ARTIGO

MORPHOLOGICAL DIFFERENCES IN THE *GALAXIAS MACULATUS* (JENYNS, 1842) POPULATION, AN OSMERIFORM FISH FROM SOUTHERN ARGENTINA

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ABSTRACT

Samples of the puyen Galaxias maculatus (Galaxiidae) from four localities at the Limay river basin were subjected to Principal Component Analysis of morphometric traits. The analysis portrayed different body characteristics among samples from sections of the river with different physical and water chemistry traits. Samples from the Ramos Mexía dam and downstream, are composed of slender individuals of varied sizes, living under slow current over vegetated muddy bottoms. Those from the Collon Cura river are smaller and robust, living under strong current. Those from Piedra del Aguila, midway from the other localities, display a heterogeneous morphology, but have larger-sized eyes and jaws relative to head size. In spite of having access to the sea (distant 600 km), Limay river populations of G. maculatus appear to be lacustrine.

Key words: *Galaxiidae; Galaxias maculatus; patagonian; population differences; Limay river system.*

INTRODUCTION

Fish of the family Galaxiidae are restricted to the southern Hemisphere in New Zealand, Australia, Tasmania and Chile (McDOWALL, 1971; CAMPOS 1979) and Argentina (RINGUELET *et al.* 1967). Two species have been reported from Argentina, the puyen grande *Galaxias platei* Steindachner 1898 and the puyen G. maculatus (JENYNS, 1842). In Argentina G. maculatus lives in lakes and rivers near the eastern side of the Andes about 40° S, in Chimpay and the "laguna" Estancia 30 km upstream of the Negro river, in Tierra del Fuego, Isla de los Estados and Malvinas (McDOWALL, 1971; AZPELICUETA *et al.*, 1996). The species has not been found in the Pellegrini man made lake or in the Neuquén river basin throughout several years of sampling. Juveniles of the species have been found in tide-pools at Puerto Deseado (47°45'S), near the Deseado river mouth, on the Atlantic coast (GOSZTONYI & McDOWALL, 1974).

Galaxias maculatus has populations with two different life histories. Adults of catadrome populations live in freshwater migrating to estuaries to reproduce. Larval stages reach the sea and postlarvae return to freshwater. In Argentina this population type is found in the Isla Grande of Tierra del Fuego and Malvinas Islands (McDOWALL, 1971). Gosztonyi (1970) suggested that the Islas de los Estados population should shed the eggs in freshwater because of lack of the gramineae fields that the New Zealand galaxiids use to desovate in estuaries.

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Table 1. Physical and chemical traits of studied environments. Temperature in C° and conductivity in μS cm $^{-1}$. Data from Land de Castello (1981) * and original ones.

	Collón Curá	Piedra del Aguila	Ramos Mexía Dam	Limay river downstream
Current velocity	Strong	Middle	Low	Low
Bottom	Pebbles	Pebbles	Sandy and muddy	Muddy
Average temperature*	10.6	11.6	13.3	14.3
Temperature range*	5.0-21.5	6.0-21.5	5.2-22.2	6.5-22.6
Average conductivity*	46	35	67	69
Conductivity range*	20-60	20-58	58-82	62-90
Average pH*	7.2	7.2	7.3	7.3
pH range*	7.1-7.5	7.1-7.4	6.9-7.9	6.9-7.6

The other population type is the locked or lacustrine one, which developed all their life cycle in freshwater including rivers, creeks and lakes. These population live in environments from the Neuquén, Río Negro, Chubut and Santa Cruz provinces (GOSZTONYI & McDOWALL, 1974; AZPELICUETA *et al.*, 1996; Pellanda pers. com.), where they have an important role as forage fish (FERRIZ 1993/94; 1996).

In this paper we examine if locked populations of G. maculatus from the Limay river ca be separated applying multivariate techniques to morphometric traits. This methodology is corrently used in the study of morphological varation in fish populations (CASTELLÓ 1983; STRAUSS & BOND 1990). For example, sympatric populations of Coregonus clupeformis from the Cuomo lake may be distinguished using Principal Component Analysis (VOURINEN *et al.*, 1993).

MATERIALS AND METHODS

Examined specimens were obtained from four localities with different hydrological regimes. They were placed along the middle and lower Limay river basin, namely the Collón Cur river, the Limay river at Piedra del Aguila, the Ramos Mexía dam (a lake 816 km2 with 24.6 m mean depth) and the Limay river below the dam (Figure 1).

Samples from the Limay river at Piedra del Aguila and the Collón Cur river were captured in environments with strong current over rocky bottoms. Within the dam lake, captures were made in a bay with muddy bottom and rich aquatic vegetation, mainly composed by species of Elodea, Potamogeton, Myriophyllum, charales and filamentous algae. In the Limay river below the dam, fishes were captured in a river branch with similar characteristics.

Samples were obtained between October 1983 and August 1984 with a seine net with a 2 mm mesh. Forty morphological measurements were obtained from twenty specimens from each locality using a 0.1 mm caliper. Data were analyzed applying Principal Component Analysis to a correlation (Pearson) matrix following Jeffers (1978), Crisci and Lopez Armengol (1983) and Pl (1986). Environmental variables were obtained by the authors and from the literature (Table 1).

RESULTS AND DISCUSSION

The first eight components with values over 1 were considered (JEFFERS, 1967). These factors accumulate 85.7% of the variance (Table 1). Only the first three components were considered in the analysis as their represents practically 70% of the accumulated variance (Tables 2 and 3).

Table 2. Eigenvalues, percentage of variance, and cumulative variance for eight principal components.

Component	Eigenvalue	Explained variance	Cumulative variance
1	22.02521	53.72	53.72
2	3.73481	9.11	62.83
3	2.73460	6.67	69.50
4	1.71549	4.18	73.68
5	1.46735	3.58	77.26
6	1.29329	3.15	80.42
7	1.12793	2.75	83.17
8	1.03932	2.53	85.70

Table 3. Contribution of morphological variables to each of the first three principal component.

Principal Component	**I**	**II**	**III**
Contribution			
Total lenght	0.973	-0.033	-0.107
Standard lenght	0.970	-0.021	-0.101
Head lenght	0.898	-0.381	-0.100
Tronco lenght	0.926	-0.012	-0.211
Orbital diameter (longitudinal)	0.781	-0.132	0.437
Orbital diameter (transversal)	0.799	-0.141	0.347
Snout length	0.741	-0.270	0.091
Interorbital lenght	0.835	0.315	-0.087
Head depth	0.951	-0.053	0.002
Body depth	0.955	0.156	-0.017
Head width	0.950	-0.037	-0.053
Body width	0.934	0.063	-0.091
Mouth width	0.787	0.093	0.282
Maxilla lenght	0.634	-0.282	0.419
Caudal peduncle depth	0.909	-0.163	0.194
Pectoral fin depth	0.822	-0.329	0.095
Ventral fin depth	0.861	-0.247	-0.032
Dorsal fin depth	0.783	-0.048	-0.283
Anal fin depth	0.709	0.004	-0.382
Caudal fin depth	0.864	0.048	0.105
Pectoral base fin length	0.730	0.060	0.367
Ventral base fin length	0.761	0.159	0.218
Dorsal base fin length	0.857	-0.034	0.089
Anal base fin length	0.890	-0.072	-0.013
Distance snouth-dorsal fin	0.941	0.040	-0.163
Distance snouth-pectoral fin	0.595	-0.312	-0.088
Distance snouth-ventral fin	0.856	-0.107	-0.070
Distance snouth-anal fin	0.946	0.031	-0.140
Distance ventral-anal fin	0.948	0.157	-0.160
Total lenght/body depth	-0.542	-0.435	-0.113
Total lenght/head lenght	0.388	0.690	-0.049
Total lenght/distance snout-dorsal fin	0.046	-0.267	0.254
Total lenght/distance snout-ventral fin	-0.025	0.183	-0.048
Total length/distance ventral-ânal	-0.398	-0.703	0.203
Standar lenght/total lenght	-0.062	0.121	-0.129
Head lenght/interorbital	-0.338	-0.779	0.017
Head lenght/orbital di meter (long.)	-0.050	-0.269	-0.722
Head lenght/dorsal fin base	-0.027	-0.561	-0.286
Head lenght/pectoral fin base	-0.002	-0.499	-0.480
Head lenght/maxilla lenght	0.289	-0.067	-0.641
Body depth/caudal peduncle depth	0.207	0.598	-0.348

Traits better represented in each component represent a type of body morphology. The first component, with a high discrimination value, put together characteristics associated with size of individuals, as length, width and height of the body. The second component is a measure of fish slenderness, according the indices head length/interorbital and total length/head length. The third component has a low discrimination value, being negatively associated with the index head length/eye diameter and head length/maxillary length. Similar results were observed in a study of Barbus b. sclateri from southern Spain (CASTELLÓ, 1983), where the first three components accumulate 75.2% of the variance. The first component grouped traits related to length and height of the body, and the body length/head length is represented in the second component.

Our results show that the first three components are related with differences in sampling localities (Figure 1), allowing identifying three groups, namely:

Group A-E is composed by individuals inhabiting the Ramos Mexía dam lake and the Limay river below the dam. They are positively correlated with the PC2 and negatively with the PC3. The body is slender and fishes of different sizes were obtained.

Group C is composed by relatively stout, small size individuals living in the Collón Cur river, negatively correlated with both PC1 and PC2. This is the best-defined group (Figure 2).

Group R is composed by individuals obtained from the Limay river at Piedra del Aguila. They do not correlate with PC1 and PC2, but slightly correlate with PC3. Fishes in this group display a heterogeneous morphology, and have the eyes and jaws of larger size relatively to head size (Figure 3).

Individuals from the lower and middle course differ along the PC2. Those from the lower course (groups A and E) are more slender than those from the middle course (groups C and R). The PC1 is uninformative about individuals from the lower course. Instead, because of size, it separates individuals from the middle course (group R), which are smaller than those of group C (Figure 2). The PC3, without much precision, indicate the heterogeneous group R, which lives in the central section of the studied area, and includes a variety of sizes (Figure 1).

Fishes from groups C and R inhabit environments with stronger currents. They have stout bodies and heads. Individuals from group C, are of smaller size, belong in a single size class, and live in the cooler and more rapid waters of the area.

Biology traits of riverine fishes may be deduced from its morphology, because many adaptive characteristics are related with it. Body form and fin sizes are good indicators of swimming behavior and habitat preference (GATZ, 1979; WINEMILLER, 1991; 1992; PAKKASMA, *et al.*, 1998). The quotient between body maximum height and body maximum width is well correlated with current velocity, and the number of smaller species is higher as stronger the current (GATZ, 1979). In G. maculatus from the Limay river at Piedra del Aguila (Group R), these two measurements contributed most to the PC1 (> 0.9), as well as nine measurement of the fins, always with values over 0.7 (Table 3). Fish of this heterogeneous group live in the middle of the studied area, in waters with the lowest conductivity.

Fishes from below the Ramos Mexía dam (group A) are geographically isolated from the other groups. Nevertheless, they show similar traits to the dam lake population (group E), with which they were probably related before the construction of the dam. The filling of the dam began in the beginning of 1970, so the two groups have remained 15 years isolated in habitats with rather different current conditions.

Individuals from groups E and A live in relatively warm waters with high conductivity and feeble current. The pH range is wide, reaching slightly acidic values. Conversely, groups C and R live in waters with lower temperature and conductivity, stronger current, where low pH values were not recorded. In laboratory conditions, adults of G. maculatus from New Zealand prefer totally alkaline pH values (WEST, *et al.*, 1997).

On account of its morphology, the population of G. maculatus from the Limay river basin is lacustrine (McDOWALL, 1971). It performs its life

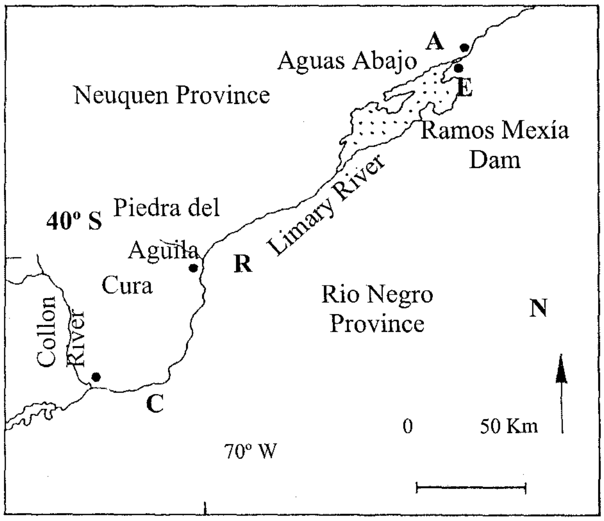

Figure 1. Sampling area in the Limay river basin. A, E, R and C: fish morphological groups.

cycle in fresh water, in spite of its euryhaline capacities. Though theoretically individuals of this population could reach the Atlantic Ocean, this appears improbable because of the long distance (600 km) to overcome by a species with a short life-cycle. Dams over the Limay river preclude this possibility at present. A similar situation has been described for Chilean rivers. There, populations that evolved isolated from the sea, appear to have developed behavioral mechanisms that make that they do not migrate, in spite of having access to the sea at present (VEGA *et al.*, 1993).

Why the populations of the Limay river, which is a tributary of the Negro river, are lacustrine (McDOWALL 1971; FERRIZ 1987) is still

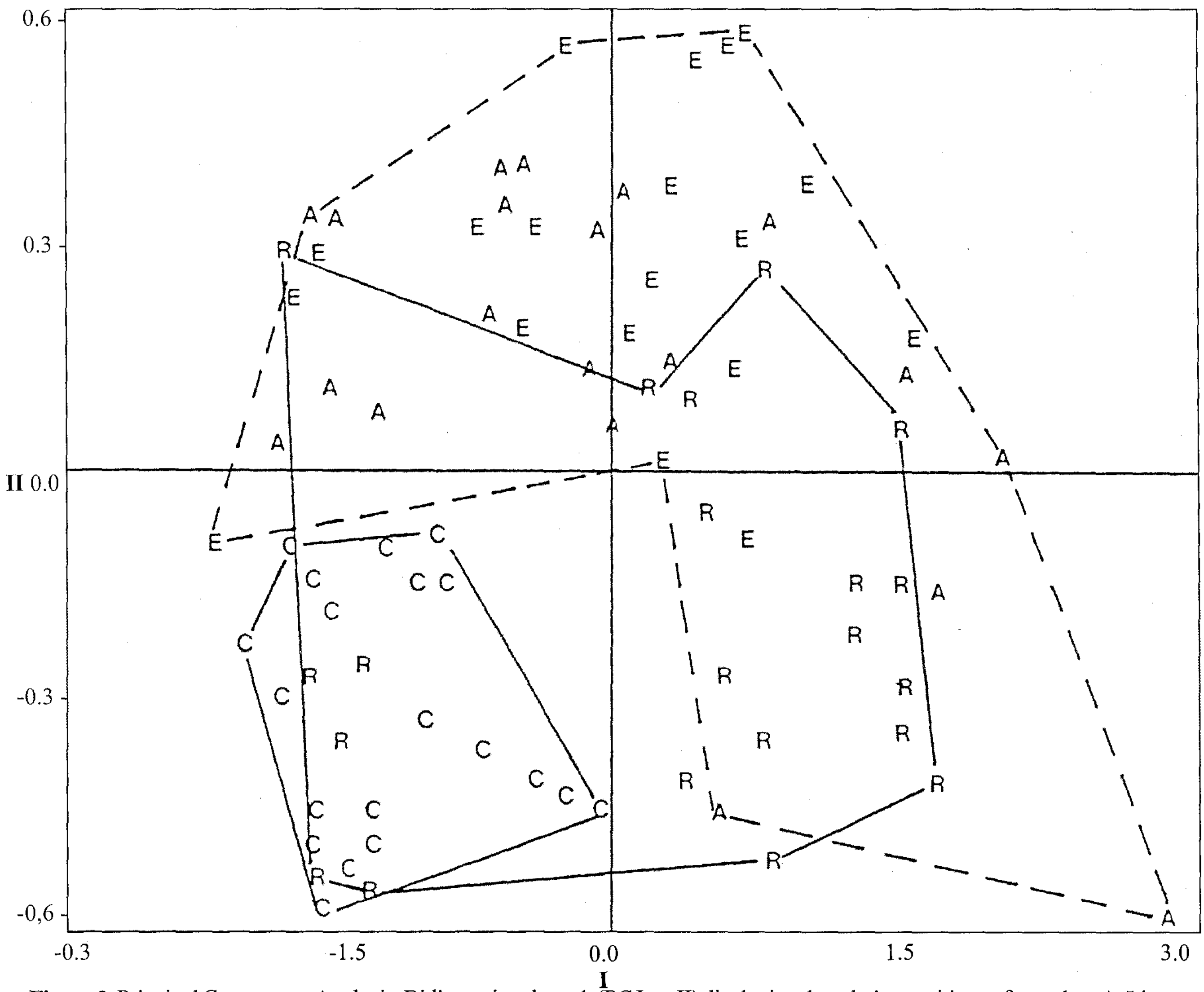

Figure 2. Principal Component Analysis. Bidimensional graph (PC I vs. II) displaying the relative positions of samples. A: Limay river downstream the dam, C: Collón Cur river, E: Ramos Mexía Dam, R: Limay river at Piedra del Aguila.

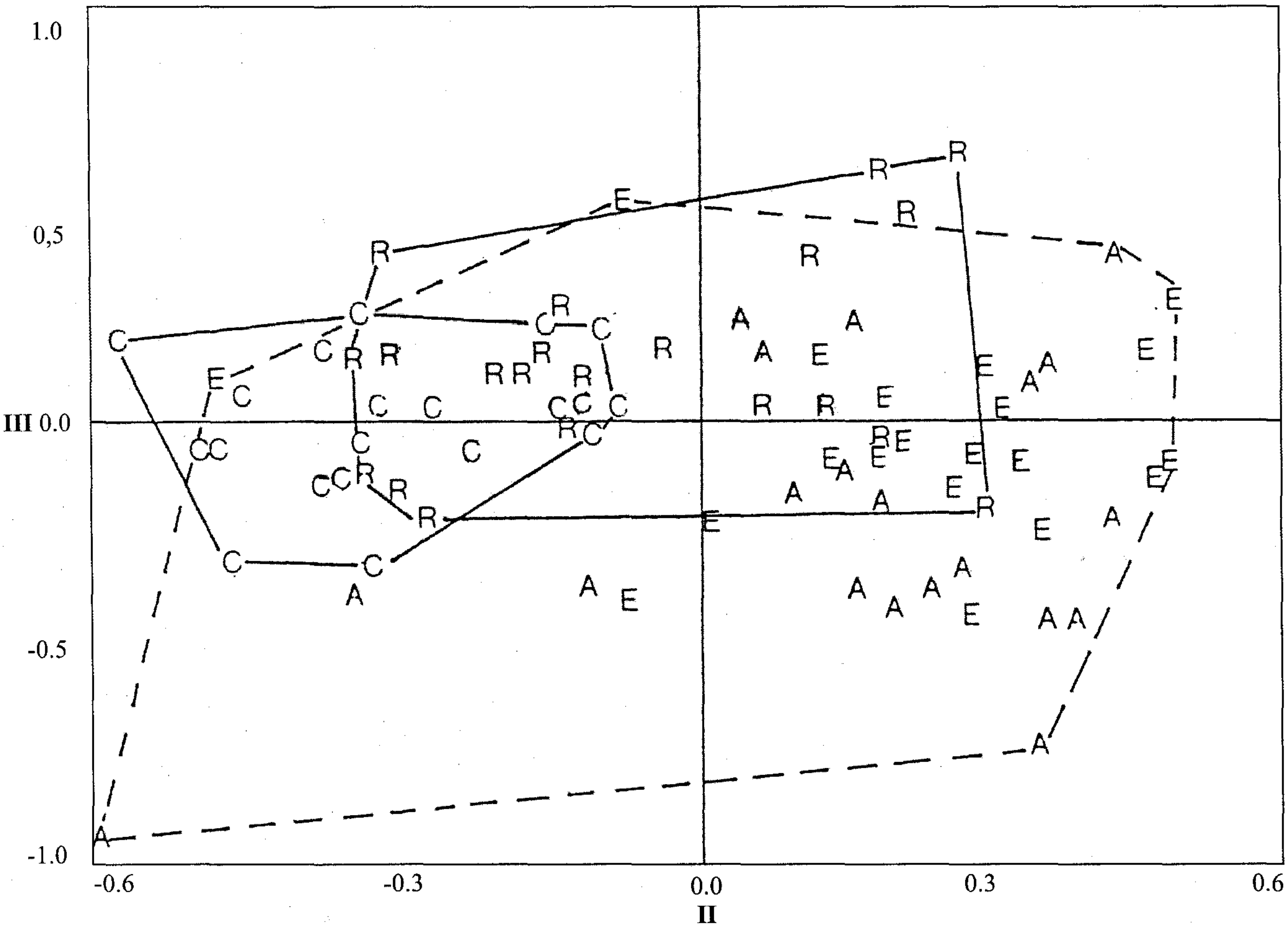

Figure 3. Principal Component Analysis. Bidimensional graph (PC II vs. III) displaying the relative positions of samples. A: Limay river downstream the dam, C: Collón Cur river, E: Ramos Mexía dam, R: Limay river at Piedra del Aguila.

unsettled. Populations of the Negro river may be diadromous, lacustrine or mixed (AZPELICUETA *et al.*, 1996).

Apparently, galaxiid populations from Australia and New Zealand and South America belong in the same genetic pool, and display low levels of heterozygosity (BERRA *et al.*, 1996). Leaving aside the subject of oceanic dispersal (McDOWALL,1970; ROSEN, 1974), data considered here are consistent with that genetic characteristic. They suggest that within the Limay river basin, G. maculatus show small regional morphological differences apparently related with physical traits. Analysis here used evidences them, but is not sufficent to sort the specimens according the section of the basin where they were collected.

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