DOI: 10.19136/ta.a2n1.5729
Original Article

Spawning Induction, Larviculture and Rearing of Mexican Snook *Centropomus poeyi* (Chávez, 1961)
Inducción al desove, larvicultura y cría del róbalo mexicano Centropomus poeyi (Chávez, 1961)

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Cite: Contreras-García MJ, Contreras-Sánchez WM, Mcdonal-Vera A, Cruz-Rosado L (2024) Spawning Induction, Larviculture and Rearing of Mexican Snook *Centropomus poe*yi (Chávez, 1961). Tropical Aquaculture 2 (1): e5729. DOI 10.19136/ta.a2n1.5729

Article Received: 03 December 2023
Article Revised: 03 March 2024
Article Accepted: 22 March 2024

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Abstract

The Mexican snook (*Centropomus poeyi*) constitutes an essential artisanal fishery in coastal areas of Mexico containing rivers that discharge into the Gulf of Mexico, and it is considered overfished in general; therefore, aquaculture can provide alternatives to this situation. Induced spawning and Larviculture have been developed in our laboratory for this critical endemic species. Using cholesterol-cellulose implants with LHRH-a, spawning is initiated 30 hours after implantation. A total of 9.5 million fertilized eggs were collected, averaging 700.35 µm in diameter. The fertilization rate was 90%, and the hatching rate was 85%. Two hundred thirteen thousand fish were fed according to a protocol generated for this species, using microalgae, rotifers, and Artemia nauplii. Weaning is initiated 15 days post-hatching using a co-feeding regime combining live food and inert diets designed for marine fish. Survival at the end of the larval period was 1.8%, with fish feeding exclusively on artificial food and acclimated to freshwater.

Keywords: induced reproduction, larviculture, *Centropomus poeyi*

Resumen

El robalo mexicano (*Centropomus poeyi*) constituye una pesquería artesanal esencial en las zonas costeras de México conformadas por ríos que desembocan en el Golfo de México, y se considera sobreexplotada en general; por lo tanto, la acuicultura puede proporcionar alternativas a esta situación. En nuestro laboratorio se ha desarrollado el desove inducido y la larvicultura para esta especie endémica crítica. Utilizando implantes de colesterol-celulosa con LHRH-a, el desove se inicia 30 horas después de la implantación. Se recogieron un total de 9.5 millones de huevos fecundados, con un diámetro promedio de 700.35 µm. La tasa de fecundación fue del 90% y la de eclosión del 85%. Doscientos trece mil peces fueron alimentados según un protocolo generado para esta especie, utilizando microalgas, rotíferos y nauplios de Artemia. El destete se inició 15 días después de la eclosión utilizando un régimen de alimentación conjunta que combinaba alimento vivo y dietas inertes diseñadas para peces marinos. La supervivencia al final del periodo larvario fue del 1.8%, con peces alimentados exclusivamente con alimento artificial y aclimatados a agua dulce.

Palabras clave: reproducción inducida, larvicultura, *Centropomus poeyi*

Introduction

In recent years, aquaculture has emerged as a viable alternative for massive production of good quality and low-price aquatic products (Greaves 2015). In addition, the industry promotes employment while improving access to healthy foods. For many years, fisheries were considered an unlimited source of resources, but capture statistics show that several fisheries have collapsed in recent decades while others are under extreme pressure (FAO 2011). Estimates for the human population indicate a 27% increase by 2050 concerning 2005, implying an enormous demand for food (Norzagaray et al. 2012), and aquaculture is considered a competitive response. In Mexico, nearly 80% of aquaculture is conducted in extensive systems. After shrimp farming, the most developed practice in our country mainly involves introducing freshwater species (tilapia, trout, and carp) in low-productivity systems (Norzagaray *et al.* 2012).

Several snook species constitute a crucial artisanal fishery in the Gulf of Mexico. These popular fish are in high demand as a food item, reaching high prices in local markets. Unfortunately, complications in identifying reported catches cause capture production to be combined under the generic name of "snooks." Recently, several reports have warned about the decline in snook catches in the Gulf of Mexico, including a decrease in volumes declared by Mexico (FAO 2011 and Chávez-Caballero 2014). Therefore, something needs to be done to support snook populations on the Mexican coasts, and aquaculture can be a significant ally. The potential for snook aquaculture has been highlighted by several authors, with emphasis on *C. undecimalis* and *C. parallelus* (Zarza *et al.* 2006, Álvarez-Lajonchère and Tsuzuki 2008, Yanes-Roca *et al.* 2009; Cerqueira and Tsuzuki 2009, Ibarra-Castro *et al.* 2011, Contreras-García *et al.* 2015). However, *C. poeyi* also has traits (large size, high tolerance to handling, grow-out in a wide range of salinities, and fast growth) that make it a good candidate for farming. This species, locally known as "robalo prieto", is endemic and occurs only in watersheds discharging to the Gulf of Mexico, from Tampico, in the state of Tamaulipas, to the Términos Lagoon, in the state of Campeche (Chávez 1961 and 1963). It is a carnivorous species, reaching sizes above 100 cm and weighing beyond 14 Kg (Lorán-Núñez *et al.* 2012). Very little is known about its biology or population status, to the point of being listed by the IUCN under the "data deficient" category (Dooley *et al.* 2015). Regarding reproduction, all snooks are considered protandric hermaphrodites (Álvarez-Lajonchère and Tsuzuki 2008), a condition properly described only for *C. undecimalis* (Taylor *et al.* 2000). In the case of *C. poeyi*, we have histological evidence that confirms protandry (unpublished data).

To incorporate snooks into aquacultural practices, we initiated a program at the Universidad Juárez Autónoma de Tabasco Marine Aquaculture Station (MAS) to develop protocols for spawning induction and larval rearing.

Materials and methods

Spawning induction

Wild broodstock was captured using gill nets placed near the mouth of the Gonzalez River in Tabasco, Mexico, and kept in captivity at the

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MAS for four years before the first spawning. Fish were fed to satiation daily with commercial food (Fish Breed-m®, INVE Aquaculture, Inc.) and frozen fish portions. During the spawning season, the fish were anesthetized with clove oil (0.015 mL/L) once a month and checked for maturity. One female was selected for induction after oocyte diameter and maturity stage were determined by taking oocytes from the genital pore with a polyethylene cannula. Oocytes were 350 ± 32 µm in diameter. The mature female (4.69 Kg) and two males (3.89 and 2.87 Kg) with running milt were implanted with LHRH-a handmade cholesterol-cellulose implants (100 µg for males and 200 µg for females) in the body cavity near the pectoral fin (Contreras-Sánchez *et al.* 2012). Afterward, fish were placed in a 12.5 m3 tank where salinity (28 ± 0.58 UPS), temperature (29.1 ± 1.35 °C), oxygen (5.12 ± 0.49 mg/L), and pH (8.25 ± 0.02) were monitored three times a day.

Egg incubation and larviculture

After spawning, five random samples of 100 eggs were collected to determine the fertilization rate. Five water samples containing eggs were placed in glass flasks to determine the hatching rate. A sample of eggs was collected using a 400 µm soft mesh and transferred to the Tropical Aquaculture Laboratory in Villahermosa, Tabasco. To assess the feeding protocol, two 500-L tanks connected to a recirculation system were stocked with 213 larvae/L (213,000 larvae total). We followed the feeding regime used in our laboratory for *C. undecimalis* (Contreras-Sánchez *et al.* 2012) with some modifications. Briefly: Tanks were filled with saltwater and stocked with a mix of the green microalgae *Tetraselmis chuii*, *T: suecica,* and *Nannochloropsis oculata* (2-4x10^5 cells/mL). Rotifer supplementation was initiated with *Brachionus rotundiformis* at 20 org/mL; at day 11, the density was decreased to 15 org/mL, and *B. plicatilis* was added at a density of 15 org/mL making a total of 30 rotifers/mL until day 22. At day 13, Artemia nauplii were added to the mix at a rate of 30 org/mL until day 22. Rotifers and *Artemia* nauplii were enriched with Selco S.presso® (INVE Aquaculture Inc.) for 12 and 20 hours, respectively. At day 15, adaptation to the intake of commercial feed was initiated using INVE O.range START-L (200-300 µm, proximate composition: 56% proteins, 13% lipids, 10% ashes, 0.7% fiber). O.range GROW-S (300-500 µm) and O.range GROW-L (500-800 µm) were added on days 23 and 34, respectively (Fig.1). Photoperiod was kept constant at 12 L: 12 D, and the fish were maintained in these conditions for 45 days. Salinity (30.00 ± 0.15 UPS), temperature (28.13 ± 1.17 °C), DO (5.70 ± 0.63 mg/L), ph (7.98 ± 0.18 IU) ammonia (1.15 ± 0.78 mg/L) nitrites (1.75 ± 1.50 mg/L) and nitrates (129.60 ± 47.50 mg/L) were monitored daily. Fifty percent of the water was exchanged daily from the tanks by siphoning from the bottom.

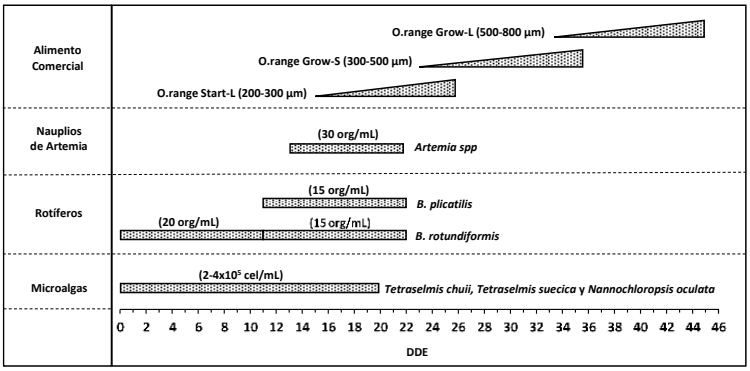

Figure 1. Feeding protocol implemented for rearing *C. poeyi* larvae and juveniles. Tanks were prepared with microalgae and rotifers since the first day. Commercial feeds were provided *ad libitum*. Bars indicate fixed amounts, while triangles reflect increasing amounts by demand.

Results

Spawning is initiated 30 hours after the injection of implants. A total of 9.5 million eggs were collected, with a fertilization rate of 90%. The average diameter of the fertilized eggs was 700.35 µm (± 24.16). Hatching is initiated 20 hours post fertilization, with a fertilization rate of 85 %. The length of the recently hatched larvae was 1.80 mm (± 0.22).

During the first week, larvae were distributed along the water column; however, it was common to see aggregates near the light sources. By day seven, the larvae tended to aggregate at the bottom of the tank. On day 15, we noticed a distinctive change in the swimming pattern since all fish in the tank passed from linear, slow, and short to circular, fast, and non-stopping. This rapid change in swimming was considered a migratory swimming pattern, so we decided to gradually change the salinity in the tank by 5 UPS/day until 0 UPS was reached. It was expected to observe a few fish (generally the largest) swimming in the opposite direction than the rest of the group. From day one to 30, we recommend avoiding any manipulation of the larvae since immediately after capture, the larvae curve their bodies and die. At the end of the trial, 4,140 juveniles were obtained. Total length and wet weight averaged 18.0 ± 0.49 mm and 1.02 ± 0.23 g, respectively. Survival at day 45 was 1.8 %.

Discussion

Reproduction of *C. poeyi* in captivity requires the stimulus provided by the hormone implanted to spawn since this specific female was in captivity for four years with no indication of maturation. A year before, another female responded to the stimulus (data not shown). A similar situation was reported for *C. undecimalis*, which requires three years in captivity before responding to induction (Ibarra-Castro *et al.* 2011 and Contreras-García *et al.* 2015). This information supports the idea presented by Donaldson and Hunter (1983) and Schreck *et al.* (2001), proposing that the stress generated by the culture conditions induces a generalized response in the fish that inhibits or disables the reproductive process. Apparently, *C. poeyi* requires at least three years of conditioning to the confinement to recover from the initial stress of captivity.

Data obtained in the present trial indicate that fertilization and hatching rates for *C. poeyi* improved considerably in comparison to those previously obtained in our laboratory for *C. undecimalis* (60-76 % and 50-100 %, respectively) (Contreras-García 2011, Contreras-García *et al.* 2015 and Contreras-García *et a*l. 2020). We consider that this improvement is due to the modifications to the feeding protocol and the incorporation of embryo and water management methods from Ibarra-Castro *et al.* (2012). In the common snook (*C. undecimalis*), several studies have reported spawning induction with fertilization rates varying from 6% (Soligo 2007) to 100% (Ibarra-Castro *et al.* 2011). While in fat snook (*C. parallelus*), fertilization rates fluctuate from 70 to 93 % (Godinho *et al.* 2000; Ferraz et al. 2004; dos Reis and Cerqueira 2003; Cerqueira and Tsuzuki 2009). Ibarra-Castro *et al.* (2011) compared results obtained during larval culture of three snook species, including barramundi. The review reported survival rates ranging from 1.0 to 50.7 % for common snook, 1.9 to 4.4 % for fat snook, and 20 to 90 % for barramundi. In the present study, we obtained

1.8 % survival after 45 days, and most of the mortality occurred during the change to exogenous feeding. A similar situation was reported for the common snook (Ibarra-Castro *et al.* 2011). The survival rate can be improved with experience and more careful observation of the larvae and juvenile requirements. In general, the larval culture of snooks is complicated; instant mortality occurs if larvae from one to 25 days post-hatching (dph) are manipulated. Stress during early development plays a vital role in this sudden mortality, and more research needs to be conducted to understand this event.

C. poeyi responds adequately to the implanted LHRHa dose, providing a large number of eggs (more than two million eggs per kilogram of female). The use of LHRHa for inducing spawning has been successful in *C. parallelus* (dos Reis and Cerqueira 2003) and *C. undecimalis* (Soligo *et al.* 2008), demonstrating that this specific hormone is a good alternative for planning the production of viable eggs of the Mexican snook. The dose used for the female (42.6 µg/Kg) effectively induced final maturation and spawning, falling in the range of dosages used for inducing Centropomids to spawn (20-70 µg/Kg) (dos Reis and Cerqueira 2003).

In general, the larval culture of marine fish species is a complex and labor-intensive operation. Cannibalism is a standard process in carnivorous species and is considered one of the leading causes of mortality (Atencio-García and Zaniboni-Filho 2006). Feeding the correct prey size at the proper amount is a crucial factor. In previous studies, we have supplemented *C. undecimalis* and *C. parallelus* with *B. rotundiformis* and *B. plicatilis* before supplementing *Artemia* nauplii (Contreras-Sánchez *et al.* 2012). Unfortunately, more research is needed since larvae do not always feed on this prey, resulting in 100% mortality (data not published). A significant modification to the protocol previously designed for culturing *C. undecimalis* larvae included the timing for adaptation to freshwater. In *C. undecimalis*, the fast swimming that we have named "migration pattern" occurs at 30 dph, almost at the end of larval culture, while in *C. poeyi*, this pattern occurs at 15 dph. This behavior may reflect the natural life history of *C. poeyi* since this species resides in freshwater lagoons and rivers most of the time, swimming out to the Gulf of Mexico only for the spawning event (Chávez-Lomelí *et al.* 1989, Lorán-Núñez *et al.* 2012). We observed more reluctance from *C. poeyi* to consume commercial food, taking 11 days more than *C. undecimalis* to start inert food intake. Our contribution demonstrates that *C. poeyi* spawning induction and larval culture is feasible, making it a good candidate for aquacultural practices in Mexico.

Conclusions

This study provides new insights regarding induced spawning and caring for *C. poeyi* larvae. These techniques enhance the potential for juvenile production in a species poorly managed in captivity. This species requires at least three to four years in captivity to respond to hormonal stimuli for reproduction. Compared to other snook species, the juveniles require less time in marine water, moving into freshwater. More studies are needed to further increase larval and juvenile survival to promote massive production of juvenile *C. poeyi* for aquaculture.

Acknowledgements

This research is a component of the AquaFish Innovation Lab, which is partly supported by the US Agency for International Development (USAID CA/LWA No. EPP-A-00-06-0012-00), and in part by participating institutions. AquaFish accession number is 1474. The opinions expressed herein are those of the authors and do not necessarily reflect the views of the AquaFish Innovation Lab or USAID. This study was also partially supported by the Universidad Juárez Autónoma de Tabasco (UJAT).

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