Lethal temperatures of a Neotropical fish relic in Patagonia, the scale-less characinid *Gymnocharacinus bergi*

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Synopsis

Southern South America has a rather low fish species diversity. *Gymnocharacinus bergi*, the southernmost characid fish of the world, is the only member of Characoidei in the Argentine Patagonia. The isolation of this species in an endorheic stream has been linked to the thermal conditions of its habitat, the head-waters of the Valcheta Stream, which is the only site where this species occurs. We provide information on the distribution and thermal habitat of this species and other fishes in the Valcheta Stream. The responses of *G. bergi* to high and low temperatures were assessed in the laboratory under different temperatures and heating and cooling rates. Our results suggest that *G. bergi* is unable to extend its distribution to the colder waters nearby, as well as to waters with greater temperature fluctuations. We discuss the implications of our experimental data, the habitat of *G. bergi*, and the known responses of a few other paranensean fishes to temperature, within the framework of the thermal ecology of freshwater fishes.

Introduction

The southernmost characid fish of the world, *Gymnocharacinus bergi* Steindachner, 1903, is the only characid reported for Argentine Patagonia. The isolation of *G. bergi* in a rather small endorheic stream (Wegrzyn et al.[1]), more than 329 km south from other characinids, was related by Menni & Gómez (1995) to the thermal conditions of its hab-

itat, the head-waters of the Valcheta Stream, which is the only known site where this species occurs. Menni & Gómez (1995) used a predictive mathematical model, in combination with temperature data, and other available information (Cei 1969, Lüling 1978a, b, Miquelarena & Arámburu 1983), to state the thermal character of a branch (the 'Frío' branch, see below) of the Valcheta Stream. They proposed that this thermal character can explain the presence of this species in a Patagonian water body. In addition, the chemical composition of water was found to be within the range of common environments of characid fishes (Menni & Gómez 1995).
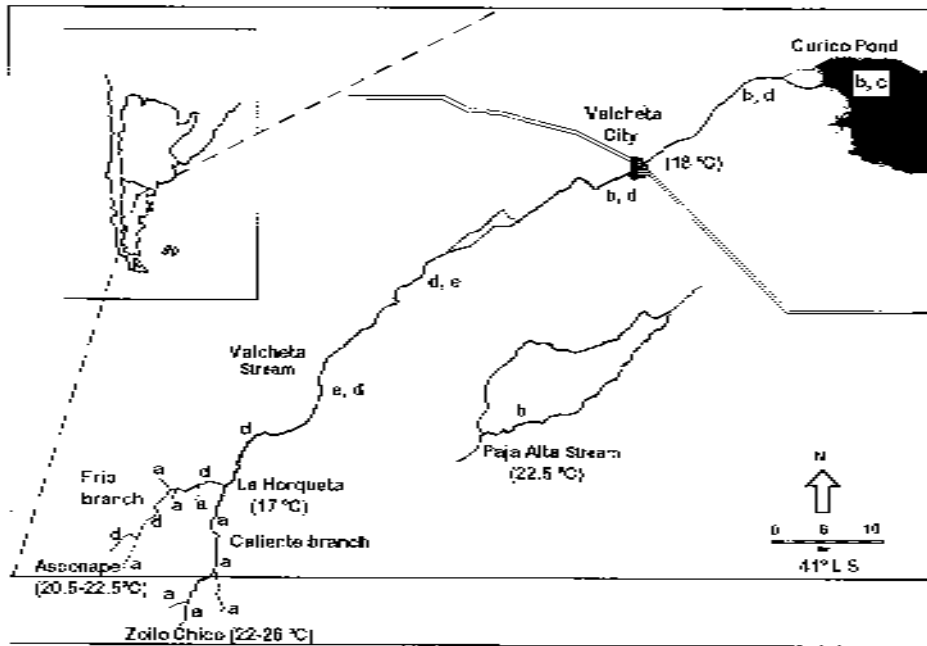
Figure 1. Fish distribution (indicated by letters) and water temperature (range or single records between parentheses) in Valcheta and Paja Alta streams: a – *Gymnocharacinus bergi*, b – *Jenynsia lineata*, c – *Cnesterodon decemmaculatus*, d – *Oncorhynchus mykiss*, e – *Salvelinus fontinalis*.

The ichthyofauna of South America is mainly composed of warm-water fishes belonging to the superorder Ostariophysi, including about 1500 species of characids and about 1100 species of catfishes (Moyle & Cech 1982). However, Patagonia is notoriously poor in species diversity (Arratia et al. 1983, Ringuelet 1975). *Gymnocharacinus bergi* is the only characid that survived the climate changes in Patagonia. In the light of above characteristics, aggravated by the introduction of two salmonid species in the Valcheta Stream, *G. bergi* received the status of 'vulnerable species' (IUCN[2]).

So far, only preliminary results on the thermal ecology of *G. bergi* (Ortubay et al.[3]) and other na-

[2] IUCN. 1988. International Union for Conservation of Nature and Natural Resources Red List of the threatened animals. IUCN, Gland. 128 pp.
[3] Ortubay, S.G., S.E. Gómez & V.E. Cussac. 1994. Determinación de las temperaturas letales máximas de *Gymnocharacinus bergi* (Pisces, Characidae). 1er Congreso y 3ra Reunión Argentina de Limnología, Tankay 1: 256–258.

Table 1. Water chemical data of the head-waters of Valcheta Stream. Specific conductivity (SC) in μS cm^{-1}, ions in mg l^{-1}.

Localities	Date	pH	SC	CA^{++}	Mg^{++}	Na+	K+	SO4 =
Asconape	4.8.1993	8.5	447	24.5	14.2	46.4	3.3	45.1
Asconape	28.10.1993	9.0	439	23.7	14.7	47.2	3.4	46.9
Asconape	15.12.1993	8.3	448	24.8	12.0	54.1	3.7	47.0
Z. Chico	4.8.1993	8.8	407	23.5	13.9	43.6	3.2	41.8
Z. Chico	28.10.1993	8.5	398	22.4	14.9	42.1	3.3	42.2
Z. Chico	15.12.1993	8.8	402	22.4	12.5	45.8	3.3	42.1

Table 2. Quick and slow change experiments of maximum lethal temperatures. AT = acclimation temperature, HR = heating rate, LET = loss equilibrium temperature (mean ± S.E.), DT = death temperature (mean ± S.E.), SL = standard length (mean ± S.E.), N = number of fishes. Regression equations (parameters ± S.E.) for (a) quick change experiments (1 to 5) and (b) slow change experiments (6 to 8) are given.

Experiment	AT (°C)	HR (°C h^{-1})	LET (°C)	DT (°C)	SL (mm)	N
1	20.0	20.0	33.9 ± 0.75	36.2 ± 1.01	37.6 ± 2.3	6
2	22.5	18.1	34.3 ± 0.0	36.3 ± 0.00	43.6 ± 1.1	5
3	24.0	19.0	34.8 ± 0.0	37.0 ± 0.00	34.1 ± 5.2	5
4	26.0	19.9	36.4 ± 0.0	38.2 ± 0.00	39.3 ± 0.8	5
5	28.0	20.0	36.9 ± 0.0	37.9 ± 0.00	37.8 ± 3.2	4
6	18.5	1.0 (°C day^{-1})		35.6 ± 0.08	34.9 ± 1.9	8
7	28.0	1.0 (°C day^{-1})		37.0 ± 0.00	36.0 ± 5.2	5
8	18.5	0.3 (°C day^{-1})		34.0 ± 0.00	34.8 ± 5.5	5

(a) ln DT = 3.07252 (± 0.146504) + 0.17049 (± 0.0461046) ln AT.

(a) ln LET = 2.69238 (± 0.156541) + 0.273911 (± 0.0492633) ln AT.

(b) DT = 29.6316 (± 2.0169) + 0.263158 (± 0.0911606) AT.

tive Patagonian fish, the siluriform *Hatcheria macraei* (Gómez 1990) are known. The aim of this work is to analyse the thermal biology of *G. bergi* under laboratory conditions and provide information on the distribution and thermal habitat of this species and other paranensean fishes (Menni & Gómez 1995, Ringuelet 1975) in the Valcheta Stream. We discuss the implications of our experimental data, the habitat of *G. bergi*, and the known responses of a few other paranensean fishes to temperature, within the framework of the thermal ecology of freshwater fishes.

Materials and methods

Environmental characteristics and fish distribution

Topographic references are based on Wegrzyn et al.[1] and charts of the Instituto Geográfico Militar of Argentina (Figure 1). Water and air diurnal temperatures were recorded to the nearest 1 °C, during fish collection in both branches of the Valcheta Stream, 'Frío' and 'Caliente' (Asconape and Zoilo Chico localities, respectively), on February, April, August, October and December 1993, and April 1994. Water and air temperatures at the junction of both branches (La Horqueta) were recorded on December 1993 and August 1994. Additional data about

Table 3. Quick and slow change experiments of minimum lethal temperatures. AT = acclimation temperature, CR = cooling rate, DT = death temperature (mean ± S.E.), SL = standard length (mean ± S.E.), N = number of fishes. Regression equation (parameters ± S.E.) for slow change experiments (11 to 13) is given.

Exp.	AT (°C)	CR	DT (°C)	SL (mm)	N
9 (*)	23.0	4.70 °C h^{-1}	4.2 to 3.0	32.8 ± 3.0	9
10 (**)	22.0	1.00 °C day^{-1}	− 10.0	31.9 ± 3.8	5
11	24.0	0.33 °C day^{-1}	10.0 ± 0.0	37.1 ° 5.1	5
12	18.5	0.33 °C day^{-1}	7.5 ± 0.5	36.9 ± 4.6	6
13	14.0	0.33 °C day^{-1}	8.5 ± 1.5	36.4 ± 6.2	6

DT = 4.55814 (± 3.10515) + 0.209302 (± 0.161121) AT.

(*) LET (loss equilibrium temperature) = 11.8 to 9.2 °C.

(**) In this experiment DT could not be taken due to a failure in the refrigerator system at 10 °C.
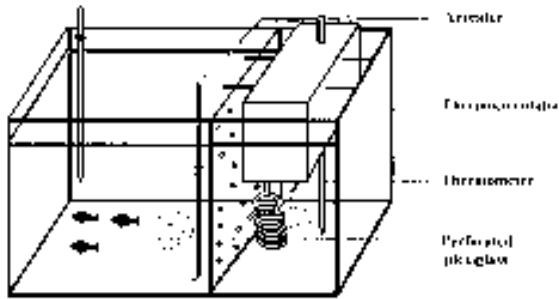
Figure 2. Equipment for maximum lethal temperature experiments. When room temperature was too high the equipment was put into a refrigerator.

the stream at Valcheta City, Curicó Pond, and the head-waters of Paja Alta Stream (a nearby endorheic hot spring) were also recorded. The presence of fish species was assessed by means of direct observation and catch with seine and dip nets. Water chemical characteristics (Table 1) of Zoilo Chico and Asconape were assessed according to EPA[4].

Experimental work

The critical thermal maximum, or minimum (CTM), is the arithmetic mean of the collective thermal points at which locomotory activity becomes disorganised and the animal loses its ability to escape from conditions that will promptly lead to its dead when heated from a previous acclimation temperature at a constant rate just fast enough to allow deep body temperatures to follow environmental temperatures without a significant time lag. The technique requires a progressive change of temperature upward or downward from acclimation and exposure until a physical disorganisation response occurs (Becker & Genoway 1979).

The CTM technique allows one to obtain useful results from a few specimens (Becker & Genoway 1979, Gómez 1988, 1990, Paladino et al. 1980). Due to the 'vulnerable species' status of *G. bergi* (IUCN)[2], the number of experimental fishes was kept to a minimum. Seventy four individuals, rang-
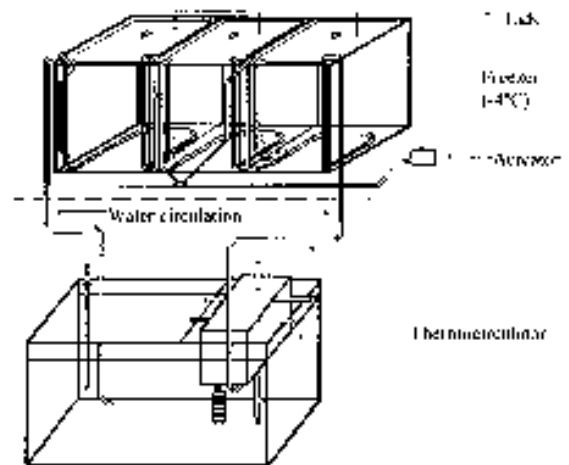
Figure 3. Equipment for minimum lethal slow change experiments. Experimentation chambers were put into the upper compartment (– 4 °C) of a refrigerator. The aquaria with thermocirculator were put in the lower compartment.

ing in standard length from 26.5 to 45.5 mm, were sampled at Zoilo Chico. Fish were carried alive and kept in thermostatized aquaria at a temperature of ca. 23 °C with biological filtration, artificial food, natural photoperiod, for a minimum of 1 month before the essays. The pH and conductivity of the water were of ca. 7.4 and 210 μS cm^{-1}, respectively.

Experiments under laboratory conditions, using several acclimation temperatures (AT) and different heating and cooling rates, were conducted in order to assess the resistance of *G. bergi* to high and low temperatures. Each experimental group was composed of similar size fish (Tables 2, 3), measured after essays to the nearest 0.1 mm.

Acclimation temperatures, heating, and cooling rates were obtained combining the use of room temperatures, a refrigerator, an immersion thermocirculator, and aerated experimental chambers (Figures 2, 3). Feeding was stopped 24 h before the beginning of 'quick change' (see below) essays in order to avoid bias linked to specific dynamic action (Eckert et al. 1988; Hill 1980). On the other hand, when the experimental temperature was changed slowly, the experiment could last more than 10 days, therefore food was supplied as long as the fish fed.

Loss of the equilibrium and death temperatures of individual fish were recorded by direct observation, according to the criteria of Becker & Genoway

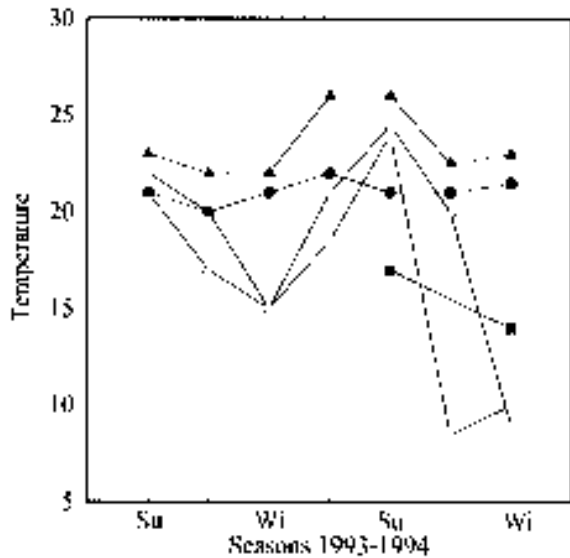*Figure 4.* Seasonal variation of water (filled symbols) and air (hollow symbols) diurnal temperatures (°C) in head-waters of Valcheta Stream (Asconape locality = circles, Zoilo Chico locality = triangles, La Horqueta locality = squares).
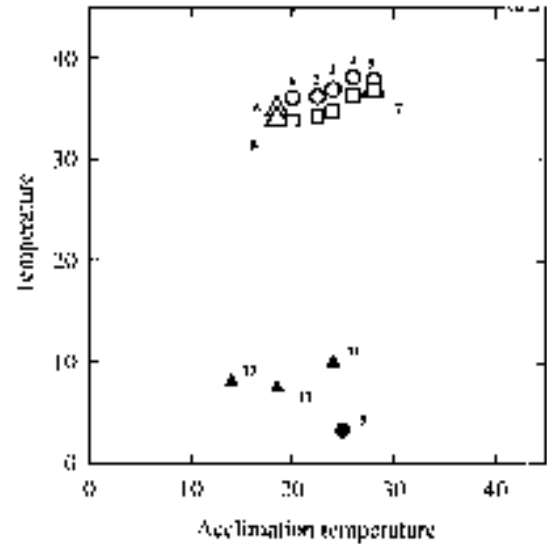

Figure 5. Maximum (hollow symbols) and minimum (filled symbols) lethal temperatures in relation to acclimatization. Circles and triangles come from quick and slow change experiments respectively. Hollow squares represent maximum loss equilibrium temperatures for quick change experiments. Numbers refer to Tables 2 and 3.

(1979). Arithmetic means of loss equilibrium temperature (LET) and death temperature (DT) for each tests were calculated. A multiplicative regression model ($Y = aX^b$) was used to describe the relationships between DT or LET (dependent variables) and AT (independent variable).

For maximum lethal temperatures two types of experiments, 'quick' and 'slow change', were performed. In quick change experiments, 25 fishes were sorted among 5 experimental groups (4 to 6 fishes per group), each of which was acclimated at different AT (20.0, 22.5, 24.0 and 26.0 °C), for at least 7 days. In order to obtain AT= 28.0 °C, acclimation was attempted during 36 hours using individuals previously acclimated to 26 °C. A heating rate of ca. 19 °C h^{-1} was used in all quick change experiments (Becker & Genoway 1979) and water temperature was registered every 5 min. Three slow change experiments were performed. The first two used a heating rate of 1.0 °C day^{-1}, applied to 8 and 5 fishes previously acclimated to 18.5 and 28.0 °C, respectively. The last AT (28.0 °C) was reached at a heating rate of 0.33 °C day^{-1} beginning at 23 °C. An additional experiment with 5 fishes, was conducted at a heating rate of 0.33 °C day^{-1}, starting from an

AT of 18.5 °C. Only DT could be taken in these experiments.

For minimum lethal temperatures, quick and slow change experiments were also carried out. A quick cooling experiment was performed at a rate of 4.7°C h^{-1} using 9 fishes acclimated to 23 °C. LET was recorded for all the individuals. DT was estimated when the opercular movements stopped and the individual failed to recover after transfer to 18 °C. Slow cooling was performed at a rate of 1 °C day^{-1} using 5 individuals acclimated to 22 °C, and at a rate of O.33 °C day^{-1} using 3 groups (5, 6 and 6 individuals) acclimated to 24.0, 18.5, and 14.0 °C, respectively. Only DT was recorded by daily observation.

In the framework of thermal ecology of fishes, the ultimate upper incipient lethal temperature (UUILT) is the highest lethal temperature that a fish can withstand by complete acclimation (Fry 1971, Fry et al. 1946) and, it is also the upper right corner of the thermal tolerance zone (TTZ sensu Fry 1971). Similarly, the ultimate lower incipient lethal temperature (ULILT) is the lowest lethal temperature attained by complete acclimation. By

extrapolating the critical thermal maximum (and minimum) slow change lines to the DT = AT line, we over (and under) estimate the UUILT (and ULILT). We estimated TTZ in two ways. The area between critical thermal maximum and minimum slow change curves (calculated from the integrals of linear models, DT = a + b AT and named 'critical thermal extreme zone') overestimates TTZ. On the other hand, the area of the feeding zone underestimates TTZ. Therefore the 'true'value must lie somewhere in-between the two areas.

Results

Environmental characteristics and fish distribution

The recorded temperatures are shown in Figure 4. Water temperature at Zoilo Chico and Asconape ranged between 20.5 and 26.0 °C during the year. In December, when the temperature at Zoilo Chico was 25 °C and 21 °C in Asconape, the temperature in La Horqueta was 17 °C. No differences were found between surface and bottom temperatures in any sampling site. No dependence was found between water and air temperatures (Kruskall-Wallis, p > 0.4 , Figure 4). Data on water chemical parameters (Table 1) are in agreement with Lüling (1978 b) and Menni & Gómez (1995).

Five species were recorded in this survey (Figure 1). *Gymnocharacinus bergi* occurs only in Valcheta stream. In the 'Frío' branch, *G. bergi* is present only in the warmer hot-springs. In the 'Caliente' branch it is present in higher densities as estimated by direct observation all along the branch, from the heads of the stream to the confluence with 'Frío' branch (La Horqueta). The water temperature in the sites *G. bergi* was caught ranged from 20 to 26 °C. *Oncorhynchus mykiss* (Salmonidae) is present in the 'Frío' branch, except in the warmer springs. It also occurs downstream La Horqueta up to Curicó Pond; occasional presence upstream the confluence in the 'Caliente' branch was observed only in winter. The presence of *Salvelinus fontinalis* (Salmonidae) is sporadic between La Horqueta and Valcheta City. *Jenynsia lineata* (Jenynsiidae) occurs in the stream at Valcheta City and in the Paja Alta
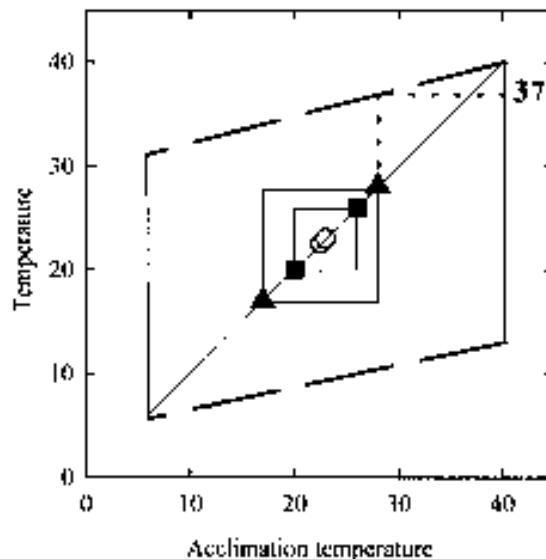

Figure 6. Feeding (triangles), distribution (squares) and thermal extreme tolerance (upper and lower dash lines) zones and central points (circles, distribution and critical thermal extremes central points are too close to be distinguished). Thermal tolerance zone (TTZ) and ultimate upper and lower incipient lethal temperatures (UUILT and ULILT) are comprised between feeding (121 °C²) and thermal extreme tolerance (906 °C²) zones. Dotted lines indicates the highest DT attained (37 °C) by the best acclimation procedure.

Stream. *Cnesterodon decemmaculatus* (Poeciliidae) occurs in Curicó Pond.

Experimental work

During acclimation and essays usually the fish stop eating below 17 °C and above 28 °C. In the last condition the individuals became notoriously darker and distressed.

In quick change experiments for maximum lethal temperature, the DT obtained with a mean heating rate of 19.4 °C h⁻¹ ranged from 36.2 to 38.2 °C. The LET was very close to DT (33.9 to 36.9 °C). The DT and LET increased significantly (p< 0.03 and 0.01 respectively) with increasing AT, that can be modelled by a multiplicative regression with an exponent significantly less than 1. The increase of DT and LET at higher AT showed that in these conditions the individuals underwent acclimation (Table 2, Figure 5).

Results of slow change experiments show that DT are lower than those obtained in quick change experiments (Table 2). The different DT values obtained in experiments 6 and 7 showed that higher AT results in higher DT, and suggest that a heating rate of 1.0 °C day^{-1} is too fast to allow complete acclimation during the essay. The difference between DT values obtained in experiments 6 and 8 can be attributed to the lower heating rate in the last experiment, that produces a longer exposure to detrimental conditions, such as fasting, and probable metabolic disorders. The high DT in experiment 7 can be explained by the fact that acclimatisation at 28 °C was optimized by means of a lower heating rate during a period when the fish still ate. Thereafter, higher heating rate allowed a briefer exposition period to a detrimental condition, reaching the highest DT value of this set of experiments.

The quick change experiment (9 in Table 3) for minimum lethal temperature showed that when the temperature decreased to 18.2 °C the fish remained on the bottom and finally lost equilibrium (11.8 to 9.2 °C). At 5.2 °C the first four individuals that ceased their opercular movements were taken out and successfully recovered in 18 °C water. Below 4.5 °C no signs of opercular movement could be seen in the remaining individuals. All fishes died between 4.2 and 3.0 °C.

The death temperatures in slow change experiments (10 to 13 in Table 3) were above 7.5 °C. The slight, non-significant effects of AT on DT precluded us to infer a real acclimatisation at cooling rates faster than 0.33 °C day^{-1}.

Construction of feeding and critical thermal extremes zones let us to propose that 121 °C^2 (feeding zone) < TTZ < 906 °C^2 (critical thermal extreme zone). The distribution zone (36 °C^2) is included into the feeding zone. Similarly, the UUILT is lower than 40.2 °C and higher than 28 °C, and the ULILT is lower than 17 °C and higher than 5.7 °C. It must be noted that the highest DT attained by the best acclimation procedure (experiment 7) was 37 °C. The central points of the distribution (23.0 °C), feeding (22.5 °C) and critical thermal extremes zones (22.95 °C) are similar, and included into the distribution zone (Figure 6).

Discussion

Due to its thermal character (Menni & Gómez 1995), the Valcheta Stream is warmer than most water bodies in Patagonia. Unlike most small streams, where water temperature is very close to the mean air temperature throughout the year (e.g., 7.8 to 21.5 °C, annual mean air temperature = 14.5 °C for Sierra de la Ventana streams, Menni & Gómez 1995), the water temperature in the upper Valcheta

Table 4. Death temperature (DT, °C) and loss equilibrium temperature (LET, °C) in critical thermal maximum or minimum test for several paranensean fish species and *G. bergi*. AT = acclimation temperature (°C), HR = heating rate (°C h^{-1}), CR = cooling rate (°C h^{-1}), SL = average standard length (mm), N = number of fishes.

Fish species	AT	HR	CR	DT	LET	SL	N	Reference
Callichthys callichthys	21.9	17.7	–	38.668	–	92.4	5	(1)
Cnesterodon decemmaculatus	20.7	18.1	–	37.91	–	20.2	5	(1)
Corydoras paleatus	21.1	19.4	–	36.86	–	39.6	5	(1)
Gymnocharacinus bergi	22.5	18.1	–	36.30	–	43.6	5	(2)
Gymnocharacinus bergi	20.0	20.0	–	36.20	–	37.6	6	(3)
Odonthestes bonariensis	20.4	16.2	–	35.38	–	49.4	5	(1)
Gymnocharacinus bergi	23.0	–	4.7	–	> 9.2	32.8	9	(5)
Phalloceros caudimaculatus	24.2	–	5.0	–	7.92	25.7	5	(4)
Pimelodella laticeps	24.2	–	5.0	–	6.46	84.5	5	(4)
Cnesterodon decemmaculatus	24.2	–	5.0	–	5.36	22.0	5	(4)
Jenynsia lineata	24.2	–	5.0	–	5.10	49.7	5	(4)

(1) Gómez pers. observ., (2) Exp. 2 in this work, (3) Exp. 1 in this work, (4) Gómez 1988, (5) Exp. 9 in this work.

Stream remains within a narrow range all the year around (20.5–26 °C), and probably during the day (Figure 1, Table 1).

So far the reported distribution of *G. bergi* was restricted to localities belonging to the 'Frío' branch in the Valcheta Stream (Lüling 1978a, b, Menni & Gómez 1995, Miquelarena 1982, Miquelarena & Arámburu 1983). Nevertheless, Wergzyn et al.[4] extended the distribution to include the 'Caliente' branch (see also Ortubay et al.[5]). While in the 'Frío' branch a small number of *G. bergi* is present only in the warmer hot-springs, high densities of *G. bergi* were registered all along the 'Caliente' branch, where the flow is higher and the water is uniformly warmer.

The distribution of others paranensean fishes at the Valcheta Stream (Ortubay et al.[5]) also deserves to be updated. In agreement with Wegrzyn et al.[1], *Jenynsia lineata* and *Cnesterodon decemmaculatus* are present in the Valcheta Stream. The reason why *J. lineata* and *C. decemmaculatus* fail to reach the upper Valcheta Stream is as yet unknown. Menni & Gómez (1995) speculated that previous competition with *G. bergi* could explain the absence of other paranensean species. Predation and long term physiological inadequacy to stable warm water conditions should also be investigated. Experimental analyses of the interaction between *G. bergi*, *J. lineata* and *C. decemmaculatus* in the laboratory could characterize the relationship among them and their environment. Another question is why *G. bergi* is absent in the Paja Alta Stream, even though, *J. lineata* is present. A potential explanation could be the extremely low flow of the thermal springs and the subsequent unstable temperature, requiring a high fish eurythermicity.

It is known that the different tolerances to factors such as temperature can condition the geographic distribution of fishes. Gómez (1988) noted that the southern distribution limit of fish species in South America is directly associated with the resistance to cold temperatures estimated in the laboratory. Of the only three Patagonian siluriforms, *Hatcheria macraei*, *Diplomystes viedmensis* and *Trichomycterus areolatus* (Arratia & Menu-Marque 1981, Arratia et al. 1983, Azpelicueta 1994, Ringuelet 1975, Ringuelet et al. 1967), *H. macraei* has the southernmost distribution (Berra 1981) thanks to its adaptation to cold water. As regard to high temperatures, the DT of *H. macraei* (31.16 °C with TA= 9.2 °C) is similar to that of other warm water fishes, but the lower value of LET (22.16 °C) is related to the cold habitat where this species lives (Gómez 1990).

Gymnocharacinus bergi belongs to a family of wide Neotropical distribution. It has high DT for maximum temperatures, but not so high as some paranensean fishes (Table 4). Higher LET for minimum temperatures, in relation to *Cnesterodon, Callichthys* and *Corydoras*, could be a consequence of living in a warm and stable habitat. *Gymnocharacinus bergi* appears to have partially lost its resistance to low temperatures, being thus constrained in its downstream dispersion. From this point of view DT should not be considered a relic but a functional paranensean adaptation.

The experimental results with *G. bergi* fit well into the general pattern of responses described in thermal ecology of freshwater fishes. The CTM values for stenothermal fish are lower than those for eurithermal ones. Generally, higher acclimation and faster rates of temperature increases produce higher CTM values (Fry 1971, Becker & Genoway 1979, Gómez 1990, 1993). Rates of adjustment to acclimation temperature vary from ca. 1 to 24 °C day^{-1} for several freshwater fish species (Fry 1971). Although several authors have used heating rates of 1 °C day^{-1} or slower to determine the UUILT (Kilgour & McCauley 1986), the acclimation rate of *G. bergi* was very slow (Table 2, 3), showing that a heating rate of 1 °C day^{-1} was too fast to enable total acclimation. It must be kept in mind that normal daily cycle of temperature in paranensean lentics environments ranges 3 °C day^{-1} (Drago 1984), so this low acclimation rate would be another consequence of living in stable warm water conditions. Collectively, the magnitude of TTZ (513.5 ± 392.5 °C^2, with 5.7 °C < ULILT < 17 °C and 28 °C < UUILT < 40.2 °C), the above comparison of DT

[5] Ortubay, S.G., D.R. Wegrzyn & V.E. Cussac. 1995. Distribución, comportamiento y hábitat de *Gymnocharacinus bergi* (Pisces, Characidae) en el arroyo Valcheta, Río Negro, Argentina. pp. 288. *In*: Resúmenes Reunión Argentina de Ecología, Mar del Plata.

and LET with paranensean fishes and, particularly, the rather slow acclimation rate of *G. bergi*, suggest that this species is a stenothermal warm water fish.

The similarity of central points of distribution zone (23.0 °C), feeding zone (22.5 °C), and critical thermal extremes zone (22.95 °C) allows us to postulate a physiological optimum (sensu Pianka 1982) for the average point (22.8 °C). This values are relevant to management and aquarium culture.

We can say that the thermal character of the Valcheta Stream, as stated by Menni & Gómez (1995), and the characteristics of the thermal physiology of *G. bergi*, described in this paper, explain the isolation of this species in a small area within a temperate zone. *Gymnocharacinus bergi* cannot extend its distribution to the temperate nearby waters, nor to waters with major temperature fluctuations.

Acknowledgements

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