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FIRST FISH RECORD IN THE LAGO BELGRANO OF ARGENTINA AND THE ORIGIN OF FISH POPULATIONS IN PATAGONIAN LAKES

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ABSTRACT.- The austral teleost *Galaxias platei* was recorded for the first time in the lago Belgrano during the summer 1994-1995. Present aquatic organisms from this lake, as well as the aquatic and most terrestrial fauna and flora of Patagonian Andes and southern Chile, was displaced during the glacial maxima, when a relatively large ice cap developed in the area. During the interglacial periods, fishes and other aquatic animals had to enter the glacial-origin lakes from : 1) drainages of Atlantic slope or 2) the Pacific Ocean. The lago Belgrano flows to the Pacific Ocean today. However, it has been shown that it has changed to the Atlantic slope several times. Consequently, fish populations could have entered the lago Belgrano from refugia in Patagonian rivers. The case of the lago Belgrano shows that the hydrographic history of southern Andean lakes is very complex.

KEY-WORDS.- Southern South America, Teleostei, *Galaxias*, Biogeography, Glaciations

RESUME.- Le teleostei austral *Galaxias platei* a été signalé pour la première fois dans le lago Belgrano au cours de l'été 1994-1995. Les organismes aquatiques actuels de ce lac, ainsi que la majorité de la faune et flore des Andes de Patagonie et du sud du Chili ont été déplacés pendant les maxima des glaciations, quand une calotte glaciaire assez importante s'est développée dans la région. Au cours des périodes inter-glaciaires, les poissons et autres animaux aquatiques ont du gagner les lacs d'origine glaciaire à partir de : 1) drainages des versants atlantiques ou, 2) l'océan Pacifique. Des nos jours le lago Belgrano coule vers l'océan Paficique. Cependant, il a été démontré que cet écoulement a été modifié vers le versant atlantique, à plusieurs reprises. En conséquence, les populations des poissons auraient pu pénétrer le lago Belgrano à partir des refuges situés dans des rivières en Patagonie. Le cas du lago Belgrano démontre que l'histoire hydrographique des lacs des Andes du sud est très complexe.

MOT-CLES.- Amérique du Sud méridionale, Teleostei, Galaxias, Biogéographie, Glaciations

INTRODUCTION

Patagonia is defined here as the South American territory located to the south of the río Colorado and east of the Cordillera de los Andes. For Chilean researchers, Patagonia also includes southern Chile, however.

Very few fish records have been published from Patagonian lakes and rivers (see RINGUELET *et al.*, 1967 ; MCDOWALL, 1971 ; ORTUBAY *et al.*, 1994 ; MENNI & GOMEZ, 1995). Many Patagonian rivers and lakes, especially in the provinces of Santa Cruz and Tierra del Fuego, have not been sampled by scientists. Consequently, it is not bizarre that no fish has been cited for the Patagonian Lago Belgrano before (47°50'S 72°15'W ; Fig. 1).

Teleostean fishes of the family Galaxiidae presently inhabit circum-Antarctic continents and islands: New Zealand, Australia, Tasmania, Macquarie, Chile, Argentina, and Africa del Sur (McDOWALL, 1971 ; GOSZTONYI & McDOWALL, 1974 ; NELSON, 1994). Notwithstanding that there are populations completely stranded in freshwater, several species show great tolerance to normal marine salinity (NELSON, 1994).

The purpose of this paper is to describe the first fish record from the lago Belgrano but especially to discuss the origin of aquatic organisms in western Patagonian lakes after the last glacial maximum of the latest Pleistocene.

MATERIAL AND SYSTEMATIC COMMENTS

Galaxias platei STEINDACHNER, 1898

Material : MLP 9266. The material was collected in the lago Belgrano during the summer 1994-95 by the geologist M.A.González.

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Measurements (mm) and counts. Total length, 254 ; standard length (SL), 223 ; caudal peduncle length, 21 ; predorsal length, 171 ; preanal length, 180 ; prepelvic length, 137 ; pelvic-fin length, 18.4; anal-fin length, 43 ; prepelvic length/SL, 0.61 ; pelvic-anal fin length/SL, 0.17 ; pelvic length/ pelvic-anal fin length, 0.43, pelvic-fin rays, 8; anal-fin rays, 11; caudal-fin rays, 16; branched caudal-fin rays, 14.

The material is assigned to the family Galaxiidae because of the presence of 14 branched caudal-fin rays and a visible lateral line and absence of scales, ventral keel, or maxillary teeth. It is assigned to the subfamily Galaxiinae because of the lack of adipose fin, and the presence of the dorsal-fin near the caudal-fin and the caudal-fin truncated. In South America, the subfamily Galaxiinae includes the genera *Brachygalaxias* (*B. bullocki*) and *Galaxias* (*G. globiceps*, *G. platei*, *G. maculatus* ; McDOWALL, 1971 ; ARRATIA *et al.*, 1983 ; BERRA & RUIZ, 1994 ; NELSON, 1994). The material differ from *B. bullocki* and *G. maculatus* because of the anal-fin originates behind the dorsal-fin and the total length (McDOWALL, 1971). The number of anal-fin rays (McDOWALL, 1971) and the prepelvic-fin/SL and pelvic-anal fins length/SL rates differentiates the material from *G. globiceps* and agree with those of *G. platei* (BERRA & RUIZ, 1994).

GEOMORPHOLOGY

The lago Belgrano is a lake of glacial origin located in a Patagonian cordilleran valley. The Cordillera de los Andes south of 40 °S is comparatively low, with most summit altitudes between 1500 and 2.000 m (FLINT & FIDALGO, 1969). The water divide frequently is located to the east of the highest summits line and many Patagonian basins such as the lago Belgrano flow to the Pacific Ocean. In some areas of the Patagonian Andes, the floor of the crossing valleys is located at about 200-300 m above sea level (FLINT & FIDALGO, 1969 ; CFI, 1962). North to 40° S the Cordillera is much higher and the lago Lácar is the last eastern basin washing out to the Pacific Ocean.

ICHTHYOGEOGRAPHY

RINGUELET (1975) proposed that, according to fish distribution, the Neotropic Regions is divided into two subregions: Brazilic and Austral. The Austral Subregion spans Central and southern Chile, and Patagonia and Cuyo in Argentina, with three provinces : Chilean, Subandean-Cuyan, and Patagonian (RINGUELET, 1975 ; ARRATIA *et al.*, 1983 ; ARRATIA, 1997). The Brazilic Subregion encompasses the rest of South America. These ichthyogeographic units are phenetic (BURR & MAYDEN, 1992) but, constitute an important basis for analyzing the fish distribution.

The rise of the Cordillera de los Andes and the climatic changes that occurred during the late Neogene greatly influenced the ichthyogeography of southern South America. The present height of the Andes began to develope in the middle Miocene and occasioned relevant viacariant events on both sides reflected in the biogeographic pattern (e.g. the neat separation of the icthyofaunas of Central Chile and Cuyo in Argentina (Austral and Brazilic).

In southern South America, the Cordillera de los Andes show many low valleys with many basins crossing through the mountain range (see above). The Chilean province, which is characterized by several endemites, begins to the north of the first Argentinean basin with Pacific outwash, i.e. the lago Lácar. South of 40° S, RINGUELET (1975) only recognizes the Patagonian province to the west and east of the Andes. However, the Chilean province spans more to the south than the lago Lácar, and Chilean rivers which originate in this lake include fishes of the ichthyogeographic Chilean province. There are no edit fish records from the lago Lácar to let know if it would be included in the Chilean province.

Galaxiid fishes are exclusive of the Austral Subregion. There is no fossil record in South America and its history in the continent seems to be relatively recent (CIONE, 1986).

CLIMATE AND BIOGEOGRAPHY

During late Pliocene-Pleistocene times (approximately 2.5 Ma and especially since the last 0.8 yr) there was alternation of cold and warm periods, the glacial and interglacial periods (PIELOU, 1992 ; CLAPPERTON, 1993 ; CROWLEY & NORTH, 1993). MÖRNER and SYLWAN (1989) dated the first Patagonian glaciation at about 2.4 Ma. In the southern Cordillera de los Andes and Chile, glaciations provoked the developement of an important ice cap (Fig. 1 ; CALDENIUS, 1932 ; FERUGLIO, 1946 ; FLINT and FIDALGO, 1969 ; CLAPPERTON, 1993 ; TONNI *et al.*, in press). CALDENIUS (1932) established that the glaciers extended to the east through short distance and that only reached the Atlantic Ocean at 52°S (see also FLINT & FIDALGO, 1969 ; CLAPPERTON, 1993). The distribution of the ice lobes to the east was greatly determined by the Andean morphology (FLINT & FIDALGO, 1969 ; CLAPPERTON, 1993). The extension of the ice cover diminished from the older to the younger glacial periods.

During the glacial periods, the climate was very cold, and the cordilleran lakes did not exist (Fig. 1). At this time, typical Patagonian birds and mammals inhabited the Pampean area (CLAPPERTON, 1993 ; TONNI & CIONE, 1994, 1995 ; TONNI *et al.* in press). The last important ice covering developed at about 20,000-18,000 yr. BP (Last Glacial Maximum, Isotopic Stage 2; late part of the Würm Glaciation in the Alps, Weichsel in northern Europe, Wisconsin in the center of North America). The posterior ice melting during the present interglacial period determined important changes in basin conexions that have been poorly studied. There is some differences in the dating of the beginning of melting in different parts of the world and South America (i.e. Antarctic

and Greenland ice cores compared with South America, see RABASSA & CLAPPERTON, 1990 ; CLAPPERTON, 1993 ; SOWERS & BENDER, 1995; TONNI *et al.*, in press). The postglacial climatic history is complex (HEUSSER *et al.*, 1981 ; CLAPPERTON, 1993 ; TONNI *et al.*, in press). However, it seems that the ice cap began to melt in the Andes since 18,000 yr. BP.

Consequently, the galaxiid (and other organisms) populations presently inhabiting the Patagonian Andean and southern Chilean lakes and rivers had to enter the area recently. The present populations are alloctonous and penetrated into the lakes after the melting of the ice cap. The Patagonian rivers could have acted as refugia to those fishes that presently inhabit lakes of the Atlantic slope. Quite the contrary, for the fishes inhabiting lakes flowing to the Pacific Ocean, the only possible dispersal way should be the sea, because practically all southern Chilean territory was covered by the ice (Fig. 1). Galaxiids are fishes of the secondary division of Myers (MCDOWALL, 1971). The secondary division consists of families or other groups of fishes that occur chiefly in fresh water but that can enter the sea and survive there for a limited time or, are recently descended from forms that could do so, so that their present distributions may be and apparently often are partly the result of dispersal along coast lines or across narrow ocean gaps (DARLINGTON, 1957).

However, the melting of the large ice cap surely produced enormous volumes of meltwater (similarly, though in a lesser extent, to North America; PIELOU, 1992). In many cases, the development of the present lakes was complex because some hydrographic conexions that are different to the present ones existed then. These geomorphic modifications provoked that some lakes changed flow direction from one slope to the other. This was the case of the lago Belgrano.

THE LAGO BELGRANO CASE

The lago Belgrano is presently included in a basin flowing to the Pacific Ocean (Fig. 2). The lake emit a branch to the lago Azara which is connected with the lago Nansen. In the southern extreme of the lago Nansen originates the río Carrera, tributary of the río Mayer, which washes out into the nordwest branch of the lago San Martín (O'Higgins in Chilean nomenclature). The nordwest branch of the lago San Martín washes out into the río Pascua which flows into the Pacific Ocean (PALESE DE TORRES, 1958).

The lago Belgrano basin suffered profound changes during the last glacial and postglacial times (GONZALEZ, 1992). These changes are documented by the evidence of temperature drops (morrenas, till) and temperature rises (lacustrine deposits and geoforms of coast lines). The lago Belgrano basin was part of a larger lake with a maximum level at 900 m above sea level which is 100 m higher than the present level of the lake. The present lagos Belgrano, Burmeister, Azara, and Mogote constitute the deepest parts of this paleolake (Fig. 2). The west boundary of the paleolake would be located immediately to the west of the present lago Mogote, in the Chilean-Argentinean boundary, although it could be located even more to the west. The paleolake flowed to the Atlantic ocean by means of the río Belgrano which washes out to the río Chico (FERUGLIO, 1946). The closure of the paleolake to the Pacific Ocean should be located in the place where glacial deposits descending from the Cerro Aspero separates the lagos Nansen and Azara (Fig. 2). The glacier should have closed the valley « Nansen-Azara » in levels higher than the paleolake maximum level. When the glacier receded because the the global postglacial temperature rising, it opened the present drainage to the Pacific Ocean (GONZALEZ, 1992). Presently, the río Belgrano, originates in the cerro Belgrano, at few kilometers of the lago Belgrano and it is completely separated from the lago Belgrano basin (see PALESE DE TORRES, 1958). *Galaxias platei* was previously

recorded in the río Chico of Santa Cruz at 15 km from the mouth of the río Belgrano (McDowall, 1971). As the lago Belgrano basin formerly washed out to the Atlantic Ocean, the fish populations could enter from refugia in the río Chico of Santa Cruz by means of the río Belgrano. Besides, it has not been demonstrated (although there are some indirect evidence) that *Galaxias platei* is capable to withstand normal marine salinity (McDowall, 1971).

CONCLUSIONS

The fauna and flora of great part of southern Andes, southern Chilean lowlands and Tierra del Fuego was extirpated from the area during the glacial maxima. Refugia permitted the occurrence of some species in peri-glacial environments. Vegetation and animals returned during the interglacial periods. Fishes that presently inhabit the lakes should have returned from refugia in Patagonian rivers or by the sea. The river basins of the Atlantic slope were longer than today because the sea-level drop left a wide area over sea level (Fig. 1). Those fishes that inhabit the lago Belgrano could come from the ríos Belgrano and Chico of Santa Cruz because the basins modified its oceanic slope.

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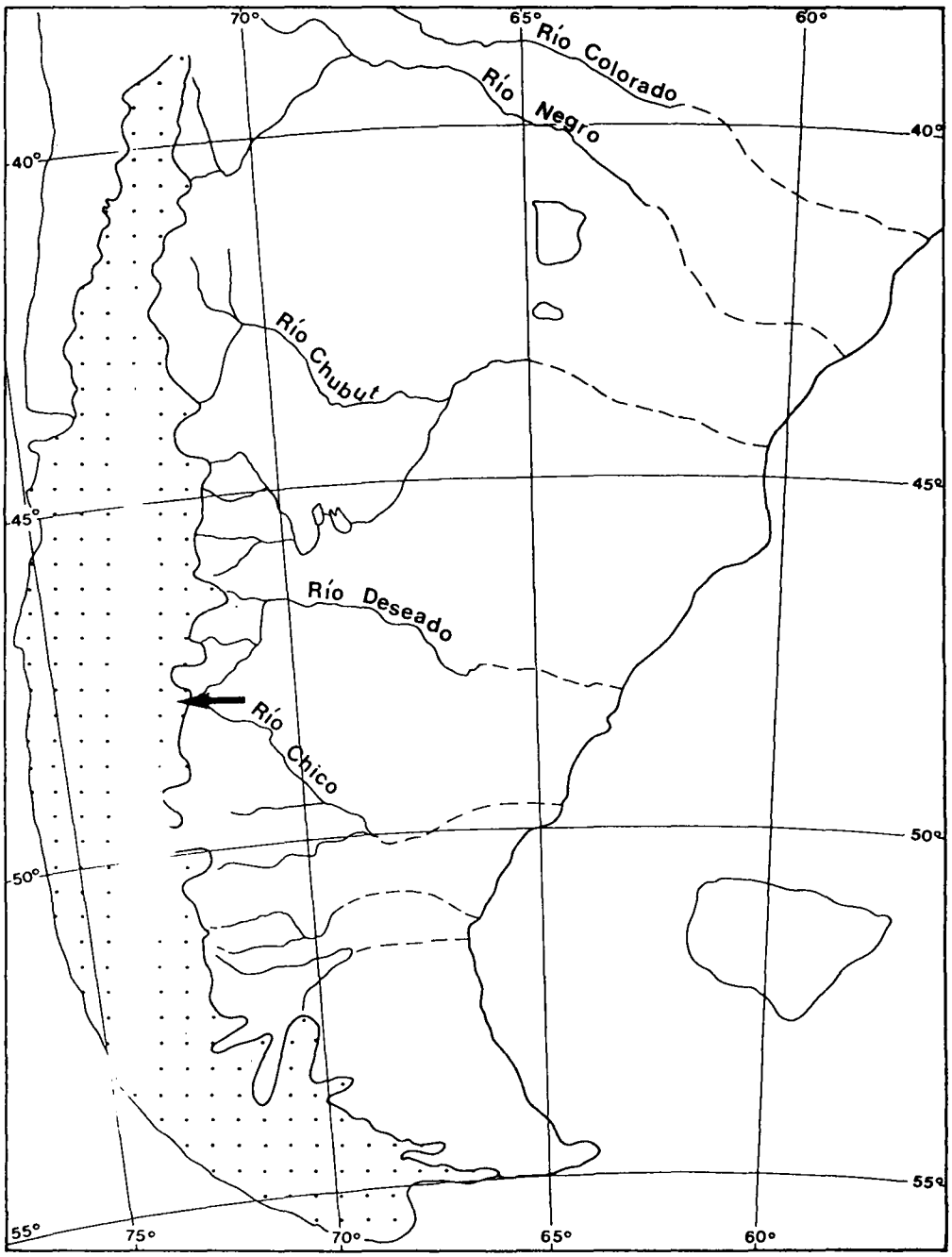

Fig. 1. Southern South America during the last glacial maximum (18-20 yr. BP : ice cap according to CALDENIUS, 1932 and CLAPPERTON, 1993 ; coast line designed at the line of - 120m).

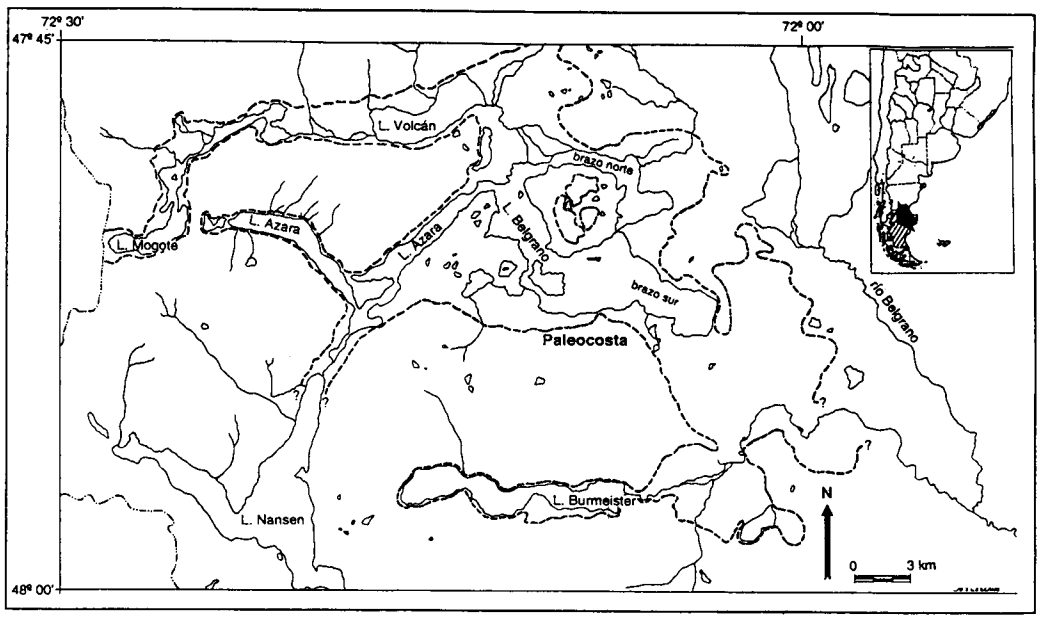

Fig. 2. Lago Belgrano basin and neibourhoods. The broken line indicates the boundaries of the paleolake in the immediate post-glacial times (GONZALEZ, 1992).

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