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Short Communication

Preliminary observations on *Cichlasoma beani* in culture conditions

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ABSTRACT. The Mexican cichlid, *Cichlasoma beani* has potential to be a candidate for the aquarium trade and the food industry. However, currently there are no studies regarding the effect of environmental factors on the species in culture conditions. The aim of this study was to assess the potential of *C. beani* to be maintained in cultured conditions. Additionally, the fish were exposed to different temperatures to examine the effect of temperature on growth, condition and survival of cultured juveniles in 26, 28 and 30°C, for six weeks in recirculation systems. Fish were fed 2.4 mm pellets (40% protein, 15% fat) at a ration rate of 5% body weight per day (dry weight food: wet weight fish). An aggressive behavior in all treatments led to lowered survival, making it impossible to conclude that temperature had an effect on the recorded variables. However the results showed a tendency that indicated the final weight and specific growth rate at 30°C was greater than in 26 and 28°C, perhaps due to a better metabolism and nutrient assimilation.

Keywords: *Cichlasoma beani*, cichlid, culture, temperature, acclimation, metabolism, aggressiveness.

Observaciones preliminares sobre *Cichlasoma beani* en condiciones de cultivo

RESUMEN. El cíclido mexicano, *Cichlasoma beani* presenta potencial para ser un candidato como pez ornamental y ser considerado en la industria alimentaria. Sin embargo, no hay estudios sobre el efecto de los factores ambientales sobre la especie en condiciones de cultivo. El objetivo de este estudio fue evaluar el potencial de *C. beani* para ser mantenido en condiciones de cultivo. Adicionalmente, los juveniles fueron expuestos a diferentes temperaturas para examinar el efecto de la temperatura sobre el crecimiento, la condición y la supervivencia de juveniles cultivados a 26, 28 y 30°C, durante seis semanas en sistemas de recirculación. Los peces fueron alimentados con pellets de 2,4 mm (40% proteína, 15% grasa) a una tasa del 5% de peso corporal por día (peso seco del alimento: peso húmedo de los peces). Un comportamiento agresivo en todos los tratamientos redujo la supervivencia haciendo imposible concluir que la temperatura tuvo un efecto sobre las variables registradas. Sin embargo, una tendencia indicó que el peso final y la tasa de crecimiento específica de *C. beani* cultivados a 30ºC fue mayor que en *C. beani* cultivados a 26 y 28°C, quizás debido a un metabolismo más activo y una mejor asimilación de nutrientes.

Palabras clave: *Cichlasoma beani*, cíclidos, cultivo, temperatura, aclimatación, metabolismo, agresividad.

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In Mexico, natural populations of native fishes are under pressure, mainly due to anthropogenic alteration of habitat and introduction of exotic species. The Mexican native cichlid *Cichlasoma beani* is distributed along the Pacific slope in lower river valley sections in the states of Jalisco, Nayarit, Sinaloa, Sonora and Zacatecas. According to Miller *et al.* (2005) the water temperature in the natural environment of *C. beani* normally ranges between 23-25°C and has been found in fresh and brackish waters, although there is no report of a preferred or tolerance limit level for these factors. During the present study, *C. beani* was found in shallow waters of the San Pedro fluvial system at temperatures as high as 32°C. Apart (quotes) for San Pedro from an ecological study (García-Lizárraga *et al*., 2011) and a few parasite related studies (Caspeta-Mandujano *et al.*, 1999, 2001; Camacho *et al.*, 2002; De Leon *et al.*, 2008), there is no existing scientific information on the biology of *C. beani*. The development of culturing techniques has been a successful strategy to protect species. Food consumption and food conversion efficiency can be improved by optimizing water temperature, which can lead to growth improvement in teleosts (Jonassen *et al.*, 2000). As several native species of cichlids from around the globe are currently highly prized to be part of collections, independent of their size or coloration, *C. beani* could be part of the aquarium trade. At present, *C. beani* forms part of the diet for several Mexican communities that prefer the meat quality of this species when compared to tilapia. This raises the possibility of *C. beani* to be an aquaculture candidate for the food industry. Given the lack of knowledge on the biology of the species, the primary aim of this study was to assess the potential of *C. beani* to be maintained in culture conditions and additionally to compare the effect on growth, condition and survival of different temperatures.

Fish collection was conducted at the site "El Chilte" (21°45'15"N, 104°51'30"W). The recorded temperature range during collection was 26-30°C. After collection the fish were transported to the wet laboratory located in Tepic, Nayarit, Mexico, where the experiment was conducted. Following a 15 min temperature acclimation period a total of 105 individuals (8.15 ± 0.25 g; 7.6 ± 0.08 cm; mean ± 1SE) were allocated to a 200-L holding tank at a temperature of 28°C and a salinity of 0 g L^{-1} for seven days prior to the experiment. The holding tank was fitted with a plastic mesh to prevent fish from jumping out of the water, as the species was observed to present a strong jumping behavior. Three separate 160-L recirculating systems were used simultaneously to maintain 26, 28 and 30°C. Each system had three 40-L tanks (working volume) connected to a 40-L biofilter. In each reservoir a 200 W heater (Hagen, Montreal, Canada) was set to maintain the desired water temperatures. A 12:12 (L:D) photoperiod was provided (lights on at 08:00 h, lights off at 20:00 h) by a timer controlled cool white light 35 W (General Electric Company, Fairfield, CT, USA) producing an intensity of 5.2 μE s^{-1} m^{-2} at the water surface. Water quality for the experiment was maintained as follows: dissolved oxygen >75% saturation, total ammonia nitrogen (TAN) <0.5 mg L^{-1}, nitrite <0.25 mg L^{-1}, nitrate <5 mg L^{-1}, average pH 7.8 (range 7.6-8.1). For the determination of pH, TAN, nitrite and nitrate, a colorimetric saltwater liquid test kit (Aquarium Pharmaceuticals Inc., Chalfont, PA, USA) was used. Temperature was monitored every 24 h while TAN, pH, nitrite and nitrate were recorded every 48 h during the experiments. Tanks were inspected daily for mortalities, and any excess food and faeces were siphoned to waste.

The fish were fed 2.4 mm pellets of a commercial diet for tilapia (40% protein, 15% fat). The pellets were offered at a ration rate of 5% body weight per day (dry weight food: wet weight fish), divided into three equally sized meals (10:00, 13:00 and 16:00 h). Feeding adjustments were calculated based on the daily mortality (assigned by the previously recorded mean weight) and weekly bulk weight per tank in both trials (the rations corresponding to mortalities were not fed to the remainder of fish). Standard length was measured by placing the fish on a 1 mm scaled sheet covered with plastic. Wet weight was measured on an electronic scale and recorded to the nearest 0.1 g. Fish were not fed for 24 h prior to each weighing. The standard length and wet weight of individual fish were recorded on day zero. After six weeks the surviving fish were counted and their wet weight and standard length measured individually. To assess fish condition Fulton's K was calculated as $K = (W/L^3) \times 100$, where W = wet weight (g) and L = standard length (cm). Specific growth rate (SGR) was calculated as (SGR % increase in body weight per day) = $[(\ln W_f - \ln W_i)/t] \times 100$, where W_f = final weight (g), W_i = initial wet weight (g), and t = time (days). Forty-five fish were randomly selected from the 105 fish. Prior to the start of the experiment, fish were transferred from 28°C, to the next temperature at a rate of 1°C per day until fish were acclimated to all the temperatures used in this experiment (48 h to 26°C, 48 h to 30°C). Although a number of ten individuals per replica is statistically recommended, given the lack of knowledge on the behavior of the species it was decided to use only five (to avoid any negative overcrowding response) over six weeks in each of nine 40-L tanks (nine tanks, three treatments with three replicates each).

To compare the metabolism efficiency among treatments (at the end of each experiment) one fish per tank was randomly selected to be euthanized with an overdose of benzocaine (400 mg L^{-1}). Each euthanized individual was then blotted dry and its wet weight and standard length were recorded. Each whole fish was then freeze-dried until constant weight was achieved. As low moisture content has been associated with good condition in fish (Shackley *et al.*, 1993), moisture content comparisons were conducted by determining the difference between dry weights from wet weight. Those dried samples were then used to determine fat and protein content. Crude protein and fat in muscle tissue were analyzed according to standard methods (AOAC, 1995). A one-way ANOVA (SPSS 17.0) was used to compare the means among treatments of: survival, initial standard length, final standard length (mm), initial weight, final wet weight (g), moisture (%), protein and fat content, Fulton's K (K) and SGR (%/day). A significance level of $P < 0.05$ was used. Levene's test and residual plots were used to test homogeneity of variance. Tukey's HSD *post-hoc* test was used to identify differences among treatment means (SPSS 17.0).

There were no significant differences ($P > 0.05$) in either standard length or wet weight among treatments at the start of the trial (Table 1). After six weeks the final wet weight and specific growth rate were significantly greater ($P < 0.05$) in fish cultured at 30°C compared to the rest of the treatments. There were no significant differences ($P > 0.05$) in any of the remaining parameters recorded such as survival, final standard length, Fulton's K, moisture content, protein and fat. Survival in all treatments was lowered due to an aggressive response of one dominant fish per replica, which in most cases killed the rest of the fish in each tank (Table 1, Fig. 1). From the fifth bulk measuring to the end of the trial the growth profile of the fish in 30°C was higher compared to the rest of the treatments (Fig. 2).

The aggressive behavior observed in all treatments made it impossible to conclude that temperature had an effect on the recorded variables. However, the results showed a tendency that indicated the final growth observed at 30°C was probably produced by a higher metabolism and nutrient assimilation efficiency. It would be expected that the other response variables were consistent with the growth results, though the results of protein and fat indicated no nutritional stress. Temperatures of 29.5-31.6°C produced improved growth in *C. istlanum* juveniles and adults respectively (Luna-Figueroa *et al.*, 2003). This finding is similar to the results of the present study, perhaps due to the temperature similarities between the habitats of both species. In the present study, despite the fact that some of the fish used were caught in waters at 26°C, the higher metabolism and assimilation efficiency tendency of *C. beani* recorded in 30°C could be related to the water temperatures recorded in most collection sites, which were 30°C or higher. However, due to aggression, the reduction of the number of fish per tank from five to one made it impossible to conclude that temperature had an effect on fish growth. As observed in the dissections of two mortalities *C. beani* can reach sexual maturity at a relatively small size (aprox. 8.5 cm; 22 g) one of the mortalities resulted to be a male and the other a female. Early stages of some teleosts present a preference for warmer temperatures which changes ontogenetically in late stages associated with colder temperatures (Morita *et al.*, 2010), while *C. beani* appears to inhabit warm waters as long as possible, perhaps reaching sexual maturity at a small size before these sites either dry or flood according to the seasonal changes. The maximum reported size of the species (30 cm total length) is one of its attributes to be considered as an aquaculture candidate for the food market (Froese & Pauly, 2013). However the size of the collected fish in the present study may be explained by unregulated fishing of large individuals as they are part of the diet of the local communities. Another cause for its limited growth *in situ* could be the poor availability of food, which can be provided in culture conditions to achieve commercial sizes. There may be a need in commercial production to implement a technique such as monosex culture to avoid reproduction at relatively small sizes that can make it difficult to achieve marketable sizes. However, the fact that the species is able to reproduce at small sizes could be an advantage for the aquarium market as massive infrastructure may not be required for reproduction. This is the first report on the species acceptance of a pellet diet. These observations contrast with the findings on the native Mexican cichlid *C. istlanum* fed with a commercial diet compared to live feed (Luna-Figueroa & Figueroa, 1999). The authors suggested that the use of commercial diets in *C. istlanum* (instead of live feed, *Daphnia pulex* and *Culex quinquefasciatus*) produced fish condition detriment and poor growth. *C. beani* accepted the commercial diet used in the experiment within two days after collection, presumably when its energy levels lowered by starvation. Further research is needed to determine the nutritional profile for this species as the diet used in the present study could not be considered optimal for *C. beani*. A stocking density of five fish per 40 L was selected to prevent a potentially negative crowding effect which could lead to the characteristic aggressive behavior of cichlids (McCarthy *et al.*, 1999; Leiser *et al.*, 2004; Teresa & Gonçalves-de-Freitas, 2011). Despite this measure a hierarchical aggressive behavior caused mortalities as in most cases one dominant indi-

Table 1. Survival, initial and final wet weight, initial and final standard length, coefficient of variation, size heterogeneity, moisture, Fulton's K, protein, fat and specific growth rate (SGR) (mean ± 1SE of three replicates per treatment) of *Cichlasoma beani* cultured at 26, 28 and 30°C in a six-week growth trial. Means with different superscripts within a row are significantly different (one-way ANOVA, $P < 0.05$). SE: standard error.

Temperature	26°C	28°C	30°C
Final observed survival (%)	20.0 ± 0.0[a]	40.00 ± 20.0[a]	20.0 ± 0.0[a]
Initial individual weight (g)	8.0 ± 0.11[a]	8.5 ± 0.6[a]	7.9 ± 0.35[a]
Final individual weight (g)	32.66 ± 3.52[a]	32.41 ± 2.10[a]	46.33 ± 2.33[b]
Initial standard length (cm)	7.63 ± 0.03[a]	7.56 ± 0.06[a]	7.56 ± 0.08[a]
Final standard length (cm)	11.43 ± 0.56[a]	11.36 ± 0.41[a]	12.17 ± 0.88[a]
Moisture (%)	67.10 ± 0.48[a]	66.95 ± 0.48[a]	66.05 ± 0.92[a]
Fulton's K	2.18 ± 0.11[a]	2.22 ± 0.10[a]	2.71 ± 0.54[a]
SGR (%/day)	3.32 ± 0.26[a]	3.17 ± 0.14[a]	4.20 ± 0.03[b]
Protein content (%)	70.30 ± 6.88[a]	72.47 ± 0.85[a]	70.27 ± 2.20[a]
Fat content (%)	48.83 ± 1.91[a]	50.84 ± 2.66[a]	55.96 ± 2.24[a]

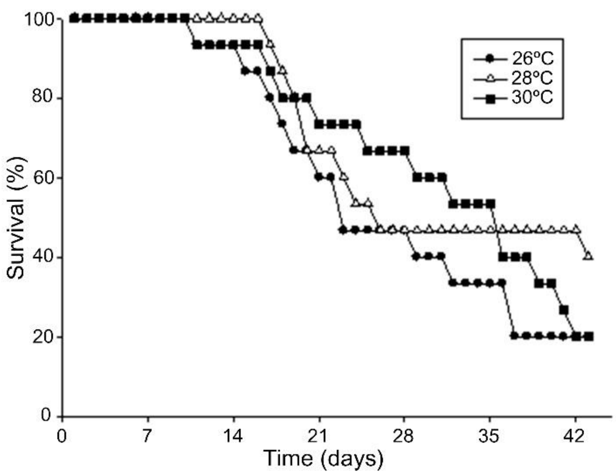

Figure 1. Daily survival (% mean of three replicates per treatment) of *Cichlasoma beani* cultured at three different temperatures in a growth trial following a temperature-acclimation of 1°C every 24 h. Fish were fed a commercial pellet diet at a ratio of 5% body weight per day, adjusted based on weekly growth and daily mortality. Standard error bars were omitted to aid visualization.

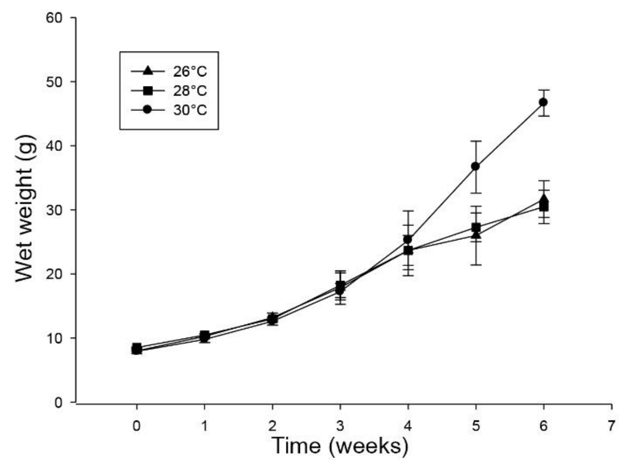

Figure 2. Wet weight of *Cichlasoma beani* cultured at three different temperatures in a growth trial following a temperature-acclimation of 1°C every 24 h. Fish were fed a commercial pellet diet at a ratio of 5% body weight per day, adjusted based on weekly growth and daily mortality. All values represent the mean of three replicates per treatment ± 1 SE. SE: standard error.

vidual in each tank killed the rest of the fish but did not cannibalize them, therefore could not obtain a nutritional benefit from the mortalities. There was no need for cannibalism, as observed by the acceptance of the tilapia diet offered, as a few uneaten pellets were siphoned to waste. The killed fish presented abrasions at the base of the fins and missing scales, produced by the constant attacks of the dominant fish. This aggressive behavior was not observed before experi-ments while the fish were maintained in the holding tank at a density of approximately one fish per liter, but it started during the experiment when stocking density was lowered to one fish per eight liters. Perhaps the species responds particularly aggressive when there are less than 10 individuals in a tank (40 L).

Therefore, further research is needed to observe if this aggressive behavior of *C. beani* is reduced in the presence of habitat structure *e.g.*, plastic shelter, submerged vegetation (Barley & Coleman, 2010) or at a higher stocking density. Further research is needed to determine the optimal stocking densities of *C. beani* in each stage of the life cycle. The present study demonstrates that under the experimental conditions described *C. beani* can be reared in recirculating systems, that the species accepted a standard pellet fish diet and that there was a tendency that showed temperatures up to 30°C may improve growth.

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