THE USE OF RAPID ASSESSMENT APPROACH TO DISCUSS ECOLOGICAL THEORIES IN WETLAND SYSTEMS, SOUTHERN BRAZIL

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SUMMARY

The Rapid Assessment Program (RAP) constitutes a powerful tool used to select important areas for the conservation of biodiversity. The relationships between species diversity and the ecosystem size have been investigated by biologists, mainly in terrestrial ecosystems. Recent biodiversity surveys of algae, macrophytes and macroinvertebrates were developed in the Sinos river basin (southern Brazil) using the Aqua-Rap approach as a tool. The selection of wetlands (different size and classes) was fundamental to discuss the relationship between biodiversity and the size of ecosystems. Only macrophyte richness was positively correlated to the size of the wetland. The richness of algae and macroinvertebrates was not influenced by the size of the wetlands. These results show the importance of the inclusion of different biological communities to test ecological theories and to propose strategies for conservation programs.

RESUMEN

El Programa de Evaluación Rápida (RAP) es una herramienta que puede ser usada para seleccionar áreas prioritarias para la conservación de la biodiversidad. La relación entre diversidad de especies y tamaño del ecosistema ha sido investigada por biólogos, principalmente en ecosistemas terrestres. Estudios sobre diversidad de algas, macrófitos y macroinvertebrados han sido llevados a cabo recientemente en la cuenca del Río do Sinos (sur de Brasil) a través del Programa Aqua-Rap. La selección de los humedales (distintos tamaños y clases) fue fundamental para discutir la relación entre la diversidad de especies y el tamaño del ecosistema. Solo la riqueza de macrófitos estuvo correlacionada con el tamaño de los humedales. La riqueza de algas y de macroinvertebrados no estuvo influenciada por el tamaño de estos sistemas. Estos resultados muestran la importancia de la inclusión de diferentes comunidades biológicas para testar teorías ecológicas y proponer estrategias a los programas de conservación.

One of the central theoretical tasks of conservation biology is to assign priorities to environments on the basis of their diversity value (Sarkar *et al.*, 2002). In the tropics, the fundamental constraint for biodiversity conservation is the poor knowledge about its high diversity and hotspots assessments (Barbosa and Callisto, 2000). In aquatic ecosystems, the biodiversity has received even less attention during the last decades. However, the fast degradation of these ecosystems brings forth the urgent need for biodiversity surveys. Almost 50% of the total wetlands

KEYWORDS / Aqua-Rap / Biodiversity / Brazil / Neotropical Region / Wetlands /

Received: 07/02/2003. Modified: 03/30/2004. Accepted: 03/31/2004.

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RESUMO

O Programa de Avaliação Rápida (RAP) é uma ferramenta que pode ser usada para selecionar áreas prioritárias para a conservação da biodiversidade. A relação entre diversidade de espécies e o tamanho de ecossistema tem sido pesquisada por biólogos, principalmente em ecossistemas terrestres. Estudos recentes sobre diversidade de algas, macrófitas e macroinvertebrados foram desenvolvidos na bacia do Río dos Sinos (sul do Brasil) usando a abordagem Aqua-Rap. A seleção de áreas úmidas (com diferentes tamanhos e classes) foi fundamental para discutir a relação entre a diversidade de espécies e tamanho do ecossistema. Somente a riqueza de macrófitas foi correlacionada com o tamanho da área úmida. A riqueza de algas e de macroinvertebrados não foi influenciada pelo tamanho dos ecossistemas. Estes resultados mostraram a importância de incluir diferentes comunidades biológicas para testar teorias ecológicas e propor estratégias para programas de conservação.

have disappeared in the last century due to agriculture and urban development (Shine and Klemm, 1999), and almost $^{2}/_{3}$ of European wetlands were lost in the beginning of the 20th century (Santamaria and Klaassen, 2002).

The Rapid Assessment Programme (RAP) constitutes a powerful program used to select important areas for the conservation of biodiversity, concentrating the efforts of specialists in sampling the highest possible number of sites in the shortest possible time (Mittermeier and Forsyth, 1992). An extension of the RAP approach for aquatic ecosystems is the Aqua-Rap Program, developed by Conservation International and the Field Museum of Natural History (Chernoff *et al.*, 1996).

The South American Aquatic Rapid Assessment Program (Aqua-Rap) was a multidisciplinary program devoted to identify conservation priorities and sustainable management opportunities in freshwater ecosystems in Latin America (Willink *et al.*, 2000). Aqua-Rap´s main focus was to assess the biological value of selected tropical freshwater ecosystems through rapid inventories, and to report the information quickly to local policy makers, conservationists, scientists and international funding agencies. The studies can be useful for the establishment of conservation policies for biodiversity in tropical lands for two reasons: the high biodiversity values have been poorly assessed, and there is a lack of experts able to identify the taxa down to species level (Barbosa and Callisto, 2000). Aqua-Rap experiences (see Table I) were carried out at the upper Orthon river Basin (Tahuamano and Nareuda rivers) in the Bolivian Amazon area in 1996 (Chernoff and Willink, 1999), the Paraguay river basin (covering a considerable area of the Chaco) in 1997 (Chernoff *et al.*, 2001), Pantanal, Mato Grosso do Sul, Brazil in 1998 (Willink *et al.*, 2000), and Laguna del Tigre National Park, Petén-Guatemala in 1999 (Bestelmeyer and Alonso, 2000). Other studies have been carried out in the Pastaza river basin, Ecuador-Peru, in 1999 (Conservation International, 2004), and the Caura River Basin, Venezuela, in 2000 (Chernoff *et al.*, 2003). These areas were evaluated and selected for further detailed studies (Barbosa and Callisto, 2000). The Aqua-Rap experiences concentrated mainly in the assessment of freshwater biodiversity in selected areas of high biodiversity and low scientific knowledge, and it has never been used to test ecological theories.

In North America there has been a renewed interest in the use of rapid assessment approaches, primarily because of the high economic and time costs of quantitative approaches. The purpose is to identify water quality problems associated with both point and non-point source pollution and to document long-term regional changes in water quality (Resh and Jackson, 1993). A similar approach is being used also to assess status of fish communities (Plafkin *et al.*, 1989; Chernoff *et al.*, 2004). Resh and Jackson (1993) proposed some ways to reduce the cost of the effort in assessing environmental conditions at a site: 1) the number of habitats sampled and replicate sample units taken per habitat are reduced; 2) less silt and particulate debris are collected, which makes sorting easier and faster; 3) only a fraction of the animals collected is considered, which means fewer have to be identified; or (4) specimens are identified to family or even higher taxonomic levels.

The relationship between species diversity and the size of an ecosystem has been investigated by biologists. Numerous experiments have developed general theories about the habitat size in order to construct species-specific regression models (MacArthur and MacArthur, 1961; Petit and Petit, 1999). Much of this research was conducted in terrestrial ecosystems (Harris, 1984; Fernández, 1997) and was intended to produce suggestions of tools for conservation practices and to assess how size, shape or connection

TABLE I
NUMBER OF SPECIES RECORDED IN SOME AQUA-RAP EXPERIENCES IN SOUTH AND CENTRAL AMERICA, AND IN SINOS RIVER BASIN

Taxa	Río Orthon, Bolivia[1]	Río Paraguay[2]	Pantanal, Brazil[3]	LdTNP, Guatemala[4]	Río dos Sinos[5]
Phytoplankton	-	-	-	71	61
Zooplankton	120	-	-	-	-
Aquatic insects on *S. auriculata*	-	-	-	44	-
Shrimps and crabs	10	13	10	-	-
Snails and mussels	-	10	-	-	-
Benthic macroinvertebrates	36	121	70	-	57
Plants	-	385	670	130	56
Fishes	313	173	193	41	-
Birds	-	-	-	173	-
Reptiles and amphibians	-	-	65	36	-
Mammals	-	-	-	40	-
Ants	-	-	-	112	-

[1] Upper Río Orthon Basin, Pando, Bolivia (Chernoff and Willink, 1999)
[2] Río Paraguay Basin, Alto Paraguay, Paraguay (Chernoff *et al*., 2001)
[3] Pantanal, Mato Grosso do Sul, Brazil (Willink *et al.*, 2000)
[4] Laguna del Tigre National Park, Petén, Guatemala (Bestelmeyer and Alonso, 2000)
[5] Río dos Sinos, Río Grande do Sul, Brazil (Maltchik *et al.*, 2002; Matsubara *et al*., 2002; Stenert *et al*., 2002)

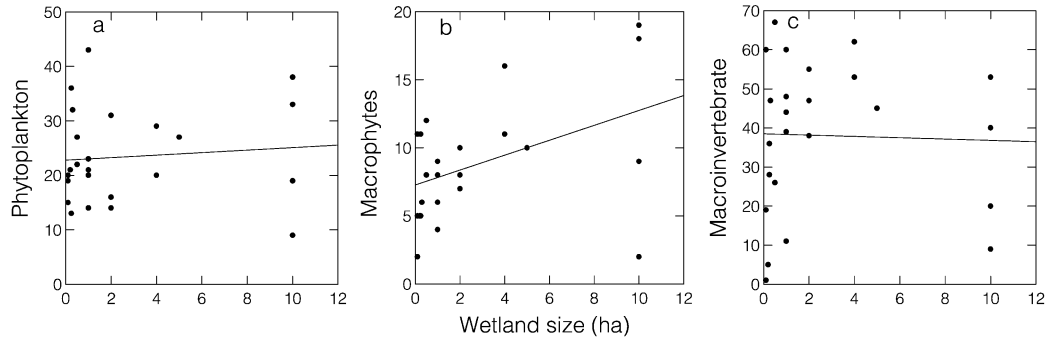

Figure 1. Relationships between wetland area and a: richness of phytoplankton (R^2=0.009, $F_{1,22}$=0.199, P=0.660), b: macrophytes (R^2=0.195, $F_{1,22}$=5.338, P=0.031) and c: macroinvertebrates (R^2=0.001, $F_{1,22}$=0.022, P=0.883) in the Sinos river basin (n=24). Sources: a) Matsubara *et al*., 2002, b) Maltchik *et al*., 2002, c) Stenert *et al*., 2002.

between fragments can influence species diversity.

Wetlands are amongst the most productive ecosystems on Earth and they are patches of high biological diversity (Hails, 1996; Barbier *et al*., 1997; Tiner, 1999). In this context, wetlands are important areas for conservation. Wetlands may be seen as natural ecological islands of freshwater habitats surrounded by terrestrial habitats. These ecosystems provide excellent opportunities to assess the relationship between species diversity and ecosystem size in undisturbed areas. In wetlands, the relationships among species diversity and wetland size have been analyzed for invertebrates (Lassen, 1975; Broenmark, 1985; Aho, 1978; Allen *et al*., 1999), plants (Honnay *et al*., 1999; Møller and Rørdam, 1985; Rorslett, 1991), amphibians (Babbit and Tanner, 2000; Houlahan and Findlay, 2003; Snodgrass *et al*., 2000) and birds (Tyser, 1983; Brown and Dinsmore, 1991; Naugle *et al*., 1999; Caziani *et al*., 2001; Riffell *et al*., 2001). These results have been useful for the establishment of wetland regulations in the United States (Snodgrass *et al*., 2000).

Recent biodiversity surveys of algae (Matsubara *et al*., 2002), macrophytes (Maltchik *et al*., 2002) and macroinvertebrates (Stenert *et al*., 2002) were carried out in the Sinos river basin, southern Brazil, using the Aqua-Rap Program. A total of 24 wetlands were selected in the Río dos Sinos basin (~4000km^2), with different areas (between 0.25 and >10ha) and wetland classes (shallow lakes, floodplain systems, bogs and marshes). The sampled wetlands constitute a great part of the wetland classes in southern Brazil, and they may be flooded permanently, periodically, or never flooded but saturated for extended periods during the annual cycle. The hydrology of the majority of the sampled wetlands was affected by precipitation, runoff, groundwater discharge and flooding from the streams and rivers in different combinations.

The selection of wetlands in these studies (biodiversity survey through Aqua-Rap approach) was fundamental to discuss ecological theories, such as the relationships between biodiversity and the size of the ecosystem. The difference in sizes, altitude and classes of the selected wetlands allowed establishing regression lines between the wetland size and the richness of algae, macrophyte and macroinvertebrates. The results provided criteria for the conservation policy in the Sinos river basin.

Samplings were carried out from August to November 2001. The samplings of algae, macrophytes and macroinvertebrates were qualitative, to identify more precisely the total biodiversity of the studied ecosystem. However, the time spent for collections varied between 20 and 70 minutes, depending on the wetland area. The sampling was performed along the whole wetland area and distributed throughout the various habitats (water depth and distance from the margins). The sampling effort carried out among the different wetlands areas was sufficient to search through the edges and the major part of the different habitats, and to compare the differences in species richness.

Only the richness of macrophytes was positively correlated to the size of the wetlands; that of algae and macroinvertebrates was not influenced by the size of the wetlands (Figure 1). The poor relationships to algae and macroinvertebrates richness was probably due to the high species richness found in wetlands of small areas. These results were important to include small wetlands in the conservation programs in southern Brazil (Maltchik *et al*., 2003).

TABLE II
RICHNESS OF ALGAE (GENERA), MACROPHYTE AND MACROINVERTEBRATE FOUND IN A SHALLOW OF THE SINOS RIVER BASIN LAKE ALONG AN ANNUAL CYCLE (2000-2001)

	Shallow lake	Sinos river basin
Macrophyte	9	56
Macroinvertebrate	27	57
Algae	75	61

The different regression lines found for aquatic macrophytes, algae and macroinvertebrates corroborate the importance of the inclusion of different biological communities to test ecological theories and the weakness of the conservation strategies originated from studies that analyze only a small part of the whole biodiversity. Chernoff *et al*. (2004) stated that the strategies for conservation of wetlands should ideally be based upon as many groups of organisms as possible, including information of their distributions and their biotic and abiotic interactions. Findlay and Houlahan (1997), Semlitsch and Bodie (1998) and Oertli *et al*. (2002) analyzed the effect of area on species richness using different groups of organisms. In the tropical region, the biodiversity surveys including results of several organism groups are scarce (Willink *et al*., 2000), probably due to the lack of specialists needed to identify some organism groups at a specific level, as is the case with aquatic macroinvertebrates.

Studies carried out in a shallow lake associated to a floodplain system in the Sinos river basin showed that the richness of algae (Maltchik *et al*., 2004a), macrophytes (Maltchik *et al*., 2004b) and macroinvertebrates (Stenert *et al*., 2003) varied along an annual cycle. However, the number of macrophyte and macroinvertebrate species found were much smaller than the diversity found in the sampled wetlands in the Sinos river basin (Table II). For algae, the result was inverse,

with a larger number of algae genera identified in the shallow lake along an annual cycle. These results indicate that, depending on the analyzed group, the species oscillations through the year may express a larger or smaller importance in the biodiversity surveys. However, we are convinced that these results suggest the efficiency of the RAP approach in recognizing the biological diversity in the wetlands of southern Brazil.

Our experience with the Rap approach in the analysis of ecological studies was satisfactory. The results gave some scientific support to launch new studies involving the relationships between biodiversity and wetland area, at a larger spatial scale, especially considering the total area of the State of the Río Grande do Sul (~250000km^2). However, our field experience led to several considerations as to the relationships between species richness and wetland size through the Aqua-Rap approach, which must be highlighted: 1) the need for qualitative sampling to obtain better representations of the biological diversity; 2) the use of the sample effort as a comparative measurement of the biological diversity among wetlands; 3) finding the most appropriate time for sampling the individual wetlands in order to go through the whole wetland area (various habitats) and to compare the differences among the species richness; and 4) outlining the sampling procedure in wetlands with sizes above 10ha.

Finally, it is of paramount importance to summarize the results of site surveys in a way that they can be understood by non-specialists such as managers, other decision-makers, and the concerned public. Moreover, the rapid assessment approach can help in the definition of new Conservation Units, involving the partnership among the scientific community (which makes available the information related to the biodiversity inventories), the government and the local society (Primack and Rodrigues, 2001). However, a rapid expedition is not a substitute for long-term scientific studies, mainly for some specific groups where the seasonal variations throughout the year are very high (as in algae). Besides, the ecological fragility of wetlands (Callisto *et al*, 1998), the urgent need for the implementation of efficient conservation policies and the monitoring species diversity indicators must be pointed out (Cavalcanti, 1999). Future scientific surveys must consider the biological and conservation value of a region, and how integrated solutions can work in order to preserve the maximum amount of biodiversity in face of current and future threats (Willink *et al.*, 2000).

ACKNOWLEDGEMENTS

The authors are grateful to Cristina Stenert, Ana Silva Rolon, Edison dos Santos and Carla Matsubara for their technical assistance. This study was supported by CNPq, CAPES and UNISINOS.

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