An isopod from the Codó Formation (Aptian of the Parnaíba Basin), Northeastern Brazil

*Um isópode da Formação Codó (Aptiano da Bacia do Parnaíba),
Nordeste do Brasil*

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ABSTRACT: The Codó Formation is a lithostratigraphic unit with predominant carbonate sedimentation of the Aptian age situated in the intracratonic Parnaíba Basin. In this formation, the only known crustaceans were conchostracans and ostracods. Systematic collections conducted in the Brejo city, in the Maranhão State, have provided new taxa for the cited lithostratigraphic unit. A new genus and species of isopod is described with the following set of features: cephalon elliptical deeply inserted in the first pereonite; eyes located dorsolaterally; body oblong oval; and isomorphic pereonites and pleonites, which indicate an affinity with the family Archaeoniscidae. The presence of this taxon in the limestone deposits from the Codó Formation reinforces prior inference of a lacustrine/marine paleoenvironments, and indicates a greater diversity of aquatic arthropods during the opening of the South Atlantic in the Early Cretaceous.

KEYWORDS: Archaeoniscidae; Codó Formation; Parnaíba Basin.

RESUMO: A Formação Codó constitui unidade litoestratigráfica com predominância de sedimentação carbonática de idade aptiana, e situa-se na bacia intracratônica do Parnaíba. Nessa formação, os crustáceos eram conhecidos apenas por conchostráceos e ostracodes. Coletas sistemáticas realizadas no município de Brejo, Maranhão, forneceram novos taxa para a citada unidade litoestratigráfica. Um novo gênero e espécie de isópode é descrito apresentando o conjunto de caracteres: céfalo elíptico, profundamente inserido no primeiro pereonite; olhos localizados dorsolateralmente; corpo oblongo-ovalar; e presença de pereonites e pleonites isomórficos indicando afinidade com a família Archaeoniscidae. A ocorrência deste táxon em depósitos calcários da Formação Codó reforça prévias inferências de paleoambiente lagunar/marinho, e demonstra uma diversidade maior de artrópodes aquáticos durante a abertura do Atlântico Sul no Cretáceo Inferior.

PALAVRAS-CHAVE: Archaeoniscidae; Formação Codó; Bacia do Parnaíba.

INTRODUCTION

The Codó Formation is distributed over an area of approximately 170,000 km² (Lima 1982) and is part of the Mesozoic sedimentary sequences in the Parnaíba Basin. This lithostratigraphic unit is composed of bituminous shales, evaporites, limestones, and sandstones formed under low-energy lacustrine environmental conditions with water stratification, which resulted in episodes of anoxia (Reis & Caputo 2007). Faciologial and palynostratigraphic studies of this unit indicate an Aptian/Albian age (Lima 1982, Rossetti *et al.* 2001, Antonioli 2001). Fossil occurrences date back to the first half of the 20th century and include fishes, crustaceans, plants, insects, and gastropods (Lisboa 1914, Cardoso 1962, Pinto & Ornellas 1974, Lima & Leite 1978). The ichthyofauna is

the most significant of these fossils and can be correlated to the Santana Formation in the Araripe Basin and Riachuelo Formation in the Sergipe/Alagoas Basin (Santos & Carvalho 2009).

Crustaceans in these deposits are rare and poorly studied; until recently, they were only represented by ostracods and conchostracans (Cardoso 1962, Leite *et al.* 1975, Lima & Leite 1978, Krömmelbein & Weber 1985, Silva *et al.* 1985, 1989). In the city of Brejo (Fig. 1), northeastern Maranhão, outcrops attributed to the Codó Formation occur in open pit mines at two locations: Faveirinha Quarry and Perneta Ranch. In these outcrops, the collections have allowed finding new crustaceans such as decapods and a rare appendage print, which might be related to the infraorder Brachyura (Lindoso *et al.* 2011).

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This study aims to describe a new genus and species of isopod for the Codó Formation (Aptian of the Parnaíba Basin), which is the third species from Brazil described for the Cretaceous. Paleoenvironmental inferences are also made from this new fossil.

Geological setting

The new isopod comes from the intracratonic Parnaíba Basin located in a large area of the western portion of Northeast Brazil, covering the states of Maranhão, Piauí and part of Tocantins, Pará, Ceará and Goiás. This basin has a total area of 600,000 km², and its sedimentary succession is 3,500 m thick in its depocenter, 500 m of which belong to Mesozoic rocks (Campbell 1949, Mesner & Wooldridge 1964).

The sedimentary and magmatic succession of the Parnaíba Basin is divided into five supersequences: Silurian, Middle-Devonian, Early-Carboniferous, Late-Carboniferous-Early-Triassic, Jurassic, and Cretaceous, and the latter consists of the following formations: Corda, Grajaú, Codó and Itapecuru (Vaz *et al.* 2007). However, according to Carneiro (1974) and Rezende (2002), the Corda, Grajaú and Codó formations are interfingered and chronostratigraphically equivalent. The Corda Formation is composed of reddish-brown, very fine, semi-friable and semi-cohesive sandstones. The Grajaú Formation, in turn, consists of whitish-pale-beige medium/coarse sandstones and conglomeratic levels. In the Codó Formation, there are bituminous shales, siltstones, limestones, evaporites, and sandstones. Superimposed on these deposits is the Itapecuru Formation of the Middle-Albian-Late Cretaceous age, which is composed of fine, friable sandstones and pelites (Vaz *et al.* 2007).

The areas where the Codó Formation occurs are restricted and discontinuous, appearing in river beds that

drain the central basin at the confluence of the Tocantins and Araguaia rivers, approaching the Parnaíba River, in the Brejo city and Codó (Santos & Carvalho 2009). The inferred age for these deposits is Aptian/Albian (Lima 1982), and their strata are deposited in an arid to semiarid climate regime (Rossetti *et al.* 2001).

According to Lima & Leite (1978), paleontological data indicate deposition occurred under marine and brackish lacustrine environments. The stratigraphic and faciological analyses in the region of Codó, Maranhão State, by Rossetti *et al.* (2001) indicated three depositional environments: (1) central lake; (2) transitional lake; and (3) marginal lake. The depositional environments were interpreted in the upper sequence, which corresponds to an upper shoreface, interdistributary lagoon/bay, suspension lobe, and distributary channel (Rossetti *et al.* 2001, Paz & Rossetti 2001). In a palynostratigraphic study, Antonioli (2001) divided the Codó Formation into three lithostratigraphic units: (1) Lower, which had an incipient marine character; (2) Middle, which was essentially evaporitic; and (3) Upper, which had a marine character.

MATERIALS AND METHODS

Nine isopods were collected in the Faveirinha Quarry (42°44'45,4"W and 03°49'20,1"S) and Perneta Ranch (42°44'21,1" W and 03°48'50,0"S), located approximately 20 km from the city of Brejo, northeastern Maranhão. These outcrops have a predominantly carbonatic lithology interbedded with marls; the Faveirinha Quarry is currently abandoned (Fig. 2). The specimen UFRJ DG 170-Cr is bidimensionally preserved in a fragment of massive limestone, which was subjected to mechanical preparation techniques and photographed under a binocular Carl Zeiss Discovery v.12 lens. It is housed in the paleontological collection of the Geology Department of the Federal University of Rio de Janeiro.

PALEONTOLOGICAL SYSTEMATICS

MALACOSTRACA Latreille, 1802

ISOPODA Latreille, 1817

SPHAEROMATIDEA Wägele, 1989

SPHAEROMATOIDEA Latreille, 1825

ARCHAEONISCIDAE Haack, 1918

Codoisopus gen. nov.

(Fig. 3)

Etymology. The generic name refers to the Codó Formation, the lithostratigraphic unit where the specimen comes from.

Figure 1. Location of the city of Brejo, Maranhão State.

Diagnosis. The same as for the species. *Codoisopus brejensis* gen. nov. et sp. nov.

Etymology. The specific designation, *brejensis* (latin), refers to Brejo city.

Holotype. UFRJ DG 170-Cr

Location. Faveirinha Quarry, city of Brejo, Maranhão State.

Stratigraphic Context. Parnaíba Basin, Codó Formation, Lower Cretaceous (Aptian).

Diagnosis. Body oblong-oval measuring 13 mm length and 7 mm width. Cephalon elliptical deeply inserted within the first pereonite. Dorsolateral eyes; somites thoracic and abdominal isomorphic (seven pereonites and five pleonites). Pleotelson small, subtriangular, having half the length of the pereon. Presence of subrectangular exopodites.

DESCRIPTION

Specimen UFRJ-DG 170-Cr measures 13 mm length and 7 mm width. It is dorsoventrally preserved in light-yellow massive limestone. The entire body is preserved in dorsal view. It is possible to identify the cephalon, which has the first somite diamond-shaped and a total of 12 thoracic

and abdominal somites, which gives it an oblong-oval shape. Antennules and antennae are not preserved. Exopodites only occur as printings. The pleotelson is subtriangular and twice the length of the pereon.

DISCUSSION

The fossil record for isopods has been limited, partly due to their small size (usually less than 30 mm) and delicate structure (Taylor 1972). Therefore, isopods are rare but important ecological forms, especially in benthic marine habitats (Ruppert *et al.* 2005).

The occurrence of these crustaceans in Brazil is notable as only two species have been described: *Unusuropode castroi* Duarte & Santos (1962), Turonian of the Group Apodi, Açú Sandstone, Ceará, and *Saucrolus silvai* Santos (1971), Aptian of the Areado Formation in the Sanfranciscana Basin. For the carbonate deposits of Brejo, Maranhão, which correspond to the Codó Formation, a new genus and species of isopod, *Codoisopus brejensis* gen. et sp. nov., is proposed. This species differs from *U. castroi* for having elliptical cephalon and lateral pleural expansions that are strongly distally arched, although the possibility

Figure 2. Stratigraphic profile of the Faveirinha Quarry in the city of Brejo, Maranhão (A); Geological cross-section of the same outcrop demonstrating the predominance of carbonate sedimentation (B); Panoramic view of the site where the isopod was found (C).

Figure 3. Isopod *Codoisopus brejensis* gen. et sp. nov. in dorsal view (A); Reconstitution of *C. brejensis* gen. et sp. nov. from identifiable regions (B). Ce: cephalon, Pe: pereon (= 7 pereionites), Pl: pleon (= 5 pleonites), Pt: pleotelson, Ex: exopodites.

that this feature was taphonomically produced has not been ruled out, both 7 pereionites and 5 pleonites, and reduced, subrectangular exopodites. Such distinct features also distance *C. brejensis* gen. et sp. nov. from any association with *S. silvai*, which exhibits a sub-hexagonal body with trilobed and subtriangular ophistosoma that distally narrows toward the pleotelson. However, *C. brejensis* gen. et sp. nov. exhibits the following features observed for taxa belonging to the family Archaeoniscidae (Haack 1918): a cephalon elliptical deeply inserted in the first pereionite, eyes dorso-laterally located, body oblong-oval, and the presence of seven similar pereionites. According to Vega *et al.* (2005), Archaeoniscidae is a monogeneric extinct family which belongs to the suborder Sphaeromatidea (Wägele 1989), that includes the taxa *Archaeoniscus brodiei* Milne Edwards, 1843, from the Late Jurassic of Europe, which represents the species type, *Archaeoniscus texanus* Wieder & Feldmann 1992 from the Late Cretaceous of Texas, and *Archaeoniscus aranguthyrorum* Feldmann, Vega, Applegate and Bishop, 1998 from the Late Albian of Mexico. *C. brejensis* gen. et sp. nov. shares only the general body shape and number of pereionites (seven) with *A. brodiei* (Milne Edwards 1843, Feldmann *et al.* 1998). In turn, *C. brejensis* gen. et sp. nov. also differs from *A. texanus* because the latter has a markedly oblong body, semicircular pleotelson, and an oval protuberance in the axial region (Wieder & Feldmann 1992). The new Brazilian taxon resembles the taxon *A. aranguthyrorum* from the Middle Member of the lithographic limestones of the Tlayúa Formation, in the quarries of Tepexi de Rodríguez, Puebla, Mexico. Prior paleoenvironmental

interpretations of a restricted lagoon with episodes of marine incursions and fluvial influence in these deposits are consistent with the nature of the arthropod fauna (Feldmann *et al.* 1998, Applegate *et al.* 2005, Vega *et al.* 2005).

In addition, members of the family Archaeoniscidae are characterized by a posterior sagittal crest that extends from the central portion of the pleotelson toward the base of the first pereionite, which is a feature apparently absent in *C. brejensis* gen. et sp. nov. In fact, Feldmann *et al.* (1998) interpreted this feature as being the dorsal reflection of a ventral structure in females, which is most likely an incubator chamber (sexual dimorphism). Given the set of features outlined above, we propose a new genus and species of isopod for the Cretaceous of Brazil (Codó Formation, Parnaíba Basin) (Fig. 3).

To date, faciological studies have indicated a strictly lacustrine depositional environment for the Codó Formation; therefore, no support for a possible marine invasion existed (Paz & Rossetti 2001). However, when conducting palyno-chronostratigraphic studies in the Codó region, Antonioli (2001) concluded the Codó Formation was deposited in an environment sometimes continental (lacustrine) and sometimes coastal marine, and the presence of dinoflagellates becomes steadier toward the upper strata (Antonioli & Arai 2002).

However, the presence of *C. brejensis* gen. et sp. nov. in carbonatic deposits of Brejo and the associated paleobiota reinforce prior inferences of a marine/lacustrine paleoenvironment for the Codó Formation, which was first only supported by palynological evidence. The

paleobiota recorded in Brejo, Maranhão, includes coquina with gastropods, decapods, plants, ichnofossils and euryhaline fishes (Lindoso 2012). Moreover, this finding is in accordance with the hypothesis of a marine transgression via the Parnaíba Basin during the Lower Cretaceous (Maisey 1991, 2000, 2011; Arai 1995, 1999, 2000, 2011).

FINAL CONSIDERATIONS

Until recently, the only known crustaceans from the Codó Formation were conchostracans and ostracods. Recent fieldwork conducted at the Faveirinha Quarry, municipality of Brejo, Maranhão State, identified a new genus and species of isopod for the Cretaceous of Brazil (Codó Formation, Parnaíba Basin). *C. brejensis* gen. et sp. nov. shares features with taxa of the family Archaeoniscidae Haack, 1918, which was not yet documented in Brazil.

This finding demonstrates the lack of knowledge about this group of crustacean fossils in Brazilian sedimentary basins. In

addition, the occurrence of *C. brejensis* gen. et sp. nov. in carbonate deposits of the Codó Formation along with a diverse paleobiota composed of gastropods, decapods, plants, ichnofossils, and fishes reinforces prior inferences of a marine/lacustrine paleoenvironment for the cited lithostratigraphic unit. However, the collection of new specimens with greater anatomical detail is necessary to better understand the biota diversity of aquatic arthropods during the opening of the South Atlantic.

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REFERENCES

- Antonoli L. 2001. *Estudo palino-cronoestratigráfico da Formação Codó – Cretáceo Inferior do Nordeste brasileiro*. Tese de Doutorado, Instituto de Geociências, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 265 p.
- Antonoli L. & Arai M. 2002. O registro da Ecozona *Subtilisphaera* na Formação Codó (Cretáceo Inferior da Bacia do Parnaíba, Nordeste do Brasil): seu significado paleogeográfico. In: Simpósio Sobre o Cretáceo do Brasil, 6, São Pedro – SP, *Boletim*. Rio Claro, p. 25-30.
- Applegate S.P.L., Espinosa-Arrubarrena J., Alvarado-Ortega, Mouloud B. 2005. Revision of recent investigations in the Tlayúa Quarry. In: Vega F.T.G., Nyborg M.C., Perrillat M., Montellano-Ballesteros S.R.C., Cevallos-Ferriz, & Quiroz-Barroso S. (eds) *Studies on Mexican Paleontology, Topics in Geobiology*. The Netherlands, Springer, p. 265-291.
- Arai M. 1995. *Hipótese de entrada do mar albo-aptiano na Bacia do Araripe, via bacias de São Luís/Parnaíba: novas evidências baseadas na Ecozona de Subtilisphaera (Dinophyceae)*. Anais da Academia Brasileira de Ciências, Resumo das Comunicações, 67, p. 394.
- Arai M. 1999. Transgressão marinha mesocretácea: sua implicação no paradigma da reconstituição paleogeográfica do Cretáceo no Brasil. In: Simpósio sobre o Cretáceo do Brasil, 5/ Simpósio Sobre O Cretáceo de América Del Sur, 1. Serra Negra, *Boletim*. Rio Claro, p. 577-582.
- Arai M. 2000. Chapadas: relicts of mid-Cretaceous interior seas in Brazil. *Revista Brasileira de Geociências*, 30:436-438.
- Arai M. 2011. Paleogeografia do Atlântico Sul no Aptiano: um novo modelo a partir de dados micropaleontológicos recentes. *Boletim de Geociências da Petrobras*, 17(2):331-351.
- Campbell D.F. 1949. *Revised report on the reconnaissance geology of the Maranhão Basin*. Rio de Janeiro, Conselho Nacional do Petróleo, Relatório Interno, 117 p.
- Cardoso R.N. 1962. Alguns conchostráceos mesozoicos do Brasil. *Boletim da Sociedade Brasileira de Geologia*, 25(2):21-28.
- Carneiro M.V. 1974. *Mapeamento estrutural da área de Grajaú-Imperatriz*. Belém, Petrobras, Relatório Técnico 358, 45 p.
- Duarte L. & Santos R.S.S. 1962. Fósseis do Arenito Açú. *Anais da Academia Brasileira de Ciências*, 34(1):57-68.
- Feldmann R.M., Vega F.J., Applegate S.P., Bishop G.A. 1998. Early Cretaceous arthropods from the Tlayúa Formation at Tepexi de Rodríguez, Puebla, Mexico. *Journal of Paleontology*, 72:79-90.
- Haack W. 1918. Ueber einen Isopoden aus dem Sepulit des weslichen, Osnege (Archaeoniscus Brodei, Milne-Edwards). *Jahrbuch der Königlichen Preussischen Geologischen Landesanstalt*, 39:73-102.
- Krömmelbein K. & Weber R. 1985. *Ostracodes do "Wealden" do Nordeste brasileiro*. Tradução. G. Beurlen. Rio de Janeiro, Petrobras, Cerpes, Sintep, Ciência-Técnica-Petróleo. Seção de Exploração de Petróleo, Publ. 16, 63 p.
- Latreille P.A. 1802-1803. *Histoire naturelle, générale et particulière, des crustacés et des insectes*, Volume 3, Paris, Dufart F., 468 p.
- Latreille P.A. 1817. Les crustacés, les arachnides et les insectes. In: Cuvier G., *Le regne animal distribué d'après son organisation, pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée*, Volume 3, Paris, Dérerville, p. 1-653.
- Latreille P.A. 1825. *Familles naturelles du règne animal, exposées succinctement et dans un ordre analytique, avec l'indication de leurs genres*. Paris, Baillière, 570 p.
- Leite J.F., Aboarrage A.M., Daemon R.F. 1975. *Projeto Carvão da Bacia do Parnaíba*. Recife, DNPM/CPRM, Relatório Final das Etapas II e III, 5.
- Lima E.A.A. & Leite J.F. 1978. *Projeto estudo global dos recursos minerais da bacia sedimentar do Parnaíba*. Recife, Integração Geológica-Metalogenética, DNPM/CPRM, Relatório, 437 p.

- Lima M.R. 1982. Palinologia da Formação Codó na região de Codó, Maranhão. *Boletim do Instituto de Geociências, USP*, **13**:116-128.
- Lindoso R.M., Carvalho I.S., Medeiros M.A., Pereira A.A., Santos R.A.B., Mendes I.D., Brito J.M., Vilas Bôas I., Araújo M.N., Ferreira N.N. 2011. Novos sítios fossilíferos em carbonatos da Formação Codó (Aptiano/Albiano) da Bacia do Parnaíba, Maranhão, Brasil. In: Carvalho I.S., Srivastava N.K., Strohschoen Jr. O.S., Lana C.C., (eds), *Paleontologia: Cenários de Vida*. Volume 4, Interciência, p. 819-827.
- Lindoso R.M. 2012. *Paleobiota dos depósitos calcários de Brejo, Maranhão (Formação Codó, Bacia do Parnaíba), Nordeste do Brasil*. Dissertação de Mestrado, Instituto de Geociências, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 73 p.
- Lisboa M.A.R. 1914. The Permian geology of Northern Brazil. *American Journal of Science*, **4**(37):425-443.
- Maisey J.G. (ed). 1991. *Santana Fossils: an illustrated atlas*. Neptune City, NJ, T.F.H. Publications, 459 p.
- Maisey J.G. 2000. Continental break up and the distribution of fishes of Western Gondwana during the Early Cretaceous. *Cretaceous Research*, **21**:281-314.
- Maisey J.G. 2011. Northeastern Brazil: out of Africa. In: Carvalho I.S., Srivastava N.K., Strohschoen Jr. O.S., Lana C.C. (eds), *Paleontologia: Cenários de Vida*, Volume 4, Interciência, p. 545-559.
- Mesner J.C. & Wooldridge L.C.P. 1964. Estratigrafia das bacias paleozóica e cretácea do Maranhão. Rio de Janeiro, *Boletim Técnico PETROBRAS*, **7**(2):137-164.
- Milne Edwards H. 1843. Note sur deux Crustacés fossiles de l'Ordre des Isopodes. *Annales des Sciences Naturelles, 2e série (Zoologie)*, **20**:326-329.
- Paz J.D.S. & Rossetti D.F. 2001. Reconstrução paleoambiental da Formação Codó (Aptiano), borda leste da Bacia do Grajaú, MA. In: Rossetti D.F., Góes A.M., Truckenbrodt W. (eds), *O Cretáceo na Bacia de São Luís-Grajaú*. Belém, Museu Paraense Emílio Goeldi, Coleção Friedrich Katzer, p. 77-100.
- Pinto I.D. & Ornellas L.P. 1974. New cretaceous Hemiptera (Insects) from Codó Formation – Northern Brazil. In: Congresso Brasileiro de Geologia, 28, *Anais*, p. 289-304.
- Reis D.E.S. & Caputo M.V. 2007. Potencial industrial e energético do folhelho pirotetuminoso Formação Codó, Bacia do Parnaíba. In: 4º PDPETRO, Campinas, SP, p. 1-10.
- Rezende N.G.A.M. 2002. *A zona zeolítica da formação corda, Bacia do Parnaíba*. Dissertação de Mestrado, Instituto de Geociências, Universidade Federal do Pará, Belém, 142 p.
- Rossetti D.F., Góes A.M., Arai M. 2001. A passagem Aptiano-Albiano na Bacia do Grajaú. In: Rossetti D.F., Góes A.M., Truckenbrodt W. (eds), *O Cretáceo na Bacia de São Luís-Grajaú*. Belém, Museu Paraense Emílio Goeldi, Coleção Friedrich Katzer, p. 101-117.
- Ruppert E.E., Fox R.S., Barnes R.D. (eds). 2005. *Zoologia dos invertebrados: uma abordagem funcional-evolutiva*. São Paulo: Roca, 1.168 p.
- Santos M.E.C.M. 1971. Um novo artrópodo da Formação Areado, Estado de Minas Gerais. *Anais da Academia Brasileira de Ciências*, **43**(2):415-420.
- Santos M.E.C.M. & Carvalho M.S.S. 2009. *Paleontologia das bacias do Parnaíba, Grajaú e São Luís*. Rio de Janeiro: CPRM Serviço Geológico do Brasil- DGM/DIPALE, 215 p.
- Silva M.D., Kaercher E.G., Barbosa E.G.S. 1985. Bioestratigrafia do furo 1-UN-32-PI, Roça do Meio, Município de Duque Bacelar, Formação Codó, Cretáceo Inferior, bacia do Maranhão. In: Congresso Brasileiro de Paleontologia, **9**, Fortaleza, *Resumos*, SBP, p. 80.
- Silva M.D., Barbosa E.G.S., Kaercher E.G. 1989. Bioestratigrafia do furo 1-UN-24, Buriti, Maranhão, Formação Codó, Cretáceo Inferior da bacia do Maranhão. In: Simpósio de Geologia do Nordeste, **13**, Fortaleza, Atas, SBG, Núcleo Nordeste, p. 188-192.
- Taylor B.J. 1972. An urdidid isopod from the Lower Cretaceous of South-East Alexander Island. *Br. Antarct. Surv. Bull.*, **27**:97-103.
- Vaz P.T., Rezende N.G.A.M., Filho J.R.W., Travassos W.A.S. 2007. Bacia do Parnaíba. Rio de Janeiro, *Boletim de Geociências Petrobras*, **15**(2):253-263.
- Vega F.J., Bruce N.L., Serrano L., Bishop G.A., Perrilliat M.C. 2005. A review of the Lower Cretaceous (Tlayúa Formation: Albian) Crustacea from Tepexi de Rodríguez, Puebla, Central Mexico. *Bulletin of the Mizunami Fossil Museum*, **32**:25-30.
- Wägele J.W. 1989. Evolution und Phylogenetisches System der Isopoda. Stand der Forschung und neue Erkenntnisse. *Zoologica (Stuttgart)*, **140**:1-262.
- Wieder R.W. & Feldmann R.M. 1992. Mesozoic and Cenozoic fossil isopods of North America. *Journal of Paleontology*, **66**:958-972.