Growth and morphology of larval and juvenile captive bred yellowtail snapper, *Ocyurus chrysurus* 

Cecilia M. Riley  
G. Joan Holt  
Connie R. Arnold  
Marine Science Institute  
The University of Texas at Austin  
P.O. Box 1267, Port Aransas, Texas 78373

The snappers (Lutjanidae) are major components of the reef fishery in the Gulf of Mexico (Nakamura, 1976), and recent declines in their populations have prompted interest in a number of management practices including limited catches, size limits, area closures, and additions of artificial reef habitat to improve survival of wild stocks (Leis, 1987; Munro, 1987). Studies on the spawning, distribution, larval and juvenile ecology, and stock assessment of new recruits are crucial to the development of management strategies for reef species since little is known about their early life history (Grimes, 1987). During most developmental stages, snapper larvae are pelagic and widely dispersed, limiting the numbers of specimens to be found in taxonomic collections (Munro, 1987). The similarity in size and pigmentation of small larval lutjanids (<5 mm) and the paucity of species-specific details of size at age and morphological development has made identification of individuals in ichthyoplankton samples difficult (Leis, 1987). Of the fourteen species of snappers that are found in the Gulf of Mexico, larval development has been fully described for only three species: red snapper, *Lutjanus campechanus*, from both laboratory spawned (Rabalais et al., 1980) and wild caught larvae (Collins et al., 1980); gray snapper, *L. griseus*, from wild eggs reared in the laboratory (Richards and Saksena, 1980); and vermilion snapper, *Rhomboplites aurorubens*, from wild preserved specimens (Laroche, 1977). A recent NOAA report by Richards et al. summarizes the larval lutjanid descriptions listed above and introduces some newly available descriptive material for several additional species of snappers including some stages of yellowtail snapper, *Ocyurus chrysurus*. In their report, the yellowtail snapper is included in the genus *Lutjanus*, a change suggested as a result of two recent treatments by Loftus (1992) and Domeier and Clark (1992).

The commercial and recreational importance of snappers has also been recognized by the aquaculture industry, and efforts are underway to culture several of these species in captivity. In this paper we describe the development and growth of laboratory spawned and reared yellowtail snapper. This species is found from Massachusetts through the Caribbean and south to Brazil (Hoese and Moore, 1977). Laboratory culture allowed us to document the effects of a commonly used preservative (ethyl alcohol) on length measurements and pigmentation characteristics of laboratory-cultured larvae for purposes of comparative use with wild-collected larvae.

**Materials and methods**

Young adult *Ocyurus chrysurus* were collected by hook and line in July 1990 from the Florida Keys and were transported to the laboratory where they were matured and cycled for one year following the methods described by Arnold (1988). Adults began spawning in July 1991 and continued to March 1994.

Eggs were stocked at a density of 50/L in fiberglass tanks (300 and 600 L) with internal biofilters. Larvae were reared at 27–28°C with 12 hours light at salinities of 33–38 ppt on a diet of zooplankton (collected from the Corpus Christi Ship Channel), rotifers (*Branchionus plicatilis*) and brine shrimp nauplii (*Artemia salina*).

The description of larval development is based on larvae from multiple spawns of two different groups of broodstock (15 adults/tank). Larvae were measured live (SL=tip of snout to posterior tip of notochord) to the nearest 0.01 mm on a stereomicroscope equipped with a drawing tube and digitizing...
Results

Pigmentation and overall development

Daily measurements and developmental milestones are presented in Table 1. The pelagic eggs were spherical, averaged 0.96 mm diameter, had a single oil globule, and hatched in 22–24 hours at 27°C. Eggs were essentially transparent, the only pigment observed was a series of small chromatophores on the dorsal surface of the embryo (Fig. 1A). After hatching and through the two day yolk-sac stage, larvae possessed a single unpigmented oil globule in the anterior end of the yolk-sac, an unpigmented finfold, and 24 myomeres. Within 12 hours after hatching (Fig. 1B), the dorsal chromatophores of the embryo had migrated to form a series along the ventral surface of the body and tail; a single stellate chromatophore was present on the gut anterior to the anus, and a light scattering of dark pigment was found on the yolk-sac and lateral surfaces of the head. Exogenous feeding coincided with development of eye pigmentation, functional jaws, and gas bladder inflation at 3.36 mm (age 3 days, Fig. 1C). Pigmentation at this stage included a large dark chromatophore on the ventral surface of the gut, four chromatophores over the dorsal surface of the gut and gas bladder, and a single, dark chromatophore on the ventral tip of the notochord. In live specimens at this stage, we first observed the development of a yellow chromatophore (indicated by arrow on Fig. 1C) located on the lateral surface of the body at about midgut. Larvae 3.67–3.82 mm (Fig. 2A) showed dramatic developmental changes. The development of numerous yellow chromatophores (indicated on illustrations by solid arrows) scattered on the lateral surfaces of the head, gut, and upper body near the base of the pectoral fin, as well as dark stellate chromatophores on the hindbrain and on the ventral edge of the cleithrum coincided with eruption of the pelvic fin buds and the appearance of preopercular spination. Larvae 4.10–4.53 mm (Fig. 2, B–D) were characterized by daily increases in the number of dorsal spines and by elongation of the pelvic fins, as well as by an increase in the density of yellow chromatophores on the lateral head region. Notochord flexion occurred when larvae reached 4.40 mm at 15–16 days posthatch (Fig. 3A) and was followed by full fin formation. Changes in pigmentation consisted primarily of increasingly dense concentrations of yellow pigment on the lateral upper body and head, dark web-like pigment in the membranes of developing fins, and diffuse internal pigment over the gut surface (Fig. 3B). The first indication of adult coloration was visible on early juveniles approximately 14.00 mm SL (Fig. 3C) where yellow chromatophores formed a horizontal line through the eye onto the snout and were also interspersed with the dark chromatophores lining the dorsal and ventral margins of the body at the fin bases. Yellow pigment was also present along the lateral midline of the tail. Near-adult pigmentation was present by 16.00 mm (age 62 days) at which time juveniles were fully scaled (Fig. 3D).
Head spination

One or two paired, smooth spines on the posterior edge of the preoperculum first occurred in larvae 3.67–3.82 mm (Fig. 2A). Preopercular spination increased to four and a supraocular ridge with one spine was present at 4.10 mm (Fig. 2B). At 4.50 mm (Fig. 2C), 5 or 6 elongated preopercular spines were present, the longest of which occurred at the preopercal angle. Larvae at 4.80 mm and 16 days of age (Fig. 3A) had a fully formed supraocular ridge with 4 short, smooth spines and 3 supracleithral spines. A reduction in the length of all head spines began at approximately 6.00 mm, but some short, opercular spines remained on the oldest juveniles.

Fin formation

The adult meristic complement of *O. chrysurus* is X+12–14 dorsal, 9 + 8 caudal, I + 5 pelvic, III + 8–9 anal, and 15 or 16 pectoral (Hoese and Moore, 1977). In laboratory-reared larvae, fin development oc-
occurred in the following sequence: pelvic and dorsal spines, caudal, dorsal and anal soft rays, pectoral rays (Table 1). The spinous pelvic and dorsal fin formation occurred simultaneously at 4.10 mm. Dorsal and anal fin analage were first visible at 4.51 mm and ray bases were fully formed by 5.35 mm. Caudal flexion and caudal ray formation occurred in larvae between 4.40 and 4.75 mm and was followed by development of the soft rays of the dorsal and anal fins (Fig. 3A); additionally, the spines of the dorsal and pelvic fins were strongly serrated. By 6.23 mm SL, all juveniles had the full adult complement of fin spines and rays (Fig. 3B); however, serrated spines, characteristic of larvae, were still present on juveniles 14.66 mm.

**Growth and shrinkage**

Laboratory-reared yellowtail snapper showed large variation in size among larvae of the same age (Table 1), and key developmental events were tightly linked to larval size more than to age. Growth rates prior to flexion averaged 0.31 mm/day and decreased to only 0.18 mm/day during the process of transformation to juveniles (4.83–7.00 mm SL, ages 14–28 days). During the last month and a half of recorded development, juvenile growth averaged 0.25 mm/day.

Mean daily lengths of postpreservation larvae are listed on Table 1. Shrinkage after preservation was greatest in larvae prior to any fin development (<4.00 mm), averaging 10.36% through the first 13 days. Larvae with partial fin development (4.83–5.72 mm SL) shrank an average of 9.32%. Once larvae attained complete development of the dorsal and pelvic fins (>5.00 mm); shrinkage was reduced to an average of 7.24% throughout the remaining juvenile stages examined.

**Discussion**

*Ocyurus chrysurus* have similar larval characteristics to the previously described snappers *Lutjanus campechanus* (Collins et al., 1980), *L. griseus* (Richards and Saksena, 1980), and *Rhomboptilus aurorubens* (Laroche, 1977). Preflexion larvae of each of the four species have a series of chromatophores along the ventral midline and have pigment covering the dorsum of the gut and gas bladder. All have
Table 1

Sizes and meristic characteristics of laboratory-spawned and reared larval and juvenile yellowtail snapper, *Ocyurus chrysurUB*. All ages listed are in days except for NH = newly hatched < 1 hr old, n = number of individuals examined, SD = standard deviation, Shrinkage = % decrease in mean SL after preservation.

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
<th>Live SL (mm)</th>
<th>Preserved SL (mm)</th>
<th>Dorsal fin</th>
<th>Pelvic fin</th>
<th>Anal fin</th>
<th>Caudal fin</th>
<th>Pectoral fin</th>
<th>Notocord flexure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Spines</td>
<td>Rays</td>
<td>Spines</td>
<td>Rays</td>
<td>Spines</td>
<td>Rays</td>
</tr>
<tr>
<td>EGG</td>
<td>30</td>
<td>0.92</td>
<td>0.99</td>
<td>0.96</td>
<td>0.02</td>
<td>0.94</td>
<td>0.02</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NH</td>
<td>42</td>
<td>1.99</td>
<td>2.78</td>
<td>2.23</td>
<td>0.16</td>
<td>2.09</td>
<td>0.23</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>56</td>
<td>2.47</td>
<td>3.60</td>
<td>3.14</td>
<td>0.25</td>
<td>2.85</td>
<td>0.16</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>42</td>
<td>3.09</td>
<td>3.99</td>
<td>3.57</td>
<td>0.26</td>
<td>3.00</td>
<td>0.21</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>39</td>
<td>2.76</td>
<td>3.72</td>
<td>3.36</td>
<td>0.23</td>
<td>3.07</td>
<td>0.20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>23</td>
<td>3.12</td>
<td>3.68</td>
<td>3.44</td>
<td>0.16</td>
<td>3.05</td>
<td>0.28</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>3.24</td>
<td>3.76</td>
<td>3.49</td>
<td>0.18</td>
<td>3.08</td>
<td>0.36</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>23</td>
<td>3.33</td>
<td>3.92</td>
<td>3.64</td>
<td>0.15</td>
<td>3.21</td>
<td>0.28</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>34</td>
<td>3.18</td>
<td>4.22</td>
<td>3.67</td>
<td>0.27</td>
<td>3.35</td>
<td>0.22</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>21</td>
<td>3.51</td>
<td>4.46</td>
<td>3.92</td>
<td>0.25</td>
<td>3.43</td>
<td>0.36</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>13</td>
<td>3.44</td>
<td>4.38</td>
<td>3.82</td>
<td>0.23</td>
<td>3.66</td>
<td>0.46</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>21</td>
<td>3.59</td>
<td>4.76</td>
<td>4.10</td>
<td>0.34</td>
<td>3.67</td>
<td>0.38</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>3.88</td>
<td>5.13</td>
<td>4.53</td>
<td>0.37</td>
<td>4.03</td>
<td>0.36</td>
<td>2-3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>14</td>
<td>3.50</td>
<td>5.45</td>
<td>4.51</td>
<td>0.59</td>
<td>3.84</td>
<td>0.66</td>
<td>3-4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>24</td>
<td>3.77</td>
<td>5.40</td>
<td>4.11</td>
<td>0.35</td>
<td>3.77</td>
<td>0.41</td>
<td>3-4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>14</td>
<td>3.95</td>
<td>5.47</td>
<td>4.69</td>
<td>0.57</td>
<td>4.01</td>
<td>0.80</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>3.80</td>
<td>5.52</td>
<td>4.80</td>
<td>0.76</td>
<td>4.59</td>
<td>0.61</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>6</td>
<td>5.70</td>
<td>6.56</td>
<td>6.22</td>
<td>0.31</td>
<td>5.63</td>
<td>0.33</td>
<td>8</td>
<td>13</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>21</td>
<td>8</td>
<td>4.80</td>
<td>7.46</td>
<td>5.72</td>
<td>0.86</td>
<td>5.34</td>
<td>0.82</td>
<td>8-9</td>
<td>13</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>25</td>
<td>11</td>
<td>5.31</td>
<td>8.86</td>
<td>6.69</td>
<td>1.12</td>
<td>6.05</td>
<td>0.82</td>
<td>10</td>
<td>13</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>28</td>
<td>7</td>
<td>5.68</td>
<td>9.32</td>
<td>7.00</td>
<td>1.28</td>
<td>6.75</td>
<td>1.15</td>
<td>10</td>
<td>13</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>31</td>
<td>4</td>
<td>7.80</td>
<td>14.66</td>
<td>11.52</td>
<td>3.31</td>
<td>12.19</td>
<td>1.75</td>
<td>10</td>
<td>13</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>62</td>
<td>5</td>
<td>14.48</td>
<td>17.71</td>
<td>—</td>
<td>—</td>
<td>16.05</td>
<td>1.32</td>
<td>10</td>
<td>13</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

1 = Preserved lengths only
large solitary chromatophores on the cleithral symphysis, gut ventrum, anus, and on the notochord at the point of flexure, and all undergo flexion within a narrow size range of 4.2–5.2 mm SL.

There are, however, a few distinctive characteristics that can be used to separate the larvae of these species. Immediately following flexion at 4.40 mm, larvae of O. chrysurus and R. aurorubens (flexion at 4.7 mm, Laroche, 1977) possess large serrations on both the anterior and posterior margins of the dorsal spines, but these are not present on larvae of L. campechanus (Collins et al., 1980) or L. griseus (Richards and Saksena, 1980). Preopercular spination is also a useful character in that the longest spine (located at the preopercle angle in each described species) is serrated in R. aurorubens but not in L. campechanus, L. griseus (Laroche, 1977), or O. chrysurus (present study). Lyczkowski-Shultz and Comyns compared small, preserved larval R. aurorubens and L. campechanus, and found that both species had two dorsal spines and 4 or 5 preopercular spines at 3.3 to 3.9 mm SL. Yellowtail snapper differ in having fewer or no dorsal spines and only three preopercular spines at the same preserved sizes (corresponding to days 7–11, Fig. 2,A and B). Lyczkowski- Shultz and Comyns also examined pigmentation differences in <4.0 mm larvae and identified a characteristic pigment spot in R. aurorubens located on the branchial chamber and visible through the operculum; they also observed pigment on the anterior surface of the gut (at the level of the pectoral fin base) in L. campechanus. Larval O. chrysurus of the same size range were devoid of pigment in either of these locations. Larval R. aurorubens (Laroche, 1977) had numerous, dark chromatophores located on both the midbrain and hindbrain regions in all sizes of larvae examined, however, the two species of Lutjanus and O. chrysurus had head pigment only on the hindbrain area. The yellow chromatophores found on live or recently preserved specimens of O. chrysurus are definitive characteristics for identification of this species; unfortunately, this light-colored pigment was not visible after the 30-day preservation period in larvae <7.00 mm SL and would not likely be detected in ichthyoplankton samples preserved in ETOH. The yellow chromatophores were faintly visible on the snout, operculum, and lateral line of the larger preserved individuals. Larval O. chrysurus can be distinguished from the other described lutjanid species by utilizing combinations of the above characteristics including the presence of heavy serrations on both the anterior and posterior margins of the dorsal spines at the time of flexion, lack of serrations on the longest preopercle spine, reduced number of preopercle spines and dorsal spines at comparable sizes, and lack of internal pigment on the anterior surface of the gut or branchial chamber.

Newly hatched and early developmental stages of larval fishes are rarely collected or retained in net samples.3 Those larvae that are collected show significant handling effects (Theilacker, 1980; Hay, 1981; McGurk, 1985), including distortion and size reduction that result in less than optimal depictions of size at critical stages of development. In contrast, laboratory-reared specimens provide more realistic size values and information on age and pigmentation not available to studies with field-caught larvae. The shrinkage rates at each age and phase of morphological development in O. chrysurus are conservative measures because field-collected larvae show additional shrinkage from net damage. In small unossified larvae, reduction in SL as a result of net collection alone increased shrinkage rates of laboratory-preserved northern anchovy by 19% (Theilacker, 1980) and in Pacific herring by about 8% (Hay, 1981). From these results it is clear that some additional allowance for net shrinkage should be applied to the laboratory-preserved lengths of O. chrysurus when compared to those of field-caught individuals; however, shrinkage rates may be variable between species; therefore the value to be used is unclear. Shrinkage rates have been shown to decrease with increasing age and size of larvae (Theilacker, 1980; McGurk, 1985) and to become equivalent to that of larvae exposed to laboratory handling only (e.g. no net damage) once larvae are completely ossified. Shrinkage rates of laboratory O. chrysurus also decreased in postflexion larvae, stabilizing at <10% in early juveniles. Therefore, to make predictions regarding the live size or age of field-collected larval snappers, an additional, though unknown, rate of shrinkage due to net damage should be taken into account in prefexion stages but not in postlarvae and juveniles.

The nomenclatural status of the yellowtail snapper has come under review recently. After describing the morphology of the natural hybrid between O. chrysurus and Lutjanus synagris (Loftus, 1992) and the laboratory-produced hybrids of O. chrysurus and L. synagris (Domeier and Clarke, 1992), the authors of these studies concluded that the morphological and meristic data indicated that Ocyurus is probably not a distinct genus from Lutjanus. The larval morphology described in this study of O. chrysurus also confirms the very similar size and developmental characteristics of this species with the previously described members of the genus Lutjanus.

Acknowledgments

We would like to thank Joanne Lyczkowski-Shultz and Scott Holt for their comments and suggestions on the original draft of this manuscript. This work was funded in part by Grant NA16RG0457-03 from the National Oceanic and Atmospheric Administration through the Texas Sea Grant College Program.

Literature cited

Arnold, C. R.


Domeier, M. L., and M. E. Clark.

Grimes, C. B.

Hay, D. E.


Laroche, W. A.

Leis, J. M.

Loftus, W. F.

McGurk, M. D.

Munro, J. L.

Nakamura, F. I.


Richards, W. J., and V. P. Saksena.

Theilacker, G. H.