Acta Limnol. Brasil.	Vol. III	49-75	1990

LIMNOLOGY IN ARGENTINA

DRAGO, E.C.*

RESUMO - LIMNOLOGIA NA ARGENTINA

Neste trabalho se resume as diversas etapas do progresso da Limnologia na Argentina. As primeiras medidas de caráter limnológicos foram feitas por LEOWEHRLI no lago Nahuel Huapi (Província de Rio Negro), em 1897-1898. Posteriormente, os nomes de HANS SECKT (1918) e EMILIANO MAC DONAGH (1928) assinalam os primeiros passos no desenvolvimento da ciência das águas continentais em nosso país. RAFAEL CORDINI é o investigador que marca a etapa da consolidação da Limnologia Argentina, podendo ser considerado seu fundador. Desde 1927 até 1964, as investigações de CORDINI constituem um grande suporte na estrutura desta ciência. Sua importância reside não somente nos estudos sobre geologia, química da água e plâncton, mas também por se introduzir profundamente no campo da limnologia física, onde traz muitas informações sobre morfologia lacustre, tipologia de sedimentos e propriedades térmicas de lagos. Desde 1942, a limnologia começou a apresentar um enfoque mais ecológico, sendo estimulada neste sentido por RAUL RINGUELET, da Universidade de La Plata (Província de Buenos Aires), cujas investigações ocuparam um lugar preponderante no campo da hidrobiologia.

* INALI-CONICET - Santo Tomé, Santa Fé, Argentina

Foi o fundador do Instituto de Limnologia de La Plata (LPLA). Se destacam os importantes suportes científicos de ARGENTINO BONETTO e seu grupo desde a criação do Instituto Nacional de Limnologia (INALI); também se destacam as atividades do Centro de Limnologia Aplicada do Litoral (CECOAL) e do Departamento de Águas Continentais do Instituto Nacional de Investigações e Desenvolvimento Pesqueiro (INIDEP). A criação da Sociedade Argentina de Limnologia, em 1984, se destaca como um marco necessário para o desenvolvimento limnológico neste país. Finalmente, este estudo apresenta ainda uma primeira tentativa de divisão da República Argentina em seis regiões limnológicas: 1) Região Fluvial Paraná-Prata, 2) Região lacustre dos Andes Patagônicos, 3) Região Patagônica Extra-Andina, 4) Região Endorréica, 5) Região Sub-Antártica e 6) Região Antártica.

ABSTRACT - LIMNOLOGY IN ARGENTINA

This paper deals with the advances of Limnology in Argentina since its origin. The first measurements of limnological characteristics were performed by LEO WEHRLI in Lake Nahuel Huapi (Rio Negro Province), in 1897-98. Later on, the names of HANS SECKT (1918) and EMILIANO MAC DONAGH (1928) deserve mention because of their early contributions to the development of the science of inland waters in the country. The scientist who marks the consolidation stage of Argentine limnology and is considered its founder was RAFAEL CORDINI. Beginning in 1927 and continuing to 1964, CORDINI's researches form a prominent background in the structure of Argentine limnology. His importance rests not only in his studies of geology, water chemistry and plankton, but his work took him deeply into the field of physical limnology, and there he discovered much concerning lacustrine morphology, bottom

sediments, and thermal properties of lakes and ponds. By 1942, limnology acquired a more ecological approach, being stimulated to a great extent in this direction by RAUL RINGUELET of the University of La Plata (Buenos Aires Province), who carried out important investigations in the field of hydrobiology. He was the founder of the Institute of Limnology of La Plata (ILPLA) in 1968. The investigations of ARGENTINO BONETTO and his group since the foundation of the National Institute of Limnology (INALI) in 1962, and the scientific activities of the Littoral Center of Applied Ecology (CECOAL, 1974) and those of the Inland Waters Department of the National Institute of Fisheries Research and Development (INIDEP) are deseriked. The creation of the Argentine Association of Limnology in 1984 satisfied a real necessity in the limnological development of the country. Finally, a division of Argentina into limnological regions is suggested: 1) Paraná-Plata Fluvial Region, 2) Patagonian-Fuegian Andes Lacustrine Region, 3) Extra-andine Patagonia Region, 4) Endorheic Region, 5) Subantartic Region, and 6) Antarctic Region.

INTRODUCTION

At present, when an increasing international interest in the limnology of the Southern Hemisphere is increasing, it is important that comprehensive reviews on the history of progress in the inland water studies of that region be made available, in order to stimulate the interest of the general scientific community and encouraging thereby a greater participation in limnological research in the Southern Hemisphere. There is an amazing diversity of features in the Argentine hydrosystems, since the territory includes diverse water types located on regions as different as the lowlands of the Pampa Plains

and the highlands of the Andes Mountains, and under climates that rank from subtropical to antarctic. Therefore, the limnological development in Argentina was difficult, although the early field trips required little special equipment for making the observations and collecting the specimens. The increasing sophistication of limnological techniques involving chemical measurements, began to complicate the fulfillment of field surveys. Due to the advances in limnological knowledge, it became clear that short-term trips, though still valuable for collecting preliminary or special information from remote regions, cannot provide the kind of knowledge, now needed, about the processes and cyclical (specially seasonal) changes operating in a hydrosystem, and which relate to productivity. Investigations along several years, preferably from a fixed and adequately equipped stations, are required. In spite of its inland water diversity, Argentina was not limnologically explored by foreign scientists of develop countries, such as some African countries or Brazil and Venezuela. So that, the Argentinean researchers were almost exclusively responsible of the progress of limnology in Argentina. In our country, only two different water systems received long-term measurements, the middle reach of the Paraná River and its tributaries and the ponds of the Pampas, in Buenos Aires Province.

DISCUSSION

Limnology is a very new science. Although the ancestry of freshwater study is varied and old, its place as a circumscribed and directed area of scientific endeavor and achievement was not established until the last years of the 19th century and the beginning of the 20th century. The publication of several papers on geology, chemistry,

physics and biological aspects of Lac Léman (now Lake Geneva), Switzerland, by F.A. FOREL, according to many historians, marked the beginning of the scientific study of the inland waters between 1869 and 1904.

Curiously, during this period the first limnological measurements were performed in Argentina. In fact, between December 1897 and February 1898, the Swiss LEO WEHRLI (1919) measured depth, water temperature, transparency and made some observations on the origin of Lake Nahuel Huapi (Río Negro Province).

Later, a biologist of the National University of Córdoba (Córdoba Province), HANS SECKT, remarked on the importance of an integrated study of inland waters (1918, 1921, 1924a, 1924b). During the First National Meeting of the Argentine Society of Natural Sciences, held in San Miguel de Tucumán (Tucumán Province) in 1916, SECKT pointed out: 'It would be advisable to perform carefully investigations on the chemical, bacteriological, flora and fauna characteristics (especially on the microscopic inhabitants) of rivers, lakes, ponds, brooks, etc., in order to resolve several biological and physiological questions on the aquatic organisms and their systematic problems' ... 'or in order to resolve water management problems, e.g., drinking water as well as fish culture and others...'. In a review on floristic and faunistic studies of Argentine freshwaters (1921), SECKT dealt with the subject again, saying: 'we should not limit ourselves only to a superficial knowledge of the representative Argentine microflora and microfauna, nor should we limit ourselves only to an inventory of aquatic animals and plants. On the contrary, we should know the freshwaters from a geological, physical, chemical and biological point of view'.

SECKT's remarks were decisive in the evolution of Argentine limnology, because the disciplines mentioned by him, namely Geology, Physics, Chemistry and Biology, form the core of the study of inland waters.

These early contributions to the field of Argentine limnology, received a new impulse from 1928 to 1935 thanks to EMILIANO MAC DONAGH. His investigations were the first attempts to study the aquatic fauna with an ecological criterion (1928, 1931, 1934, 1935). He studied the growth of the 'pejerrey' (*Odontheates bonariensis*) in Del Monte Pond (Guaminí, Buenos Aires Province), within 'the unexplored field of its interactions with its environment', affording meteorological, chemical and physical data. In the Proceedings of the International Association of Limnology (SIL), MAC DONAGH published 'The physiography and plankton in the lagoons of Buenos Aires' (1935), where the physical and biological features of the ponds of the Pampas were described.

Evidently, these were the first steps in the progress of Limnology in Argentina. Nevertheless, the contribution of both ideas and knowledge, however important, were insufficient to constitute exhaustive limnological analyses of the water bodies studied.

From my point of view, the work carried out by RADAEL CORDINI in Lake Nahuel Huapi (Río Negro Province), begun in 1927 and continued, with some interruptions, till 1930, mark the consolidation period in Argentine limnology. Furthermore, his work on Chascomús Pond (Buenos Aires Province) appearing in 1938, was the first contribution to the study of an aquatic habitat performed according to a limnological criterion. Subsequently, CORDINI published limnological information on Lake Nahuel Huapi (1939), affording data on lacustrine morphology, granulometric, chemical and petrographic features of the bottom sediments, and on the thermal behavior of the superficial and deep waters of the lake.

This work reported the first limnological information about a great glacial lake of the Andine-Patagonian Lake District. At present, the larger lakes of this region are limnologically unknown, and

CORDINI's contributions are the best studies carried out, up to now, on an oligotrophic lake in Argentina (1939, 1950). CORDINI (1938, 1942) also described the limnological features of the Chascomús and La Brava Ponds (Buenos Aires Province), and in 1964 appeared his last contribution on the Patagonian Lake Lácar.

CORDINI's original and solitary task, to explain the dynamics of different water bodies, studied by means of integrated data, gives a clear vision of the limnological criterion. CORDINI's contributions, undoubtedly fundamental, lead me to consider him the founder of Argentine Limnology.

I should also mention JUAN CORDINI's papers, one of which deals with the seston and diatom content of the Río de la Plata waters (1939); the other presents the first data from a man-made lake, Río Tercero Reservoir (Córdoba Province, 1950).

The successful scientific work of RAUL RINGUELET began in 1942 with a paper on feeding ecology of 'pejerrey' (*Odontheste bonariensis*), including limnological data of Chascomús Pond (Buenos Aires Province). He was one of the most enthusiastic impellers of aquatic ecology studies in Argentine. It is impossible to overestimate the influence of RINGUELET's work on Argentine limnological thought. In addition to his significant contributions, this scientist was responsible for the creation and training of a group of young researchers who began working on different limnological subjects. Later this group would be the origin of the 'Dr. RAUL RINGUELET' Institute of Limnology (ILPLA), founded in La Plata City (Buenos Aires Province) in 1968. The characterization of water bodies, their management and rational exploitation, and the ecology of several groups of organisms were demonstrated by RINGUELET's contributions. Among many works, I must quote his paper on inland aquatic environments with a biological assay particularly applied to Argentina (1957). His book 'Ecología Acuática

Continental' (1962) is the first and most complete treatment of the subject written in Argentina up to now. In this book, RINGUELET explains the characteristics of different types of inland water bodies, especially including several concrete examples of aquatic habitats commonly found in our country.

His works include landmark principles that remain unalterable to this day... 'a lake, a pound, are not merely physical accidents, geographical features that can be measured by their area, depth, residence time, in order to manage and modify according to a unilateral criterion. They are sets formed by inanimate and living parts having a history, a delicate dynamic and an evolution in time that can be studied and upon which a prognosis can be made' ... 'If we either do not know or undervalue the close relationships between living things and their environment, their evolution as a whole, if we do not remember that these form harmonious circuits from inanimate to living matter, we will attain the regrettable destruction of the natural resources' ... (RINGUELET, 1962).

Subsequent papers of RINGUELET deal with the freshwater fishes of Argentina (RINGUELET et alii, 1967), chemical limnology of the ponds of the Pampas (RINGUELET et alii, 1967), biogeography of freshwater copepods from Argentina (1968a), typology of ponds in Buenos Aires Province (1968b, 1972), and zoogeography and ecology of Argentine inland water fishes with consideration of other areas of South America (1975). RINGUELET's work shows a distinctive and creative continuity in Argentine limnological activity.

Professor RINGUELET was Director of the ILPLA from its creation in 1968 until his death in 1982, and he was also Professor of Limnology at La Plata University (Buenos Aires Province). This course, initiated in 1967, was the first of its subject to be taught in Argentina.

The important limnological activity of the ILPLA

continues to the present. Investigations are being carried out in different geographical areas of Argentina, like the ponds of the Pampas, the reservoirs of the central area and the glacial lakes of Tierra del Fuego Island.

One of RINGUELET's first followers was SANTIAGO R. OLIVIER. In 1948, he began a series of studies on the limnology of inland waters in the Province of Buenos Aires (1949), including some aspects of regional limnology (1952, 1955a, 1955b, 1961). In these studies he also fully described the geological, hydrological, physical and chemical features of these aquatic environments.

ARGENTINO A. BONETTO, another outstanding leader of Argentine limnological research, promoted the creation in 1962 of the National Institute of Limnology (INALI), and directed the Institute since is founding. This center, the first research institute founded by the National Council of Scientific and Technological Research (CONICET), is located in Santo Tomé City (Santa Fé Province).

One of the most important of BONETTO's tasks was the formation of a team of young researchers who initiated studies on the physical, chemical, and biological characteristics of the aquatic environments of the Paraná River Basin, emphasizing the shallow water bodies of the Middle Paraná River floodplain.

Later on, the geographical coverage of the INALI was considerably expanded and diversified. Studies on the Andine-Patagonian lakes and on the rivers and reservoirs situated in the central region of the country were carried out (BONETTO et alli, 1971; BONETTO & DI PERSIA, 1984; DRAGO, 1972, 1974; DRAGO & DEPETRIS, 1974a, 1974b, 1975; GARCIA de EMILIANI & SCHIAFFINO, 1974; INALI, 1973a, 1973b; LUCHINI, 1973, 1974; MAGLIANESI et alii, 1973; NEIFF, 1973; OLIVEROS & CORDIVIOLA de YUAN, 1974; PAGGI, 1973). During this period, BONETTO and his group published 157 papers, affording important information about the water quality and on the communities that inhabit these aquatic habitats.

From 1974 onwards, a research program entitled 'The Ecological Study of the Middle Paraná' was designed, and the INALI's staff concentrated especially on this complex hydrosystem. Different aspects of the lotic-lentic relationships in the Middle Paraná floodplain are being investigated through extensive sampling along the middle reach and its tributary streams, and by intensive sampling in a cross-section of the main channel and in alluvial ponds with different degrees of connection to the adjacent rivers (INALI, 1981, 1982a, 1982b, 1982c, 1985).

Recently, a small group of researchers began two important projects, the 'Argentine Fresh Water Fauna Project' and the Limnoantar Program. The former project's goals are the identification of taxa, the determination and understanding of the physical and chemical features of the environments and their biogeography. The aims of the second project are the geographical location, bathymetric survey and limnological characterization of lakes and ponds of Continental and Maritime Antarctica (DRAGO, 1980, 1983, 1987, 1988; JOSE de PAGGI, 1982; JOSE de PAGGI & KOSTE, 1984; KIEFFER & COPES, 1987; PAGGI, 1983, 1987a, 1987b). This project is included in the BIOTAS International Program, whose goal is to promote and coordinate the development of biological investigations in Antarctic and Sub-Antarctic terrestrial systems, including the inland waters.

It is evident that the 1960's mark the onset of a decisive period in the modern development of Limnology in Argentina. The creation of the INALI in 1962 and the ILPLA in 1968 formed two research centers dedicated exclusively to limnological study of diverse geographical areas, thus allowing the training of researchers from Argentina and also from other Latin American countries.

In 1974, the creation of the Littoral Center of Applied Ecology (CECOAL), belonging to CONICET, and the consolidation of a group of researchers under the direction

of ROLANDO QUIROS at the Inland Waters Department of the National Institute of Fisheries Research and Development (INIDEP), in 1979, permitted initiation of investigations in new geographical areas.

I must also mention the valuable work begun by QUIROS and collaborators (1983) with three volumes of 'The Geographical Dictionary of Inland Aquatic Environments of Argentina, Part I: Lentic Environments'. In this work, which I hope can be continued, much data concerning climatic, geological and edaphic characteristics of the catchment areas of lakes, ponds and reservoirs, as well as information on the morphometric parameters of lacustrine troughs are given.

During recent years there has been an approach toward research on causality of the phenomena detected in hydrosystems. Nevertheless, dispite great efforts made by a few researchers from different centers, advances are slow and quite difficult, due essentially to the following features:

1) The influence on scientific activity of political changes through modifications in research projects implying often the withdrawal of financial support that produces either internal migration or exodus to other countries. These features, usually prevents the planning of long and medium-term research projects.

2) Discontinuity of funds that derive generally from political instability, as well as imbalances in funding to the centers.

3) Lack of special regulations allowing normal acquisition of instruments and replacement parts.

4) The peculiar geographical features of Argentina, particularly its great latitudinal range, the north-south arrangement of large mountain systems, the low altitude of the preponderant plains (47% of the Argentine territory) and the large area within mean latitudes (45% of the country lies between 30^{o} and 40^{o} S). Rainfall

distribution is irregular, affecting the distribution of very different kinds of aquatic habitats having diverse waters types.

Long distances to study sites require extensive logistic and economic support, which is seldom possible. Limnological centers are located along the fluvial stem of the Paraná-La Plata Rivers (CECOAL, INALI, INIDEP and ILPLA, Fig. 1), far from the large lake district of the Patagonian-Fuegian Andes and from the desert region of the Puna. A typical limnological sampling trip along the Middle Paraná (707 km long) demands planning of navigation along 1 500 km.

Since the creation of the Argentine Association of Limnology on March 1984, several meetings and three workshops have been held. The Association Bulletin has been published periodically and a third (1988) edition of the Argentine Directory of Limnologists has also been published (Fig. 1). Finally, I must mention the importance of the task carried out by the staff of the 'Dr. R. RINGUELET' Institute of Limnology (ILPLA), who compiled and published the Argentine Limnological Bibliography (LOPEZ, 1984, 1988), embracing articles produced between 1961 and 1983 with more than 1700 titles.

LIMNOLOGICAL REGIONS

Finally, it is of interest to introduce a first attempt at division of Argentina into limnological regions. This division is based both on the volume content of lotic and lentic waters in the geographical areas and on the greater or smaller development of those different types of aquatic environments. These factors are closely related to the wide climatic variety and the peculiar orographic distribution in Argentina.

It is well known that the richness of inland

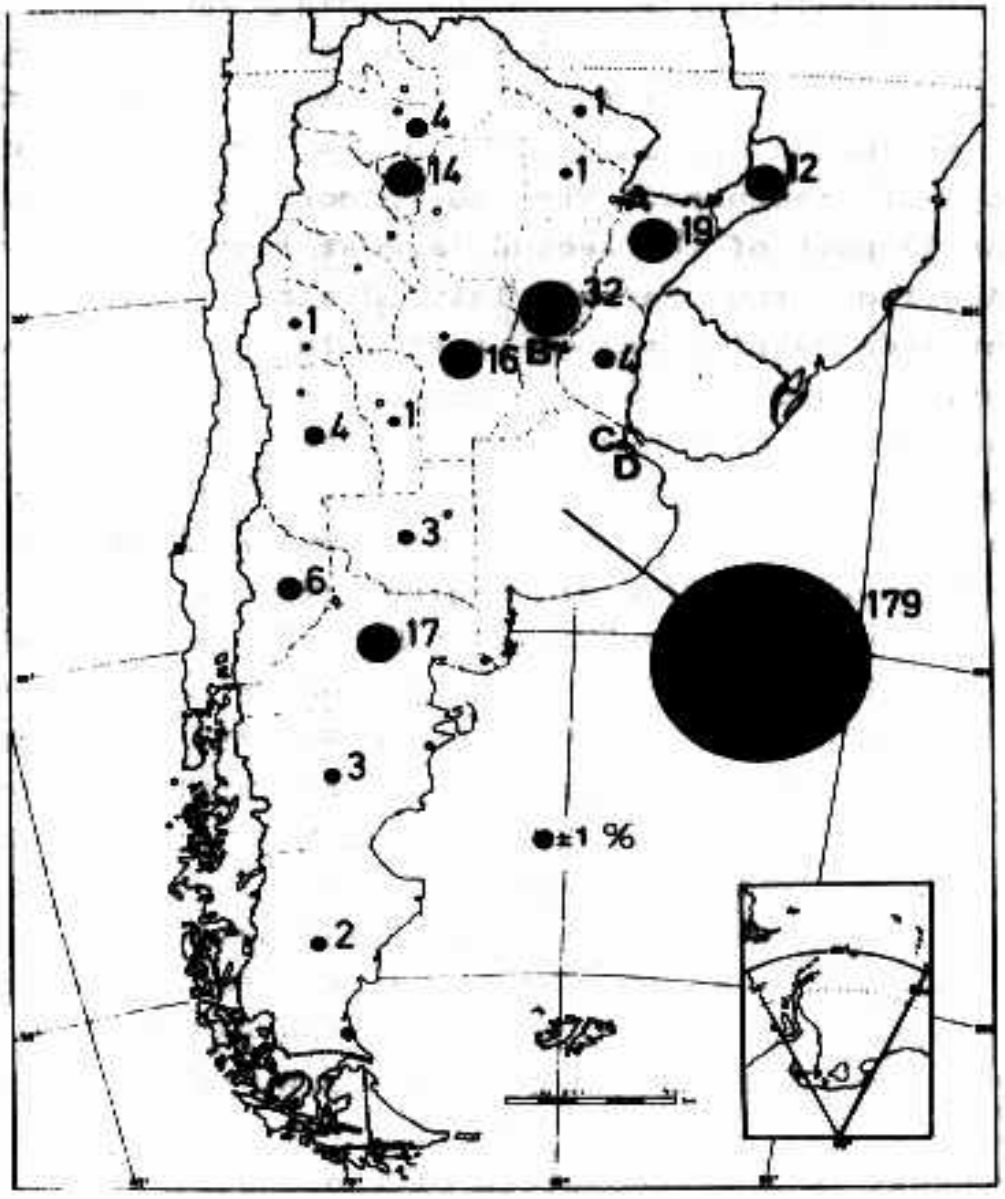

Figure 1 - Number and percentages (black circles) of limnologists in the Argentine Provinces (data from Argentine Association of Limnology). A: CECOAL (Corrientes City, Corrientes Province); B: INALI (Santo Tomé City, Santa Fe Province); C: INIDEP (Buenos Aires City, Buenos Aires Province); D: ILPLA (La Plata City, Buenos Aires Province).

waters of a region depends on two main factors: relief and climate. Relief features, the nature of the soils, and rainfall determine the magnitude of the drainage, and originate three types of hydrological regions: exorheic regions, from which rivers reach the sea; endorheic regions, within wich rivers arise but from which these rivers never reach the sea, losing themselves in dry water courses or entering closed lake basins; arheic regions, within which no rivers arise (DE MARTONNE & AUFRERE, 1928).

Argentine hydrographic systems include an amazing diversity of features. The north-northeastern zone of Argentina is part of the second largest fluvial region in South America, the Paraná-Plata drainage basin. This catchment area carries the greatest volume of lotic waters in Argentina, having an annual average discharge of 23.000 m^3s^{-1}, and drains to the Atlantic Ocean a region of 830.000 km^2 (equivalent to 3% of the continental area of Argentina), through over 10.000 km of stream channels. This is the **Paraná-Plata Fluvial Region** (Fig. 2), which is characterized by a predominance of big rivers. To the east, it is bounded by the fluvial stem formed by the La Plata, Uruguay, Pepirí Guazú and San Antonio Rivers. Its northern border is also formed mainly by rivers such as Iguazú, Paraná, Paraguay, Pilcomayo, Grande de Tarija and Bermejo. Its southern and western boundaries run from Samborombón Bay (Punta Norte, San Antonio Cape), including the Salado del Sur catchment area (Buenos Aires Province), northwards between the 61° and 62° meridians, to the Salado del Norte River. From this point the border follows the Salado del Norte River course northwest to 25°40' S, turning then west-southwest to the headwaters of the Santa María River (from the Salado del Norte drainage basin). It turns again northwards to La Quiaca (Jujuy Province, 22°05' S - 65°35' W). Curiously, most of its boundaries are also formed by river channels.

Within this vast region are two peculiar features:

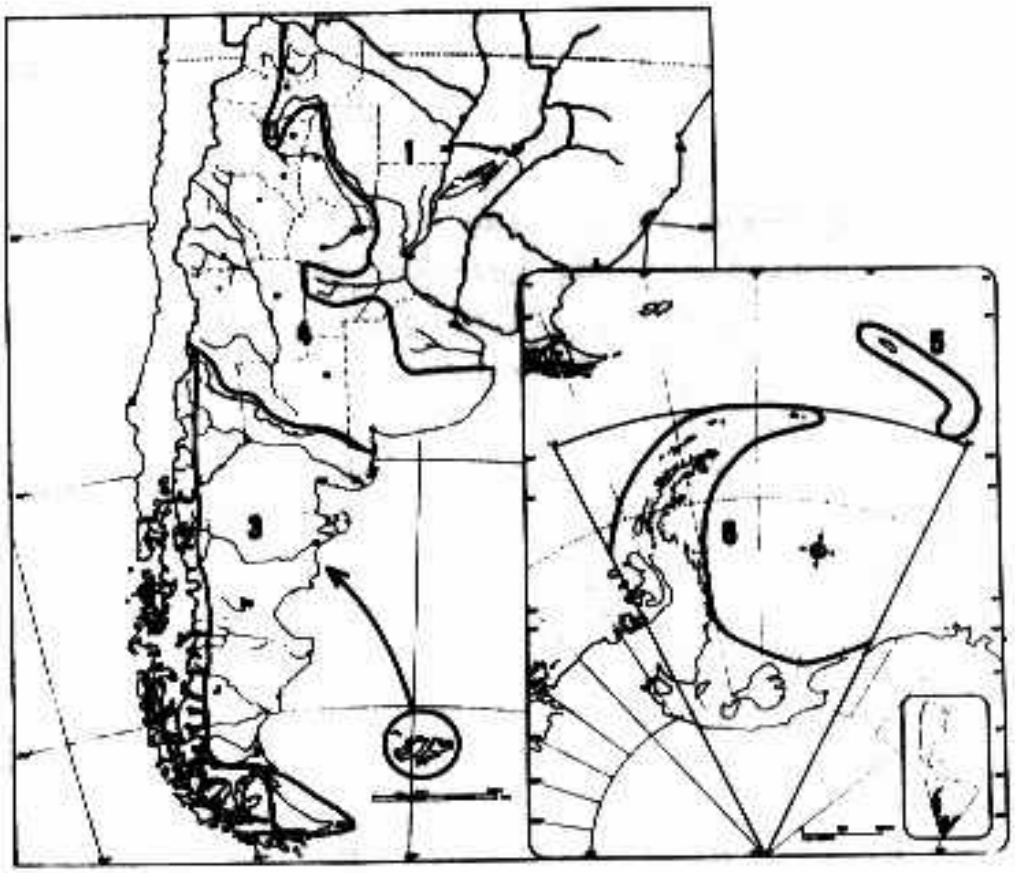

Figure 2 - Limnological Regions in Argentina. 1 - Paraná-Plata Fluvial Region; 2 - Patagonian-Fuegian Andes Lacustrine Region; 3 - Extraandine Patagonia Region; 4 - Endorheic Region; 5 - Subantartic Region; 6 - Antarctic Region.

1) a large arheic region of 365.000 km², the central fringe of the Chaco plain, called the 'depressed Chaco', which extends between 25° - 29° S and 60° - 63° W, and contains some temporary lentic water bodies; 2) toward the north and south of the Chaco depression are allochthonous streams like the Pilcomayo, Bermejo, and Salado del Norte Rivers which have 'crises of hydric continuity', i.e., sometimes the flow ceases.

In southern Argentina and Chile is the largest lacustrine region of South America. More than 250 glacial lakes form the **Patagonian-Fuegian Andes Lacustrine Region** (Fig. 2). This Region extends between 35° and 55° S, along a narrow belt 2.200 km long, from the headwaters of the Colorado River (Mendoza Province), to De Los Estados Island. Here occurs the greatest volume of lentic waters in Argentina, where ten of its most important large lakes extend over more than 6.000 km². Several catchment areas in this region drain toward the Pacific Ocean (e.g., Hua-Hum River - Lácar Lake system, Manso-Puelo Rivers, Futaleufú River, Fagnano Lake, etc.). This lacustrine region is almost unknown limnologically since only some lakes have been partially investigated (Nahuel Huapi, Lácar, Mascardi, Roca, Escondido, Yehuin, Fagnano, etc.).

The **Extra-andine Patagonia Region** (Fig. 2) is third in importance regarding the volume of flowing waters. It is bounded to the north by the Colorado River (from its headwaters at 35° S - 70° W to its mouth at 40° S - 62° W); to the west by the Andine - Patagonian Range; to the south by Drake Strait and to the east by the Atlantic Ocean. According to their geological and geographical affinities, we must also include the Malvinas Islands, which are 300 km from De Los Estados Island. The following features are distinctive to this region: 1) It is traversed from west to east by allochthonous rivers with total mean annual discharge over 2.000 m^3s^{-1}. These fluvial systems drain the great glacial lakes of the **Andine-Patagonian Range**: the

Negro River (Lakes Nahuel Huapi and Traful), Senguerr River (Lake Fontana), Santa Cruz River (Lake Argentino). Some rivers, like the Chubut, Chico and Deseado, have hydric continuity crises whereas others, like the Hua-Hum, Manso, Puelo and Futaleufú Rivers flow towards the Pacific Ocean.

2) The epeirogenic movements have formed subsidence basins, some of which contain permanent or temporary lentic water bodies. Thus, the large depressions which are surrounded by high relief have formed teh few permanent lakes that exist in this region, e.g., Lakes Colhué Huapi (803 km²), Muster (434 km²), Cardiel (460 km²) and Strobel (132 km²). Many other depressions contain shallow saline ponds and salinas (playa lakes). Most of these troughs have been modified to some extent by wind erosion.

The **Endorheic Region** (Fig. 2) lies southwest of the Paraná-Plata Region, and is bounded by the Andes Range in the west and by the Atlantic Ocean in the east.

This region, which has a very poor hydrographic development, is a great endorheic basin with an area of almost 1×10^6 km² in which the total volume of flowing water does not exceed an annual average of 50 m^3s^{-1}. The 'Argentine arid corridor', from the Atlantic Ocean (south of the Buenos Aires Province, 39° S) to the Bolivian border (22° S), belongs to this region. This region has the largest number of man-made lakes.

The two main river systems are the Salí-Dulce and Desaguadero-Chadileuvú. The former is an allochthonous river that drains into Mar Chiquita saline pond (Córdoba Province), having an annual average discharge lower than 80 m^3s^{-1}, after flowing more than 400 km across a very arid region. The Mar Chiquita terminal pond is the greatest saline waterbody of Argentina, 2.000 km² in area, and with a maximum depth of 4.5 m.

The Desaguadero-Chadileuvú River is a large hydrosystem (1.200 km long) that collects waters coming

from the Andes Centrales Range and from the Precordillera Range, extending between 28° S and 38° S. The Andes Mountains between 27° and 36° S are the most arid and are called the Andes Aridos; nevertheless, due to their great development (a 900 km long mountain front) and to its altitude (over 7.000 m), these mountains are covered annually by a large amount of snow, yielding high summer stream discharges. Main tributaries are the Jáchal (12 m^3s^{-1}), San Juan (69 m^3s^{-1}), Mendoza (52 m^3s^{-1}), Tunuyán (33 m^3s^{-1}), Diamante (36 m^3s^{-1}) and Atuel (32 m^3s^{-1}) Rivers. The Desaguadero-Chadileuvú River outlet is in the Province of La Pampa, in a tectonically depressed zone with a number of large and shallow ponds, such as Urre Lauquem Pond, into which the river drains with an annual average discharge not exceeding 12 m^3s^{-1}.

Another distinctive feature in the hydrography of this region is the centripetal drainage basins, where large salares develop, most of them being associated with very shallow saline ponds. These environments attain their maximum density in the Puna, a region with an area of 10.000 km^2 and a mean altitude of 4.000 m. Some are ancient lakes (mega-lakes) like Bebedero Pond (San Luis Province) and Llancanelo Pond (Mendoza Province), situated in large and deep depressions ('bolsones') where some arid forms lie over humid forms. These illustrate the typical discrepancies between climate and geomorphology that exist in this region.

Inland waters in this region show a great diversity in their salt content, from 0.029 g l^{-1} to 380 g l^{-1}.

The **Subantarctic Region** (Fig. 2) includes the South Georgia Islands and South Sandwich Islands between 54° S and 60°S. These subantarctic islands belong to the Scotia Ridge which starts in De Los Estados Island and terminates in the Antarctic Peninsula, including the Antarctic South Orkney Islands and South Shetland Islands.

This region is considered to be the transition from the Patagonian-Fuegian Andes Lacustrine Region to the Antarctic Region. San Pedro Island (South Georgia Islands) which is 180 km long, is not completely glaciated and attains elevations over 2.500 m (Mt. Paget: 2.804 m) and a snow line between 500-600 m. In this location and with a marked maritime climate, it is possible that the lakes and ponds on this island resemble the water bodies of the Lacustrine Region.

The South Sandwich Archipelago has about ten small, completely glaciated volcanic islands which extend between 56° S and 60° S. If there were lakes and ponds, excepting those having a volcanic origin, their limnological features would be similar to waterbodies on the Antarctic Islands (South Orkney Islands and South Shetland Islands).

The **Antarctic Region** (Fig. 2) encompasses the islands of the Scotia Ridge as well as the adjacent mainland which extend south of 60° S. Within this region, the South Orkney Islands and South Shetland Islands, the northern part of the Antarctic Peninsula and its adjacent islands are considered as Maritime Antarctica. Continental Antarctica extends from the southern part of the Antartic Peninsula. With long winters and cold summers, it is surprising that lakes and ponds exist at all. The islands and the northern Antarctic Peninsula have a maritime climate, where precipitation is relatively low but humidity is high. The low-lying land becomes snow-free in summer and meltwater is plentiful, so that lakes and ponds are common on the fringes of the continent and coastal islands.

The ice regime is a distinctive feature of the lakes and ponds belonging to this region. A 'polar lake' is a permanent standing water body which never freezes solid. Those which freeze to the bottom in winter are considered to be ponds. Moreover, the lakes vary in time and thick ness of their ice cover depending on their continental or

insular situation. The lakes have ice covers 8 to 10 months of the year. Deep lakes on the continent usually are overlain by a permenent ice cover 2 to 4 m thick, which decreases by about 1 m during summer.

The lacustrine troughs were mainly formed by glacial activity, though some were formed by volcanic activity, such as the lakes and ponds of Deception Island (South Shetlands Islands).

REFERENCES

BONETTO, A.; DIONI, W.; DEPETRIS, P., ed. Investigaciones limnológicas en la cuenca del río Manso y lago Mascardi. Santa Fé, Fundación Bariloche, 1971. 62 p.

BONETTO, A. & DI PERSIA, D. The San Roque Reservoir and other man-made lakes in the central region of Argentina. In: TAUB, F.B., ed. Lakes and reservoirs. Amsterdam, Elsevier, 1984. p. 541-56.

CORDINI, J.M. Contribución al conocimiento limnológico del Embalse del Río Tercero (Córdoba). Dir. Gral. Pesca Conserv. Fauna, Buenos Aires, 331: 56, 1950.

_____. El seston del Río de la Plata y su contenido diatómico. R. Centro Est. Doc. Ci. Nat., 2: 157-72, 1939.

CORDINI, R.I. Algunas características limnológicas del lago Nahuel Huapi. An. Mus. Nahuel Huapi-Perito Dr. F.P. Moreno, 2: 113-27, 1950.

_____. El lago Lácar del Parque Nacional Lanín (Neuquén). An. Parques Nac., 10: 111-83, 1964.

_____. El lago Nahuel Huapi. Contribución a su conocimiento

limnológico. Bol. Dir. Minas Geol., Buenos Aires, 47: 56, 1939.

CORDINI, R.I. La laguna de Chascomús (Prov. de Buenos Aires). Contribución a su conocimiento limnológico. Bol. Dir. Minas Geol., Buenos Aires, 44: 33, 1938.

_____. Laguna La Brava. Contribución a su conocimiento limnológico. R. Arg. Zoogr., 2: 3-53, 1942.

DRAGO, E. Estructura térmica del lago Mascardi (Prov. de Río Negro, Argentina). Physis B, Buenos Aires, 33: 207-16, 1974.

_____. Estudios limnológicos en la Península Potter, isla 25 de Mayo (Shetland del Sur): características térmicas de los ambientes lenîticos durante el verano 1977-78. Contr. Inst. Antárt. Arg., 226: 29-38, 1980.

_____. Estudios limnológicos en la Península Potter, isla 25 de Mayo (Shetland del Sur): morfología de ambientes lenîticos. Contr. Inst. Antárt. Arg., 265: 1-20, 1983.

_____. Limnological studies on Deception Island, South Shetland Islands: morphology and origin of lentic environments. Biomass Sci. Ser., 7: 193-205, 1987.

_____. Relevamiento batimétrico y notas morfológicas del lago Mascardi. Santa Fé, Fundación Bariloche, 1972. 12 p.

_____. Thermal summer characteristics of lakes and ponds on Deception Island, Antarctica. (Hydrobiologia, 1988 - no prelo)

DRAGO, E. & DEPETRIS, P. Erosión en la cuenca imbrífera y sedimentación en el embalse de Río Tercero (Córdoba,

Argentina). R. Asoc. Geol. Arg., 29: 470-78, 1974.

_____. Sedimentación en el embalse Los Molinos (Córdoba, Argentina). Physis. B, Buenos Aires, 34: 175-78, 1975.

_____. Sedimentación en el embalse San Roque (Córdoba, Argentina). R. Asoc. Arg. Min., Petrol. Sedim., 5: 59-62, 1974.

GARCIA de EMILIANI, M. & SCHIAFFINO, M. Fitoplancton del lago Mascardi (Río Negro, Argentina). B. Soc. Arg. Bot., 15: 411-26, 1974.

INALI. Estudio ecológico del río Paraná medio. Informe. Santa Fé, 1981. 135 p. (Contrato A y E - INALI)

_____. Estudio ecológico del río Paraná medio. Informe. Santa Fé, 1982. 302 p. (Contrato A y E - INALI)

_____. Estudio ecológico del río Paraná medio. Informe. Santa Fé, 1982. 310 p. (Contrato A y E - INALI)

_____. Estudio ecológico del río Paraná medio. Informe Final. Santa Fé, 1982. 317 p. (Contrato A y E - INALI)

_____. Estudios limnológicos en la cuenca del Futaleufú (Chubut). Santa Fé, 1973. 236 p. (Convenio A y E - INALI)

_____. Estudios preliminares en la cuenca del río Saladillo (Santa Fé). Informe Final. Santa Fé, 1985. 275 p. (Contrato A y E - INALI)

INALI. Evaluación de los recursos ictícolas de aguas interiores, Provincia de Santa Cruz. Santa Fé, Fundación Bariloche, 1973. 156 p. (Convenio INALI)

JOSE de PAGGI, S. *Nothelca walterkostei* sp. nov. y otros rotíferos dulceacuícolas de la Península Potter, islas 25 de Mayo (Shetland del Sur, Antártida). R. Asoc. Ci. Nat. Litoral, 13: 81-95, 1982.

JOSE de PAGGI, S. & KOSTE, W. Checklist of the rotifers recorded from Antarctic and Subantarctic areas. Seckenbergiana Biol., 65: 169-78, 1984.

KIEFFER, L. & COPES, C. Limnological studies on Deception Island, South Shetland Islands: chemistry of lentic environments. Biomass Sci. Ser., 7: 193-205, 1987.

LOPEZ, H.L., ed. Bibliografía Limnológica Argentina 1979 - 1983. s.i., 1984. 55 p. (Biologia Acuática, 6)

_____. Bibliografía Limnológica Argentina 1961-1978. s.i., 1988. 140 p. (Biologia Acuática, 13)

LUCHINI, L. Contribución al estudio de la flora perifítica diatómica del lago Mascardi (Prov. de Río Negro). Physis B, Buenos Aires, 32: 223-42, 1973.

_____. Diatomeas epífitas de algunas macrófitas del lago Situación (Prov. del Chubut). Physis B, Buenos Aires, 33: 127-39, 1974.

MAC DONAGH, E.J. La ecología del pez dientudo (*Acestrorhampus jenynsi*) en la laguna Cochicó y estudio lepidológico de la especie. Notas Mus. La Plata, 1: 255-89, 1931.

_____. Estudio preliminar de la ecología del pejerrey en las lagunas Del Monte y Cochicó (Guaminí). An. Ofic. Quím., 1: 1-40, 1928.

_____. Nuevos conceptos sobre la distribución geográfica de los peces argentinos basados en expediciones del Museo

de La Plata. R. Mus. La Plata, 34: 21-170, 1934.

MAC DONAGH, E.J. Physiography and plankton in the lagoons of Buenos Aires. Verh. Int. Ver. Limnol., 7: 517-20, 1935.

MAGLIANESI, R.; RADICI, M.; GARCIA, M. Análises de la productividad primaria a nivel del fitoplancton y principales variables asociadas, en el brazo Catedral del lago Mascardi. B. Soc. Arg. Bot., 15: 12-22, 1973.

NEIFF, J. Contribución al conocimiento de la distribución y biomasa de hidrófitos en el lago Mascardi (Río Negro, Argentina). R. Asoc. Ci. Nat. Litoral, 4: 129-60, 1973.

OLIVEROS, O. & CORDIVIOLA de YUAN, E. Contribución al conocimiento de la biología del "puyen" (*Galaxias variegatus*) (Lesson) del lago Argentino, Provincia de Santa Cruz (Pisces, Galaxiidae). Physis B, Buenos Aires, 33: 227-31, 1974.

OLIVIER, S.R. Variaciones estacionales del plancton y del seston en la laguna de Chascomús durante el año 1948. Argentina, Faculdade de Ciencias Naturais y Museo La Plata, 1949. (Tesis)

_____. Contribución al conocimiento limnológico de la laguna Salada Grande (Bs. As., Arg.). I. Distribución horizontal del plancton. R. Bras. Biol., 12: 161-80, 1952.

_____. Contribution of the limnological knowledge of the Salada Grande lagoon. II. Plankton seasonal variation and some correlations with physical chemical factors. Verh. Int. Ver. Limnol., 12: 302-08, 1955.

_____. Estudios limnológicos en la laguna Vitel (Pdo.

Chascomús, Bs. As., Arg.). Argentina, Agro, 1961. 128 p. (Publicacion Tecnica, 6)

OLIVIER, S.R. A few aspects of the regional limnology of the province of Buenos Aires. Verh. Int. Ver. Limnol., 12: 296-301, 1955.

PAGGI, J. Contribución al conocimiento de la fauna de Cladóceros dulceacuícolas argentinos. Physis B, Buenos Aires, 32: 321-30, 1973.

_____. Estudios limnológicos en la isla Decepción, Shetland del Sur, Antártida: aspectos taxonómicos de los crustáceos del zooplancton. Contr. Inst. Antárt. Arg., 338: 1-34, 1987.

_____. Estudios limnológicos en Península Potter, isla 25 de Mayo (Shetland del Sur, Antártida): morfología y taxonomía de *Pseudoboeckella poppei* Mrazek 1901 (Crustacea: Copepoda). Contr. Inst. Antárt. Arg., 303: 1-34, 1983.

_____. Limnological studies in the Potter Peninsula, 25 de Mayo Island, South Shetland Islands: biomass and spatial distribution of zooplankton. Biomass Sci. Ser., 7: 175-91, 1987.

QUIROS, R.; DELFINO, R.; CUCH, S.; MERELLO, R. Diccionario Geográfico de ambientes acuáticos continentales de la República Argentina. Parte I: Ambientes lenîticos. Buenos Aires, INIDEP. Departamento de Aguas Continentales, 1983. 475 p.

RINGUELET, R.A. Ambientes acuáticos continentales. Ensayo bioecológico con particular aplicación a la República Argentina. Holmbergia, 5: 155-207, 1957.

_____. Biogéographie des Copépodes d'eau douce de

l'Argentine. Biol. Amer. Austral, 4: 261-67, 1968.

_____. Ecología Acuática Continental. Buenos Aires, EUDEBA, 1962. 138 p.

_____. Ecología alimenticia del pejerrey (*Odontheates bonariensis*) con notas limnológicas sobre la laguna Chascomús. R. Mus. La Plata, 2: 427-61, 1942.

_____. Ecología y biocenología del hábitat lagunar o lago de tercer orden de la región neotrópica templada (Pampasia Sudoriental de la Argentina). Physis, Buenos Aires, 31: 55-75, 1972.

_____. Tipología de las lagunas de la provincia de Buenos Aires. La Limnología regional y los tipos lagunares. *Physis*, Buenos Aires, 28: 65-76, 1968.

_____. Zoogeografía y ecología de los peces de aguas continentales de la Argentina y consideraciones sobre las áreas ecológicas de América del Sur. Ecosur, 2: 1-122, 1975.

RINGUELET, R.A.; ALONSO, R.; ARAMBURU, R. Los peces de agua dulce de la República Argentina. La Plata, Com. Inv. Cient. Prov. Buenos Aires, 1967. 602 p.

RINGUELET, R.A.; SALIBIAN, A.; CLAVERIE, E.; ILHERO, S. Limnología Química de las lagunas pampásicas. Physis, Buenos Aires, 27: 201-21, 1967.

SECKT, H. Estudios hidrobiológicos: primera Reunión Nacional de la Soc. Arg. Cienc. Nat. Buenos Aires, 1918. p. 303-23.

_____. Estudios hidrobiológicos en la Argentina. Contribución al conocimiento de los microorganismos del

agua dulce y de sus condiciones vitales. R. Univ. Nac. Córdoba, 11: 55-110, 1924.

SECKT, H. Estudios hidrobiológicos en la Argentina. Observaciones sobre la "autopurificación" de los ríos. R. Univ. Nac. Córdoba, 11: 3-11, 1924.

_____. Sobre la flora y la fauna del agua dulce en la República Argentina. Fenix, Buenos Aires, 1: 53-66, 1921.

WEHRLI, L. Tiefenmessungen im lago Nahuel Huapi. Vierteljahrsschrift der Naturfor. Gesellschaft in Zürich, 64: 487-98, 1919.

ACKNOWLEDGMENTS

I wish to thank the Argentine Association of Limnology and also the 'Dr. R. RINGUELET' Institute of Limnology (ILPLA) for their invaluable cooperation.

ENDEREÇO DO AUTOR

DRAGO, E.C.
Instituto Nacional de Limnología (INALI-CONICET)
J. Macía 1933, 3016 Santo Tomé. Santa Fe
Argentina