# GAIN AND LOSS OF HEAT RESISTANCE IN THE TROPICAL FISH *Astyanax bimaculatus* OF VENEZUELA

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## Abstract

Venezuelan tetra *Astyanax bimaculatus* juveniles of 34.1-36.7 mm standard length and 0.83-1.0 g wet weight were acclimated for four weeks at 24-33°C, which are approximate average minimum and maximum river temperatures throughout the year. The fish acclimated at 24, 27, 30, and 33°C were exposed for 10,000 minutes at 25, 36, 37, 38, and 39°C to determine median resistance time. For determination of acclimation rate, the juveniles acclimated at 24 and 30°C were tested for individual heat resistance times at 39°C by exchanging acclimation temperatures. The median heat resistance times were increased in accordance with an increase in acclimation temperature and a decrease in test temperature, indicating that acclimation level has a great influence on thermal resistance of the fish tested. The upward acclimation, the fish transferred from 24 to 30°C, completed their acclimation level in a few days, while those transferred from 30 to 24°C (downward acclimation) required about 14 days, indicating this species can adapt well in thermally fluctuating tropical waters.

## Introduction

Venezuelan tetra, tropical characin *Astyanax bimaulatus* has a high ecological adaptability to thrive in tropical waters; and thus, they are widely distributed in confined waters, ponds, reservoirs, lagoons, estuaries, and rivers of all Venezuelan territories (Fernandez, 1972). This species can be used as bait fish for sport and commercial fishing. The fish juveniles are abundant in the tributaries of the Manzanares River (Sucre State, Venezuela), where water temperatures of the river fluctuate approximately 22-34°C throughout the year.

Temperature is one of the most significant role in aquatic lives among various biotic and abiotic factors influencing on growth, survival, and distribution of aquatic organisms (Lee & Rinne, 1980; Martin, 1988; Wax & Pote, 1990). Temperature was a significant factor for growth of tropical and subtropical fish, which grew three times faster at a moderately high temperature than at a lower temperature (Chung, 1983; Chung et al., 1992). Acclimation temperatures influence on thermal tolerance, and organisms acclimated a high temperatures, usually can resist much longer times than those acclimated at lower temperatures at a given lethal temperature (Fry, 1957; Allan & Strawn, 1971; Ciurcina and Chung, 1983; Chung, 1981, 1985, 1995). Also thermal acclimation rate was faster in an increasing temperature than in a decreasing temperature (Allan & Strawn, 1971; Ciurcina and Chung, 1983; Chung, 1981, 1985, 1995).

However, temperature effects of acclimation level on local species have not been studied. The studies have been carried out to provide an information, which could be useful in possible tetra culture and in ecological fishery evaluation of the tropical waters.

## Material and Methods

The fish were collected from the San Juan River, a tributary of the Manzanares River (Sucre State, Venezuela). This species *Astyanax bimaculatus* are found in this river system during the year. The standard length and body wet weight of the juveniles ranged 34.1-36.7 mm and 0.83-1.0 g, respectively.

Once they were acclimated for four weeks under laboratory conditions, the food was not supplied 24 hours before the bioassays. Thermal tolerance experiments were carried out in the morning to prevent possible diel effects except for acclimation rate assays. The photoperiod was not controlled; however, it was approximately 12 L and 12 D. The biomass in aquaria did not exceed two grams per liter of water for all experiments.

The temperatures (24-33°C) were selected for acclimation level, which approximate minimum and maximum temperature ranges of the regions throughout the year. Water in experimental tanks was filtered every day with diatom filter and whole water was changed every week. Dissolved oxygen and pH values ranged 5.2-7.6 ppm and 6.5-7.7, respectively; and thus, they never appeared to be critical or limiting.

Tropical fish food, UNIVERSAL (minimum protein contents 61.5%, minimum fat 4.5%, minimum fiber 5.5%) was supplied *ad libitum* twice a day, in the morning (0800) and in the evening (1800). The fish were measured total wet weight (g) and standard length (mm) in conjunction with the experiments.

Three hundreds twenty fish juveniles were acclimated for four weeks at 24, 27, 30, and 33°C. Twenty fish were exposed for 10,000 minutes at experimental lethal temperatures of 35, 36, 37, 38, and 39°C to determine individual heat resistance times, and then the median tolerance times were found at each acclimation temperature. The group of two hundreds seventy fish acclimated for four weeks at 24 and 30°C were tested at lethal temperature of 39°C for determining individual heat resistance times by exchanging acclimation temperatures. One hundred sixty fish (ten at each bioassay) were exposed to 39°C, before transfer and every day up to 15 days after transferred from 30 to 24°C to determine downward acclimation rate. One hundred ten juveniles were tested just before transfer and 1/8, 1/4/, 1/2, and every day up to seven days after transferred from 24 to 30°C to find upward acclimation rate. The cessation of opercular motion was a criterion for death of the fish.

## Results and Discussion

Acclimation temperature significantly influenced on individual heat resistance time of *Astyanax bimaculatus* tested, and showed a direct relationship between acclimation level and median heat resistance (Fig. 1). The median heat resistance times of *A. bimaculatus* ranged over 10,000 minutes at lethal temperature of 35ºC; from 56 to 3,279 minutes at 36ºC; from 8.5 to 2,825 minutes at 37ºC; from 4.2 to 1,136 minutes at 38ºC; and from 3 to 369 minutes at 39ºC.

Median heat resistance times for *Astyanax bimaculatus* in thermal changes, both increasing (upward) and decreasing (downward) periods, are presented in figure 2. At an increase in temperature from 24 to 30°C for upward acclimation, the fish started to gain acclimation level after one day, required four days to fully get up to a higher level of resistance, and then maintained similar tolerance levels. Analysis of variance indicated that median heat resistance times were significantly different during acclimation periods (Table 1). Dunan's multiple range test showed that the values determined during two- to six-day-acclimation-period were not significantly different (Table 1). This indicates that the fish acclimated for two days in an increase in temperature reached a higher level of acclimation on thermal stress. Similar results were reported by Doudoroff (1944), Spoor (1955), Sprague (1963), Allan & Strawn (1971), Chung (1981, 1985, 1995), and Segnini et al. (1993) for different aquatic organisms. At a decrease in temperature from 30 to 24°C for downward acclimation, they began to lose their acclimation level after 1 day, slowly reduced their tolerance level, and took 14 days to reach a lower level of thermal resistance (Fig. 2). Analysis of variance indicated that median heat resistance times were different during the acclimation period (Table 1). Duncan's test showed that values determined after 14 days acclimation period were significantly lower than those determined before these days (Table 1). This confirms that it takes about two weeks to lose its highest level of acclimation in a temperature change from 30 to 24°C. Former studies indicated that loss of thermal resistance after a decrease in acclimation temperature required much longer than acclimation to an increase in temperature (Doudoroff, 1944; Spoor, 1955; Allan & Strawn, 1971; Chung, 1981, 1985, 1995; Segnini et al., 1993).

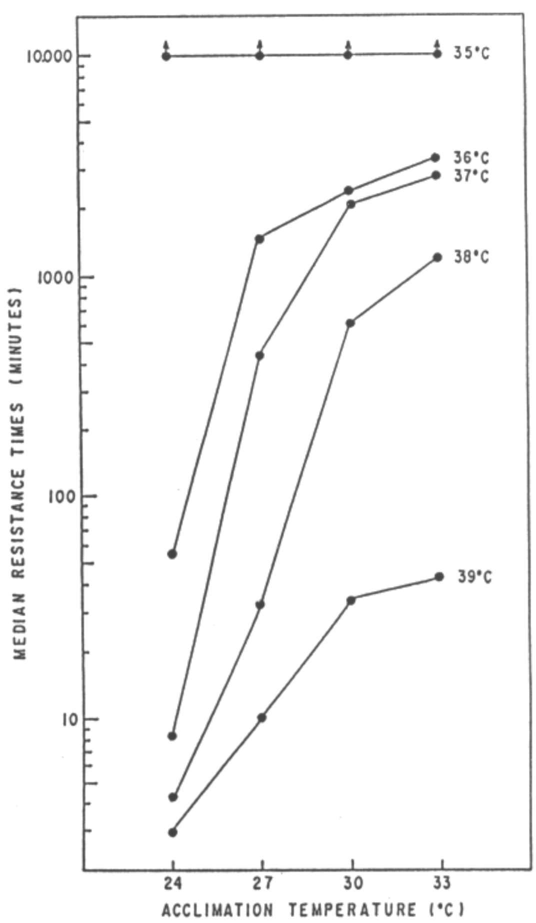


Figure 1. Median heat resistance times of *A. bimaculatus* acclimated for four weeks and tested at various temperatures

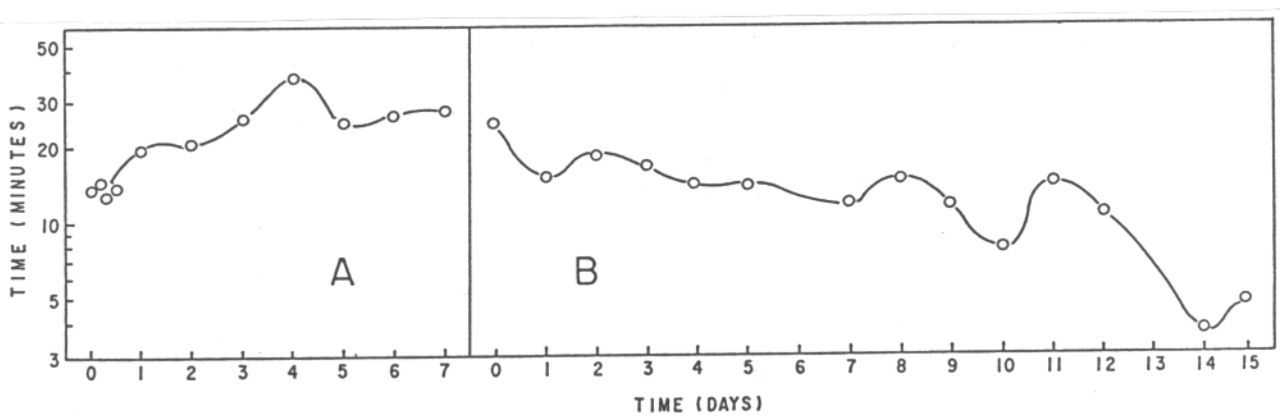


Figure 2. Median heat resistance times of *Astyanax bimaculatus* acclimated for four weeks at 24°C (A) and 30°C (B), and exposed to 39°C during seven days upward and fifteen days downward acclimation periods.

Table 1. Results of ANOVA and Duncan's multiple range test (DMRT) of the median heat resistance times of *Astyanax bimaculatus* acclimated for four weeks at 24°C (30°C) and transferred to 30°C (24°C) in upward (downward) acclimation periods for seven (fifteen) days.

| Acclimation rate | Degrees of freedom | $F$-value | $p$ |
|---|---|---|---|
| Upward acclimation | 10, 55 (total 65) | 7.90 | $<0.01$ |
| Downward acclimation | 13, 84 (total 97) | 5.96 | $<0.01$ |

DMRT (Upward)

| Days | 0 | 1/2 | 1/6 | 1/8 | 1 | 2 | 5 | 6 | 3 | 7 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Median (min) | 11.4 | 12.0 | 12.3 | 13.2 | 18.8 | 20.6 | 23.5 | 27.8 | 28.9 | 31.3 | 35.1 |

DMRT (Downward)

| Days | 14 | 15 | 10 | 12 | 9 | 11 | 5 | 4 | 8 | 7 | 3 | 1 | 2 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Median (min) | 4.8 | 6.2 | 9.5 | 10.7 | 11.5 | 12.0 | 12.9 | 14.0 | 14.6 | 14.7 | 15.4 | 18.5 | 18.7 | 24.0 |

Medians not spanned are not significantly different at 5% level.

## Conclusion

It has been confirmed the general paradigm: the rate of gain in thermal resistance (upward acclimation) is rapid and the loss in heat tolerance (downward acclimation) is slow. This phenomenon is very important in tropical fish in shallow river system. A tropical fish acclimate rapidly in increasing temperature during the day and does not lose this level in decreasing temperature during the night. And thus, a tropical fish maintain its maximum tolerance level in high temperatures caused by sudden increase in temperature during hot day.

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