

A New Permian Bivalve (Megadesmidae, Plesiocyprinellinae) from the Serrinha Member, Rio do Rasto Formation, Paraná Basin, Brazil

Um Novo Bivalve Permiano (Megadesmidae, Plesiocyprinellinae) do Membro Serrinha (Formação Rio do Rasto), Bacia do Paraná, Brasil

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Received 24 August 2009; accepted 11 January 2010

ABSTRACT

During a recent inspection in the Paleontological Collection of the Institute of Geosciences, University of São Paulo, we have identified some specimens of undescribed mollusk bivalves. These called our attention for the following reasons: a) all specimens are internal molds of conjugated and closed articulated valves, some of them presenting fragments of silicified shells; b) all internal molds have similar general shape and internal characters, representing specimens of the same taxon; c) the internal molds and silicified valves are well preserved, including fragile structures, which are hardly preserved, such as the internal mold of the external ligament and muscle scars; d) and equally important, according to the labels of all specimens, they were collected from rocks of the Passa Dois Group (Permian), Serrinha Member of the Rio do Rasto Formation. Although who collected the shells and the precise geographic location of the specimens are still unknown, the detailed study of these fossils brings us to the conclusion that they are morphologically distinct from any heretofore published genus of the endemic fauna of bivalves from Passa Dois Group. Based in its general shape, hinge structure and muscles scars, the new form can be classified under the Family Megadesmidae Vokes, 1967, the most diverse group of Permian bivalves of the Paraná Basin. The specimens are referred as *Beurlenella elongatella* new gen. and sp. The shell shape and taphonomy indicate that this bivalve was a shallow, rapid, active burrower, suspension feeder, probably preserved in situ, in event deposits.

Keywords: Bivalvia; Megadesmidae; Permian; Paraná Basin; Serrinha Member; Rio do Rasto Formation.

RESUMO

Durante recente organização das coleções paleontológicas do Laboratório de Paleontologia Sistemática do Instituto de Geociências, Universidade de São Paulo, foram localizados alguns espécimes de moluscos bivalves, ainda não descritos, que chamaram nossa atenção pelas seguintes razões: a) todos os espécimes são moldes internos de valvas conjugadas, articuladas fechadas, alguns destes com restos da concha silicificada; b) todos os moldes internos têm a mesma forma geral e características internas, representando espécimes de um mesmo táxon; c) os moldes internos e as valvas silicificadas estão bem preservadas, e incluem estruturas frágeis de difícil preservação, tais como o molde interno do ligamento externo e também as cicatrizes musculares; d) e igualmente importante, todos os espécimes estão registrados como provenientes das rochas do Grupo Passa Dois (Permiano), Membro Serrinha, da Formação Rio do Rasto. Embora não existam informações sobre o autor da coleta e localização geográfica dos espécimes, o estudo detalhado da morfologia desses fósseis evidencia tratar-se de um gênero de bivalve distinto dos já descritos para a fauna endêmica do Grupo Passa Dois. Fundamentado na forma geral da concha, estrutura da charneira e cicatrizes musculares, o novo táxon é atribuído

à Família Megadesmidae Vokes, 1967, a mais diversificada dentre aquelas do Permiano da Bacia do Paraná. Os espécimes são aqui designados como *Beurlenella elongatella* gênero e espécie novos. A forma geral dos espécimes, bem como o modo de preservação, indica que se trata de um bivalve escavador raso ativo, rápido, suspensívoro, que foi provavelmente preservado *in situ*, em depósitos gerados por sedimentação episódica.

Palavras-chave: Bivalvia; Megadesmidae; Permiano; Bacia do Paraná; Membro Serrinha; Formação Rio do Rasto.

INTRODUCTION

The classical endemic, Permian molluscan fauna of the Passa Dois Group, Paraná Basin (Mendes, 1952; Runnegar and Newell, 1971; Simões, Rocha-Campos, Anelli, 1998) includes, according to the present knowledge, the following biozones (Rohn, 1994) in stratigraphic succession: *Anhembia froesi* (Serra Alta and Corumbataí formations), *Pinzonella illusa* (Teresina and Corumbataí formations), *Pinzonella neotropica* (Teresina and Corumbataí formations), *Leinzia similis* (Rio do Rasto Formation, Serrinha Member), and *Palaeomutela? platinensis* (Rio do Rasto Formation, Morro Pelado Member). Most of the previous studies have dealt with the systematics, paleoecology and taphonomy of bivalves of the *Pinzonella illusa* and *Pinzonella neotropica* biozones, where the shells are usually silicified and well preserved (Torello and Simões, 1994; Simões and Anelli, 1995; Simões, Torello, Rocha-Campos, 1996; Simões et al., 1997; Simões, Rocha-Campos, Anelli, 1998; Simões and Kowalewski, 1998; Ghilardi, 1999; Mello, 1999; Kowalewski et al., 2000; Ghilardi and Simões, 2002; Simões et al., 2000; Simões and Torello, 2003). Less well known are the faunas of the Serra Alta Formation (*Anhembia froesi* Biozone, Maranhão and Petri, 1996), and Serrinha (*Leinzia similis* Biozone) and Morro Pelado (*Palaeomutela? platinensis* Biozone) members, of the Rio do Rasto Formation. Actually, despite the exhaustive studies of Rohn (1985, 1988, 1994), and a short note in Rohn and Simões (1997), the bivalves of the Serrinha Member of the Rio do Rasto Formation are still poorly studied, described and drawn (Mendes, 1954; Rohn, 1994; Rohn and Simões, 1997). Several lines of evidences suggest that the bivalve fauna of the Serrinha Member is more diverse than previously reported in the literature (see, for example, Rohn, 1994; Rohn and Simões, 1997). In fact, during a recent examination of the bivalve collection of the Institute of Geosciences, University of São Paulo a considerable number of forgotten, and undescribed bivalve specimens of the Serrinha Member were found. These specimens were donated to Professor Josué Camargo Mendes (Institute of Geosciences, University of São Paulo) in the seventies, when he immediately recognized the importance of those specimens, due to their good preservation (A. C. Rocha-Campos, personal communication, 2009). However, for

unknown reasons, J. C. Mendes was not able to study those bivalves, and since then, they have been forgotten. In the present study, we describe these bivalves with the following purposes: first, to add new systematic information about the bivalve fauna of the Serrinha Member; second, to show that the examination of this interval harbors bivalves could provide relevant taphonomical and paleoecological information, and finally, to call attention of geologists and paleontologists working with the Rio do Rasto Formation to the possible occurrence of unknown fossil material.

MATERIAL AND METHODS

As mentioned above, all specimens herein described are housed in the Scientific Collection of the Institute of Geosciences, University of São Paulo, São Paulo, under the code GP/1E. Although the specimens had been extracted from the rock matrix prior to their addition to that collection, the internal molds are made of grayish mudstone, which is the same matrix infilling of the closed articulated silicified shells. The type of preservation and lithology of the internal molds seem to be similar to that of bivalve-rich horizons found in the basal portion of Serrinha Member (see Rohn, 1994; Warren et al., 2008). However, the specimens were labeled only as placed in Passa Dois Group, Serrinha Member. Hence, the exact location and stratigraphic horizon where the specimens were collected are still unknown.

In total, ten bivalve specimens were studied and all of them are internal molds of conjugated valves of closed articulated shells. This set of specimens consists of three internal molds with silicified shell remains, six internal molds (two are almost completely preserved internal molds and four have the posterior end of the shell missing) and one deformed internal mold (dorso-ventrally compressed). Plasticine casts and impregnation with magnesium show internal anatomical characters of the examined specimens, including muscle scars and hinge features. Finally, the suprageneric systematics is based on Morris, Dickins and Astafieva-Urbaitis (1991), and, at the family level, on Runnegar and Newell (1971), Runnegar (1974), and Simões et al. (1997). Shell obesity and elongation indexes were calculated according to Stanley (1970).

SYSTEMATIC PALEONTOLOGY

Subclass HETEROCONCHIA Hertwig, 1895

Superorder ANOMALODESMATA Dall, 1899

Order PHOLADOMYOIDA Newell, 1965

Superfamily PHOLADOMOIDEA (King, 1844) Gray, 1847

Family MEGADESMIDAE Vokes, 1967

Subfamily PLESIOCYPRINELLINAE Simões et al., 1997

Comments. Runnegar and Newell (1971) assigned to Megadesmidae Vokes, 1967 the bivalves that yield robust and nacreous shells, with short siphons, a stout external ligament, lacking teeth or with a blunt tooth in the right or both valves. Simões et al. (1997) performed a cladistic analysis on the monophyly of the Family Megadesmidae and found it supported only by the blunt tooth of the right valve. The bivalve shells from the Serrinha Member have short and distinct nymph and a well marked blunt tooth in the right valve. These features suggest that the specimens belong to the Family Megadesmidae Vokes (1967). The absence of the accessory muscle scars (a, b, ava, see Runnegar, 1966, 1974) suggests affinities to the Subfamily Plesiocyprinellinae (Simões et al., 1997).

Genus *Beurlenella* new genus

Figures 1, 2, Table 1

Type-species. *Beurlenella elongatella* n. gen. and sp.

Diagnosis. Megadesmid very elongate posteriorly; anterior margin rounded and expanded. Umbonal ridge well defined, slightly curved, located very close to posterior dorsal margin. A well developed blunt tooth is present in the right valve.

Etymology. It is named *Beurlenella* in honor of the eminent German geologist Karl Beurlen (1901 - 1985), in recognition of his contribution to the knowledge of the paleontology and stratigraphy of the Gondwana sequence of the Paraná Basin (states of Paraná, Santa Catarina and Rio Grande do Sul), Brazil. Data gathered by K. Beurlen during the fifties provided some clues to understating of the evolution of the endemic molluscan fauna of the Passa Dois Group, Permian.

Remarks. The new genus *Beurlenella* has several characters that make it very distinct from other endemic bivalve species from the Permian Paraná Basin. Actually, the shells of *Beurlenella* share a set of common characters that, isolated, can be seen in distinct megadesmids of the Passa Dois Group. For example, the shells of *Beurlenella* are elongated; a feature also noted in *Jacquesia* Mendes, 1944, *Favalia* Mendes, 1962, and *Houdhausiella* Mendes, 1952, but, on the other hand,

these shells are edentulous or have a poorly developed megadesmid blunt tooth in the right valve. Carinate, elongated shells are also found in *Leinzia* (Holdhaus, 1918) and *Anhembia* (Mendes, 1949), but a remarkable rostrum, which is absent in *Beurlenella*, is present in the anterior extremity of these shells. Although *Plesiocyprinella* Holdhaus, 1918, and *Ferrazia* Reed, 1932 have a well developed megadesmid tooth in the right valve, just like *Beurlenella* does, those shells are not elongate. In addition to that, *Ferrazia* has a completely distinct ornamentation.

Beurlenella elongatella new species

Figures 1A to 1K, 1M, 1N, 2

Holotype. GP/1E 4816.

Comments: The holotype specimen GP/1E 4816 (Figures 1A to 1E) is an internal mold, which comprises a preserved and nearly complete silicified right valve, showing the expanded anterior region of shell, the umbonal carina located close to the posterior dorsal margin and the internal mold of the parivincular ligament.

Paratypes. GP/1E 4815, 4817, 4818, 4919, 4920, 4021, 4022, 4823, 4825.

Comments. Plasticine casts of hinge area of paratypes GP/1E 4815 (Figures 1G to 1I) and GP/1E 4825 (Figures 1J, 1K) clearly show the presence of megadesmid blunt in their right valves (arrows).

Diagnosis. As for the genus (see above).

Etymology: *elongatella*, referring to the posteriorly elongated nature of *Beurlenella* shells.

Stratigraphy. Passa Dois Group, Serrinha Member (?), Rio do Rasto Formation, eastern margin of the Paraná Basin.

Locality. Unknown.**Age.** Permian, Guadalupian to Early Lopingian.

Description. Megadesmid shell of medium size, varying in length from 44 - 49 mm for incomplete specimens (see Table 1), thick, equivalve, inequilateral, very elongate posteriorly, moderate inflated, non-gaped anteriorly. Posterior end of the shell unknown. Umbones low, slightly prosogyrous; postero-umbonal ridge, slightly curved, well defined but slender, located very close to posterior dorsal margin. Lunule absent; escutcheon very narrow. Ligament short, opisthodontic, parivincular, external, attached to a very slender nymph placed deep on the anterior portion of the escutcheon. Anterior margin expanded and rounded; ventral margin anteriorly convex and straight posteriorly; dorsal margin straight. Surface ornament of well-marked, irregularly spaced comarginal growth lines of varying width. Hinge of right valve with a well defined blunt tooth; left valve with a well defined socket. Posterior adductor

and pedal retractor scars well defined, not connected to the adductor. Anterior adductor muscle scars and pallial line not observed.

Discussion. The new species from Paraná Basin here described presents robust valves and a blunt tooth in the right valve, features that properly include them in the Family Megadesmidae. The elongated nature of their shells is also observed in other elements of the endemic fauna of the Passa Dois Group, such as *Holdhausiella* (Holdhaus) and *Jacquesia* (Reed). However, in these genera, the hinge is edentulous (*Holdhausiella*) or with a poorly developed megadesmid tooth in the right valve (*Jacquesia*). These hinge characteristics are in remarkable contrast with those shown by *Beurlenella elongatella*, where the megadesmid tooth is well developed. *B. elongatella* resembles *Favalia arcuata* in general shell shape (see Runnegar and Newell, 1971, p. 43, fig. 17b, e), but its shells are thicker and its obesity index is higher. In addition, the shells of *F. arcuata* are edentulous. Finally, the size and position of the opisthodontic ligament in *B. elongatella* are very similar to that observed in *Plesiocyprinella* (see Figures 1D, 1L).

TAPHONOMY, PALEOECOLOGY AND FACIES ASSOCIATION

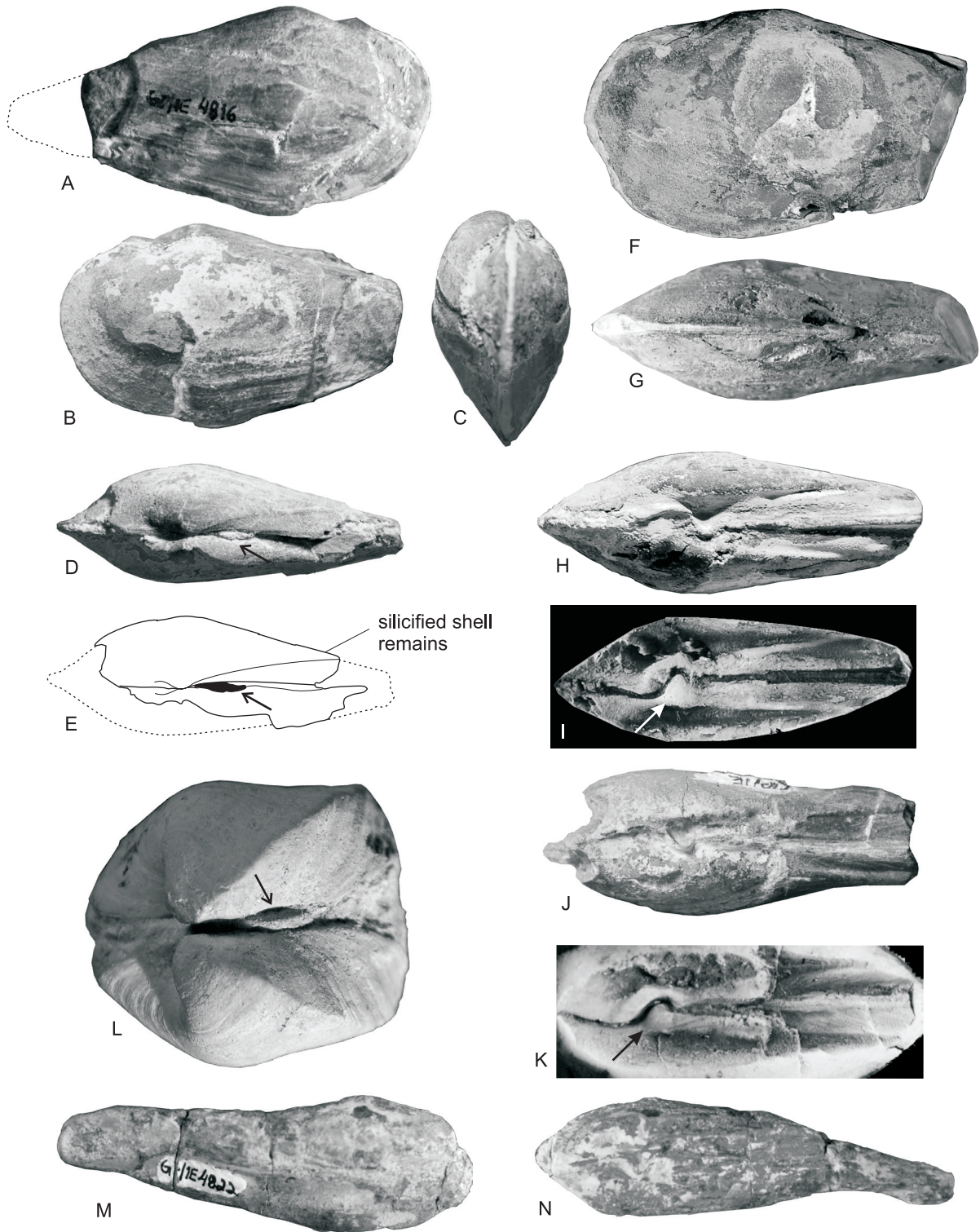
As demonstrated by Stanley (1970, 1972), Kondo (1987, 1989) and Ghilardi and Simões (2000), the biostratigraphy and functional anatomy of infaunal bivalves are potential sedimentological tools for stratigraphical analyzes. In this context, the mode of preservation and the paleoautoecology of the shells of *Beurlenella elongatella* can provide several clues about the kind of strata where they were preserved, despite the fact this information is missing.

Beurlenella elongatella is a very elongated, compressed to moderately inflated, non-gaped shell, with a broad anterior margin that may have accommodated a large foot during life. Hence, the anatomy of *B. elongatella* indicates that this species was an active, rapid, suspension-feeder and shallow burrower (see Stanley, 1970). In this context, the life habit of *B. elongatella* was similar to that of other megadesmids with posteriorly elongated shells, such as *Myonia*, *Holdhausiella* and *Jacquesia*, except, perhaps, by the fact that the new species was a rapid burrower. As suggested by Stanley (1970), recent bivalves with very

Table 1. Measurements (mm) of *Beurlenella elongatella* new gen. and sp.

Specimen Code	Valve	Length	Height	Width	Elongation	Obesity
					L/H	H/W
GP/1T 4818	R/L	49.68	25.88	-	1.92	-
GP/1T 4816	R/L	44.20	26.51	15.19	1.67	1.74
GP/1T 4825	R/L	-	27.74	17.74	-	1.56
GP/1T 4815	R/L	-	28.72	17.76	-	1.62
GP/1T 4817	R/L	-	24.03	14.33	-	1.68
GP/1T 4920	R/L	-	27.42	-	-	-

Figure 1. A-K, M-N, *Beurlenella elongatella* new gen. and sp., Passa Dois Group, Serrinha Member, Paraná Basin, Permian. All specimens x1.3. **A.** Incomplete silicified internal mold with silicified shell remains, right valve view, GP/1E 4816. **B.** Internal mold with fragments of silicified shell, left valve view, same specimen. **C.** Anterior view, same specimen. **D.** Dorsal view, same specimen, with the internal mold of the ligament preserved (arrow). **E.** Drawing representation of the dorsal view, same specimen. **F.** Incomplete internal mold, left side view, GP/1E 4815. **G.** Ventral view, same specimen. **H.** Dorsal view, same specimen showing hinge region. **I.** Plasticine mold, internal view of articulated hinge region, showing the blunt tooth of right valve (arrow), based on the same specimen. **J.** Internal mold showing the posterior part of shell covered with silicified shell, dorsal view, GP/1E 4825. **K.** Plasticine mold, internal view of articulated hinge region, showing the blunt tooth of right valve (arrow), based on the same specimen. **L.** *Plesiocyprinella carinata* (Holdhaus) 1918, Corumbataí Formation, Upper Permian; silicified articulated shell, dorsal view showing the silicified ligament (arrow), DZP-681. **M.** Almost dorsoventrally compressed internal mold, right side view, GP/1E 4822. **N.** Dorsal view, same specimen.



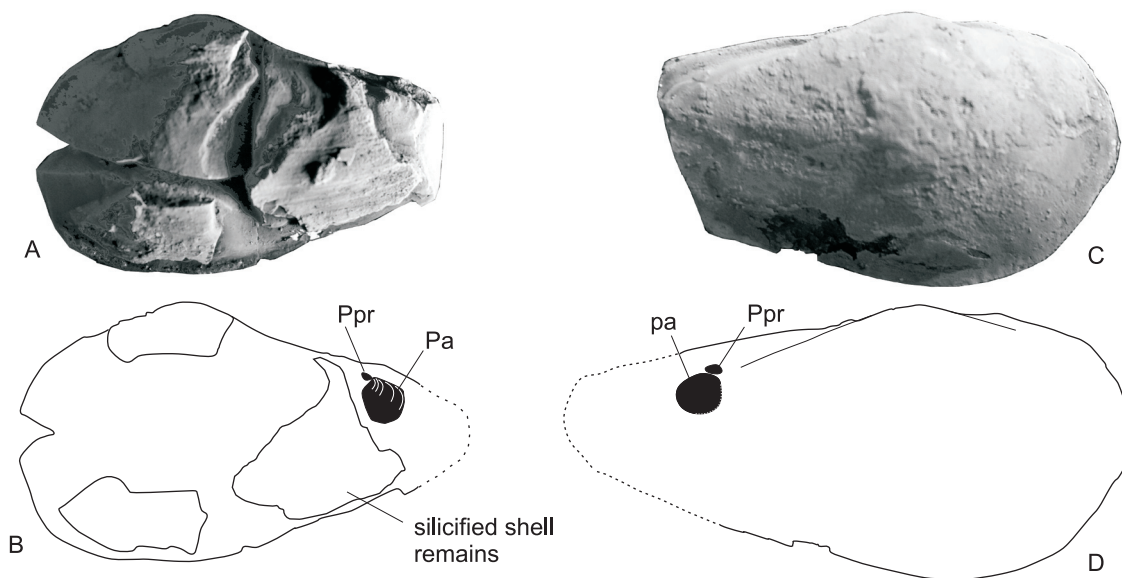


Figure 2. *Beurlenella elongatella* new gen. and sp., Passa Dois Group, Serrinha Member, Paraná Basin, Upper Permian. All specimens $\times 1.3$. **A.** Fragmentary internal mold with silicified shell remains, left side view, GP/1E 4819. **B.** Muscle scars based in the same specimen. **C.** Fragmentary internal mold, right side view, GP/1E 4815. **D.** Muscle scars based on the same specimen. Muscles scar, **ppr** = posterior pedal retractor, **pa** = posterior adductor.

elongated valves use very little or no rocking movement (see also Rocha-Campos and Simões, 1993) and the foot of these bivalves normally emerges in a direction parallel to the long axis of the shell. In this way, the mode of life of *B. elongatella* was probably with its shell positioned with the main axes nearly perpendicular to bedding. It was inferred that the mode of life of Late Paleozoic megadesmids was similar (see Rocha-Campos and Simões, 1993). Since the shells keep the same position when burrowing into the sediment (Stanley, 1970), bivalves with very elongated shells are preserved *in situ*, within the substrate, in the same position (see Anelli, Simões, Rocha-Campos, 1998). In other words, erosional and rapid depositional events can be identified based only on the preserved position of the infaunal bivalve shells (Ghilardi and Simões, 2000). Finally, like other megadesmids, *B. elongatella* was probably a suspension-feeder bivalve, indicating that food resources were dominantly in suspension in the water.

The taphonomy and functional morphology of Paleozoic marine bivalves are well known from a number of papers (see a review in Ghilardi, 1999). Most of shell-rich beds from Paleozoic epeiric seas (see, for example, Brett and Baird, 1986), as was the case of Paraná Basin during the Mid Permian, were formed under the influence of storms (see Torello and Simões, 1994; Simões, Torello, Rocha-Campos, 1996, Simões et al., 2000; Simões

and Kowalewski, 1998; Simões and Torello, 2003). As discussed by Kondo (1997), storm process may be erosional or depositional, depending on the environment and severity of the storm. In shallow water (well above storm wave base), or in very shallow seas (as it was the case of Paraná Basin), a large amount of sediment may be removed during storms, causing infaunal disruption. On the middle to lower shelf (well below the normal wave base), however, there may be rapid deposition of suspended muddy blankets after a storm, without significant erosion or substrate disruption. Thus, the sedimentological and taphonomical record of bivalve shells within a storm-dominated succession will differ greatly, depending on the position with respect to water depth or storm wave base (see Rodrigues, Simões, Leme, 2003, for a similar pattern with Paleozoic cnidarians).

As demonstrated by various authors (Seilacher, 1982; Seilacher, Reif, Westphal, 1985; Brett and Baird, 1986; Brett, 1990; Brett and Seilacher, 1991; Anelli, Simões, Rocha-Campos, 1998; Simões and Kowalewski, 1998), infaunal bivalves preserved *in situ* are invariably associated to storm events, especially obrution deposits. The shells of *B. elongatella* are conjoined and pristine. Although the original position in the rock matrix is missing, the fact that the shells are closed articulated, without signs of abrasion, fragmentation, and encrustation, indicates that those shells

were not exposed to the sediment/water interface. In summary, there are no signs that *B. elongatella* shells were repeatedly washed out and transported, which ultimately indicates that the shells were probably preserved in deposits generated just in and/or below storm wave base, probably in distal tempestites (obration deposits).

Hummocky and swaley cross-stratification, which have often been pointed out as sedimentary structures characteristic of storm events, are in fact the unique sedimentary structures originated during storm sedimentation. Therefore we may search in the stratigraphical record of the Rio do Rasto Formation for the most plausible interval where storm sedimentation prevails. These intervals are likely to preserve bivalve shells with similar taphonomic signatures, as those found in the shells of *B. elongatella*. According to Warren et al. (2008), the lower portion of the Rio do Rasto Formation is characterized by beds that were deposited in offshore environments subjected to storm action (see also Rohn, 1994). These rocks are part of storm-dominated facies, where sandstones with hummocky cross-stratification and heterolithic mudstones are common (Warren et al., 2008). This lower portion of the Rio do Rasto Formation is part of the interval of the Serrinha Member, the same assigned in the label of our examined specimens. According to Rohn (1994) and Rohn and Simões (1997), the base of the Serrinha Member is, in part, the interval of the *Leinzia similis* Biozone, but when considering the examined collection, typical members of this biozone are missing. However, Rohn and Simões (1997) have defined a distinct (unnamed) bivalve biozone in the basal portion of the Serrinha Member, which is a little older than the typical *Leinzia similis* Biozone. The bivalves from this interval are commonly preserved as molds in green-yellowish shale, as articulated valves, either closed or butterflyed, some probably preserved *in situ* (Rohn and Simões, 1997). Hence, the taphonomical conditions of the bivalve shells present in this basal interval are similar to that of the specimens herein described. Alternatively, however, it should be remembered that the fact that the studied shells are close articulated does not exclude *per se* the possibility of an occurrence of these shells in the strata of the Morro Pelado Member of the Rio do Rasto Formation. This is explained by the fact that some shells of the *Palaeomutela? platinensis* Biozone (above the Serrinha Member) were also found articulated (Rohn, 1994), indicating they were abruptly buried by sediments associated to turbulent hyperpycnal flows, such as at river mouths in lakes (R. Rohn, personal communication, 2009). Unfortunately, only further research can confirm or refute the assertion above mentioned, named the identification of bivalve shells preserved *in situ* in storm deposits in the basal portion of the Rio do Rasto Formation (Serrinha Member), or otherwise in marginal lacustrine to fluvial deposits in the

mid portion of this unit (Morro Pelado Member). Since the studied specimens were labeled as “Serrinha Member”, the first option seems to be the most plausible in light of the information available.

FINAL REMARKS

All the examined specimens were referred to the new megadesmid genus and species *Beurlenella elongatella*. It is not a surprise that the small assemblage studied here is dominated by megadesmid bivalves, since this group was the most diverse and abundant in the Paraná Basin during Permian times. Hence, our data is not only another indication of the dominance of Megadesmidae in the Passa Dois Group fossil record, but also a remarkable evidence of the morphological disparity showed in this group of Permian bivalves of the Paraná Basin. Therefore, we assign this new element to the Serrinha Member molluscan fauna.

ACKNOWLEDGEMENTS

We would like to thank CNPq and FAPESP for the financial support. This study is a contribution to the following projects: FAPESP (96/9708-9), and CNPq (500694/92-3, 151853/2008-8). The final version of this paper was improved, thanks to helpful and constructive comments of R. Rohn and an anonymous reviewer.

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