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Reproduction, early development, and larval rearing strategies for two sponge-dwelling neon gobies, *Elacatinus lori* and *E. colini*

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ABSTRACT

A major goal of the aquaculture industry is to reduce collection pressure on wild populations by developing captive breeding techniques for marine ornamental species, particularly coral reef fishes. The objective of this study was to develop a rearing protocol for two recently described species of neon gobies that are endemic to the Mesoamerican Barrier Reef: 1) *Elacatinus lori*; and 2) *Elacatinus colini*. First, the current study describes the reproductive behavior and larval development of both species. Second, it evaluates the effects of different rotifer and *Artemia* densities on the survival and growth of *E. lori* and *E. colini* larvae. Third, it compares the survival and growth of *E. colini* larvae fed wild plankton to those fed a combination of rotifers and *Artemia*. Once acclimated, pairs of *E. lori* began spawning in 53.2 ± 12.4 *d* (mean ± sd), while pairs of *E. colini* took only 12.2 ± 10.3 *d*. *E. lori* produced more embryos per clutch (1009 ± 477) than *E. colini* (168 ± 83). *E. lori* larvae hatched 8.18 ± 0.4 days after initial observation with a notochord length of 3.67 ± 0.2 mm. In comparison, *E. colini* larvae hatched 6.8 ± 0.4 days after initial observation with a notochord length of 3.51 ± 2.3 mm. Both species settled as early as 28 days post hatch at 9–9.5 mm standard length, following the fusion of the pelvic fins to form a pelvic disc. During rotifer density trials, from 0 to 6 days post hatch, there was no significant difference in survival or standard length between treatments fed 10, 15 or 20 rotifers ml^{-1} for either species. During *Artemia* density trials, from 6 to 14 days post hatch, control treatments fed solely on 15 rotifers ml^{-1} had significantly higher survival than treatments that were fed rotifers in combination with 3, 6 or 9 *Artemia* ml^{-1}. Finally, *E. colini* larvae that were fed wild plankton had significantly higher survival and growth than those fed with a combination of 15 rotifers ml^{-1} and 3 *Artemia* ml^{-1}. The results of this study suggest that *Artemia* nauplii are not a suitable prey for *E. lori* or *E. colini* larvae. Our results demonstrate the feasibility of rearing *E. lori* and *E. colini* to settlement, and suggest that 10–20 rotifers ml^{-1} and wild plankton provide a viable starting point for optimizing the survival and growth of *Elacatinus* spp. larvae.

1. Introduction

Coral reef ecosystems are declining rapidly in response to global climate change and anthropogenic activities that threaten reef resilience (Bruno and Valdivia, 2016). Among these activities, the marine aquarium trade has been cited as a potential threat to the biodiversity of coral reefs (Dee et al., 2014; Domínguez and Botella, 2014; Moorhead and Zeng, 2010; Rhyne et al., 2012, 2014). Indeed, recent estimates suggest that > 11 million marine ornamental fishes, representing 1802 species, are imported into the U.S. annually for distribution in the marine aquarium trade (Green, 2003; Rhyne et al., 2012; Wabnitz, 2003). Of these, < 1% of specimens are cultured in captivity, while the vast majority are wild caught from reefs in South-East Asia and the Caribbean (Domínguez and Botella, 2014; Rhyne et al., 2012). In some areas, overexploitation and destructive fishing practices have led to the localized decline of reef fish populations and have compromised the ability of reef ecosystems to recover (Domínguez and Botella, 2014). Despite these issues, the demand for marine ornamentals is expected to expand as new technologies simplify the care and maintenance of home aquaria (Moorhead and Zeng, 2010). Therefore, a major goal of the aquaculture industry is to reduce collection pressure on wild populations by developing captive culture techniques for marine ornamental species, particularly coral reef fishes.

Neon gobies of the genus *Elacatinus* were among the first reef fishes to be cultured for distribution in the aquarium trade (Feddern, 1967; Moe, 1975; Valenti, 1972). The genus is composed of 26 species that are primarily distributed on coral reefs throughout the Western Atlantic (Colin, 1975; Froese and Pauly, 2016). Their vibrant coloration and

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Table 1
Characteristics of reproduction from different *Elacatinus* species that have bred in captivity.

Species	Time to 1st spawning (days)	Spawning interval (days)	Clutch size (eggs clutch^{-1})	Chorion width (mm)	Chorion length (mm)	Incubation time (days)	Hatching success (%)	Reference
Elacatinus evelynae	21	14 9–20	200–250	–	–	7	94 ± 3	Colin (1975), Olivotto et al. (2005)
Elacatinus figaro	20.3 ± 5.9 24–31	11.2 ± 2.1 8–10	648 ± 183 140–1020	0.58–0.7	1.8–2.1	6.8 ± 8 5–8	69.7 ± 24.1 34–100	Côrtes and Tsuzuki (2012), da Silva-Souza et al. (2015), Meirelles et al. (2009), Shei et al. (2010, 2012)
Elacatinus genie	–	9 8–10	–	–	1.8–1.9	–	–	Colin (1975)
Elacatinus horsti	–	–	–	–	2.5	–	–	Colin (1975)
Elacatinus louisae	–	–	–	–	2.8–2.9	–	–	Colin (1975)
Elacatinus multifasciatus	< 1 month	–	250	–	–	5–8	–	Wittenrich (2007)
Elacatinus oceanops	1–3.5 months	10–28	50–600	–	2–3.3	6–10	–	Colin (1975), Feddern (1967), Moe (1975), Valenti (1972), Wittenrich (2007)
Elacatinus puncticulatus	–	7–10	153 ± 28	0.55 ± 0.11	–	6–7	98.5 ± 0.6	Pedrazzani et al. (2014), Wittenrich et al. (2007)
Elacatinus xanthiprora	–	12 7–14	–	–	1.7–2.0	–	–	Colin (1975)
Elacatinus colini	12.2 ± 10.3 3–44	7.8 ± 1.7 2–16	168 ± 19 19–388	–	–	6.8 ± 0.4 6–7	86 ± 16 48–100	Majoris et al. (this study)
Elacatinus lori	53.2 ± 12.4 30–69	19.0 ± 7.2 13–35	1009 ± 477 564–1763	0.66 ± 0.22	2.54 ± 0.05	8.18 ± 0.4 8–9	98.2 ± 2 96–100	Majoris et al. (this study)

Time until 1st spawn was measured in days after pairs were acclimation to aquaria. Spawning interval is reported as days between spawning events. Incubation time is reported in days after a clutch was first observed.

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