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Evaluation of the aquaculture potential of *Dormitator maculatus* (Bloch, 1792) from the Alvarado lagoon, Veracruz, Mexico

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ABSTRACT
Objective: The naca fish, *Dormitator maculatus*, is a species which commercial importance is based exclusively on the extraction of the mature gonads of the females, which reach a high price in the regional market as a gourmet dish. However, there is scarce information regarding its biology.
Design/methodology/approach: Their aquaculture potential (survival and growth) was evaluated in a recirculation system, in which the response in captivity of stages of their life cycle (treatments) were tested: T1=fry (8.35±2,83 g), T2=juveniles (17.22±5,13 g) and T3=adults (25.55±6,05 g), in triplicate, for 90 days. Measurements were performed every 15 days, the diet supplied was a commercial balanced feed for tilapia 3.5 mm in diameter (GrowFish® Protein 35%, fat 5.5%), at 1.5% of the biomass which was positively accepted.
Results: At the end of the experiment, it was observed that Treatment 1 (fry) presented a greater survival and growth. This result may be related to the fact that the species is very resistant to environmental changes in its natural environment.
Limitations on study/implications: However, this growth was slow, which may be since *D. maculatus* has a stationary diet.
Findings/conclusions: The results encourage more studies on its cultivation, such as the influence of environmental conditions on reproduction, which would help to mitigate the pressure on natural populations.

Keywords: recirculation, culture, life stage, survival, growth, gourmet fish.

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INTRODUCTION

Worldwide, there are many species of fish that are not used massively as food resources, despite having the potential to meet to meet the growing demand sources of protein (Larumbe, 2002). In Mexico, there is a great diversity of native species of crustaceans, mollusks and fish that have been traditionally captured with artisanal fishing. In the State of Veracruz, this activity bases its practice on rustic fishing gear for fish, mollusks and crustaceans (Arreguin-Sanchez, 1986). This is the case of the fishery for the "naca" *Dormitator maculatus* that has been carried out for decades in the Alvarado Laguna. These

fish have a small size (6-12 cm), a discreet appearance, a grayish color and their meat has a flaccid consistency, so they are not used for human consumption. Its use is based exclusively on the extraction of mature gonads of females, which reach a high price in the regional market (Chávez *et al.*, 1997).

The *Dormitator maculatus* species is traditionally exploited in the Alvarado Lagoon System, Veracruz, Mexico. It is a species that has an important ecological role by transforming the energy of detritus into useful forms for organisms of higher trophic levels (Yánez-Arancibia and Díaz-González, 1976). Its commercial importance lies exclusively in the consumption of the mature gonads of the females known as “roe”, which is highly valued locally. In the Alvarado Lagoon System there are few reports on this resource that provide statistics and volumes of annual catches at the regional or national level. The extraction season takes place from September to October when the mature fish come to spawn in the lagoon (Chávez *et al.*, 1997). It is a fish that is captured seasonally due to its economic importance, which places it among the ten most important species captured in the Alvarado lagoon system (CONAPESCA, 2005). Despite its regional importance due to its commercial value and reported catch volume, to date there is still no basic information on its reproductive biology or farming aspects. Therefore, it is necessary to carry out studies regarding the culture in recirculation systems for this species and to gather scientific information that allows knowing the current situation of its fishery and thus being able to propose management plans for its protection and sustainable use in Alvarado, Veracruz. The objective of this study is to evaluate the aquaculture potential of the Naca *Dormitator maculatus* in a recirculating aquaculture system.

MATERIALS AND METHODS

Study area

Alvarado’s Laguna (parallels 18° 46’ and 18° 42’ north latitude and meridians 95° 34’ and 95° 58’ west longitude) in southeastern Mexico, 70 km from the port of Veracruz (Figure 1). The Alvarado lagoon system is made up of a complex network of

Figure 1. Lagoon system of Alvarado, Veracruz (Google Earth, 2017).

more than 28 permanent and temporary lagoons, rivers/streams, which are associated with mangrove vegetation. The main water bodies that converge in the study area are the Papaloapan, Blanco, Acula, Limón, El alacrán, La manta, El Pájaro and Palma Real rivers. The permanent streams are Paso del Burro, Mano Perdida, Puente Amaca and Paso del Zapote; the intermittent stream Caño de Arena and the shrimp lagoons, Buen País, Alvarado, Tlalixcoyan, Las Pintas, Pajarillos, Santacomapan, El Embarcadero, Coyol, María Elvira, El Pájaro, Popuyeca, El Lodo and Coralillo (SEDAP 1997; INEGI 1990 ab). The system extends longitudinally in an east-west direction for approximately 26 km from the point of Isla Vives to the northwestern end of Laguna Camaronera.

Experimental design

An experiment was carried out for 90 days under controlled conditions, where 216 *D. maculatus* fish were used, the tested treatments were: T1=24 fish (fry, 8.35±2.83 g), T2=24 fish (juveniles, 17.22±513 g) and T3=24 fish (adults, 25.55±6.05 g), each treatment was tested in triplicate.

Experimental organisms (collection, transport and acclimatization)

The collection of the fish was carried out in the Alvarado Laguna system, Veracruz; Using local fishing gear, they were transported in a rectangular tank with a capacity of 500 L supplied with air with three diffusers to the Applied Aquaculture Research Laboratory (LIAA) of the Technological Institute of Boca del Río (ITBOCA), subsequently, they were measured with a 40 cm ichthyometer (with a precision of 0.1 mm) and weighed with a 5 kg digital scale (±2g). For their acclimatization, they were introduced into a 3000 L reservoir to observe their behavior and the possible appearance of diseases caused by bacteria and fungi for 40 days in October 2015.

Experimental system

A recirculation system was used that included nine rectangular fiberglass tubs with dimensions of 2.40 m×56 cm×40 cm, with a capacity of 442 L, which were under controlled conditions in the Laboratory (LIAA). The mechanical filter used was built with oyster shells, 5 mm gravel and 1 mm silica sand, in addition a 2.0 hp Flipperl pump was used to supply a water flow of $3m^3/h$. For water quality monitoring, the following was measured every 15 days: pH, dissolved oxygen (mg L^{-1}), salinity (g L^{-1}) and temperature (°C) for which a multiparameter probe (YSI 556 MPS) was used, In addition, for the monitoring of ammonium (mg L^{-1}), nitrites (mg L^{-1}) and nitrates (mg L^{-1}), a Nutrafin® colorimetry test kit was used.

Feeding

The diet used was commercial balanced feed for tilapia 3.5 mm in diameter (GrowFish® protein 35% and fat 5.5%), supplying 50% of the recommended ration (1.5% of the biomass), based on the manufacturer's feeding tables.

Fish husbandry

To avoid the accumulation of nitrogenous residues, such as feces and uneaten food, the maintenance of the tanks consisted of eliminating them daily by siphoning and general cleaning every 14 days.

Measuring

The fish were weighed every 15 days using a digital scale with a capacity of 5 kg (±2 g) and the total length was recorded using a 40 cm ichthyometer (accuracy of 0.1 mm); which were made at the beginning of the experiment and after 30 days of cultivation, determining the total length in cm and weight in g.

Statistic analysis

A statistical method of means (Tukey) with 95% confidence was used. For the normality and homoscedasticity tests, a one-way analysis of variance (ANOVA) was used, later it was analyzed using the statistical package Statistical version 7.

RESULTS AND DISCUSSION

Adaptation in captivity

During the quarantine period, some diseases caused by fungi and bacteria occurred, causing the organisms: a) frayed fins, b) small lacerations, c) skin tumors, d) opaque coloration, e) loss of scales, f) skin lesions, this was due to stress (Figure 2).

Weight gain

The results obtained from the measurements for weight during the experiment did not show significant differences between the treatments, as shown in (Figure 3).

Growth

It was observed that treatment 1 (fry) obtained a greater favorable response during the experiment compared to the other treatments, as shown in (Figure 4).

Figure 2. A) Frayed fins, B) small lacerations, C) skin tumors, D) opaque coloration, E) loss of scales, F) skin lesions.

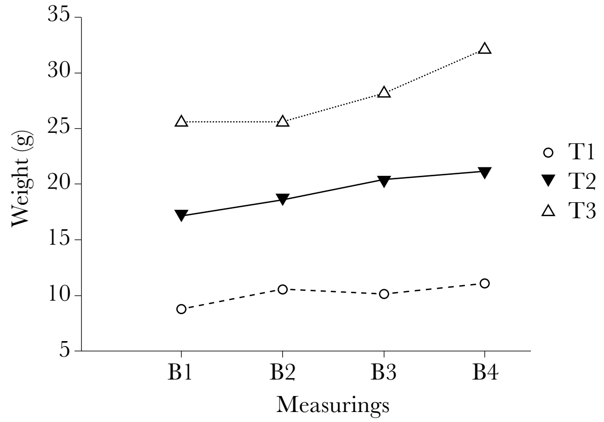

Figure 3. Measurement results (weight) of the three treatments T1=24 fish (fry), T2=24 fish (juveniles) and T3=24 fish (adults), every 15 days, during the 90 days of the experiment.

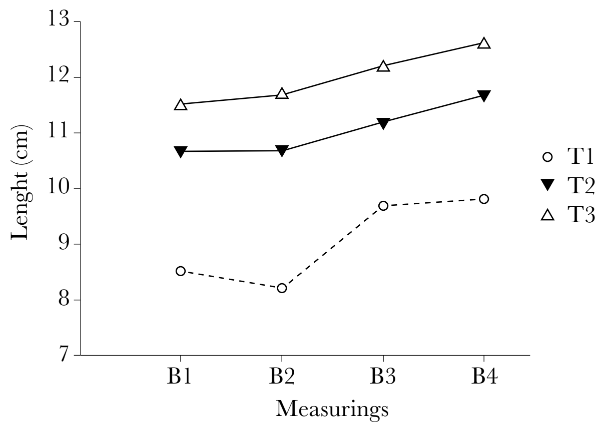

Figure 4. Measurement results (length) of the three treatments T1=24 fish (fry), T2=24 fish (juveniles) and T3=24 fish (adults), every 15 days, during the 90 days of the experiment.

Survival

During the 90 days of the experiment, survival between treatments was evaluated, observing that; treatment 1 (fry) and treatment 3 (adults) did not show differences, maintaining 100% survival. However, treatment 2 (juveniles) obtained a survival of 96%, which was not significant among treatments as can be seen in (Figure 5).

Water quality

In this study, the water quality did not present significant variations, since all the conditions were controlled with a recirculation system, the monitoring of the variables was carried out every 15 days and they remained within the standard values for the species (Table 1).

Despite the diseases present at the start of the experiment, all the organisms of the different treatments avidly consumed the commercial diet provided, which was favorable since feed on organic matter in their natural environment. The adaptation of *D. maculatus* was largely due to the good acceptance and consumption of the balanced food during the

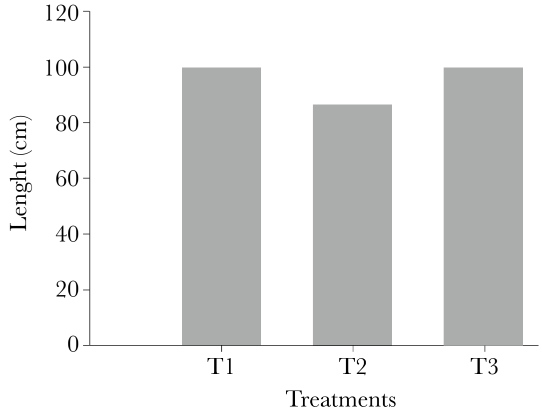

Figure 5. Evaluation of final survival among treatments T1=24 fish (fry), T2=24 fish (juveniles) and T3=24 fish (adults).

culture, this was favorable for fish development and growth of the in all the treatments, recording a slow but growth.

The lack of significant differences during the measurements for weight during the experiment could probably their seasonal behavior to rise to the surface and feed very slow and scarcely, this agrees with (Castro *et al*., 2005) who mentions that *D. maculatus* has a similar behavior to *D. latifrons*; The authors also observed that at the beginning of his experiment, they used to appear on the surface to feed, noticing important changes in their behavior over time, since they began to decrease the frequency of going up to the surface, until finally, they stopped doing it. Basically, it is a stationary feeding fish (it feeds at times) with a very slow digestive system, which means that they do not feel hungry all the time (Chang and Navas, 1984).

The greater growth observed in Treatment 1 (fry) suggests that this species easily adapts to artificial feeding during its first stage of life, thanks to its double mandibular and pharyngeal dentition, which allows it to eat different types of food. This agrees with (Larumbe, 2002) who evaluated the growth and weight gain of *D. latifrons* feeding balanced feed and reported that growth in his study was slow. In addition, various investigations indicate that growth is an indicator of the adaptation of the organism to the environment, if this is favorable the fish grows, but when it is subject to variables that cause stress, growth stops. Several factors influence the rate of growth; stand out the stage of development, activity, food availability, photoperiod, salinity and temperature. It should be noted that the relationship between growth and intake rate is not simply linear; in studies on the effect

Table 1. Record of water quality in the *D. maculatus* culture recirculation system.

Sample	Temperature (°C)	Salinity (g L^{-1})	DO (mg L^{-1})	pH	Ammonia (mg L^{-1})	Nitrites (mg L^{-1})	Nitrates (mg L^{-1})
M1 (may/23th/2016)	28	20	5.58-7.21	7.97-8.72	0.1	2	0.1
M2 (june/7th/2016)	28	20	3.27-7.3	7.94-8.75	0.1	2	0.2
M3 (june/22th/2016)	28	20	5.35-7.20	7.91-8.70	0.1	3	0.05
M4 (july/7th/2016)	28	20	5.45-7.56	7.95-8.77	0.2	3	0.1

of environmental factors on growth, it is essential to consider this phenomenon (Jobling, 1994). Fish obtain their maximum potential for physiological growth due to a series of conditions: chemical composition of the water (water quality), water temperature, genetic characteristics and physiological state (Hepher and Proginin (1985).

Despite there were not significant differences recorded in survival, it should be noted that there is no reports on survival in captivity at experimental level for this species. In addition, research work on *D. latifrons* and *D. maculatus* is not recent and basically focuses on describing its abundance and the ecological role that these species have in different bodies of water and lagoon systems, and on the physiological characterization to differentiate the *D. maculatus* from *D. latifrons* (Yánez-Arancibia and Díaz-González 1977; Uribe *et al.*, 1988; Hendrickx *et al.*, 1996; Clive *et al.*, 1995). Perhaps the low mortality during the experiment could be due wáter quality was maintained adequate for the cultivation of the species (temperature of 28 °C, a salinity of 20 g L^{-1}, dissolved oxygen 5.27-7.56 mg L^{-1}, pH 7.91-8.77, ammonium 0.1-0.2 mg L^{-1}, nitrites 2-3 g L^{-1}, nitrates 0.05-0.2 mg L^{-1}. This agrees with Nicovita (2007), who mentions that the adequate temperature for example will depend on the species to be cultivated.

CONCLUSIONS

Comparing the data obtained in this experiment, with the theoretical background of commercial species, it was found that the values obtained for *D. maculatus* were positive, because they presented a good response to captivity at the experimental level; the fry showed greater adaptation, growth and survival; since, in the natural environment, they are very resistant to environmental changes. As for weight gain, it was slow, which may be due to their stationary feeding. However, the balanced food was positively accepted, this is since they have double mandibular and pharyngeal dentition, which allows them to eat different types of food. In this sense, it can be concluded that the species does have a favorable aquaculture potential. However, further studies on cultivation are recommended; the influence of environmental conditions on captive reproduction; the identification of the stages in the life cycle and the dissemination of the importance of fishery management among the sectors involved.

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