

New Orthoptera Stenopelmatoidea and Hagloidea (Ensifera) from the Santana Formation (Lower Cretaceous, Northeast Brazil) with description of new taxa

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ABSTRACT

This work presents the results of a taxonomic study carried out on three specimens of fossil Orthoptera from the Crato Member laminated limestone, lowest unit of the Santana Formation (Lower Cretaceous), Araripe Basin. All fossils were found in Pedra Branca Quarry, near Santana do Cariri and Nova Olinda municipalities in Ceará State, northeast Brazil. The following new taxa are proposed: *Brauckmannia groeningae* Martins-Neto, n. gen. et n. sp. (Brauckmanniidae Martins-Neto, n. fam.), *Euclides ramosfernandesii* n. gen. et n. sp. (Mimnermidae: Euclidesinae Martins-Neto, n. subfam.), and *Prezottophlebia helbae* Martins-Neto, n. gen. et n. sp. (Hagloidea: Prezottophlebiidae Martins-Neto, n. fam.). The meaning of their morphological characters (robustness and body shape) and their presence in the laminated limestone is discussed like a contribution to the past distribution of Ensifera and to the paleoecological inferences.

Key words: Ensifera, Santana Formation, Araripe Basin, Lower Cretaceous, Brazil.

RESUMO

Este trabalho apresenta o estudo taxonômico de três espécimes de ortópteros fósseis, provenientes dos níveis de calcários laminados do Membro Crato, unidade inferior da Formação Santana (Cretáceo Inferior), bacia do Araripe. Os fósseis provêm do afloramento da Mina Pedra Branca, nas proximidades dos municípios de Santana do Cariri e Nova Olinda, no Estado do Ceará, nordeste do Brasil. Os seguintes novos táxons são propostos: *Brauckmannia groeningae* Martins-Neto, n. gen. et n. sp. (Brauckmanniidae Martins-Neto, n. fam.), *Euclides ramosfernandesii* n. gen. et n. sp. (Mimnermidae: Euclidesinae Martins-Neto, n. subfam.) e *Prezottophlebia helbae* Martins-Neto, n. gen. et n. sp. (Hagloidea: Prezottophlebiidae Martins-Neto, n. fam.). O significado dos caracteres morfológicos (a forma do corpo e sua robustez) e de sua presença entre os níveis de calcários laminados é discutido como uma contribuição para a distribuição pretérita de Ensifera e para a paleoecologia do grupo.

Palavras-chave: Ensifera, insetos, Formação Santana, bacia do Araripe, Cretáceo Inferior, Brasil.

INTRODUCTION

The Orthoptera and Neuroptera are the most common orders of insects from the Araripe Basin in terms of collected specimens and number of named species (Martins-Neto, 1991, 1995, 2006). Orthopterans are mainly represented by Grylloidea, among the Ensifera, and by Locustopsoidea, among the Caelifera. Some groups are especially rare such as Hagloidea, Tettigonioidea, and Gryllotalpoidea. The present study is a contribution and addition to past research made by the author, and reveals new forms of orthopterans.

MATERIAL AND METHODS

The material consists of three selected slabs collected in Pedra Branca Quarry, located at Nova Olinda-Santana do Cariri road, 4 km from the municipal district of Nova Olinda and was originated from the laminated limestone from the Crato Member, lowermost unit of the Santana Formation, Araripe Basin (Ponte and Appi, 1990), considered Upper Aptian in age (Ponte and Ponte-Filho, 1996; Coimbra *et al.*, 2002).

The adopted terminology is based in Martins-Neto (1991) and the taxonomic insertions follows Martins-Neto (1991) and

Gorochov (1995). Abbreviations cited in the text: **MA**, anterior media; **R**, radial; **RA**, anterior radial; **RP**, posterior radial; **ScA**, anterior subcosta; **ScP**, posterior subcosta.

SYSTEMATIC PALEONTOLOGY

Order ORTHOPTERA Olivier, 1789
Suborder ENSIFERA Chopard, 1920
Superfamily STENOPELMATOIDEA
Burmeister, 1838

Brauckmanniidae, n. family

Diagnosis. Big sized ensiferan, macropterous, stout, body length around

40 mm. All tibia robust, smaller than femora and tarsi longer than tibia. Fore, mid and hind tarsi four segmented and all articles with a notably developed pulvilli. Segment IV of all tarsi modified in a stickle-like structure, without terminal claws.

Discussion. Within Stenopelmatoidea, only Cooloolinae Rentz (Mimnermidae Brunner-Wattenwyl) shares some apomorphic characteristics with Brauckmanniidae, such as the modification of the fore legs (tibia short and robust, tarsi four-segmented) and body stunt. Brauckmanniidae n. fam. differs from all known Stenopelmatoidea in having all three pair of legs modified (tibia shorter than femur, tarsi longer than tibia and with well-developed pulvilli).

Brauckmannia n. gen.

Type species. *Brauckmannia groeningae*, n. sp., designated here.

Etymology. In honour to Carsten and Brigitte Brauckmann (Clausthal University, Germany).

Diagnosis. As for the family, with tibia without spines or apical spurs.

Discussion. The most similar known genus is *Cooloola* Rentz (Cooloolinae) in having the fore and hind pair of legs modified. However, *Brauckmannia* n. gen. greatly differs in having also the mid pair of legs modified, longer tarsal elements (short in *Cooloola*), macropterous (micropterous in *Cooloola*), and virtually no spines, apical spurs and distal claws (present in *Cooloola*).

Brauckmannia groeningae n. sp.
(Figure 1)

Etymology. In honor to Elke Gröning (Clausthal Institute, Germany).

Holotype and only specimen. RGMN-500, housed at Sociedade Brasileira de Paleoartropodologia (Rua Arnaldo Vitaliano, 150, 14091-220, Ribeirão Preto, SP, Brazil).

Type locality. Pedra Branca Quarry, Nova Olinda-Santana do Cariri road, 4 km from the municipal district of Nova Olinda, Ceará State, Brazil.

Type stratum. Laminated limestone level, Crato Member, lowermost unit of the Santana Formation, Araripe Basin.

Age. Aptian, Lower Cretaceous.

Diagnosis. As for the genus.

Description. Big sized orthopteran, macropterous, stunt, with body length around 40 mm, probably male (no evidence of ovipositor preserved). Head twice wider than long, 9 mm wide and 4 mm long. Pronotum seliform little wider and shorter than the head. Fore femur (Figure 1B.1), 12.6 mm long and 2.6 mm wide, with 0.20 of robustness index (RI=width/length). Fore tibia 6.6 mm long and 2.4 mm wide (RI = 0.36), and no evidence of tympanums. Mid tibia (Figure 1B.2), 7.1 mm long and 3 mm wide (RI = 0.42). Mid tarsus length, 9.6 mm. Hind femur 25 mm long and 6.5 mm wide (RI = 0.26). Hind tibia (Figure 1B.3) 13.8 mm long and 3 mm wide (RI = 0.21). Hind tarsus 14.5 mm with digit

IV sickle-like, distally curved, without terminal claws, and intensely pubescent. Fore, mid and hind tarsi four segmented and all articles with a notably developed pulvilli. No evidence of spines or apical spurs in the tibia. No evidence of cerci. Wings poorly preserved, longer than the body. Those characters make *Brauckmannia groeningae* n. sp. one of the biggest known Cretaceous orthopteran.

Family MIMNERMIDAE Brunner-Wattenwyl, 1888
Euclidesinae, n. subfamily

Diagnosis. Big sized ensiferans with body length around 23 mm. Females with long setiform ovipositor, longer than the body. Fore wing with wide costal area toward the apex, narrow at the wing base; **ScA** short and **ScP** reaching the apical area; **RA** unbranched; **RP** three-branched and **MA** two-branched; **RP** origin close to the wing base; conspicuous ma-mp. Hind wing with not well-developed anal fan and costal area homogeneously narrow.

Discussion. Euclidesinae n. subfam. is similar to the Zeuneropterinae Kevan & Wighton, in the general wing morphology, specially in having **MA** two-branched and the presence of ma-mp. Euclidesinae n. subfam. differs from Zeuneropterinae in having **ScA** short (relatively long in Zeuneropterinae), **ScP** long, reaching the apical area (the costal margin circa 1/3 of the wing apex), **RA** unbranched (multi-branched in Zeuneropterinae).

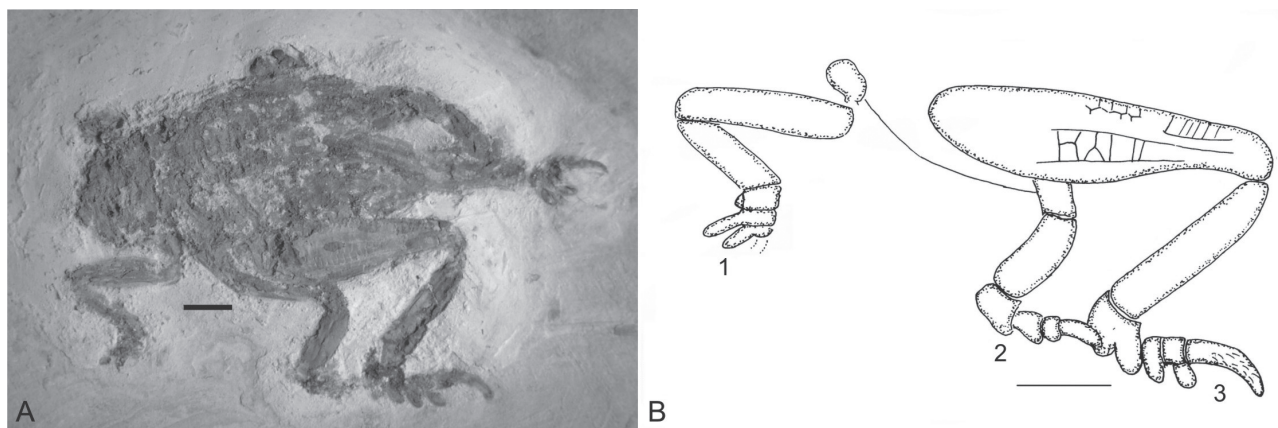


Figure 1. *Brauckmannia groeningae* Martins-Neto, n. sp. A. Holotype; B. 1, fore leg; 2, mid leg; 3, hind leg. Scale bar: 5 mm.

Additionally *Euclidesinae* n. subfam. exhibits a notably distally wide costal area (narrow in *Zeuneropteridae*). The new subfamily differs also from other *Mimnermidae* subfamilies by its notably long and setiform ovipositor, normally shorter and blade-like in the known subfamilies.

Euclides n. gen.

Type species. *Euclides ramosfernandesi*, n. sp., designated here.

Etymology. Generic and specific names in memoriam of the Brazilian naturalist, Euclides Ramos Fernandes.

Diagnosis. As for the subfamily.

Discussion. The closest known *Zeuneropterinae* genera, *Zeuneroptera* Kevan and Wighton and *Albertoilus* Kevan and Wighton, from the Canadian Paleocene (Kevan and Wighton, 1981), originally placed in *Prophalangopsidae*, were subsequently placed in the *Mimnermidae* by Gorochov (1995). *Euclides* n. gen. greatly differs from both mentioned genera, as previously discussed (see subfamily discussion). A third genus, *Kevania* Martins-Neto, 1991, described from the same sediments from the Araripe Basin, exhibits a very similar hind wing but differs in having **RA** and **RP** multi-branched and **RP** origin close

to the mid length of wing (close to the wing base in *Euclides* n. gen.). *Kevania* Martins-Neto, originally interpreted as *Prophalangopsinae* (Martins-Neto, 1991), and later as *Hagloidea incertae sedis* (Gorochov, 1995), is now transferred to the *Euclidesinae* n. subfam., within *Mimnermidae*. Another genus, *Cratobagloopsis* Martins-Neto (1991), also described for the Crato Member, although poorly preserved, also exhibits a lance-like ovipositor and wing venation pattern, which could permit its inclusion in this new subfamily. However *Euclides* n. gen. differs from *Cratobagloopsis* Martins-Neto, 1991 by having a hind wing with notably narrower radial sector area, **RA** without secondary branches (three in *Cratobagloopsis*) and **RP** with only one secondary branch (six in *Cratobagloopsis*).

Euclides ramosfernandesi, n. sp.
(Figure 2)

Holotype and only specimen. RGMN-501, housed at Sociedade Brasileira de Paleontologia (SBPr).

Type locality, type stratum, and age. The same for *Brauckmannia groeningae* n. sp.

Description. Body stout, 23 mm long, proventriculum preserved (Figure 2B.3). Big and prominent eyes. Pronotum trapezoidal, shorter than the head, and

abdomen as wide as the thorax. Ovipositor long, lance-like, 33 mm long. Fore wing 32 mm long and 13 mm wide (Figure 2B.1), after pushing back (the costal area is preserved and folded along **ScP**). Costal area very narrow at the wing base and widening toward the apex, filled by several cross veins. **ScA** short, close to the wing base, and **ScP** long, sinuous, reaching the apex. **RA** sinuous and unbranched, parallel to **ScP**. **RP** origin close to the wing base, originating three long secondary branches: **RP1** divergent of **RP2**, and **RP3** parallel to **RP2**. **MA** origin at the wing base. **MA1** curved, convergent to the **RP3** extremity. **MP** apparently two-branched and ma-mp conspicuous at the wing base. Several cross-veins in the whole wing. Hind wing with a narrow and homogeneous costal area (Figure 2B.2). **ScA** and **ScP** as for the fore wing, but **ScP** reaching the apical area boundary. **RA** unbranched and **RP** apparently two-branched. **MA** two-branched and **MA1** and **MA2** long and distally convergent.

Superfamily HAGLOIDEA
Handlirsch, 1906

Family Prezottophlebiidae, n. fam.

Diagnosis. Fore wing with costal margin narrow and radial area wide. **RA**

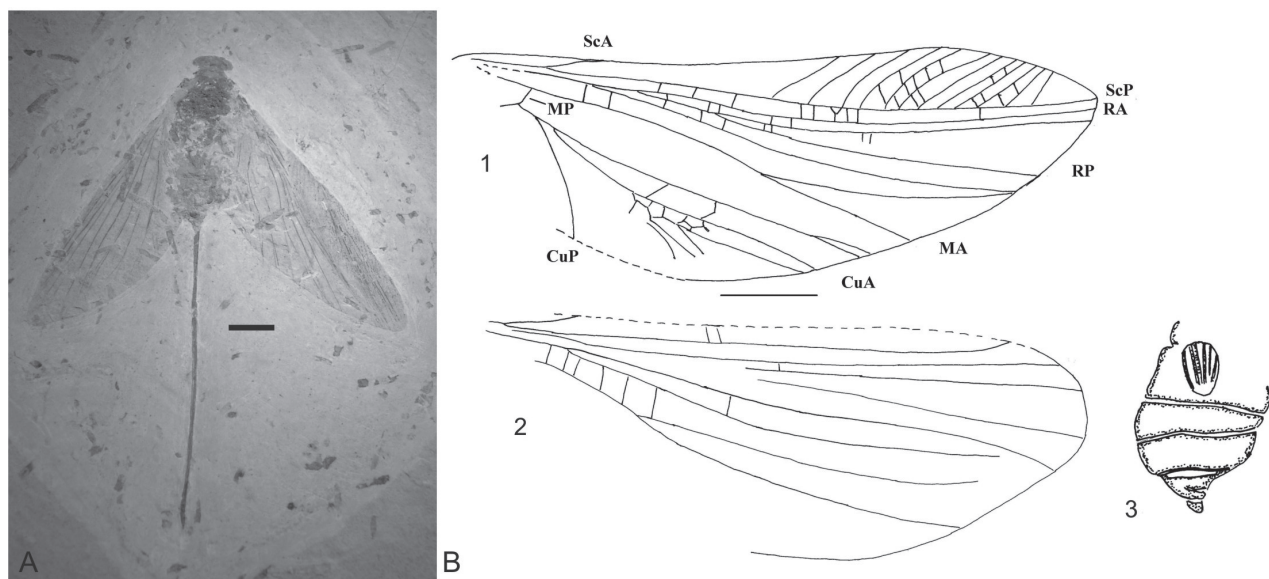


Figure 2. *Euclides ramosfernandesi* Martins-Neto n. sp. A. Holotype; B. 1, fore wing; 2, hind wing; 3, body detail. Scale bar: 5 mm.

distal branches long, branching at the wing mid length. Presence of intercalary veins.

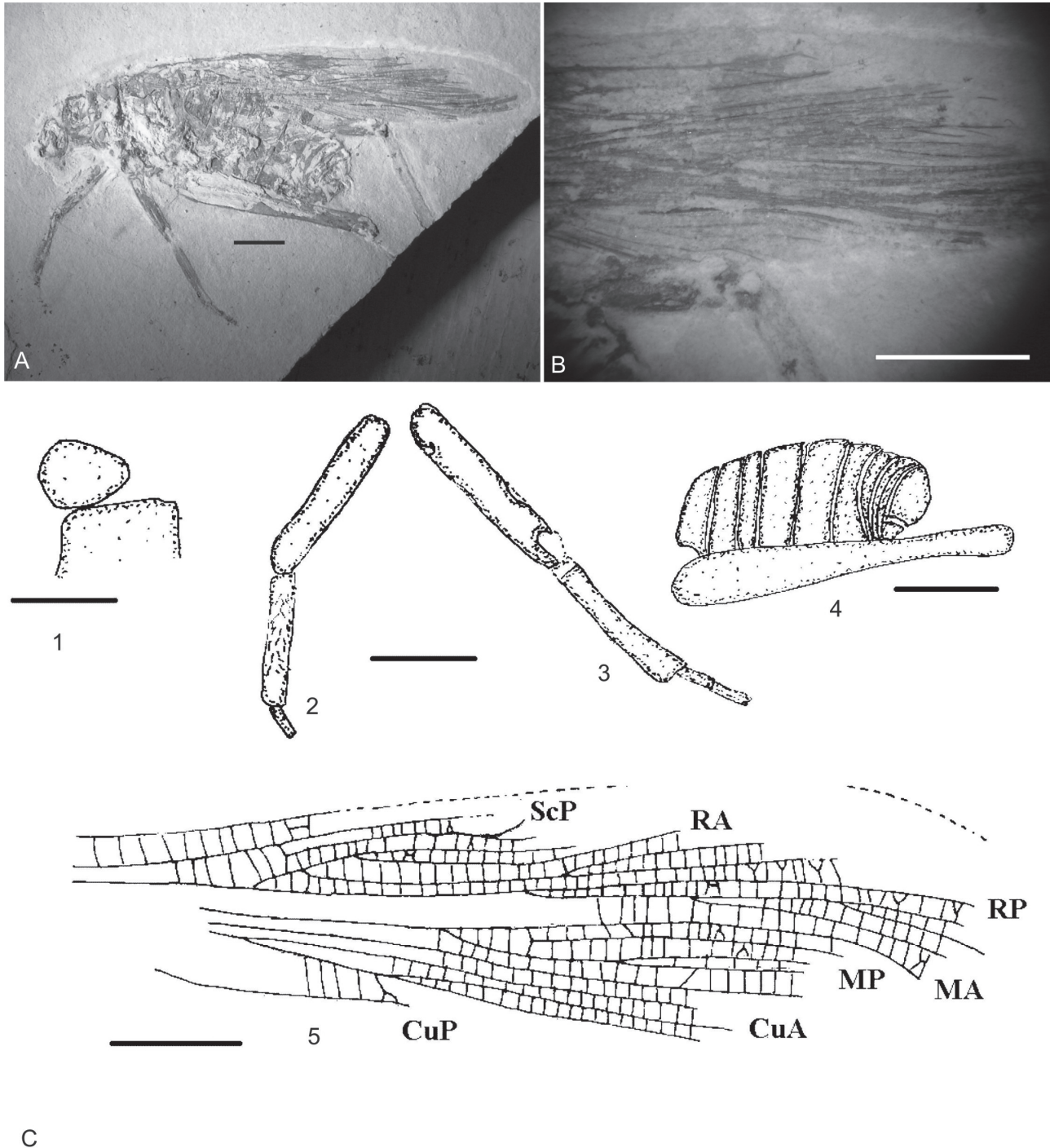
Discussion. Differs from all known Hagloidea families by the unique location of **R** branching of **RA** and of secondary

branching of **RP** at mid length, close to the apex in the other families, presence of intercalary veins that is absent in the other families, and by a wide radial field, normally narrow and homogeneous in the other ones.

Prezotophlebia Martins-Neto, n. gen.

Etymology. In honor to the Brazilian ethologist Fábio Prezoto.

Type species. *Prezotophlebia helbae*, n. sp., designated here.



C

Figure 3. *Prezotophlebia helbae* Martins-Neto, n. sp. A. Holotype; B. Wing detail; C. 1, head leg; 2, fore leg; 3, mid leg; 4, detail of abdomen; 5, fore wing. Scale bar: 5 mm.

Diagnosis. As for the family.

Prezotophlebia belbae, n. sp.
(Figure 3)

Etymology. In honor to the ethologist Helba Helena Santos Prezoto.

Holotype. RGMN-511, housed at Sociedade Brasileira de Paleontologia (SBPr).

Type locality, type stratum and age. As for *Brauckmannia groeningae* n. sp.

Description. Mid-sized Orthoptera, body length 28 mm, macropterous, with relatively small triangular head (Figures 3A and 3C.1). Pronotum trapezoidal, larger than the head. Abdomen stunted, with the last four segments compressed (Figure 3C.4). Fore leg relatively small (Figure 3C.2), with femur 10 mm long and 1 mm wide, tibia 6 mm long and 1 mm wide, intensely pubescent and with just one small tarsal segment preserved. Mid leg (Figure 3C.3), 12 mm long and 2 mm wide, with 7 mm long and 1.5 mm wide, smooth tibia and only two small tarsal segments preserved. Hind femur 20 mm long and 4 mm wide (RI = 0.20) with a smooth tibia. Fore wing 40 mm long and 6 mm wide (Figures 3B and 3C.5), costal area narrow, filled by pectinate cross veins, with **ScP** running directed toward to the costal area, **RA** origin about 1/3 of the wing base, sinuous with two sigmoid secondary branches, distally dichotomous. Area between **ScP** and **RA** with intercalary branches. **RP** slightly sigmoid, distally multibranching, and with at least three secondary branches preserved. **MA** two-branched, distally dichotomous and with at least one intercalary vein preserved. Unbranched **MP**, parallel to the **MA** branches. **CuA** three-branched. Dense cross-vein pattern.

REVIEW OF THE HAGLOIDEA AND PHASMOMIMOIDEA FROM THE BRAZILIAN LOWER CRETACEOUS

Recent studies are given a great contribution in the knowledge of the diversity and taxonomic insertion of the Lower Cretaceous insects, mainly in northeast Brazil.

Martins-Neto (1991) attributed two new species *Kevania araripensis* and *Cratohaglopsis santanaensis* to the Hagloidea, both transferred here to the Stenopelmatoidea. Furthermore, illustrates another specimen (Martins-Neto, 1995, fig. 64) that also was attributed to Hagloidea. This form, represented by a bizarre neuropteran, is assigned to the genus *Rafaelia* by Nel *et al.* (2005), recently renamed to *Rafaelliana* Nel *et al.* (2006) and motivates the creation of a new family of neuropterids, Rafaelidae (Nel *et al.* 2005). Finally, a wing fragment described as *Phasmomimella? araripensis* (Martins-Neto, 1991) shows to be very similar to the apical area of the fore wing from *Rafaelliana* and could be also assigned to this genus.

As a result, the Hagloidea is only represented now in Araripe basin by the new genus and specie *Prezotophlebia belbae* described here. On the other hand, this family and other related forms strongly dominate over Grylloidea in the Asian Lower Cretaceous (Gorochoy, 2001a). For the England Lower Cretaceous, the frequency of these taxa is more or less intermediate (Gorochoy, 2001b), and as discussed here, rare in the Brazilian Lower Cretaceous.

This clearly reflects geographical and/or ecological differences, as first pointed by Gorochoy (2001b). For this author this could be due to a humid tropical climate present in Brazil, in opposition to the drier temperate climate existing in Siberia-Mongolia, and intermediate within these extremes in England. Nevertheless, a hot, dry, tending to arid climate has been widely suggested in the literature during the Crato's time at Araripe Basin (Lima, 1983; see also Martins-Neto, 2006 to a revision). The new data here presented gives support to the more recent studies made with the other elements of the Early Cretaceous life in the basin, that proposed a hot, but not so arid climate, to this time in the interior areas of northeast Brazil (Carvalho, 2005; Dilcher *et al.*, 2005) or at least, maintain some dubiety about the dry conditions in the surrounding environments of the Araripe paleolake (Kunzmann *et al.*, 2006).

FINAL COMMENTS

The insect fauna described until the moment to Crato Member, Santana Formation, are revealing an unexpected diversity in the Lower Cretaceous times to northeast Brazil, presently dominated by Orthoptera (Ensifera and Caelifera), as well as Neuroptera. The present contribution reveals that this dominance also includes bizarre forms of Stenopelmatoidea members and new elements belonging to poorly known groups, such as Grylotalpoidea (to be described). Another interesting aspect regards to the use of those insects in paleoecology, showing groups morphologically as distinct as Euclydesinae and cearygryllyds exhibiting similar habitus, expressed in the ovipositor shape and length (notably long and narrow), body shape and robustness. This could represent a strategy in relation to the occupation of the ecological niche. Like was suggested also in previous works, under the soil lives a diverse community of burrowing crickets (Grylotalpoids and closely related species) and on the leaves, a diverse community of grasshoppers (especially Locustopsidae).

ACKNOWLEDGEMENTS

Thanks are due to Federica Menon (Manchester) for the English corrections, comments and suggestions, and to Carsten and Brigitte Brauckmann (Clausthal University, Germany), by the collaboration and friendship. This research was supported by the Centro de Ensino Superior de Juiz de Fora – CES/JF, Grant 228.18.08.2006.

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Submetido em 27/02/07

Aceito em 15/05/07