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Consumption Rates of Summer Flounder Larvae on Rotifer and Brine Shrimp Prey during Larval Rearing

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Abstract.—Larval summer flounder Paralichthys dentatus were hatched and reared through metamorphosis in the laboratory. At several points in the rearing cycle, larvae were removed from their rearing chambers and placed in small bowls, where they were fed known quantities of the rotifer Brachionus plicatilis (flounder larvae age 6, 10, or 13 d posthatch) or nauplii of brine shrimp Artemia sp. (flounder larvae age 23, 28, 34, or 47 d posthatch). Counts of prey organisms remaining in the bowls after 24 h allowed us to calculate numbers of prey consumed. Consumption rates increased from 62 rotifers/24 h (6-d larvae) to 301 rotifers/24 h (13-d larvae) and from 59 brine shrimp/24 h (23-d larvae) to 394 brine shrimp/24 h (47-d larvae). These rates can be used to calculate the approximate rotifer and brine shrimp production necessary for rearing summer flounder through metamorphosis in aquaculture hatcheries.

The aquaculture industry for summer flounder Paralichthys dentatus is currently going through its developmental stages on the Atlantic coast of North America. Both technical and economic aspects of production are being addressed during the process of research and development leading to commercialization (Bengtson 1999). Larval rearing through metamorphosis and weaning to a prepared diet are critical parts of the production process. In our research hatchery, operating at about 20°C, we typically raise summer flounder larvae by feeding them ad libitum on rotifers alone from age 3 d after hatch (DAH; when they initiate feeding) until 15 DAH; they are then fed a transition diet of both rotifers and nauplii of brine shrimp Artemia sp. from 16 to 22 DAH. Finally, they are fed a diet of brine shrimp alone from 23 DAH through metamorphosis (which normally occurs sometime from 35 to 65 DAH).

The commercial industry needs information on specific costs related to production. We therefore wanted to quantitatively estimate consumption rates of the larvae on each type of diet so that hatchery operators could calculate the costs of food production required to raise batches of larvae. We conducted a series of determinations of prey consumption rates by groups of larvae that had been removed from their rearing aquaria and placed in small bowls with known quantities of prey.

Methods

Eggs from captive broodstock summer flounder were hatched, and the larvae were reared by the methods described by Bisbal and Bengtson (1993). Larvae were removed from the rearing aquaria on the afternoon before each consumption rate determination and placed in four 190-mm crystallization bowls (number per bowl for each age tested is given in Table 1) containing filtered (10-mm), autoclaved seawater with a salinity of 30½ (i.e., no food was available to them for 18 h before the experiment). Prey items (rotifers cultured with Tetraselmis suecica or newly hatched nauplii of Reference Artemia III nauplii [Collins et al. 1991]) were harvested from their culture vessels and diluted to a standard volume. From that volume, four 1-mL subsamples were taken to obtain estimates of number of prey per milliliter. Counting of 1-mL subsamples was accomplished with a Sedgwick–Rafter counting cell. An appropriate subvolume was then removed from the standard volume of prey and added to each crystallization bowl to provide the nominal initial number of prey per bowl. In addition, similar subvolumes were added to two control bowls (with no fish). Bowls contained 1 L of seawater for the rotifer experiments and 2 L of
Table 1.—Data on summer flounder larvae and prey used in the experiments on prey consumption rates, including ages of larvae used in days after hatch (DAH), number of larvae of each age placed in each replicate crystallization dish, and the initial nominal number of each prey type added to each crystallization dish for each age group. Calculated values are provided for milligrams dry weight of fish per liter for each crystallization dish. Actual number of prey per crystallization dish was determined as the number of prey remaining in two control crystallization dishes at the end of each experiment.

<table>
<thead>
<tr>
<th>Age of larva (DAH)</th>
<th>Number of larvae/dish</th>
<th>Dry weight fish per volume (mg/L)</th>
<th>Nominal number prey/dish</th>
<th>Prey type</th>
<th>Actual number prey/dish</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>50</td>
<td>2.15</td>
<td>5,000</td>
<td>Rotifers</td>
<td>3,835 ± 191</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>4.10</td>
<td>8,000</td>
<td>Rotifers</td>
<td>11,200 ± 3,210</td>
</tr>
<tr>
<td>13</td>
<td>30</td>
<td>41a</td>
<td>8,000</td>
<td>Rotifers</td>
<td>11,725 ± 2,510</td>
</tr>
<tr>
<td>23</td>
<td>10</td>
<td>1.42</td>
<td>1,000</td>
<td>Brine shrimp</td>
<td>1,050 ± 28</td>
</tr>
<tr>
<td>28</td>
<td>10</td>
<td>2.37</td>
<td>2,000</td>
<td>Brine shrimp</td>
<td>2,065 ± 49</td>
</tr>
<tr>
<td>34</td>
<td>10</td>
<td>5.00</td>
<td>2,000</td>
<td>Brine shrimp</td>
<td>2,070 ± 0</td>
</tr>
<tr>
<td>47</td>
<td>10</td>
<td>15.93</td>
<td>4,000</td>
<td>Brine shrimp</td>
<td>4,080 ± 71</td>
</tr>
</tbody>
</table>

* Dry weight data for fish on day 13 were not properly collected.

FIGURE 1.—Consumption of prey (mean ± SD) by summer flounder larvae from day 3–47 after hatching at 19°C in the laboratory. The data, curve, and equation on the left represent numbers of rotifers consumed per 24 h by larvae from day 6 to day 13 after hatching. The data, curve, and equation on the right represent numbers of brine shrimp nauplii consumed per 24 h by larvae from day 23 to day 47 after hatching. Numbers on the ordinate axis refer to either rotifers or brine shrimp, depending on the age of the fish (see Table 1).
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Figure 2.—Dry weights (mean ± SD) of representative subsamples of summer flounder larvae taken on the day of each determination of prey consumption rate, as a function of age in days, for larvae reared at 19°C in the laboratory.

that numbers of brine shrimp were very close to expected.

The increase in weight of flounder with age was well described by an exponential function (Figure 2). To our knowledge, this is the first report of laboratory growth data for summer flounder larvae. To calculate the total number of rotifers and total number of brine shrimp nauplii needed per larva to achieve metamorphosis, we integrated the areas under the curves in Figures 1a and 1b. We further assumed a linearly decreasing usage of rotifers from 16 to 22 DAH and a concomitant linearly increasing usage of brine shrimp nauplii in the same period. We then calculated that each larva requires about 3,500 rotifers and about 4,800 brine shrimp nauplii to reach metamorphosis. A hatchery operator can use these numbers to calculate the approximate food costs per metamorphosed larva, given the costs of acquiring or producing rotifers and brine shrimp nauplii. It must be pointed out, however, that metamorphosed, settled summer flounder still require brine shrimp nauplii for some period of time, and apparently the longer the better (Bengtson et al. 1999, this issue), until they can be weaned to a formulated diet. One other caveat is that these results were obtained using a 12 h light: 12 h dark photoperiod, and it is reasonable to assume that the larvae, which are probably visual feeders, fed only during the light phase. If a longer photophase is used, the larvae may have more time per day to consume prey. In a commercial hatchery that raises summer flounder larvae in constant light, the consumption rates are approximately twice those reported here (G. Nardi, Great Bay Aquafarms, personal communication).

Acknowledgments

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References


