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HATCHING and GROWING BRINE SHRIMP

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The usual method for providing brine shrimp (*Artemia franciscana*) (**Fig 1**) as live food for fish involves making new batches every day in freshly prepared saltwater. This means preparing and disposing of lots of saltwater. More than one fish breeder has decided that feeding live brine shrimp just isn't worth the trouble.

I devised a novel method for the casual fish breeder like myself. I use eggs sparingly and reuse the saltwater. I raise the shrimp for 3-4 days before feeding them to the fish. During this time, I feed them such that their nutritional value increases. The shrimp are still small enough for newborn livebearers, but now, having grown 3-4 times their hatched size, they are a good food for juvenile fish (**Fig 2**).

Fig 1 Brine Shrimp are a wonderful live food for fish and worth culturing.

Fig 2 Three-Day-Old Brine Shrimp are hors d'oeuvres for these 3-month-old Guppies but essential for rapid growth of fry. I feed baby Guppies live brine shrimp twice per day during their first two weeks.

For growing *nauplii* (baby brine shrimp), I use an ecosystem approach. I encourage the growth of algae that not only feed the shrimp but purify the system (i.e., oxygenate the water, remove ammonia, etc). Algae benefit the shrimp just as plants do for fish in a planted aquarium.

I've found that there is plentiful leeway in temperature, salinity, egg source, etc. For example, if the water temperature is 65ºF instead of 80ºF, the eggs will take longer to hatch, but they will still hatch.

More important factors are not overpopulating the bottles, providing light, feeding the shrimp, and keeping the aeration gentle.

[1] I would like to thank Gerald Pottern, charter member of the Raleigh Aquarium Society—and an authority on live foods—, for his assistance on this article.

GETTING STARTED

I assume that most readers are familiar with the basics of hatching brine shrimp. I recommend that hobbyists start out small just to see for themselves how the hatching bottle—with patience—can be turned into a brine shrimp nursery. Try hatching a small quantity of eggs as usual but add a "pinch" of food to encourage bacterial growth. Harvest the nauplii the next day, but instead of discarding the hatch water, filter out the egg shells and pour the water back into the same bottle. Start another hatch in the bottle with the filtered saltwater. If the water is completely clear, add more food. (You want the water to be slightly cloudy but not smell.) Keep using the bottle and old saltwater for a couple weeks. Ideally, you should be getting the same hatch rate that you got when you first set up the bottle. Over time, the bottle (**Fig 3**) will "season" naturally—become colonized by useful bacteria and microalgae from the shrimps' native habitat that have hitched a ride on the eggs.

If you are encouraged, then use the seasoned bottle to grow the shrimp out for a few days before harvesting. You can set up a new bottle for just providing nauplii. In this way, you add new bottles to the system while getting an idea of what works best.

For my rotating system, I have 4 bottles going at a time, each seeded with eggs on a different day. The oldest culture contains mostly 3-day-old shrimp (**Fig 4**) and enough to feed about a hundred young Guppies for a day. Generally, I start a new hatch each day, but the system is flexible.

Fig 3 Seasoned Bottle contains an ecosystem of shrimp, bacteria, and algae.

HATCHING and FACTORS

Eggs: It is important to not over-load the bottles. I add 1/8 tsp (teaspoon) of brine shrimp egg to bottles containing about 2 qt (quarts) of saltwater. Cultures started with more eggs will not last the required 4-5 days. (As the shrimp grow, they require an increasingly greater water volume.)

Years earlier, when I had less fish to feed, I kept a shrimp batch going 5-6 days with a higher egg concentration (1/4 tsp per 2 qt). However, I harvested a small portion of the shrimp each day and let the rest continue growing. This partial, daily removal prevented the bottle from becoming overpopulated and going into a death spiral.

I've gotten essentially the same results using eggs from either San Francisco Bay or the Great Salt Lake. Brine shrimp eggs that I bought in 1990 and stored in the freezer still hatch after 27 years.

Fig 4 Juvenile Brine Shrimp grown out for 3 days. They are about 3 times larger than nauplii.

Food: In nature, brine shrimp feed off of microalgae and bacteria. I cannot provide readers here with hard-and-fast rules on what to feed, how much to feed, and how often to feed. However, Spirulina algae seems to work well. It is readily obtainable and nutritious. I purchased my Spirulina algae as pills from nutrition centers, but the powdered form is readily available from several Internet vendors. With a

mortar and pestle, I grind up a crumb piece—about the size of a green pea—into a powder and mix it with 2-3 tablespoons of water. I let any chunks settle before adding just enough of the mix to the shrimp bottles to turn the water faintly green. For a new culture, I add the algae food 2-3 times the first week. After that, assuming the water doesn't smell nor is too cloudy, I add more fresh mix every week or two. Continuous feeding is not necessary, because the shrimp feed on the algae and bacteria growing in the bottle. And it could overload the ecosystem.

After a few months, my bottles formed a thick, green algal coating on the insides. Originally, I thought this was a good thing; more algae meant more food for shrimp, more water purification, etc. However, I noted that the shrimp yield had decreased substantially. As possible remedies, I first tried adding new saltwater, new food, etc. Didn't help. Much to my surprise, the harvests returned to normal when I removed the algal coating by cleaning the bottles. I reasoned that not all algae is food for brine shrimp. Indeed, it could be detrimental by crowding out the microalgae species that the brine shrimp like to feed on.

Indeed, brine shrimp are somewhat picky eaters, at least with bacteria. Investigators using bacteria as the their only food source showed that not just any bacterium would do. Shrimp grew much faster when fed Pseudomonads than Vibrio bacteria. At 4 days, shrimp fed on Pseudomonad bacteria did as well as those fed rice bran, considered to be a good shrimp food. In contrast, starved shrimp or those fed Vibrio bacteria were dead at ~4 days [1]. Other investigators showed significantly greater survival for shrimp cultured in old, reused shrimp water than in seawater seeded with biofilter bacteria [2].

Fig 4 Brine Shrimp Setup consists of four ~2 qt (quart) bottles positioned under a clamp light with a 23 watt CFL bulb. The intense light stimulates the growth of microalgae in the water. Aeration is gentle. Clothespin on the one bottle signifies that this is the next bottle to harvest.

Brine shrimp probably do best feeding off a combination of food sources. In my bottles, they feed on microalgae and bacteria, plus the Spirulina algae food that I add every week or two.

Lighting: My bottles get 12 hr (hours) of intense light per day (**Fig 4**).[2] I've gotten much better shrimp harvests since I employed better lighting. Good lighting stimulates the growth of microalgae in the bottles. Microalgae is not only a natural food for the shrimp, but it consumes ammonia and CO_2, keeps the pH up, and produces oxygen. I can add more food to the bottles without the water fouling.

Aeration: Most hatching setups show vigorous aeration. This is totally unnecessary and can be harmful. Brine shrimp—like newborn fish—will lose energy and gradually die off if they are constantly fighting a cyclonic current. In my setups, gentle aeration works because the bottles are not over-populated AND algae helps keep the water sufficiently oxygenated. I regulate the bubbling such that the water surface is

[2] Although some fish breeders recommend continuous light, it is not necessary. One investigation [3] showed no significant difference in hatching efficiency using either a 2, 12, or 24 hr photoperiod.

barely disturbed, no foam is generated, and eggs aren't thrown up onto the side. Large air bubbles are released from a glass tube. The glass tube (5 mm O.D. X 12 inches long) is attached to airline tubing, a 4-outlet gang-valve, and a small air-pump. I cover the bottles with pieces of saran wrap to minimize water evaporation. When the water level gets low, I just add tapwater or more saltwater.

Saltwater: I prepare my salt water in a gallon jug by adding 1/3 cup of marine salts (e.g., Instant Ocean®) to a gallon of tapwater. This produces a salinity of ~27‰ (or 2.7%) and a density of ~1.020 g/ml.[3] And it automatically adjusts the pH to an alkaline ~8.3.

Although table salt (NaCl) plus a little baking soda works okay, marine salts are better over the long run. For they provide the minerals (e.g., calcium, potassium, etc) and micronutrients required by both shrimp and microalgae.

Reused saltwater can go for many months producing abundant brine shrimp. I see no reason to throw it out. I've stored old saltwater for a year before putting it back to use.

Bottles: I slice off the tops of ordinary, 2 qt plastic bottles. Any bottle will work, but I like the big 2 qt ones sold in grocery stores containing vegetable juice mixes.

Harvesting: For partial harvests, I siphon out as much brine shrimp as I need through a very fine net (**Fig 5**). [If you don't have a fine-enough net to capture baby brine shrimp, just lay a piece of cloth (e.g., from a bed sheet) over a fish net.] Light will encourage the shrimp to collect in a certain area of the bottle, but a goodly portion will be feeding at the bottom.

To collect an entire batch, I pour the bottle contents through a net and into a pitcher. I transfer the shrimp with tapwater into a cup.

I can feed the fish directly from the cup, but often I get rid of the egg shells first. I pour the cup's contents into a tall, narrow cylinder. The egg shells float to the surface while the brine shrimp, debris, and unhatched eggs collect at the bottom. I pull the shells off—using an eye dropper—before feeding the fish.

Fig 5 Partial Harvest To collect the brine shrimp, I use a 2 qt pitcher, net, airline tubing (attached to a glass tube), clothespin and gravity.

Setting up a New Hatch: After harvesting, I pour the collected saltwater back into the shrimp bottle and add 1/8 tsp of eggs. I'm careful not to jostle the bottle such that the eggs are thrown up onto the sides. If the inside of the bottle is heavily encrusted with algae, I'll clean it off beforehand using tapwater and a long-handled brush.

Timing the Harvest: Aquarium hobbyists are instructed to use the nauplii soon after hatching. The problem is that brine shrimp eggs don't all hatch at 24 hr, so many eggs are wasted. One investigator

[3] Brine shrimp can be hatched at 5‰ to 85‰ [4]. One investigator [5] got his brine shrimp to grow and reproduce just fine at 20‰. My 27‰ salinity represents an arbitrary compromise.

found that only about 50% of the eggs hatched within 24 hr (at 82°F), with some eggs taking 2-3 days to hatch (**Fig 6**). However, if one waits for a more complete hatch, many of the older shrimp will have lost their food value. It is virtually impossible to get an optimal harvest with the conventional method.

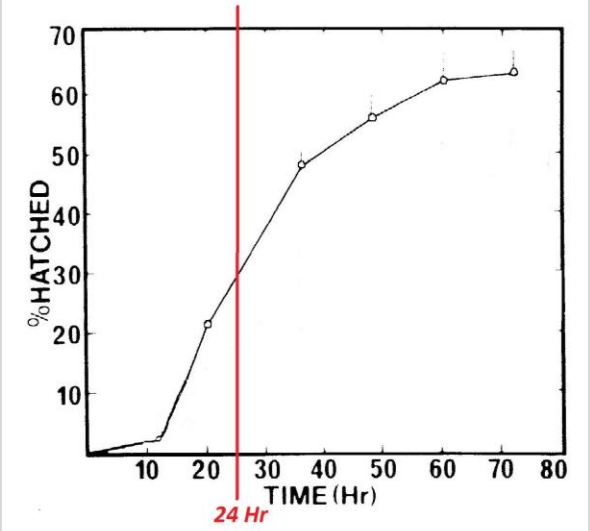

Fig 6 Brine Shrimp Hatching v. Time [8]

Culturing the shrimp for a few days after hatching solves the harvest timing problem. Moreover, the *overall* nutritional value of brine shrimp increases once the brine shrimp start feeding. For example, the average protein concentration increases from 42% in nauplii to 60% in adults [4].

I don't try to raise the nauplii to adulthood. I found that the 2-3 weeks required just wasn't worth the trouble for the very small number of adults produced. Adult brine shrimp require huge volumes of water. [4] Investigators showed experimentally that shrimp populations—whether starved or well-fed—began to decline 4-5 days after hatching [1].

My method represents a timing "sweet spot." The 3-4 days of culturing allows all the eggs to hatch, but the harvest comes before the shrimp start dying off.

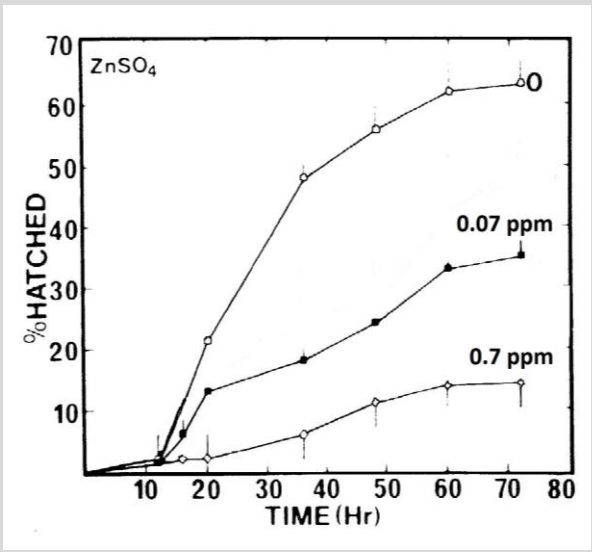

Fig 7 Effect of Zinc on Egg Hatching [8]

The investigators also showed that copper inhibited hatching over 10 more than zinc.

Metal Toxicity: Metal toxicity probably explains why some hobbyists never get a decent hatch. Hobbyists who continuously get suboptimal hatches should try using an aquarium water conditioner. Most conditioners contain EDTA, which chelates heavy metals, thereby rendering the metals non-toxic to the eggs and young shrimp.

Zinc and copper are occasionally present in tapwater at levels that—while not harmful for humans—can cause problems for aquatic animals, especially invertebrates [7]. The graph (**Fig 7**) shows zinc's toxic effect on brine shrimp hatching. The zinc concentration blocking 50% of hatching was found to be 0.07 ppm. My well water contains 0.8 ppm zinc. Unsurprisingly, eggs will not hatch in freshly prepared saltwater unless I add a water conditioner. [My reused saltwater has enough DOC (dissolved organic carbon) to chelate the zinc and prevent its toxicity.]

DISCUSSION

Readers should not expect to get a perfect harvest every time. Once in awhile, I get a lousy harvest, but the next time it might be spectacular. Sometimes, a bad harvest just prompts me to feed more

[4] The maximum density of adult brine shrimp under the best natural growth conditions (summertime in Mono Lake, Calif.) is 6-8 adults per liter (~quart). Peak densities in the Great Salt Lake are only ~3 per liter [6].

Spirulina algae or clean the bottles. Bottles can go downhill fast, but they can recover just as quickly. The bacteria and microalgae within have population doubling times of minutes and hours. I've had cultures crash after a long electrical power outage. Afterwards, I just filtered out the debris and reused the saltwater as usual.

My four bottle system allows me to experiment and perfect culture conditions. I can easily make a change to one bottle and see what the effect is compared to the other bottles.

A seasoned, well-functioning shrimp bottle is analogous to the "Balanced Aquarium." Nutrient input (eggs and shrimp food) is balanced by nutrient removal (shrimp harvesting, debris removal, bottle cleaning). Algae stabilizes the bottle's ecosystem by removing ammonia, consuming CO_2, maintaining a high pH, and producing oxygen. Photosynthetic oxygen helps keep a nutrient-rich system like this from going anaerobic. Like plants in an aquarium, algae contribute to a healthier environment. The fact that microalgae is also good food for the shrimp is an added bonus.

Live brine shrimp have long been recognized as a superior food for fry and young aquarium fish. Aqua culturists the world over have not yet found a better food source for raising their farmed lobsters, scallops, crabs, tiger shrimp, and aquarium fish. Unlike other live foods, one can hatch out stored eggs at one's convenience; no need to keep a live culture going when there are no fish to feed. Disease transmission from shrimp to freshwater fish is virtually impossible because of the osmotic barrier between saltwater and freshwater.

Due to their value as live food for farmed fish and marine invertebrates, the demand (and high price) for brine shrimp eggs is predicted to continue [9]. Aquarium hobbyists can help themselves by learning how to use the eggs frugally and to optimize hatching conditions. Allowing the shrimp to grow 3-4 days increases the efficiency of feeding live brine shrimp to aquarium fish.

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