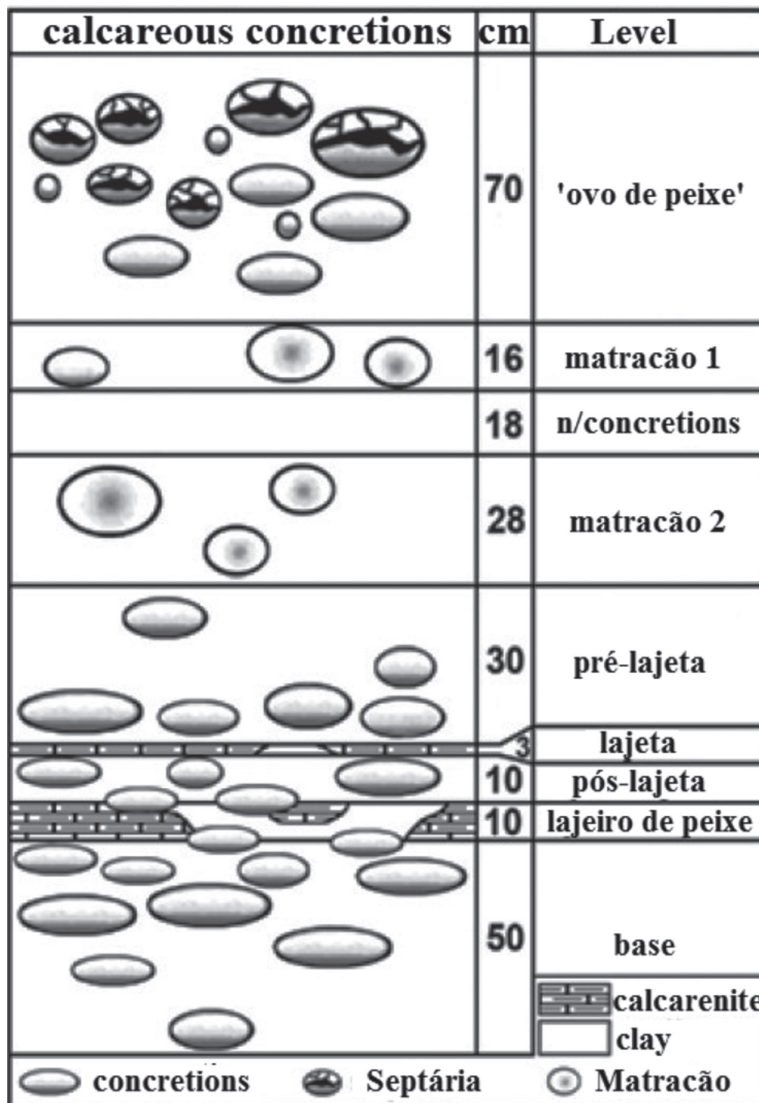


Figure 2 - Schematic profile of the distribution of the calcareous concretions and the location of the fossil finding, modified from Saraiva et al. 2007.

collection of the URCA (Regional University of Cariri) Paleontology Museum in Santana do Cariri, under list number MPSC I846 p and cp, coming from the Romualdo Member.

Systematic Paleontology

Order Orthoptera Olivier 1789

Suborder Ensifera Chopard 1920

Family Gryllidae Laicharting 1781

Genus *Araripegyllus* Martins Neto 1987

Araripegyllus romualdoi sp. nov.

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Etymology – *romualdoi*, in reference to its stratigraphic origin, Romualdo Member of the Santana Formation.

Holotype - MPSC 1846p/MPSC 1846cp (Figure 3)

Locality – *Parque dos Pterossauros* (Pterosaurs' Park) Geological site (Araripe Geopark), 3km from the seat of the city of Santana do Cariri, Ceará.

Horizon: Green shales, upper unit of the Santana Formation, Araripe Basin (lower Cretaceous).

Diagnosis:

Pronotum wider than the head, antennae coming from the center of the head, elongated cerci, robust femurs, non-elongated body and forewings with length over 5mm.

Description:

Body 10mm long and 5mm wide, 14mm (body + forewings). The thorax is very robust. The head is a little smaller than the pronotum, 3mm wide and 2mm long. The antennae were not well preserved, and there is only a short filament on the left side, coming from about the center of the head. The hind legs femurs are robust and the cerci are elongated. The femur is 7mm long and 3mm wide (widest portion of the hind leg), and the front legs are 2.5mm long and 1.2mm wide. Front tibiae are also robust, measuring about 3mm (Figure 3).

Some important features for species differentiation are absent or poorly preserved,

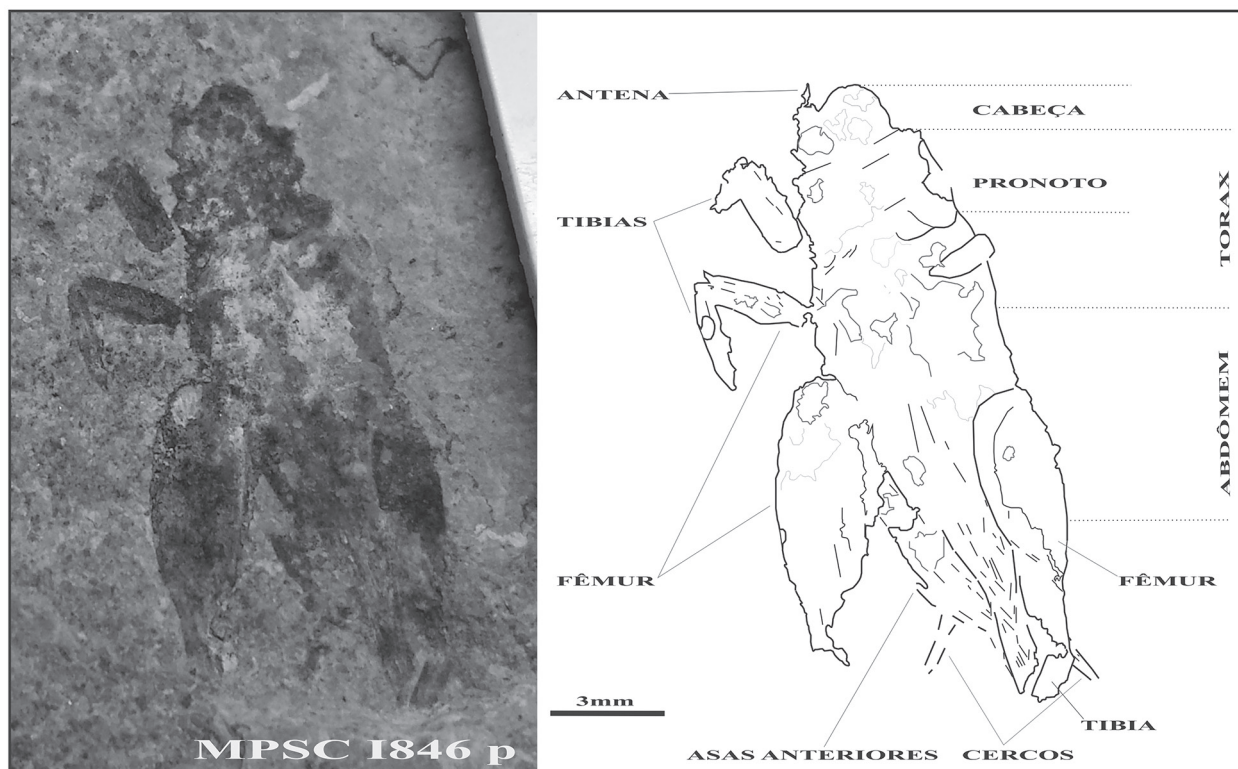


Figure 3 - *Araripegyllus romualdoi* sp. nov. (MPSC 1846p) on the left, and its schematic drawing on the right.

such as tibiae, tarsi, wings and antennae. The presence of an ovipositor is not evident, being thus impossible to initially classify it as male or female with certainty. However, it has cerci with length over 5 mm and evident folded wings covering and exceeding the length of the body. The length of the forewings is greater than that of the body.

DISCUSSION

Most *Cearagrillus* (Baissogryllidae) species are individualized by their wing features, especially the shape of the speculum, chords and harps, which are not present in this specimen.

The legs have robust femurs, a distinct feature in *Araripegryllus* (Grillidae) and *Cearagrillus*, and a common feature in Gryllotalpidae. However, the elongated cerci, usually turned into stridulatory devices, the head with smaller dimensions than the pronotum, and the non-elongated body (elongated bodies are also a noticeable Gryllotalpidae feature) allow us to place *Araripegryllus romualdoi* sp. nov. (MPSC 1846p) into the Gryllidae family. Another important taxonomic aspect is that the front tibiae are present in the specimen and are smooth, whereas in Gryllotalpidae they are covered with long spikes that are used for burrowing.

Cearagrillus are generally longer, reaching up to 32mm of body length (*C. perforatorius*) and a relatively large head (with the exception of *C. microcephalus*, that is small-headed), males have a large stridulatory organ, and females have a long, spear-shaped ovipositor, with variable lengths.

The Gryllidae family is the main family in the Grylloidea superfamily, with over 350 existing genera, and over 3,000 species distributed worldwide (Rentz and Su 2003), and is comprised of four genera in the Santana Formation. *Araripegryllus* Martins Neto 1987 (7 spp.), *Brontogryllus*, Martins Neto 1991 (1 sp.), *Cratogryllus* Martins Neto 1991 (3 spp.) and *Nanoararipegryllus*, Martins Neto 2002 (1 sp.); gathering 12 species in the Gryllidae family.

In the *Araripegryllus* genus, according to Martins Neto (1991), the female has a long, spear-shaped ovipositor, shorter than the cerci. The head is relatively large, globular, and bigger in width than in length; the antennae start from the middle of the head, a robust scape. A rectangular pronotum ranges from slightly to much larger than the head. Robust cerci, long abdomen, as the body's length. A robust femur, tibia with three apical spurs, tarsus with an extremely long first segment and the second being "heart-shaped". Forewings between 5 and 25mm long, 10mm wide and triangular, the base is larger than the apical area. The male has stridulatory organs: oval speculum.

The general features of the specimens (pronotum larger than the head, antennae coming out from the center of the head, elongated cerci, robust femur, non-elongated body, and forewings longer than 5mm) presented in the diagnosis, compared with the general features of the genus *Araripegryllus*, allow us to place them into this genus.

Comparing *Araripegryllus romualdoi* sp. nov. with other species in the genus, we can notice that the head of the analyzed specimen is relatively less thick than the pronotum and thorax, which is a constant feature of *Araripegryllus* (specially females), as well as the robust hind legs, with a length-width ratio greater than that of *A. robustos* (the specimen with the longest femur in the genus). The cerci, in the highlighted part, do not have spikes, which is by itself a difference from *A. serrilhatius* and brings it closer to *A. femininus* (with few spikes), but differs from the latter when it comes to size and thickness of the head and front and hind legs. The length of the femur is similar to others in the genus, such as *A. nanus*, although this one has short cerci. It is also worth mentioning that the length of the head corresponds to two thirds of its width, which differs from *A. femininus*.

From the features of the robust limbs, we can infer that the specimen had a great hopping ability

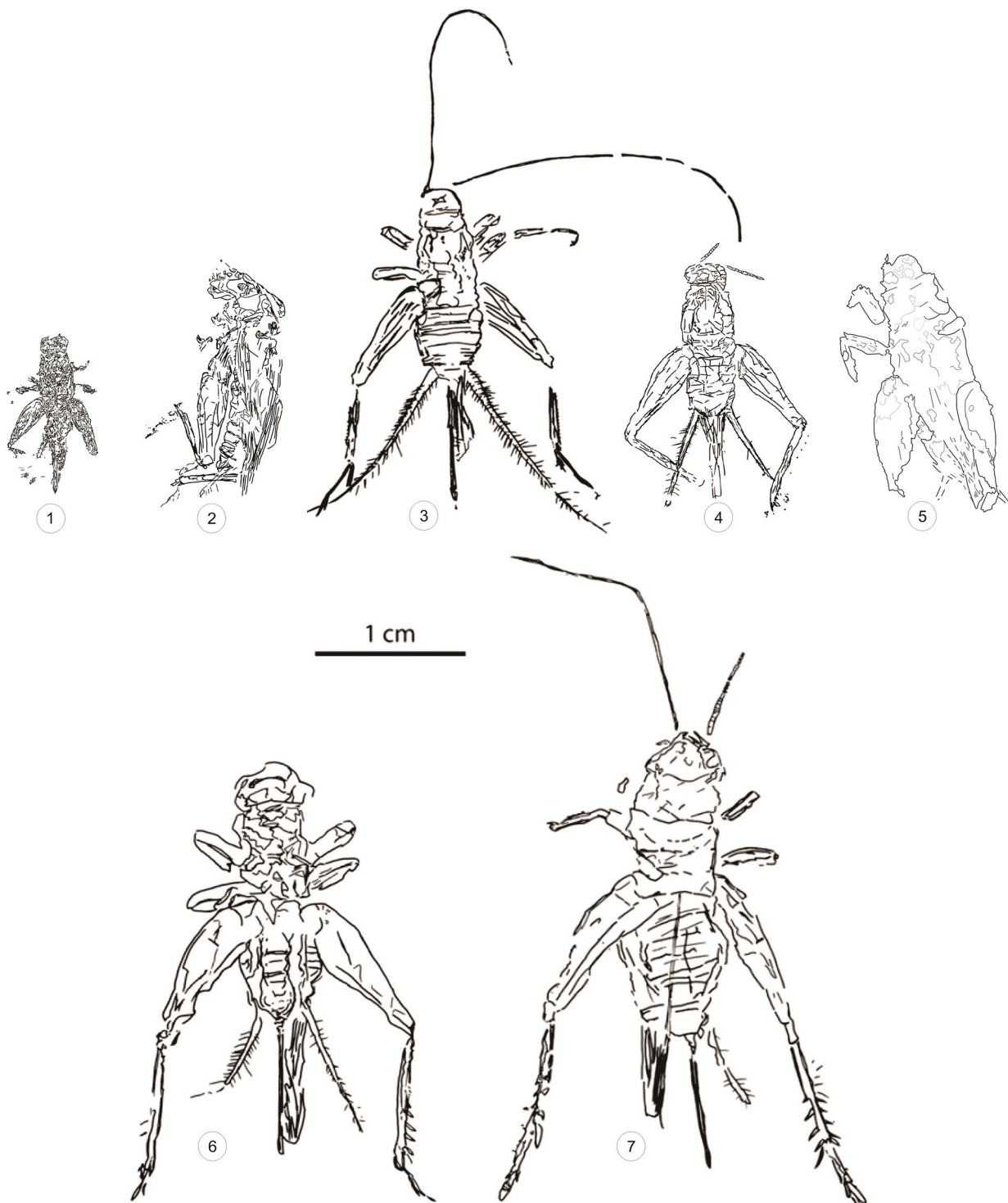


Figure 4 - Schematic drawings comparing the species – 1: *Caririgryllus brachypterus*, Martins Neto 2002; 2: *Araripegryllus nanus*, Martins Neto 1991; 3: *Araripegryllus serrilhatus*, Martins Neto 1991; 4: *Araripegryllus femininus*, Martins Neto 1991; 5: *Araripegryllus romualdoi*, sp. nov.; 6 – 7: *Araripegryllus robustos*, Martins Neto 2002. Adapted from Martins Neto 1991 and Lee 2011.

and probably lived near the ground, but was not a burrower such as Gryllotalpidae, since its legs were not used for burrowing, as they were not adapted to this function. A morphological comparison between the aforementioned species can be found in Figure 4.

The inclusion of some specimens in the genus *Araripegryllus* and *Cearagrillus* did not use all the criteria described as determining for the genera, containing some features that differ from the initial ones. Such as *A. nanus*, that has short cerci, whereas, in the general description of the genus, all should have long cerci. Or that not every species shows antennae coming out from the center of the head.

CONCLUSIONS

The morphological features shown by the specimen MPSC 1846p allow us to identify it as a new species and classify it within the family Gryllidae; genus *Araripegryllus*. However, important parts in the differentiation of species of this taxon, such as wings, antennae and legs were not well preserved, making it difficult to reach a deeper diagnosis of the specimen. Nevertheless, the preserved diagnostic features allow us to place it within this family, and differentiate it from other species within the genus *Araripegryllus*, thus being a new species of this genus (*Araripegryllus romualdoi* sp. nov.). The record of an insect in the calcareous concretions of the Romualdo Member (first recorded occurrence) is the proof that species that are sensitive to climate changes, such as insects, endured such distinct geological and climatic events as the ones that led to the formation of the Crato and Romualdo Members of the Santana Formation. They also indicate, for the original area and stratum, little transport and proximity with the ground. The fossilization of an insect in a calcareous concretion is the proof that insects are also able to trigger chemical reactions that will form concretions around them, thus

increasing the range of living beings that may have been fossilized in them, and are still to be found and studied.

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