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Assessment of the decapod crustacean diversity in the Guayana Shield region aiming at conservation decisions

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Abstract

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The current state of knowledge of freshwater decapod crustacean diversity of the Guayana Shield Region is briefly assessed, based upon information gathered from the scientific literature as well as unpublished data from academic theses, technical reports, and carcinological collections. The decapod fauna of the region is presently known to include 64 species and subspecies within six families and 17 genera. Diversity by countries, basins, and rivers is listed, comments on endemic, rare or threatened species are made, and information about relevant taxonomic literature is presented. Seven priority areas for conservation actions concerning crustacean decapods are suggested and related to the 25 priority areas defined by the Fishes and Freshwater Working Group at the Guayana Shield Conservation Priority Setting Workshop, held at Paramaribo (Suriname) in April 2002.

Keywords: *biodiversity, checklist, freshwater crabs, freshwater shrimps, Amazon basin, Orinoco basin.*

Resumo

Magalhães C. & Pereira, G. **Avaliação da diversidade de crustáceos decápodos na região do escudo das Guianas como subsídio a decisões de conservação.** *Biota Neotrop*. May/Aug 2007 vol. 7, no. 2. http://www.biotaneotropica.org.br/v7n2/pt/abstract?article+bn02007022007. ISSN 1676-0603.

Avalia-se resumidamente a situação atual do conhecimento sobre a diversidade dos crustáceos decápodos de água doce da região do Escudo das Guianas com base em informações obtidas da literatura científica e dados inéditos de trabalhos acadêmicos, relatórios técnicos e coleções carcinológicas. A fauna de decápodos da região está atualmente constituída por 64 espécies e subespécies em seis famílias e 17 gêneros. Relaciona-se a diversidade por país, bacias e rios, faz-se comentários sobre espécies endêmicas, raras ou ameaçadas, e apresenta-se informações sobre a literatura taxonômica relevante de cada grupo. Em relação aos crustáceos decápodos, sugere-se sete áreas prioritárias para ações conservacionistas e relaciona-se essas áreas com as 25 áreas prioritárias definidas pelo Grupo de Trabalho em Peixes e Organismos Dulcícolas no "Guayana Shield Conservation Priority Setting Workshop", realizado em Paramaribo (Suriname), em abril de 2002.

Palavras-chave: *biodiversidade, lista de espécies, caranguejos de água doce, camarões de água doce, bacia amazônica, bacia do Orinoco.*

Introduction

The Guayana Shield encompasses a large region of northern South America. It has an extensive and complex hydrographic network that includes several coastal river drainages and large portions of the Amazon and Orinoco River basins. A diversified fauna of freshwater decapod crustaceans occurs in the region. This fauna is constituted by several species of four families of shrimps (Atyidae, Euryrhynchidae, Palaemonidae and Sergestidae) and two of crabs (Pseudothelphusidae and Trichodactylidae). In the present contribution, we intend to briefly review the current state of knowledge about these crustacean groups by presenting a general overview of its diversity in the Guayana Shield, including a check list of the species according to the countries and hydrographic basins of this region, assessment of possible endemic, rare or threatened species, evaluate scientific efforts, and ultimately try to highlight the information gaps in order to support decisions for conservation priorities for this region.

Material and Methods

1. Study area

The Guayana Shield covers a large area of northern South America, broadly ranging from eastern Colombia to the west, to the Caribbean Sea and the Atlantic Ocean to the north and east, and to the Rio Negro and Rio Amazonas to the south. The region includes parts of Colombia, Venezuela, Brazil and almost all of Guyana, Suriname and French Guiana. The region is a very old cratonic area which underwent an orogenic cycle around 2,000 million years ago and has been tectonically stable for at least the last 1,700 million years (Bigarella & Ferreira 1985). The region is marked by a series of mountain ranges, many reaching elevations higher than 2,000 m along the border of Brazil with Venezuela and the three Guianas, and by massive table mountains known as "tepuis", which dominate the Venezuelan portion of the Guayana Shield. Upland areas, characterized by altitudes lower then 800 m, heavily eroded and covered largely by undisturbed tropical forest, extend throughout the remainder of the region. A diversity of environments can be found there, such as the swamps of the Orinoco Delta, the upland Gran Sabana, lowland tropical forest, peculiar white-sand savannas and shrublands of the upper Rio Negro Basin.

The hydrography of the region is complex. It is drained by the Orinoco River (mostly the right bank tributaries), the left bank tributaries of Amazon River and the coastal river drainages along the coastal strip of northern South America, from Guyana to the state of Amapá, in Brazil. The Amazon River tributaries include the Rio Negro and all its left bank tributaries. In the upper Rio Negro, some right bank affluents (Rio Vaupes/Uaupés, Rio Caqueta/Japurá) drain the Colombian relicts of the Guayana Shield, and an interconnection with the Orinoco Basin is made through the Casiquiare Channel. Other basin interconnections would also be possible along the Parima and Pacaraima Mountains (Brazilian-Venezuelan border) and through the inundated areas of the Rupununi, which connect the Essequibo and Cuyuni Rivers with the upper Rio Branco Basin (Rodríguez 1982b).

2. Species assessment

An accurate assessment of the decapod crustacean diversity in the Guayana Shield region is rather difficult, since knowledge of its taxonomic composition and distributional patterns is still far from complete. However, based on the existing documentation, an attempt to synthesize the current status of knowledge about the decapod fauna is made. Such synthesis relies mainly on information gathered from the scientific literature, but unpublished data from academic theses, technical reports and carcinological collections were also considered when available. These data were eventually obtained from the holdings of the following collections: Instituto Nacional de Pesquisas da Amazônia (INPA, Manaus), Instituto de Pesquisas Científicas e Tecnológicas do Amapá (IEPA, Macapá) and Museu Paraense Emílio Goeldi (MPEG, Belém), Brazil; Museo de Biologia de la Universidad Central de Venezuela (MB-UCV), Instituto Venezolano de Investigaciones Cientificas (IVIC), Caracas, Venezuela. A database was established considering entries for taxa (family, genus, species/subspecies), authorship and year of the species description, country, basin, and reference source. This database was used for compiling species lists and distributions, and for comparing the specific richness of basins and rivers.

Synonymies and classification for each major group followed Rodríguez (1982a) for Pseudothelphusidae, Magalhães & Türkay (1996a,b) for Trichodactylidae, and Holthuis (1951, 1952) for Palaemonidae. Family level classification follows Martin & Davis (2001).

Results

1. Status of knowledge of freshwater decapod crustaceans

The freshwater decapods of the Guayana Shield region are fairly well known, although this knowledge is not uniform among the groups or countries, and almost all studies have been restricted to systematic and taxonomic aspects. Currently, there are six families, 17 genera and 64 species and subspecies of decapod crustaceans known to occur throughout the entire region (Appendix 1). The decapod fauna is constituted by the palaemonid shrimps, which is the most diverse group (39% of the species/subspecies), the pseudothelphusid (33%), the trichodactylid crabs (19%), the euryrhynchid shrimps (6%), and the atyid and sergestid shrimps (1.5% each). The highest number of taxa is found in the Brazil and Venezuela (39), followed by Suriname (19) (Appendix 2), which mostly reflects the greater collecting and research efforts in these countries.

Most of the information about this fauna comes from sporadic collections and is scattered among the taxonomic literature. Perhaps the only systematic surveys of the decapod fauna in areas included in the Guayana Shield region are the inventories made by Lópes & Pereira (1996, 1998), for the Orinoco Delta, and by Magalhães & Pereira (2003), for the middle Caura River Basin.

There are some revisional works, either from the geographical or the taxonomic point of view, that provide useful information about the fauna of this region. Regional revisions were made by Young (1900) for Guyana, Holthuis (1959) for Suriname, and Rodríguez (1980) and Pereira (1982) for Venezuela; a list of the decapod species then known to tropical South America was provided by Rodríguez (1981). Taxonomic revisions, in which species occurring in the Guayana Shield region were mentioned, are available for the Pseudothelphusidae (Rathbun 1905, Bott 1969, Pretzmann 1972, Rodríguez 1982a), and Trichodactylidae crabs (Rathbun 1906, Bott 1969, Rodríguez 1992, Magalhães 1991, Magalhães & Türkay 1996b), as well as for the Palaemonidae shrimps (Holthuis 1951, 1952, Tiefenbacher 1978).

Besides these, there are also some taxonomic and zoogeographical contributions with valuable information about the decapods of this region. Concerning the Brazilian portion of the region, one can mention the papers of Magalhães (1986, 1990), Magalhães & Rodríguez (2002), and Magalhães et al. (2005) on the Brazilian pseudothelphusid crabs, Kensley & Walker (1982) and Pimentel (2003) on some Amazonian palaemonid shrimps, as well as the manual of identification of the Brazilian freshwater decapod crustaceans (Melo

2003a). The records for Colombia were done by Campos (1997) and Rodríguez & Campos (1998) for pseudothelphusid crabs. The composition and distribution of the Venezuelan Guayana decapod fauna is better known: the freshwater shrimps were treated by Rodríguez (1982b), Pereira (1985, 1986, 1991), and Pereira et al. (1996); the pseudothelphusid crabs were studied by Rodríguez (1966), Rodríguez & Pereira (1992), Rodríguez & Suárez (1994), and Rodríguez & Campos (1998). There are other contributions mentioning material from French Guiana (Miers 1877), Guyana (De Man 1900, Gordon 1935, Coifmann 1939) and Suriname (Holthuis 1993).

Just a few studies dealing with biological and ecological aspects of shrimps species that occur in the Guayana Shield region are available. The larval development of palaemonid shrimp was studied by Magalhães (1985, 1986/87, 1988a,b, 1989, 2000) and Magalhães & Medeiros (1998). Ecological distribution and life history strategies were treated by Magalhães & Walker (1988), Odinetz Collart & Enriconi (1993) and Odinetz Collart & Magalhães (1994), while Walker & Ferreira (1985) studied the population dynamics of shrimp in a terra-firme forest stream in central Amazonia. Kowalczuk (2000) studied biological aspects of the decapod community in the upper Rio Branco, in Roraima.

The identification of the Guayana region decapod species may be carried out with a few revisional works, but some taxonomic contributions must be used in complement, particularly for the shrimps. The main papers suggested for decapod identification according to the taxonomic groups are the following: Atyidae: Hobbs & Hart (1982). Palaemonidae: Holthuis (1951, 1952, 1959), Kensley & Walker (1982), López & Pereira (1996), Pereira (1985, 1986), Rodríguez (1980, 1982b), Tiefenbacher (1978), Melo (2003b). Pseudothelphusidae: Holthuis (1959), Magalhães (1986), Rodríguez (1980, 1982a), Pretzmann (1972), Rodríguez & Campos (1998), Rodríguez & Pereira (1992), Rodríguez & Suárez (1994), Magalhães & Rodríguez (2002), Magalhães (2003a). Sergestidae: Holthuis (1959), Omori (1975), Melo (2003b). Trichodactylidae: Holthuis (1959), Magalhães & Türkay (1996a), Rodríguez (1992), Magalhães (2003a).

2. Distribution of scientific efforts

Regular scientific efforts are scattered and concentrated in a few places. In Brazil, collecting efforts are mainly directed to the middle and lower Rio Negro basin (state of Amazonas) and to the Yanomami Indians area, along the Brazilian-Venezuelan border (states of Amazonas and Roraima). Crustacean collecting expeditions have already been made in restricted areas of the Rio Araguari (state of Amapá), Rio Trombetas (state of Pará) and Rio Branco (state of Roraima) basins. In general, the Brazilian portion of the Guayana Shield has not yet been systematically surveyed for decapod crustaceans.

The Venezuelan Guayana seems to be somewhat better explored, especially the area of the upper Orinoco River and upper Cuyuni River basins, which is reflected by the many contributions of G. Pereira and G. Rodríguez and their collaborators. Recently, a systematic carcinological survey was performed in the Rio Caura (Magalhães & Pereira 2003).

The decapod fauna of Suriname is quite well known and Holthuis (1959) included a report on the history of Suriname carcinology. His papers presented a very good picture of the composition and distribution of this fauna (Holthuis 1959, 1993). Currently, no efforts have been made to improve the knowledge about the decapod fauna of this country.

A similar situation is encountered in the other countries, where this knowledge comes from old or sporadic collecting efforts.

3. Decapod diversity by hydrographic basins

Taking into account the current figures, there is a great discrepancy in the species richness among the main hydrographic basins of the Guayana Shield region. The Amazon River Basin has the highest number of taxa (5 families, 16 genera and 41 species/subspecies), followed by the Orinoco (5 families, 11 genera and 35 species/subspecies), Suriname (6 families, 11 genera and 17 species) and Cuyuni (4 families, 8 genera and 11 species) River Basins (Appendix 3). The higher species richness of both Amazon and Orinoco River Basins was expected due to their age, size and heterogeneity of aquatic environments, as well as their long and complex geological history.

However, the distribution presented in Appendix 3 also suggests lack of information for many of the river systems, mainly due to shortage of detailed and systematic inventories. For instance, in Suriname, 17 species are known to occur in the Suriname River Basin, but much lower numbers are found in the nearby basins, such as the Marowijne/Maroni (10 species), Coppename (8 species) or Corantijn (4 species), in spite of their relatively similar sizes and geological histories. Perhaps due to the construction of the Brokopondo Dam, the Suriname River has received more faunistic inventory efforts than the others, thus reflecting higher species richness.

Considering only the main Amazon River tributaries draining Guayana Shield areas, distributional data are available for Rio Negro, Rio Uatumã, Rio Trombetas and Rio Jari; other rivers, such as Nhamundá and Paru do Leste, are completely unexplored concerning decapod fauna (Appendix 4). The Rio Jari sub-basin is very poorly studied and decapod records are incipient. There are records only for one palaemonid shrimp and four trichodactylid crabs species, which certainly do not allow even a preliminary analysis of its decapod species composition. The Rio Trombetas and Rio Uatumã show a similar number of taxa despite the former having a larger basin than the latter. However, the Rio Uatumã underwent more detailed faunistic inventories due both to the construction of the Balbina Hydroeletric Dam and the proximity of Manaus. The species richness for the Rio Uatumã should be even higher, considering that only its middle course was systematically surveyed. Species such as *Macrobrachium amazonicum, M. brasiliense, Fredius denticulatus* and *F. reflexifrons*, most probably occur in the basin, but are not yet recorded.

The largest left bank tributary of the Amazon, the Rio Negro has by far the highest species richness. Five families, 14 genera and 34 species/subspecies are distributed throughout this sub-basin. Some factors contribute to such richness. The size of the basin, which includes important tributaries such the Rio Branco and Rio Vaupés/Uaupés; the complex geological history and hydrography, with existing basin interconections between the upper Rio Negro and the upper Orinoco River (through the Canal Casiquiare) and between some of the main tributaries of both rivers (Rio Branco with Rio Caura and Rio Caroni, along the Pacaraima Mountains), and between Rio Branco and the Essequibo River Basin (through the wetlands of the upper Rupununi River); and the diversity of environments that can be found within the basin, including mountain ranges and highplain areas, lowland tropical florest, peculiar white-sand savannas and shrublands, several black, clear and white water rivers, lakes, forest streams, large inland archipelagos and periodically inundanted areas.

The palaemonid shrimps are always the most diverse group, and the Orinoco River Basin has the highest species richness, with 19 species known to its Guayana portion of the basin. The pseudothelphusids show a higher number of species in the region than the trichodactylid crabs. Considering that the former family is typically a montane fauna while the latter is characteristically a lowland group (Rodríguez 1981), and as the elevation of most of the region considered here is above 300 m, it should be expected that the pseudothelphusids be more diversified than the trichodactylids throughout the region.

4. Distribution, endemism and rare or threatened species

Distribution. Distribution maps of the species occurring in the Guayana Shield region can be found in Holthuis (1959), Rodríguez

(1992), Magalhães & Türkay (1996b), Magalhães & Rodríguez (2002), Magalhães (2003a) and Melo (2003b). Some species have wide distributions in the lowlands of Amazon and/or Orinoco River Basins and also occur in the middle course of the tributaries draining the Guayana Shield. This is the case of some palaemonid (for instance, *Euryrhynchus wrzesniowskii, Macrobrachium amazonicum, M. jelskii, M. brasiliense* and *Palaemonetes carteri*) and sergestid (*Acetes paraguayensis*) shrimps, as well as the trichodactylid crabs. Similarly, adults of these palaemonid and atyid shrimps living in coastal river basins and whose life cycle depends upon mixohaline waters for accomplishing larval development can occur in the middle course of coastal river basins of Guyana, Suriname and French Guiana. Species such as *Macrobrachium acanthurus, M. carcinus, M. olfersii* and *M. surinamicum* fall into this category. Some pseudothelphusid crabs also show a broad distributional pattern, such as *Fredius denticulatus, F. reflexifrons*, and *Kingsleya latifrons*.

On the other hand, there are species that, judging from available documentation, have restricted distributions. A few trichodactylid crabs have so far only been found in certain Amazon River tributaries: *Moreirocarcinus laevifrons* in the Rio Negro and Rio Uatumã; *Trichodactylus ehrhardti* has been recorded in the lower Rio Negro, Rio Uatumã and Rio Trombetas; and *Valdivia novemdentata* is only known from upper Rio Negro. A similar situation applies to some pseudothelphusid crabs: *Prionothelphusa eliasi* and *F. granulatus* are distributed in the western portion of the Guayana Shield, while *Kingsleya ytupora* occurs in Rio Uatumã, Rio Trombetas and Rio Araguari Basins; it seems that *Microthelphusa wymani* and *M. bolivari* are restricted to Surinamese rivers and to the upper Rio Cuyuni, respectively, while *Fredius chaffanjoni* is known from the upper Rio Orinoco. Some palaemonid shrimps also show delimited distributions in the region: *Pseudopalaemon* spp. and *Macrobrachium inpa* are known so far only from the Rio Negro Basin; *Macrobrachium quelchi* occurs in the upper Mazaruni and Caroni River Basins; *Euryrhynchus pemoni* seems to be endemic to the Gran Sabana region, where it is much restricted to small creeks of high altitude plateaus in the upper Rio Caroni Basin; *Macrobrachium atabapense*, *M. aracamuni* and *M. pectinatum* have narrow distributions in the Venezuelan state of Amazonas; and *Macrobrachium* sp. 1 is known from the Rio Caura and Rio Caroni Basins.

Besides the species with wide distributions, there are some continental species with transbasin distributions: the trichodactylids *Moreirocarcinus emarginatus, Poppiana dentata, Sylviocarcinus pictus* and *Valdivia serrata*; the pseudothelphusids *Kingsleya siolii, F. fittkaui, F. platyacanthus, F. stenolobus* and *F. estevisi estevisi*; the palaemonids *Euryrhynchus amazoniensis, Macrobrachium atabapense, M. cortezi, M. quelchi*, and *Palaemonetes ivonicus.*

Many species are still known only from their type locality, for instance *Valdivia haraldi* (Trichodactylidae), *Kingsleya besti, Microthelphusa somanni, M. rodriguezi, Fredius adpressus adpressus* and *Fredius estevisi siapensis* (Pseudothelphusidae), *Euryrhynchus pemoni, Pseudopalaemon* sp. 1 and *Macrobrachium aracamuni* (Palaemonidae).

Endemism and rare species. The current knowledge about the taxonomic composition and distributional patterns of the decapod species, as well as the sporadic collecting efforts and low representativeness of the existing collections, do not allow conclusive statements about the recognition of endemic species occurring in the region. Usually, pseudothelphusid crabs have higher degrees of endemism, with species restricted to a single hydrographic basin or sub-basin (Rodríguez, 1982a). However, this assertion must be taken with caution regarding the Kingsleyini, the branch of the family occurring east of the Andes. Recent collections indicate that species once considered endemic to some river basins actually show broader distributions, as is the case for *Fredius stenolobus, F. estevisi estevisi, F. platyacanthus* and *F. beccari*. A similar situation was found to *Macrobrachium quelchi*, once known only from the upper Mazaruni River Basin and later found also in the upper Rio Caroni Basin (Pereira 1985). Perhaps more intensive and broader collecting efforts will reveal the same situation for many species currently thought to have restricted distributions.

Even so, it is reasonable to affirm that the Guayana Shield region is the endemic area for some species/subspecies. A cladistic and biogeographic analysis of the genus *Fredius* (Rodríguez & Pereira 1992, Rodríguez & Campos 1998) indicated that much of the group's evolution occurred in the Guayana region, particularly in hypothetical major basins comprising the present Orinoco, Essequibo and Cuyuni River Basins. Widespread species, such as *F. reflexifrons* and *F. denticulatus*, would have evolved in the nearby area of the Atlantic Guianas and the Amazon Basin. Therefore, most of the *Fredius* species and subspecies with restricted distributions could be considered endemic to the Guayana region. However, there is no such detailed analysis for other groups, and, judging by the available documentation, it is reasonable to believe that some other pseudothelphusid species could also be endemic to the region, as would be the case at least for the *Microthelphusa* spp. and *Prionothelphusa eliasi*. The genus *Kingsleya* can be found in southern tributaries of the Amazon River as well, and the distribution patterns of its species are not very well established yet (Magalhães 2003b, 2005). Any assumption of endemism for this genus in the region is therefore premature. Regarding the palaemonid shrimps, they usually are lowland species with wide distributions. Most of the species also occur elsewhere in the Amazon and Orinoco River Basins. However, a few species, such as *Macrobrachium aracamuni, M. atabapense, M. cortezi, M. pectinatum, M. quelchi* and *Euryrhynchus pemoni*, may prove to be endemic to the region, but it is too early to be certain.

Similarly, the status of a species as rare is also directly related to the collecting efforts and to its presence in existing collections. To date, there are several species that can be considered rare based on the few specimens available in collections and these are listed as follows: Palaemonidae (*Euryrhynchus pemoni, Macrobrachium aracamuni, M. atabapense, M. pectinatum, M. quelchi, Macrobrachium* sp. 1, *Palaemonetes mercedae, Pseudopalaemon gouldingi, P. nigramnis*, and *Pseudopalaemon* sp. 1), Pseudothelphusidae (*Fredius adpressus adpressus, F. adpressus piaroensis, F. granulatus, Kingsleya besti, K. siolii, Microthelphusa bolivari, M. rodriguezi* and *M. somanni*) and Trichodactylidae (*Valdivia novemdentata* and *V. haraldi*).

Threatened species. There is very little information on threat for freshwater decapod species. Pereira (in Rodríguez & Rojas-Suárez 1995) mentioned two species of freshwater shrimps that we should be aware for conservation. One of them, *Euryrhynchus pemoni* from the Guayana Shield region, should be considered as threatened due to the low population and confined habitat. So far, no decapod species is known to be individually under threat. Although a few shrimp species are part of commercial fisheries, specially *Macrobrachium amazonicum* and *M. carcinus* in the lower Amazon River, the capture is essentially made by artisanal fishermen and consumed by locals (Moraes-Riodades & Valenti 2001), an activity that does not compromise the species.

Perhaps the main threats to the species are environmental degradation that might affect the decapod community on a local basis. Deforestation and subsequent siltation of surrounding water bodies are potential threats to the decapod community, especially in 'terra firme' (non-flooded) forest streams. Mining activities may also represent a potential threat to the carcinofauna, either due to environmental damage or to the poorly studied effect of the bioaccumulation of heavy metals through the trophic web. Species with restricted distributions

may be more affected by such threats. However, to date, there is no information available to pinpoint species that might be severely threatened by problems like these.

Another potential threat to the decapod fauna is the introduction of exotic species. The Malaysian shrimp, *Macrobrachium rosenbergii*, is largely used for aquaculture purposes throughout the world. It was introduced in Venezuela and the Brazilian Amazon region, and it appears that wild populations have already been established in the Orinoco River Delta (Pereira et al. 1996) and, possibly, in the lower Amazon (Barros & Silva 1997).

5. Priority areas and themes for conservation and further research

Definition of priority areas for conservation actions related to aquatic fauna should rely on a good knowledge about biodiversity, in particular taxonomic, distributional and ecological aspects. Although the taxonomy of most groups is fairly well known, there is a lot to be done concerning establishment of their distributional patterns and ecological interactions. More comprehensive and systematic inventories should be carried out in order to better document the alpha and beta diversity of some hydrographic sub-basins of the Guayana Shield region. Biological and ecological studies will contribute to management actions for sustainable use and conservation of aquatic resources.

Definition of priority areas for conservation and further research should take into account those areas with a number of species of restricted or patchy distribution, and areas with faunal interconnections. Concerning the decapod fauna, and based on the current documentation, briefly presented above, the following areas can be suggested for receiving priority status (Figure 1):

a) Upper Rio Negro: high species richness and place of occurrence for many species with restricted or patchy distribution, as well as faunistic interconnections with the Orinoco River Basin and with the Colombian relicts of the Guayana Shield;
b) Middle Rio Negro: high species richness and presence of diversified environments due to the extent of the periodically flooded forest and the intricate island system;
c) Upper Rio Branco basin: high species richness and faunistic interconnections either with the Orinoco (through the Rio Caroni and Rio Caura) or the Essequibo River Basins, as well as presence of a peculiar environment (savanna), which could favor diversity of other crustacean groups;
d) Upper and/or middle course of rivers coming from the mountains along the Brazilian/Guianas borders: null or low degree of knowledge about alfa and beta diversity (especially the

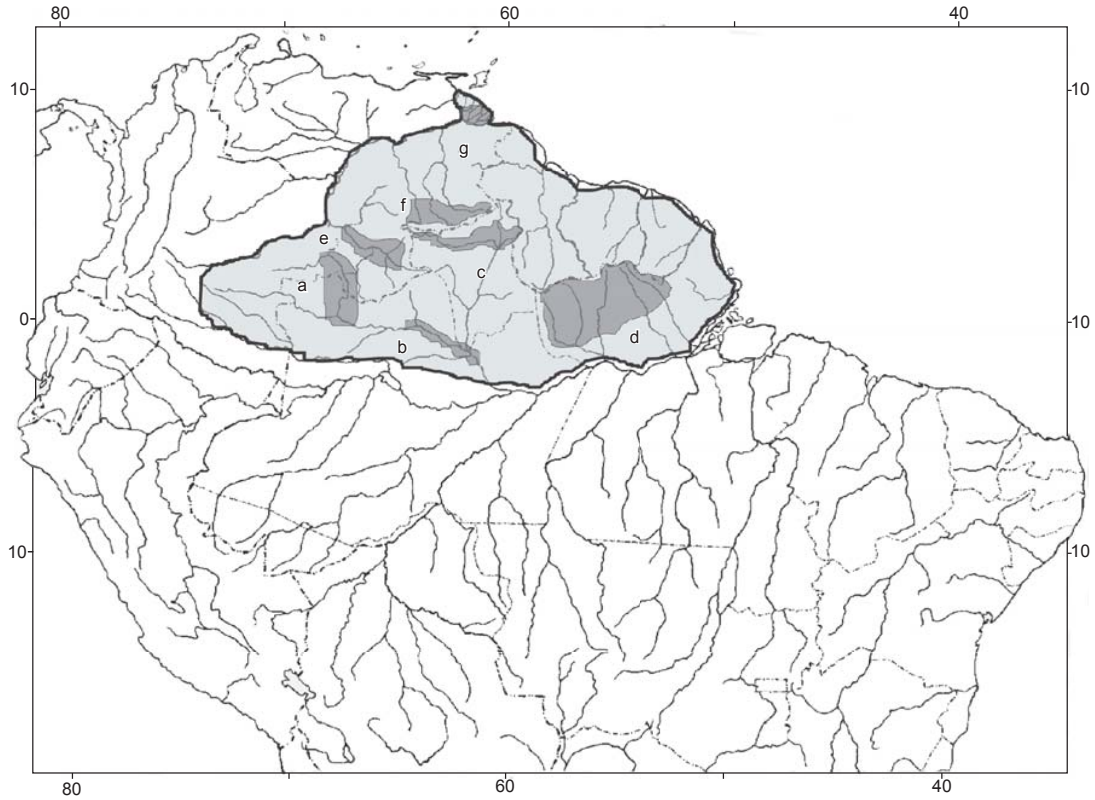

Figure 1. Map of the Northern South America, highlighting the Guayana Shield region as defined in this paper and the priority areas suggested for conservation and further research of decapod crustaceans: a) Upper Rio Negro; b) Middle Rio Negro; c) Upper Rio Branco basin; d) Upper and/or middle course of rivers from the Brazilian/Guyanas borders; e) Upper Orinoco; f) Upper Caura and Caroni; and g) Orinoco delta.

Figura 1. Mapa do norte da América do Sul, realçando a região do escudo das Guianas conforme definido neste artigo e as áreas prioritárias sugeridas para conservação e incremento de pesquisas sobre crustáceos decápodos: a) alto rio Negro; b) médio rio Negro; c) bacia do alto rio Branco; d) cursos alto e/ou médio de rios procedentes da fronteira Brasil/Guianas; e) alto rio Orinoco; f) alto rio Caura e alto rio Caroni; e g) delta do Orinoco.

Amazon River tributaries in the states of Pará and Amapá), as well as possible faunistic interconnections with coastal river basins of Guiana, Suriname and French Guiana;

e) Upper Orinoco River: high species richness and place of occurrence for many species with restricted or punctual distribution, faunistic interconnections with the Amazon Basin, as well as presence of a peculiar environment such as Tepuys which could favor diversity of other crustaceans groups;

f) Upper Caura and Caroni rivers: high species richness, endemism and faunistic interconnections either with the Orinoco, Essequibo River Basins, as well as presence of a peculiar environment (high altitude savannah, and tepuys), which could favor diversity of other crustaceans groups. This area already includes the Gran Sabana and Canaima National Parks; and

g) Orinoco Delta: the largest wet land in the region, also transitional zone of estuarine and freshwater environment; high species richness and faunistic interconnections. There is a Biosphere Reserve already in this area.

The Freshwater Working Group at the Guayana Shield Conservation Priority Setting Workshop (http://www.guayanashield.org/ev.php), held at Paramaribo in April 2002, indicated 25 priority areas for future studies and conservation based on information from fishes and decapod crustaceans (Lasso et al. 2003). These areas are distributed along three broad subregional areas, which are: eastern lowlands, southern lowlands, and a complex region comprising the uplands, highlands and the lowlands of the northwestern area of the Guayana Shield. According to the Working Group's analysis, improvement of taxonomic, biologic and ecologic studies, as well as establishment of conservation actions, in these 25 areas would affect six different faunistic groups for fishes and crustaceans, which are: (1) Areas of the Guayanas in the eastern zone from the Essequibo to the Oyapock; (2) Areas in the north-central part that drain into the Orinoco; (3) Río Ventuari Basin in the northwest of the Orinoco; (4) River basins in the southwestern extension of the Shield that includes the region of Chiribiquete which, as far as known, has a special biogeographic relationship to both the Rio Negro and the Río Caquetá; (5) Upper and middle Rio Negro and Rio Trombetas area; (6) A series of inter-basins headwater areas that drain off large mountain and tepuy areas.

The priority areas specifically for crustaceans suggested above would be included in these 25 regions, and any conservation measure that might be taken in the future will certainly protect the decapod diversity of the Guayana Shield region.

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Appendix

Table 1. Check list of decapod crustacean species distributed in the Guayana Shield region.

Tabela 1. Lista de espécies de crustáceos decápodos distribuidos na região do escudo das Guianas.

ATYIDAE	Pseudothelphusidae
Atya gabonensis Giebel	*Fredius adpressus adpressus* Rodriguez & Pereira
EURYRHYNCHIDAE	*F. adpressus piaroensis* Rodriguez & Pereira
Euryrhynchus amazoniensis Tiefenbacher	*F. beccarii* (Coifmann)
E. burchelli Calman	*F. chaffanjoni* (Rathbun)
E. pemoni Pereira	*F. denticulatus* (H. Milne-Edwards)
E. wrzesniowskii Miers	*F. estevisi estevisi* Rodriguez
PALAEMONIDAE	*F. estevisi siapensis* Rodriguez & Pereira
Macrobrachium acanthurus (Wiegmann)	*F. fittkaui* Bott
M. amazonicum (Heller)	*F. granulatus* Rodriguez & Campos
M. aracamuni Rodriguez	*F. platyacanthus* Rodriguez & Pereira
M. atabapense Pereira	*F. reflexifrons* (Ortmann)
M. brasiliense (Heller)	*F. stenolobus* Rodriguez & Suarez
M. carcinus (Linnaeus)	*Kingsleya besti* Magalhães
M. cortezi Rodriguez	*K. latifrons* (Randall)
M. ferreirai Kensley & Walker	*K siolii* Bott
M. inpa Kensley & Walker	*K. ytupora* Magalhães
M. jelskii (Miers)	*Microthelphusa bolivari* Rodriguez
M. nattereri (Heller)	*M. rodriguezi* Pretzmann
M. olfersii (Wiegmann)	*M. somanni* (Bott)
M. pectinatum Pereira	*M. wymani* (Rathbun)
M. quelchi De Man	*Prionothelphusa eliasi* Rodriguez
M. rosenbergii (De Man)	Trichodactylidae
M. sp. n. 1	*Dilocarcinus septemdentatus* (Herbst)
M. surinamicum Holthuis	*Forsteria venezuelensis* (Rathbun)
Palaemonetes carteri Gordon	*Moreirocarcinus emarginatus* (H. Milne-Edwards)
P. ivonicus Holthuis	*M. laevifrons* (Moreira)
P. mercedae Pereira	*Poppiana dentata* (Randall)
Pseudopalaemon amazonensis Ramos Porto	*Sylviocarcinus devillei* H. Milne-Edwards
P. chryseus Kensley & Walker	*S. pictus* (H. Milne-Edwards)
P. gouldingi Kensley & Walker	*Trichodactylus ehrhardti* Bott
P. nigramnis Kensley & Walker	*T. faxoni* Rathbun
P. sp. n. 1	*V aldivia haraldi* Bott
SERGESTIDAE	*V. novemdentata* (Pretzmann)
Acetes paraguayensis Hansen	*V. serrata* White

Table 2. Check list of decapod crustacean species distributed in the Guayana Shield region according to countries.
Tabela 2. Lista de espécies de crustáceos decápodos distribuidos na região do escudo das Guianas conforme os países.

	Brazil	Colombia	F. Guiana	Guiana	Suriname	Venezuela
ATYIDAE						
Atya gabonensis					●	
EURYRHYNCHIDAE						
Euryrhynchus amazoniensis	●					●
E. burchelli	●					
E. pemoni						●
E. wrzesniowskii	●		●	●	●	
PALAEMONIDAE						
Macrobrachium acanthurus					●	
M. amazonicum	●			●	●	●
M. aracamuni						●
M. atabapense						●
M. brasiliense	●		●	●	●	●
M. carcinus					●	●
M. cortezi						●
M. ferreirai	●					
M. inpa	●					
M. jelskii	●		●		●	●
M. nattereri	●		●			●
M. olfersi					●	
M. pectinatum						●
M. quelchi				●		●
M. rosenbergii						●
M. sp. n. 1						●
M. surinamicum				●	●	●
Palaemonetes carteri	●		●	●	●	●
P. ivonicus						●
P. mercedae	●					●
Pseudopalaemon amazonensis	●					●
P. chryseus	●					
P. gouldingi	●					●
P. nigramnis	●					
P. sp. n. 1						●
PSEUDOTHELPHUSIDAE						
Fredius adpressus adpressus						●
F. adpressus piaroensis						●
F. beccarii				●		●
F. chaffanjoni						●
F. denticulatus	●		●		●	
F. estevisi estevisi	●					●
F. estevisi siapensis						●
F. fittkaui	●			●		●
F. granulatus		●				
F. platyacanthus	●					●
F. reflexifrons	●		●		●	
F. stenolobus	●					●
Kingsleya besti	●					
K. latifrons	●		●	●	●	
K. siolii	●				●	
K. ytupora	●					

Table 2. Continued...

	Brazil	Colombia	F. Guiana	Guiana	Suriname	Venezuela
Microthelphusa bolivari						●
M.rodriguezi				●		
M.somanni	●					
M.wymani					●	
Prionothelphusa eliasi	●	●				●
SERGESTIDAE						
Acetes paraguayensis	●				●	●
TRICHODACTYLIDAE						
Dilocarcinus septemdentatus	●		●		●	
Forsteria venezuelensis						●
Moreirocarcinus emarginatus	●	●				●
M. laevifrons	●					●
Poppiana dentata	●				●	●
Sylviocarcinus devillei	●					
S. pictus	●			●		●
Trichodactylus ehrhardti	●					
T. faxoni	●					
Valdivia haraldi	●					
V. novemdentata	●					
V. serrata	●	●		●	●	●

Table 3. Check list of decapod crustacean species distributed in the Guayana Shield region according to the main river basins.

Tabela 3. Lista de espécies de crustáceos decápodos distribuidos na região do escudo das Guianas conforme as principais bacias hidrográficas.

	Amazon	Araguari	Coppename	Corantijn	Cuyuni	Essequibo	Marowijne/ Maroni	Mazaruni	Orinoco	Oyapock	Suriname
ATYIDAE											
Atya gabonensis											●
Euryrhynchidae											
Euryrhynchus amazoniensis	●	●							●		
E. burchelli	●										
E. pemoni									●		
E. wrzesniowskii	●				●			●			●
PALAEMONIDAE											
Macrobrachium acanthurus			●								
M. amazonicum	●	●			●		●		●		●
M. aracamuni									●		
M. atabapense									●		
M. brasiliense	●		●		●	●	●		●		●
M. carcinus							●		●		●
M. cortezi	●								●		
M. ferreirai	●										
M. inpa	●										
M. jelskii	●	●			●		●		●		●
M. nattereri	●								●		
M. olfersi			●				●				●
M. pectinatum									●		
M. quelchi								●	●		
M. rosenbergii									●		
M. sp. n. 1									●		
M. surinamicum					●				●		●
Palaemonetes carteri	●	●			●		●	●	●		●
P. ivonicus									●		
P. mercedae	●								●		
Pseudopalaemon amazonensis	●								●		
P. chryseus	●										
P. gouldingi	●								●		
P. nigramnis	●										
P. sp. n. 1									●		
PSEUDOTHELPHUSIDAE											
Fredius adpressus adpressus									●		

Table 3. Continued...

	Amazon	Araguari	Coppename	Corantijn	Cuyuni	Essequibo	Marowijne/ Maroni	Mazaruni	Orinoco	Oyapock	Suriname
F. adpressus piaroensis									●		
F. beccarii					●	●			●		
F. chaffanjoni									●		
F. denticulatus	●		●	●			●				●
F. estevisi estevisi	●								●		
F. estevisi siapensis									●		
F. fittkaui	●										
F. granulatus	●										
F. platyacanthus	●								●		
F. reflexifrons	●	●	●				●				●
F. stenolobus	●								●		
Kingsleya besti	●										
K. latifrons	●			●		●				●	●
K. siolii	●										
K. ytupora	●	●									
Microthelphusa bolivari					●						
M. rodriguezi						●					
M. somanni	●										
M. wymani			●				●				●
Prionothelphusa eliasi	●										
SERGESTIDAE											
Acetes paraguayensis	●								●		●
Trichodactylidae											
Dilocarcinus septemdentatus	●	●									●
Forsteria venezuelensis									●		
Moreirocarcinus emarginatus	●								●		
M. laevifrons	●								●		
Poppiana dentata	●		●	●	●				●		●
Sylviocarcinus devillei	●	●									
S. pictus	●	●			●	●				●	
Trichodactylus ehrhardti	●										
T. faxoni	●										
Valdivia haraldi	●										
V. novemdentata	●										
V. serrata	●		●	●	●	●	●		●		●

Table 4. Check list of decapod crustacean species distributed in the Amazon River main tributaries coming from the Guayana Shield region.
Tabela 4. Lista de espécies de crustáceos decápodos distribuidos nos principais tributários do rio Amazonas oriundos da região do escudo das Guianas.

	Rio Negro	Rio Uatumã	Rio Nhamundá	Rio Trombetas	Rio Paru do Leste	Rio Jari
EURYRHYNCHIDAE						
Euryrhynchus amazoniensis	●	●		●		
E. burchelli	●	●				
E. wrzesniowskii		●		●		
PALAEMONIDAE						
Macrobrachium amazonicum	●			●		
M. brasiliense	●			●		●
M. cortezi	●					
M. ferreirai	●	●				
M. inpa	●					
M. jelskii	●					
M. nattereri	●	●		●		
Palaemonetes carteri	●	●		●		
P. mercedae	●	●				
Pseudopalaemon amazonensis	●					
P. chryseus	●	●		●		
P. gouldingi	●					
P. nigramnis	●					
PSEUDOTHELPHUSIDAE						
F. denticulatus	●					
F. estevisi estevisi	●					
F. fittkaui	●					
F. platyacanthus	●					
F. reflexifrons	●			? ●		
F. stenolobus	●					
Kingsleya besti	●					
K. latifrons	●	●		●		
K. siolii				●		
K. ytupora		●		●		
Microthelphusa somanni	●					
Prionothelphusa eliasi	●					
SERGESTIDAE						
Acetes paraguayensis	●					
TRICHODACTYLIDAE						
Dilocarcinus septemdentatus						
Moreirocarcinus emarginatus	●					
M. laevifrons	●	●				
Poppiana dentata	●					
Sylviocarcinus devillei						●
S. pictus	●	●		●		●
Trichodactylus ehrhardti	●	●		●		
T. faxoni						●
Valdivia haraldi	●					
V. novemdentata	●					
V. serrata	●	●		●		●