

# THE BRAZILIAN MESOZOIC CONCHOSTRACAN FAUNAS: ITS GEOLOGICAL HISTORY AS AN ALTERNATIVE TOOL FOR STRATIGRAPHIC CORRELATIONS

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**ABSTRACT** – The distribution (time-space) of conchostracan across the Brazilian geological column is here analysed, and the potential application to the stratigraphical and paleogeographical correlations is proposed. The Jurassic-Cretaceous conchostracan faunas are briefly revised from the taxonomic point of view, including their problems, collecting problems and stratigraphical distribution. Such aim of the study is based on the faunal similarities, and also that there are many species in common across both periods. As previously reported by different authors, there are close relationships between Brazilian and Central African faunas, now tentatively extended to Venezuela and southern South America. Likewise, relationships between Chinese and West Gondwanan faunas are confirmed. Seven conchostracan assemblages based in their biochron are proposed and compared with the Jurassic-Cretaceous conchostracan assemblages from China and other regions.

**Keywords:** Crustacea, Conchostraca, Mesozoic, biostratigraphy, paleobiogeography.

**RESUMEN** – O.F. Gallego & R.G. Martins-Neto – *Las faunas de conchostracos mesozoicos de Brasil: su historia geológica como una herramienta alternativa para las correlaciones estratigráficas.* Se analiza la distribución de los conchostracos (en tiempo y espacio) a través de la columna geológica de Brasil y se propone su potencial aplicación a las correlaciones estratigráficas y paleogeográficas. Las faunas de conchostracos Jurásico-Cretácicos se revisan brevemente desde el punto de vista taxonómico, incluyendo sus problemáticas, problemas de colección y su distribución estratigráfica. El objetivo de este trabajo se basa en las semejanzas faunísticas y en las abundantes especies en común entre ambos períodos geológicos. Como fuera previamente reportado por diferentes autores, las estrechas relaciones existentes entre las faunas de Brasil y del centro de África, se extiende tentativamente hasta Venezuela y el extremo sur de America del Sur. Igualmente, se confirman propuestas previas sobre las relaciones entre las faunas de China y del Oeste de Gondwana. En forma tentativa, se proponen siete asociaciones de conchostracos basados en su biocrón. Se comparan las asociaciones propuestas con aquellas del Jurásico-Cretácico de China y de otras regiones.

**Palavras claves:** Crustacea, Conchostraca, Mesozoico, bioestratigrafia, paleobiogeografia.

## INTRODUCTION

Marine fossil invertebrates have successfully been used as a stratigraphic tool for a long time in different fields of the Palaeontology. Nevertheless, the non-marine or continental fossil invertebrates are poorly used with such purpose. Zhang et al. (1976) presented the stratigraphic range and distribution of the major conchostracan faunas from China, but for many years

their proposals was not disseminated in the Occident until the publication of English abstracts. After this pioneer study focusing fossil conchostracan faunas as stratigraphic tool, other contributions were published by Chen & Shen (1985), Petzold & Lane (1988), Kozur & Seidel (1983), Kozur (1993), Kozur & Mock (1993), Chen & Hudson (1991) and Chen (1994).

## TAXONOMIC PROBLEMS OF THE JURASSIC-CRETACEOUS FAUNAS

The conchostracan faunas from Brazil are known since the end of the 19<sup>th</sup> century (Jones, 1897, and others). About to 28 species were described from the Jurassic to Cretaceous sedimentary rocks from Brazil, mainly of Middle Jurassic to Middle Upper Cretaceous age (Rohn & Cavalheiro, 1996). Until now 31 species are known from the rest of South America (8 from Venezuela, one from Colombia, 3 from Uruguay and 19 from Argentina).

From the systematic point view, this abundant and diverse fauna need a review according to the new taxonomic scheme. As expressed by Rohn et al. (2005), many genera are “inflated” because much of the species belonging to it are not really related. The stratigraphic application of them would be restricted to certain groups until a deep revision of the taxonomic status is not developed. Otherwise, the authors (unpublished) carried out a preliminary revision by of certain interesting groups that brought up new evidence of the real morphological diversity of this fauna and enlarged the relationships with the Asia, Central Africa and Southern South American faunas.

Nevertheless, the available information allowed interesting interpretation on different ways, as about the paleogeographic, evolutionary and stratigraphical relationships (Carvalho, 1993; Rohn & Cavalheiro, 1996; Cunha Lana & Carvalho, 2002; Rohn et al., 2005),

and a new recent approach brought new evidence on the relationship between Jurassic-Cretaceous faunas from Brazil, Central Africa, northern and southern South America (Gallego et al., 1999; Gallego & Caldas, 2001; Gallego, 2002; Gallego et al., 2003; Gallego & Rinaldi, 2004; Gallego & Shen, 2004; Shen et al., 2004; Prámparo et al., 2005).

From the approximately 38 species from Brazil, 11 are assigned to the recent (defined on the base of the soft parts anatomy) genus *Cyzicus* (and to the subgenus *Lioestheria*), all of them ornamented with striae with less or more complicated structures. Some were informally re-assigned to the other subgenus, *Euestheria* (Carvalho, 1993). All of these species need a revision to their new location on the actual systematic scheme. Rohn et al. (2005) presented an example of this situation: a “lioestheriid” type conchostracan is assigned to the Family Jilinstheriidae due to its complicated striated ornamentation. Other example (unpublished data), is the probably new assignment of the “classical” Lower Cretaceous species “*Lioestheria codoensis*” Cardoso probably to the Eosestherioidea-Anthronestheriidae group, due to its ornamentation constituted by scarce shallow elliptical cavities, like other Lower Cretaceous species (*Pseudestherites musacchioi* and *P. rivarolai*) from Argentina (Gallego & Shen, 2004; Prámparo et al., 2005).

## FAUNAL COMPOSITION

The authors use here the original designation of the Brazilian species when it is possible, and sometimes new tentative designation are used.

Apparently, the Jurassic-Cretaceous faunas from Brazil and now the rest of South America, are strongly different from the Triassic ones, that are mainly composed by the “euestheriids-loxomegaglyptids” association, v.g., the Santa Maria Formation association (as the Chilean-Argentinean), which is also an example of the needed taxonomic revision, because many taxa are described or mentioned based only in singles often fragmentary specimens.

The Jurassic-Cretaceous fauna from Brazil are shown in Chart 1 (Carvalho, 1993; Rohn & Cavalheiro, 1996; Arai & Carvalho, 2001; Cunha Lana & Carvalho, 2001, 2002 and Rohn et al., 2005).

### “Estheriellids”

“Estheriellids” (actually Afrograptids, sensu Jones & Chen, 2000 and Shen, 2003) is a problematic group, as remarked by Kozur & Seidel (1983), Rohn & Cavalheiro (1996) and Jones & Chen (2000), as the southern hemisphere forms are a different stem against

the European Triassic forms. Jones & Chen (2000) mentioned that this group need a deep revision, probably due to that many of the Triassic forms and type specimens of the genus *Estheriella* are molluskans rather than conchostracans. Shen (2003) synonymized the southamerican *Grptoestheriella* Cardoso with the African genus *Camerunograptia* Novojilov of the Superfamily Afrograptioidea. It is necessary to remark that already Cardoso (1965) originally include his new genus *Grptoestheriella* in the family Afrograptidae and mentioned the similarities between both genera. The Brazilian fauna have got three different species of this genus distributed in five of the major Northeast basins. They are *C. brasiliensis* Oliveira, *C. fernandoi* Cardoso and *Camerunograptia* sp.. Also, other afrograptids are recorded in Brazil, *Congestheriella lualabensis* Leriche (originally described as *Estheriella* from Central Africa), recorded from the Souza basin. Other undoubtfull specimen of this species from the Barro basin, was partially identified by Carvalho (1996) as *Estheriina* (*E.*) *costai* Cardoso. This is to be discussed in a forthcoming paper, with the description

CHART 1. South American conchostracans stratigraphical and geographical distribution.

JURASSIC		CRETACEOUS										Period/ Epoch			
Mdle.	Upper	Lower					Upper					Age			
Oxfordian	Kimmeridgian	Tithonian	Berriasian	Valanginian	Hauterivian	Barremian	Aptian	Albian	Cenomanian	Turonian	Coniacian	Santonian	Campanian	Maastriachian	
		Dom João	Rio da Serra	Aratu	Buracá	Jiquiá	Alagoas								Brazilian local stages
															<i>Palaeolimnadiopsis suarezi</i>
															<i>Bauruetheria sancarlensis</i>
															<i>Estheriina astartoides</i>
															<i>Pseudesterites codoensis</i>
															<i>Palaeolimnadiopsis hectori</i>
															<i>Tenuetheria canelonesensis</i>
															<i>Dendrostracus lagarcioensis</i>
															<i>Pseudesterites rivarolai</i>
															<i>Palaeolimnadiopsis freibergi</i>
															<i>Bairdetheria barbosai?</i>
															<i>Pseudograptia erichseni</i>
															<i>Pseudoestheria iphygenioi</i>
															<i>Palaeolimnadiopsis linoi</i>
															<i>Aculestheria novojilovi</i>
															<i>Pseudesterites musacchioi</i>
															<i>"Lioestheria" mawsoni</i>
															<i>Camerunograptia fernandoi</i>
															<i>Pteriograptia cf. reali</i>
															<i>Pseudoestheria abaetensis</i>
															<i>Pseudograptia brauni</i>
															<i>Pseudoestheria pricei</i>
															<i>Estheriina costai</i>
															<i>"Lioestheria" mendesi</i>
															<i>"Lioestheria" cassambensis</i>
															<i>Camerunograptia brasiliensis</i>
															<i>Congestheriella lualabensis</i>
															<i>Camerunograptia sp.</i>
															<i>Orthesteria (M.) ferrandoi</i>
															<i>Macrolimnadiopsis barbosai</i>
															<i>"Lioestheria" mirandibensis</i>
															<i>Macrolimnadiopsis pauloi</i>
															<i>Congestheriella sp.</i>
															<i>Asiolimnadiopsis sp.</i>
															<i>Pseudesterites sp.</i>

of two probably other species of the genus *Congestheriella* from the Upper Jurassic of Venezuela and Argentina (the first closely resembles the specimen named *E.(E.) costai* by Carvalho, 1996, Plate II, Fig. A). Carvalho (1996, p. 388, Fig. 1) figured as *Estheriella lualabensis* a specimen that closely resembles *Camerunograptia fernandoi* figured by Cardoso (1965, p. 21, Fig. 4).

### Palaeolimnadiopseids

Palaeolimnadiopseids are other of the most important group in this fauna, represented by seven species of related forms in seven Brazilian basins. Many of this need a revision based on Shen's systematic scheme (Shen, 1985). Other problem to be resolved in a future, is the presence of *Palaeolimnadiopsis cf. reali* Teixeira originally assigned to the genus *Pteriograptia*, and the validity of this genus or taxonomic assessment of the palaeolimnadiopseids with anterior and posterior recurvature.

### "Lioestherids"

"Lioestherids" (probably belonging to the "Eosestherioidea-Estheriteoidea group" from Chen and Shen's systematic scheme) is the most abundant type, also problematic because it includes many different type of conchostracans, some of them species in common with Central Africa. This group include 10 species with different type of ornamentation, as the Triassic species *barbosai* (with doubtful Cretaceous record) and Lower Cretaceous *cassambensis*, *mirandibensis* and *mawsoni* with a strong striated ornamentation (sinuous and anastomosed). Other Cretaceous forms with the same type of sculpture is *brauni*, but with other variations as crenulations and nods. All of them need a detailed SEM studies to define their real taxonomic assessment.

Other forms named as "Lioestherids" are *iphygenioi*, which probably is an euestherid due to it alveolar sculpture as *pricei* with microalveolar ornamentation. The last species plus *brauni* are mentioned by Rohn et al. (2005) as related with the new

*Bauruetheria sancarlensis* Rohn, Shen & Dias-Brito as members of the Estheriteoidea group. The case of *codoensis* was already previously mentioned.

### Estherinids

Estherinids is a special and also problematic group, as to their diagnostic features depends of their type of preservation (Rohn & Cavalheiro, 1996). Jones (1897) describes the three species of this group (*Estheriina brasiliensis*, *E. astartoides* and *E. expansa*) recorded from Brazil. Also, this group has got palaeoecological interest, due to the observations of Cunha Lana & Carvalho (2001) on the *Estheriina astartoides* Jones as a brackish water conchostracan. Recently, it was tentatively reported in the same palaeoecological conditions in the Lower Cretaceous from Argentina (Prámparo et al., 2005). Cardoso (1966) describes the fourth member of this group (*Notogrypta costai* Cardoso), later assigned to the genus *Estheriina* by Tasch (1987) and Carvalho (1993).

### POPULATIONS AND GEOGRAPHICAL DISTRIBUTIONS

The number of the specimens collected and studied of many of the described Brazilian species are likely scarce. A detailed revision of the original descriptions and mentions of these species show that many of them are described based on five to twenty specimens. These situation is due to two probable reasons: one, a real scarcity in the population size, and the other due to a collecting problem related to insufficient sampling. These general data, tentatively generalized mainly from the Lower Cretaceous units, are in opposition to the population spectation (low

diversity population with high number of specimens) typical of stressed conditions, rather than normal ecological conditions with a high diversity population with low number of specimens.

Considering, the specific geographical and basin distributions, the species *brauni* (recorded in ten basins) and *pricei* (recorded in eleven basins) probably are the most common ones in the Brazilian Jurassic-Cretaceous successions. The species *pricei* extends its record from the Paraná basin in the Southern Brazil to the most northeastern Iguatu, Icó, Malhada and Sergipe-Alagoas basins. Nevertheless, *brauni*, even if abundant in basin records, is restricted to a narrow north-south fringe, across Tucano, Mirandiba, Araripe, Cedro, Padre Marcos, Belmonte and Barro, Souza, Uiraúna, Rio Nazaré, Iguatu, Icó and Malhada basins.

Other genera rather than species, that have a great distribution are the *Camerunograpt* (= *Grptoestheriella*) group recorded in five basins, from the most southern Paraná Basin to the Sergipe-Alagoas to the northern Iguatu, Icó and Malhada basins. Them, the next major species record corresponds to *C. brasiliensis* Jones, registered in four basins, *C. fernandoi* Cardoso and *Camerunograpt* sp. in two basins each one.

Other species are *barbosai*, with four presences but with doubtful record in Jurassic-Cretaceous rocks, apart from it original Triassic record. Also, *N. costai* is recorded in four basins.

The next group with three record are composed by *Pteriograpt* cf. *reali* Teixeira, "*Lioestheria*" *mawsoni* Jones, "*Pseudestheria*" *abaetensis* Cardoso and *Estheriina astartoides* Jones.

### THEIR POTENTIALLY AS STRATIGRAPHIC AND PALAEOGEOGRAPHIC TOOL

Carvalho (1993) and Rohn & Cavalheiro (1996) brought firsts approaches on the stratigraphical and geographical distribution of this fauna. In this contribution based on new evidence from the southern South American faunas, new comments and speculations are presented.

The presence of the "Afrograptids" group, shows close paleogeographical relationships between Brazil and Central Africa during the Late Jurassic to the Early Cretaceous times, as proposed by Carvalho (1993), Rohn & Cavalheiro (1996), Arai & Carvalho (2001), Cunha Lana & Carvalho (2002) and Rohn et al. (2005). New evidence (as the record of *Congestheriella*) extends tentatively this paleobiogeographical province to Venezuela and Argentina, until now only during the Middle to Late Jurassic. Also, adding the record of the genus *Camerunograpt* (= *Grptoestheriella*) in both

areas and other species as *Congestheriella lualabensis*. The species *Pteriograpt* cf. *reali*, "*Lioestheria*" *mawsoni* and "*Lioestheria*" *cassambensis* share their record in Brazil and Central Africa. The last two have strong relationship with *Orthestheria* (*Migransia*) *fernandoi* (Herbst) Shen and Gallego from the Upper Jurassic-Lower Cretaceous from Uruguay.

From the stratigraphical point of view, as mentioned by other authors (Carvalho, 1993; Rohn & Cavalheiro, 1996) their biostratigraphical application are difficult to improved, mainly because these fauna need a detailed revision and study. Nevertheless, some points are remarked by Carvalho (1993), Rohn & Cavalheiro (1996) and this work.

The Chart 2 shows the stratigraphic distribution of the Jurassic-Cretaceous conchostracan faunas from Brasil, adding other records of the South American ones

(conchostracan information is extracted mainly from Rohn & Cavalheiro, 1996, and age subdivision durations

based on the International Stratigraphic Chart, ICS-IUGS, 2004).

**CHART 2.** Stratigraphic distribution of the Jurassic-Cretaceous conchostracan faunas from Brazil and others from South American.

Taxa	Period/Age	Stratigraphic unit (Group-Fm.)	Geological-geographic precedence	
<i>Palaeolimnadiopsis swarazi</i> <i>Bauruetheria sancarlensis</i>	Upper Cretaceous/Coniacian-Santonian	Bauru Group-Adamantina and São Carlos Fms.	Paraná basin, Brazil	
<i>Etheria astartoides</i>	Lower-Upper Cretaceous/Valanginian-Turonian	Massacari-São Sebastião, Ilhas-Pojuca, Apodi-Jandaira	Reconcavo, Tucano and Potiguar basins, Brazil	
? <i>Pseudetherites codocensis</i>	Lower Cretaceous/Aptian-Albian	Codó and Santana Fm.	Parnaíba and Araripe basins, Brazil	
<i>Palaeolimnadiopsis hectori</i> <i>Tenuetheria comelonensis</i> <i>Dendrostracis lagarcitoensis</i> <i>Pseudetherites rivarolai</i>	Lower Cretaceous/Albian	Castellanos Fm.	Santa Lucia basin, Uruguay	
		Lagarcito Fm.	San Luis-San Juan, Argentina	
<i>Palaeolimnadiopsis freibergeri</i>		Lower Cretaceous/Valanginian-Aptian	Bauru-Areado, Rio do Peixe-Souza	São Francisco and Rio Nazaré basins, Brazil
" <i>Bairdetheria</i> " <i>barbosii</i>		Upper Triassic-Lower Cretaceous/Berriasian-Aptian	Piramboia Fm./Bauru-Areado, Santo Amaro-Candeias, Rio do Peixe-Souza	Paraná basin/São Francisco, and Souza basins, Brazil
" <i>Pseudograptus</i> " <i>erichseni</i>	Lower Cretaceous (Neocomian)/Berriasian-Barremian	Massacari-São Sebastião, Ilhas-Pojuca,	Reconcavo and Tucano basins, Brazil	
" <i>Pseudetheria</i> " <i>iphigeneoi</i>		Santo Amaro-Candeias	Reconcavo and Tucano basins, Brazil	
" <i>Lioetheria</i> " <i>maisoni</i>		Massacari-São Sebastião, Ilhas-Pojuca, Areia Branca-Pondência	Reconcavo, Tucano and Potiguar basins, Brazil	
<i>Etheria brasiliensis</i>		Ilhas-Pojuca, Santo Amaro-Candeias	Reconcavo and Jatobá basins, Brazil	
<i>Etheria expansa</i>		Ilhas-Pojuca	Reconcavo basin, Brazil	
<i>Camerunograptus fernandoi</i>	Lower Cretaceous (Neocomian)/Valanginian-Hauterivian	Serra Geral,	Paraná and Souza basins, Brazil	
<i>Aculestheria novojilovi</i>	Lower Cretaceous (Neocomian)/Berriasian-Valanginian	Santo Amaro-Candeias	Reconcavo basin, Brazil	
<i>Palaeolimnadiopsis linoi</i>	Lower Cretaceous (Neocomian)/Berriasian-Hauterivian	Ilhas-Pojuca	Reconcavo basin, Brazil	
<i>Pseudetherites musacchioi</i>	Lower Cretaceous (Neocomian)/Hauterivian-Barremian	La Amarga	Neuquen basin, Argentina	
" <i>Pterograptus</i> " cf. <i>reali</i>	Upper Jurassic-Lower Cretaceous (Neoc.)/Tithonian-Albian	Areado,	São Francisco, Souza and Rio Nazaré basins, Brazil	
" <i>Pseudetheria</i> " <i>abatensis</i>		Areado, Santana, Missão Velha, Rio do Peixe-Souza	Paraná, Araripe and Souza basins, Brazil	
" <i>Pseudograptus</i> " <i>brauni</i>		Santo Amaro-Candeias, Aliança, Santana, Missão Velha, Rio do Peixe-Souza and Iguatú	Tucano, Jatobá, Araripe, Uirauna, Rio Nazaré and Iguatú basins, Brazil	
" <i>Pseudetheria</i> " <i>pricei</i>		Botucatu, Santo Amaro-Candeias, Peraçaba, Aliança, Santana, Missão Velha, Rio do Peixe-Souza and Iguatú	Paraná, Reconcavo, Sergipe-Alagoas, Mirandiba, Araripe, Souza and Iguatú basins, Brazil	
<i>Notograptus costai</i>		Aliança, Santana, Missão Velha	Mirandiba, Jatobá, Barro and Araripe basins, Brazil	
<i>Camerunograptus brasiliensis</i>	Upper Jurassic-Lower Cretaceous (Neoc.)/Tithonian-Barremian	Massacari-São Sebastião, Ilhas-Pojuca, Santo Amaro-Candeias, Peraçaba, Rio do Peixe-Souza	Reconcavo, Tucano, Sergipe-Alagoas and Souza basins, Brazil	
<i>Congestheriella hualabertsi</i>	Upper Jurassic-Lower Cretaceous (Neoc.)/Tithonian-Valanginian	Rio do Peixe-Souza	Rio Nazaré and Barro basins, Brazil	
<i>Camerunograptus</i> sp.		Botucatu, Souza	Paraná and Souza basins, Brazil	
" <i>Lioetheria</i> " <i>cassambensis</i>	Upper Jurassic-Lower Cretaceous (Neocomian)/Valanginian-Barremian	Rio do Peixe-Souza	Souza and Rio Nazaré basins, Brazil	
" <i>Lioetheria</i> " <i>mendes</i>	Upper Triassic-Lower Cretaceous (Neocomian)/Valanginian-Barremian	Piramboia, Massacari-São Sebastião.	Paraná and Tucano basins, Brazil	
<i>Orthetheria</i> (M.) <i>ferranku</i>	Upper Jurassic-Lower Cretaceous/Kimmeridgian-Hauterivian	Tacuarembó	Paraná basin, Uruguay	
" <i>Lioetheria</i> " <i>mirandibensis</i>	Upper Jurassic-Tithonian	Aliança, Brejo Santo	Mirandiba and Araripe basins, Brazil	
<i>Macrolimnadiopsis barbosii</i>	Upper Jurassic-Tithonian	La Quinta	Venezuela	
<i>Congestheriella olsoni</i>	Upper Jurassic-Tithonian	? Upper Cañadón Asfalto	Extraandean Chubut basins, Argentina	
<i>Congestheriella</i> sp.	Upper Jurassic?/Kimmeridgian			
<i>Enrolimnadiopsis</i> - <i>Pseudetherites</i> - <i>Eoetheriids</i> - <i>Fushunograptids</i> association	Middle-Upper Jurassic/Callovian-Oxfordian	La Matilde, Cañadon Asfalto	Desecado Massif and Extraandean Chubut basins, Argentina	
<i>Macrolimnadiopsis pauloi</i>	Middle Jurassic	Pastos Bons	Parnaíba basin, Brazil	

Based on the common stratigraphic distribution or the known biochron of the Jurassic-Cretaceous South

American species, seven preliminary assemblages are defined (Chart 3).

**CHART 3.** Correlations between China, South American and Central African faunas during Jurassic to Cretaceous times (modified from Chen, 1994).

Areas	CHINA			SOUTH AMERICA							CENTRAL AFRICA
	SW	SE	NE-NW	Brazil, Argentina, Venezuela	Brazil, Uruguay	Brazil	Brazil, Argentina	Brazil	Brazil, Argentina, Uruguay	Brazil	
Maastricht/Campan	?	?	<i>Dactylotheria distincta</i> zone								
Santon/Turon	<i>Agdestheria</i> fauna	<i>Tenuestheria</i> fauna <i>Liodactyle</i> fauna	<i>Estherites</i> fauna								Ewango series faunas (Zaru)
Neocomian	<i>Nemastheria</i> fauna										Northern African faunas
Albian/Aptian	<i>Orthestheria</i> fauna	<i>Tenuestheria</i> fauna	<i>Crautostracus</i> – <i>Orthestheria</i> – <i>Orthestheriopsis</i> association			Assemblage e III		Assemblage e V	Assemblage e VI	Assemblage e VII	Covertostracids, <i>Afrograpta</i> and <i>Congestheriella</i>
Barremian/Berriasian			<i>Tenuestheria</i> – <i>Mygona</i> association ? P.Y.D.E.O. assemblage		Assemblage e II		Assemblage e IV				
Upper Jurassic	<i>Nemastheria</i> – <i>Kerastheria</i> fauna			Assemblage e I							
Middle Jurassic	<i>Pseudograptus</i> fauna										
Lower Jurassic	<i>Bourbonnadiopsis</i> fauna										

**Assemblage I (AI):** Middle-Late Jurassic forms, including *Eosolimnadiopsis* sp., *Pseudestherites* sp., *Congestheriella* spp. and several others Argentinean species under revision (belong to Eosestheriidae and Fushunograptidae) or “*Lioestheria*” *malacaraensis* that close resemble *L. mirandibensis*. Also include the Brazilian species *Macrolimnadiopsis pauloi*, *M. barbosai* and *L. mirandibensis* (*sensu* Rohn & Cavalheiro, 1996).

**Assemblage II (AII):** Late Jurassic-Early Cretaceous (Neocomian) forms, mainly composed by *Congestheriella lualabensis*, *Camerunograptus brasiliensis*, *Camerunograptus* sp., an Uruguayan species *Orthestheria (Migransia) ferrandoi*, and probably “*Lioestheria*” *mendesi* and “*Lioestheria*” *cassambensis* that seem to represent a more ancient stratigraphic record (since the Triassic times in the first and even the Jurassic in the second).

**Assemblage III (AIII):** Late Jurassic-Early Cretaceous (Albian) species comprised by *Pteriograptus* cf. *reali*, *Estheriina costai*, *Pseudestheria pricei*, *Pseudograptus brauni*, *Pseudestheria abaetensis*.

**Assemblage IV (AIV):** Early Cretaceous (Neocomian) forms, including *Camerunograptus fernandoi*, “*Lioestheria*” *mawsoni*, *Aculestheria novojilovi*, *Palaeolimnadiopsis linoi*, *Pseudestheria iphygenioi*

and *Pseudograptus erichseni*. This assemblage also includes the Argentinean *Pseudestherites musacchioi*.

**Assemblage V (AV):** Early Cretaceous (Neocomian-Aptian) forms, that includes *Palaeolimnadiopsis freibergeri*, ? “*Bairdestheria*” *barbosai* (probably has a more ancient biochron extended into the Triassic), and *Estheriina astartoides* (with doubt, because has a more recent record into Upper Cretaceous, see AVII).

**Assemblage VI (AVI):** Early Cretaceous (Aptian-Albian) species, including ?*Pseudestherites codoensis*, and the Uruguayan forms *Palaeolimnadiopsis hectori* and *Tenuestheria canelonesensis* and the Argentinean *Dendrostracus lagarcitoensis* and *Pseudestherites rivarolai*.

**Assemblage VII (AVII):** Lower Late Cretaceous association composed by *Palaeolimnadiopsis suarezi*, *Bauruestheria sacarlensis*, and *Estheriina astartoides*, the last two with some doubt, due to its mayor stratigraphic range that probably started or came from the Lower Neocomian (probably correspond to the AV).

#### COMPARISONS WITH OTHER FAUNAS

Chen (1994) characterized the Cretaceous conchostracan faunas from China and identified eleven ones, named as associations (three), faunas (six) and

zones (one), distributed in three Chinese regions (southwest, southeast and northeast and northwest). Some of them could be compared with the assemblages here proposed as:

- Assemblage I is related to the Jurassic faunas from China, composed by eosetherids species of the genus *Pseudograptia* and *Eosetheria* (Chen, 1994; Chen & Hudson, 1991) and different genera of Palaeolimnadiopseidae that allow to partially correlate with the upper Early Jurassic *Eosolimnadiopsis* fauna from China (Chen & Shen, 1985).
- Assemblage II shares with AI the presence of afrograptids (*Congestheriella*) and corresponds with the Chen's *Yanjietheria* fauna and *Yanjietheria-Migransia* assemblage (Neocomian) due to the presence of *O.(M.) ferrandoi* and *L. cassambensis*. On the other hand, the AII shares with Central Africa the presence of the genus *Camerunograptia* and the species *Congestheriella lualabensis* and "*Lioetheria*" *cassambensis*.
- Assemblage III lacks evidences to establish clear relationships with Chen's faunas. Nevertheless, the doubtful record of the genus *Pseudograptia* partially correlates with the Middle Jurassic *Pseudograptia* fauna from China and Europe (Chen & Hudson, 1991). Otherwise, it shares with the Upper Jurassic-Lower Cretaceous units from Central Africa the presence of *Pteriograptia* cf. *reali*.
- Assemblage IV shares with Neocomian of Central Africa, forms related with *Camerunograptia fernandoi* and "*Lioetheria*" *mawsoni*. Also *Aculestheria novojilovi* is related with the *Keratestheria-Nestoria* fauna from the lower Upper Cretaceous from China (Chen & Shen, 1985; Chen, 1994). The presence of the genus

*Pseudograptia* has got the same significance for the AIII.

- Assemblage V is composed by a peculiar group that includes *Palaeolimnadiopsis freibergeri*, probably the unique form with a range between Neocomian to the Aptian (others with the same range come from the Jurassic times). Rohn & Cavalheiro (1996) mentioned that it resembles *P. suarezi* and they suggest an interesting common and long record (Neocomian to Campanian) with *E. astartoides*. On the other hand, the presence of the Triassic ? *Bairdestheria barbosa* is very difficult to prove and probably belong to other Brazilian "lioetherid". This assemblage lacks any characteristic for correlation with other known faunas and probably correspond to other one defined here.
- Assemblage VI is related to the P.Y.D.E.O. assemblage (*Pseudestherites*, *Yanjietheria*, *Diestheria*, *Eosetheria* and *Orthestheria*, sensu Chen, 1994) from the Berriasian of China, but *Pseudestherites* is also recorded from the Hauterivian age. Also this assemblage is partially related to the Upper Cretaceous (Turonian-Santonian) *Tenuestheria* fauna (Chen, 1994), with AIII by the presence of *P. abaetensis* and with forms recorded in the Lower and Upper Cretaceous from Africa (Gallego et al., 1999).
- Assemblage VII has *B. sacarlensis* as the unique form with close relationships particularly with the genus *Plectestheria* and *Dictyestheria* from the Upper Cretaceous of China and Mongolia, and ?*Porostracus kitariensis* from the Upper Cretaceous of Africa (Rohn et al., 2005). According to this comparisons, the AVII is correlated with the Turonian-Santonian *Euestherites* fauna from the Upper Cretaceous of China.

## GENERAL COMMENTS ON THE CONCHOSTRACAN FAUNAS

Some comments are here presented on the conchostracans distribution during the Mesozoic times, according to Shen suggestions (personal communication, 2006). Nevertheless, to more accurate results of the comparisons, it is tried to establish a sequence of Jurassic and Cretaceous conchostracan faunas in South American, as the next step of this research subject. The schematic global faunal evolution trends are as follow:

1. Prior to the break-up of Pangea the conchostracans are widely distributed in the ancient continents. Euestherids and palaeolimnadids are the common

taxa during the Triassic through the Middle Jurassic. The stratigraphic correlations could be made in the large scale.

2. During the Late Jurassic and Cretaceous Africa-South America (ASA) and Asia formed two different conchostracan biostratigraphic provinces. In the Late Jurassic and Early Cretaceous ASA is represented by Afrograptidae (*Camerunograptia*, *Afrograptia* and *Congestheriella*), and Asia is characterized by *Nestoria-Keratestheria* (Late Jurassic), *Eosetheria* (Early Cretaceous) and *Yanjietheria-Orthestheria* (late Early Cretaceous)

- faunas. In Late Cretaceous Asia is represented by *Nemestheria*, *Estherites* and *Daxingestheria* fauna, but for ASA is not clear, because many specimens need a restudy.
3. There are close affinities of the conchostracans between ASA and Asia and even they share of same genera. *Orthestheria* (*Migransia*) and *Pseudograptia* were found in both areas. *Bauruetheria* from Brazil is similar to *Dictyestheria*, *Plectestheria* and *Porostracus*, which are important forms of the Late Cretaceous *Estherites* fauna in NE China. Otherwise, *Asmussia souzae* and *Palaeolimnadiopsis* sp. from the Lower Cretaceous of Brazil are probably
  4. belonged to a new genus and may be attributed to the Family Sinoestheriidae (Chen & Shen, 1982) based on their big valve (23-28 mm long), stout growth lines, recurved postero-dorsal margin and big reticulations. They differ from sinoestheriids in without a row of nodes on the stout growth lines.
  4. The resemblance of the conchostracan faunas from both areas is very significant for the stratigraphic correlations and discussions on the systematic evolution. The close relationships between ASA and Asia allow to propose a model of parallel conchostracan evolution (Shen et al., 2004; Rohn et al., 2005).

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