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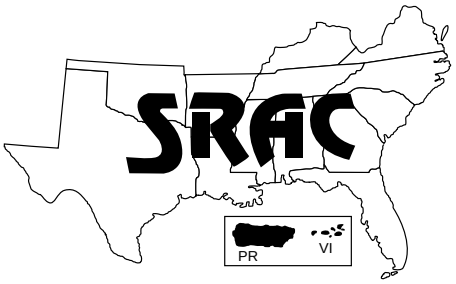

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Artemia Production for Marine Larval Fish Culture

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The brine shrimp (*Artemia*) is in the phylum Arthropoda, class Crustacea. *Artemia* are zooplankton, like copepods and *Daphnia*, which are used as live food in the aquarium trade and for marine finfish and crustacean larval culture. There are more than 50 geographical strains of *Artemia.* Many commercial harvesters and distributors sell brands of various qualities. Approximately 90 percent of the world's commercial harvest of brine shrimp cysts (the dormant stage) comes from the Great Salt Lake in Utah. However, the lake's cyst production is heavily influenced by freshwater inflow, and the supply varies dramatically. The cost of good quality cysts fluctuates with supply and demand; buyers might expect to pay $12 to $40 or more per pound (1/2 kg). Normally 200,000 to 300,000 nauplii might hatch from each gram of high quality cysts.

This publication describes the process of hatching *Artemia* cysts for use as larval food for cultured species, and the benefits of *Artemia* as a food source.

Background

Artemia are extremely euryhaline, withstanding salinities from 3 ppt to 300 ppt. They can even survive short periods of time in freshwater, but cannot reproduce in it. *Artemia* survive temperatures ranging from 15 to 55 °C (59 to 131 °F). They have two modes of reproduction. Sometimes nauplii (first *Artemia* swimming stage) hatch in the ovisac of the mother and are born live. However, when the body of water where adult *Artemia* are living begins to dry up and salinities rise, embryos are encased in a hard capsule, or cyst, so that they are protected and can hatch later when conditions are better. The cyst is 200 to 300 micrometers in diameter, depending upon the strain. Its external layer is a hard, dark brown shell. Dry conditions cause the encysted embryo to enter a dormant state, which allows it to withstand complete drying, temperatures over 100 °C (212 °F) or near absolute zero, high energy radiation, and a variety of organic solvents. The dehydrated cyst can be stored for months or years without loss of hatchability. Only water and oxygen are required to initiate the normal development of the *Artemia* embryo, but it does help the hatch rate to maintain the temperature above 25 °C (77 °F) and place a light near the eggs. The durable, easily hatched cyst makes *Artemia* a convenient, constantly accessible source of live feed for the finfish hatchery operator. *Artemia* cysts are best stored in a tightly sealed container in a cool, dry environment and, if possible, vacuum packed.

Within 15 to 20 hours after being placed in seawater at 28 °C (82 °F), the shell breaks and the pre-nauplius in E-1 stage appears (Fig. 1a). For the first few hours, the embryo hangs beneath the cyst shell in what is called the umbrella stage. The newly hatched *Artemia* relies on its yolk sac for nutrients because its mouth and anus are not fully developed. The pre-nauplius E-2 stage (Fig. 1b) is then released as a free-swimming nauplius (Fig. 1c) called an Instar 1 nauplius. In this stage it is brownish orange because of its yolk reserves. It uses specially modified antennae for locomotion and later for food filtering. Approximately 12 hours after hatch it molts into the second larval stage (Instar II) and starts filter feeding on microalgae, bacteria and detritus. The *Artemia* nauplius can live on yolk and stored re-serves for up to 5 days or through the Instar V stage (Fig. 1d), but its caloric and protein content diminish during this time.

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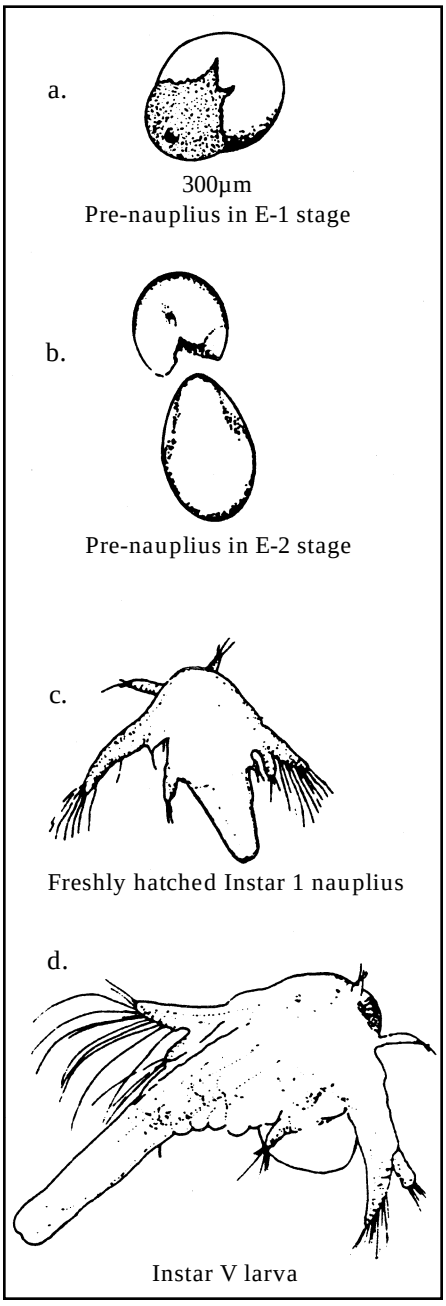

Figure 1.

The nauplius progresses through 15 molts before reaching adulthood in approximately 8 days.

The goal of the hatchery manager is to use the *Artemia* as feed as soon as possible after they hatch because that is when they are most nutritious. However, the lipid level and fatty acid composition of newly hatched *Artemia* nauplii can be highly variable, depending upon the strain and year class. Many researchers have studied the levels of highly unsaturated fatty acids (HUFA) in *Artemia*. Most of these studies indicate that the performance of larval fish is directly related to the level of HUFA in *Artemia* being fed and that essential fatty acids are the principal food value of *Artemia.* When *Artemia* contain low levels of HUFA, the survival of larval fish declines.

The type of food consumed by the parent *Artemia* greatly influences the fatty acid content of the cysts. *Artemia* composition is generally in the range of 51 to 55 percent protein, 14 to 15 percent carbohydrate, 13 to 19 percent fat, and 3 to 15 percent n-3 HUFA. When analyzed on a dry weight basis, cysts of one well-known brand of *Artemia* contained 28 percent crude protein, 10 percent crude fiber and 10 percent crude fat. To compensate for a poor HUFA level in *Artemia*, they can be enriched with omega yeast, vitamins (E, D, C and B_{12}), marine oils, vitamin B_{12}-producing bacteria, and commercial enrichment media (Super Selio®, Algamac®, etc.).

It is important to feed *Artemia* nauplii to fish larvae as soon as possible after hatching to take full advantage of the yolk and stored reserves found in freshly hatched Instar I nauplii (Fig. 1c). If there is a delay in feeding *Artemia*, they may also become too fast and too large for the fish larvae to catch and eat. Also, freshly hatched nauplii are dark orange and much easier to see than older nauplii, which are transparent. Some strains of *Artemia* may be too large for the fish being cultured, so it would be wise to ask other hatchery managers for their suggestions about which strains to use. Figure 2 shows the size of a freshly hatched *Artemia* nauplius relative to a 12- to 13-day post-hatch red drum larva. Feeding an oversized *Artemia* strain can cause fish larvae to grow poorly or even starve.

Optimum conditions for hatching *Artemia* cysts

The optimal conditions for hatching *Artemia* are: 1) temperature above 25 ºC (77 ºF), with 28 ºC (82 ºF) being optimum; 2) salinity of 5 ppt (1.030 density); 3) heavy, continuous aeration; 4) constant illumination (example: two 40-watt fluorescent bulbs for a series of four 1-liter hatching cones); and 5) a pH of about 8. Stocking density is set by adding no more than 5 grams of cysts per liter of water. Good circulation is needed to keep the cysts in suspension. A container that is V-shaped or cone-shaped is best (2-liter bottles work well; glue a valve on the bottle cap and invert it). The best container is a separation column, found in any lab supply, although it is more expensive. Unhatched cysts, empty shells and hatched nauplii can be easily removed separately. The hatching percentage and density are usually a function of water quality, circulation, and the origin of the cysts.

Preparation and use of *Artemia*

There are seven tasks involved in feeding *Artemia* to larvae.

1. Determine the weight of *Artemia* cysts required to feed the larvae in a tank of known volume.
2. Hydrate and decapsulate cysts (decapsulation is optional, but recommended).
3. Incubate cysts.
4. Separate cysts from shells and debris (not necessary if cysts were decapsulated).
5. Count the hatched *Artemia.*
6. Calculate the number of *Artemia* remaining in the rearing tank from the previous feeding.
7. Calculate the number of *Artemia* nauplii required by the larvae and transfer them to the rearing tank.

Be careful with step number 6, as remaining nauplii may have little nutritional value and may need to be flushed out of the system.

Details of each of the tasks will be discussed in the following small-scale example. Materials and equipment needed are:

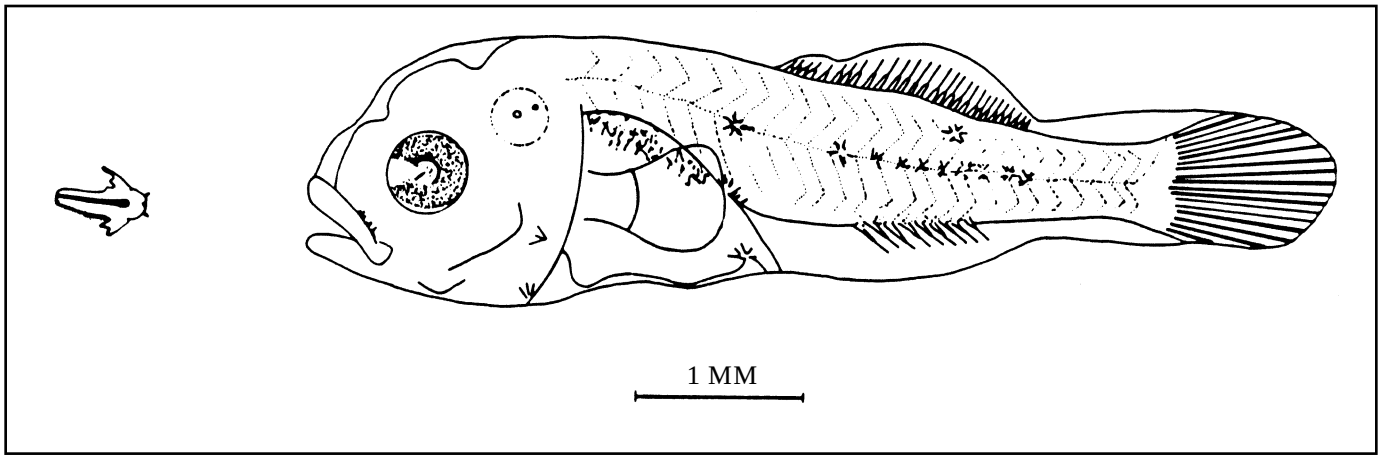

Figure 2. Larval red drum (300 hours post-hatch) and freshly hatched Artemia *nauplius (428 micrometers standard length).*

- *Artemia* cysts
- two 250-ml (8.5-fluid ounce) beakers
- distilled water
- household bleach
- sodium hydroxide (NaOH)
- 1-liter Imhoff cone or settling column
- low-pressure air supply (aquarium pump)
- seawater or equivalent (salinity of 5 to 32 ppt)
- siphon tube (approximately 4 feet long) or a valve at the bottom of the cone
- 1-ml pipet
- 10-ml pipet

1. Determine the amount of *Artemia* cysts required

Artemia nauplii are maintained in the larval culture tank at densities of 0.5 to 2 per ml for most species of finfish and up to 6 per ml in the more advanced larval shrimp stages. To estimate the amount of *Artemia* required one must consider both the volume of the tank and the expected number of *Artemia* the larvae will consume. Based on the stage or the age of the larvae, estimate a daily *Artemia* requirement per ml. This feeding rate can be adjusted slightly, depending on the stocking density (number of target larvae per liter) and the rate at which the *Artemia* are consumed. The total requirement is then calculated by multiplying the predicted requirement per ml by the total volume of the rearing tanks. Each gram of cysts contains approximately 200,000 to 300,000 cysts. *Artemia* generally have at least a 50 percent hatch. Experience with your specific brand will allow you to adjust these figures.

As an example, say that you find your target larvae are at a stage that requires two *Artemia* nauplii per ml. You wish to feed ten rearing tanks, each 16 liters (541 fluid ounces) in volume. Your requirement for hatched nauplii is therefore: 2 x 10 x 16,000 = 320,000 nauplii. If you assume a 50 percent hatch rate, you require 320,000 x 2 = 640,000 cysts. If 1 gram contains an average of 250,000 cysts, your required weight of cysts is 640,000 ÷ 250,000 = 2.56 grams.

In the form of a formula:

$$\textbf{Weight of } \textit{Artemia} \textbf{ cysts required} = \frac{\textbf{Total volume of all rearing tanks (in ml) X No. of } \textit{Artemia} \textbf{ required per ml}}{\textbf{Percentage hatch rate X No. of cysts per gram}}$$

2. Hydrate and decapsulate cysts.

Decapsulating, or removing the shell from *Artemia* cysts, serves several functions. The process disinfects the cysts, makes nauplii more digestible if they are unhatched when eaten, helps speed up the hatching process, improves hatchability, and makes it easier for the nauplii to emerge. If the nauplii have not put as much energy into emerging, they should be a better food source. Separating nauplii from their shells is desirable because shells are indigestible and can lodge in the gut of larvae, causing fatal obstructions. The shells are a known source of bacterial and viral contamination. The decapsulated cysts can be fed to smaller fish larvae than the fully developed nauplii.

Decapsulation is accomplished in three steps: re-hydrating the cysts; decapsulation; and washing and deactivating the residual chlorine.

Re-hydrating: Dry cysts have a dimple in their shell, which makes it hard to remove the complete inner membrane. For this reason, the cysts are first hydrated into a spherical shape. The cysts should be re-hydrated in soft or distilled freshwater or low salinity water (less than 10 ppt) at 25 ºC for 60 to 90 minutes. The lower the temperature, the longer it takes to re-hydrate them. But, no matter what the temperature, never leave the hydrated cysts longer than 2 hours or some of them may not survive the decapsulation procedure. Hydration should be done in a container similar to the one used for hatching regular cysts, for the same reasons of circulation and aeration. Cysts should be filtered on a 100- to 125-micrometer collection screen and rinsed, but this step may be skipped if you do not have the screen.

Decapsulating (Method 1): It is best to decapsulate the hydrated cysts immediately, but they can be

refrigerated for several hours if necessary. During the hydrating process, prepare the chlorine solution as described below.

To decapsulate, first measure 10 ml of seawater (5 ppt salinity) per gram of cysts. Place the water and a plastic-coated stirrer into a glass pie dish. Center the dish on a magnetic stir plate and turn it on. Slowly add sodium hydroxide (NaOH) to the seawater at a rate of 150 mg per gram of cysts and allow it to dissolve. Use bleach to wash the cysts from the screen and into the dish containing seawater and NaOH.

The bleach should be added at a rate of 5 ml per gram of cysts. With the addition of the bleach, the reaction (decapsulation) begins. Ice can then be placed in the solution to keep the temperature below 30 ºC (86 ºF). Slowly turn up the speed of the stirrer and run it as fast as possible, without splashing. Watch the solution carefully. A white foam layer will develop and the solution will change from brown to gray or sometimes a light orange, which should take approximately 6 minutes. When no more color change is seen, the decapsulation process is complete. Immediately drain the pie dish through a 100- to 120-micrometer sieve, over the sink, and wash the cysts thoroughly with tap water or seawater. The washing should continue for about 10 minutes until no chlorine smell can be detected. Scrape the cysts into a beaker and pour in enough 0.1 N HCl to wash the cysts, for no more than 30 seconds. This brings the pH to the neutral range. Pour the cysts into the sieve again and wash with water for 3 minutes. The cysts are now ready for incubation. Great care should be taken with the chemicals. They are caustic and can cause injury, particularly to the eyes. Always wear protective eyeware.

Decapsulating (Method 2 - Schumann, 2000): Prepare a buffer solution by dissolving 40 grams of 40% sodium hydroxide in 60 ml of freshwater. Then add seawater to yield a total amount of 0.33 ml of sodium hydroxide and 4.67 ml of seawater per gram of cysts. Cool the buffer solution to 4 ºC (39 ºF). It should be about pH 10. Add the cysts. Then add 10 ml of liquid bleach to the buffer solution. Use a thermometer to watch the temperature during the chemical reaction and keep the solution between 20º and 30 ºC (68º and 86 ºF). Starting with precooled buffered seawater makes it easier to keep the reaction in the right temperature range. If needed, an ice cube or "blu-ice" pack can be added to help drop the temperature.

Powdered pool chlorine can be substituted for household liquid bleach at a rate of 0.7 g of dry chlorine powder per gram of cysts. If pool chlorine is used, substitute sodium carbonate for NaOH as a buffer, adding 0.68 g sodium carbonate to 13.5 ml filtered seawater per gram of cysts. It is easier to split the water in two equal parts, adding the chlorine to the first part and the sodium carbonate to the second. Allow them to dissolve and react, which will cause a precipitate. Pre-cool the two solutions, mix them together, then add the hydrated cysts. After everything is placed together, note the color of the solution. It will change from a dark brown, to gray, to white, and then to a bright orange. This reaction usually takes 2 to 4 minutes. With the liquid bleach the cysts will change only to gray or light orange, and the reaction takes about 6 minutes.

The cysts must be filtered from the solution quickly and immediately after the membranes have dissolved (as indicated by no more color change or the final color—bright orange or gray); otherwise you will dissolve the whole cyst instead of only the outer shell. Washing cysts and deactivating the residual chlorine is the next step after decapsulation. The chlorine should be washed off the cysts with freshwater or saltwater until there is no more chlorine smell. The residual chlorine attaches itself to the decapsulated eggs and must be neutralized. Do this by washing the cysts in a 0.1% sodium thiosulfate (0.1 g sodium thiosulfate in 99.9 ml water) solution for 1 minute. An alternative method uses acetic acid (one part 5% vinegar to seven parts water). The first method works better, but the second method is easier because the materials are more readily available.

3. Incubate cysts.

Most hatchery managers incubate 1 to 3 grams of cysts per liter of water. It is inadvisable to incubate more than 5 grams of cysts per liter of water because a density higher than this could cause foaming. For this example, the 2.56 grams of disinfected cysts should be transferred to a 1-liter Imhoff cone (settling column) filled with seawater of 5 to 32 ppt salinity and at a temperature of 25 ºC (77 ºF) for 15 to 20 hours. Some hatcheries use diluted seawater (as low as 5 ppt) because less energy is required for the nauplii to emerge from the cysts at the lower salinity. Constant florescent light is supplied at an intensity of approximately 2,000-lux. One or two 40-watt tubes should be sufficient. The hatching container is vigorously aerated to keep the cysts in suspension and exposed to the light.

Although this example uses a small hatching container, they can range from 1 to 10,000 liters, depending on the needs of the hatchery. The container should have a conical or cone-shaped bottom to keep cysts syspended. If cysts are allowed to settle, hatch rates may be poor.

4. Separate cysts from shells.

After 15 to 20 hours of incubation, most of the cysts will be hatched and there will be a noticeable color change in the culture from brown to orange. Stop the aeration at this time. The pinkish-orange nauplii will be seen swimming in "clouds." Any empty or undissolved shells tend to float, while the full, unhatched cysts and some debris sink. If left undisturbed for 5 minutes, nauplii will concentrate toward the bottom of the container. If the con-

tainer is clear, a black cloth can be placed on top of the container to speed up the concentration of nauplii toward the bottom. Open the valve at the bottom of the container, first to remove debris and then to catch freshly hatched nauplii. A siphon also can be used to remove first the debris and then the nauplii from the bottom. The nauplii should be collected on a 100- to 120-micrometer screen, washed with clean seawater, and placed in a small volume of water. Washing removes contaminants and hatching metabolites.

It is sometimes very difficult, especially with certain brands of *Artemia*, to separate the nauplii from the empty shells and debris. Adding salt to the incubation container may help this separation and will not harm the Instar I nauplii. Try adding a small quantity of salt first to see the results, then add more if necessary until separation occurs. Any unhatched cysts should be saved to use in the next culture, because some of them might hatch with the next batch.

5. Count the hatched *Artemia*.

Hatch rates vary, so it is important to quantify the number of *Artemia* that hatched (Fig. 3). To do this, bring the level of seawater in the beaker holding the concentrated freshly hatched nauplii to some easy-to-use volume, such as 100 ml (3.38 fl oz). The nauplii should be mixed continuously while a 1-ml sample is drawn off with a pipet and placed in another beaker. The contents of this beaker should be increased to 100 ml with distilled water (1:100 dilution). Add full strength Lugol's stain or iodine to the beaker to slow down or kill the nauplii if high concentrations are present. Mix the contents of the beaker well and draw a 1-ml sample with a pipet for counting. If the numbers are high, count the nauplii in 0.1 ml. This count gives the concentration of nauplii in 0.1 ml of the dilution (H). Multiply the number counted by ten to get the number of *Artemia* in 1 ml, then multiply by the dilution factor (100) to calculate the number of *Artemia* per ml in the original beaker. To get the total number of *Artemia* in the original beaker, multiply the concentration per ml by the volume of the beaker in ml. This results in the concentration of *Artemia* per ml in the original 100-ml beaker.

In the form of a formula:

Number of *Artemia*/ml concentrated in 100 ml beaker is (G) = H x 1,000. H = number in 0.1 ml

6. Calculate the number of *Artemia* in the rearing tank.

Follow a similar procedure to determine the number of *Artemia* remaining in the rearing tank from previous feedings. Scoop a sample of approximately 100 ml from the rearing tank into a beaker. Add Lugol's stain or iodine to kill the *Artemia*. Use the same counting procedure and calculation as above, but do not dilute the sample.

The formula is:

Concentration of Artemia per ml (I) = number per 0.1 ml (J) x 10

Subsamples also can be taken with a Hensen-Stemple pipet (Fig. 4) or an automatic pipet with a large intake so as not to limit the uptake of animals.

7. Calculate the number of *Artemia* to be fed.

Because *Artemia* are quite costly and an excess in the culture system is not desirable, it is critical not to overfeed. The quantity of *Artemia* added to the larval system must be adjusted on the basis of the number remaining from the previous feeding. Each day, the stage of the fish larvae is assessed and used to determine the total quantity of *Artemia* required per ml of the rearing tank (K). Subtract the number of *Artemia* per ml in the tank from the total you need to find the quantity per ml to be added. The quantity to be added (L) equals (K) minus (J). Multiply this number by the volume of the tank in ml to find the total number you require in the tank (M). Divide this number by the number of nauplii per ml in the fresh batch of *Artemia* (G) to determine the number of ml to be transferred to the fish tank.

It may be easier to calculate with the following formula:

$$V = \frac{(K - H \times 1{,}000) \times M}{10 \times J}$$

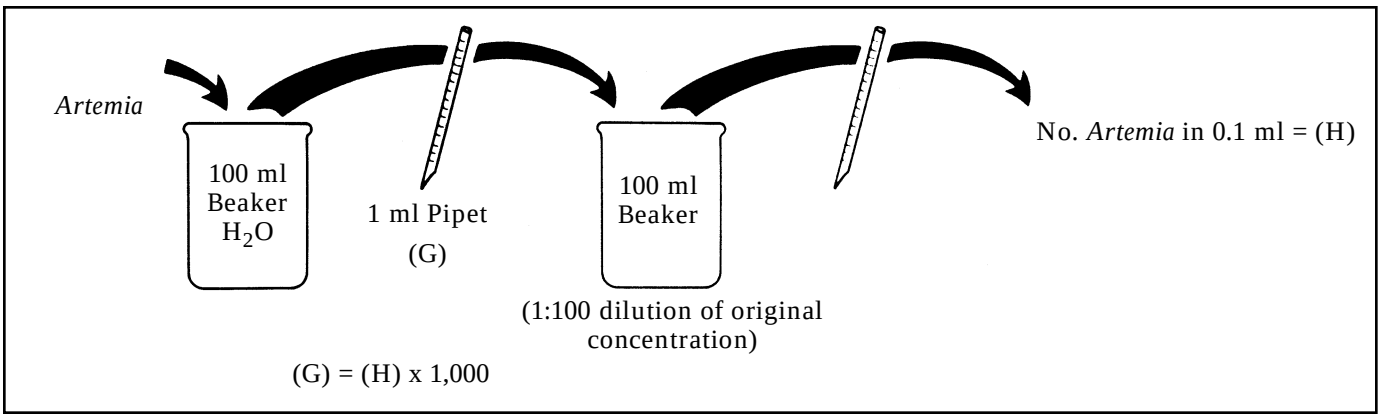

Figure 3. Counting Artemia *when concentrated.*

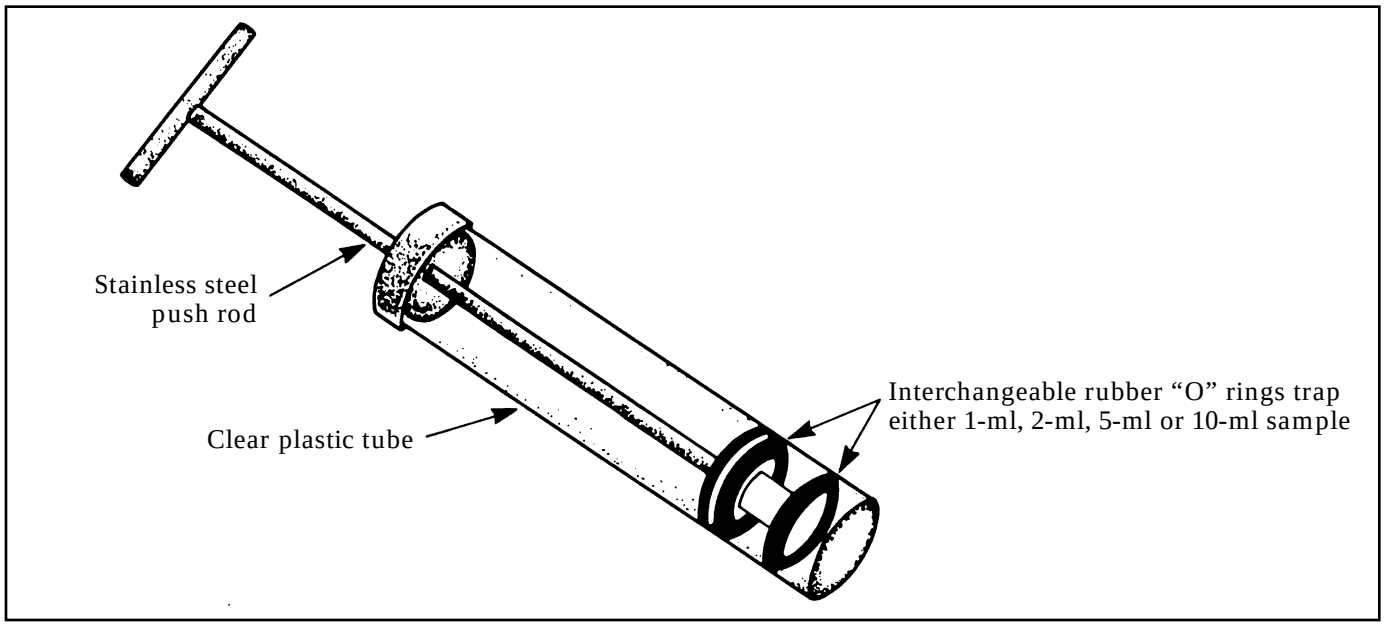

Figure 4. Hensen-Stemple pipet.

Artemia enrichment

Artemia strains differ in size and nutritional quality, particularly in content of highly unsaturated fatty acids (HUFA). In the 1980s researchers found that fish larvae feed strains containing more than 4 percent eicosapentaenoic acid (EPA) 20:5 n-3 yielded significantly better growth in fish than *Artemia* with less than 3 percent 20:5 n-3. Recent research suggests that docosahexaenoic acid (DHA) 22:6 n-3 is more important nutritionally than EPA. Premium quality *Artemia* (usually from San Francisco Bay) are higher in 20:5 n-3 (EPA), but are still lacking in 22:6 n-3 (DHA), which is the most important HUFA for marine finfish larvae. These high EPA *Artemia* are not equal to HUFA-enriched *Artemia* in terms of nutritional value, but are helpful in bridging the gap between rotifers and enriched day-old *Artemia*. The premium quality *Artemia* with high hatching rates, small size and greater HUFA levels are relatively expensive and sometimes difficult to find in quantity. As an alternative, a hatchery can purchase a commercial enrichment product to treat lower quality *Artemia*. Here is a simplified formula for *Artemia* enrichment.

Formula

Ingredients

- 800 ml (27 fluid ounces) deionized water
- 160 ml (5.4 fluid ounces) cod liver oil or other high omega fish oil
- 4 raw egg yolks (Egg yolks can be substituted with soybean lecithin—8 g or 5 percent of the weight of the oil.)
- 30 g (0.06 pound) unflavored gelatin
- 10 g (0.02 pound) vitamin premix, including E, C and B complex
- 1 g beta-carotene

Procedure

1. Dissolve gelatin in 800 ml (27 fluid ounces) boiled, deionized water and let it cool to 40 °C (104 °F).
2. Mix the oil in a blender on the highest setting for 30 seconds while adding beta-carotene.
3. With blender on, add vitamins and egg yolks. Then add gelatin and blend for 90 seconds.
4. Store the product covered in the refrigerator.

For use with hatching *Artemia*

Use about 0.5 ml (0.01 fluid ounce) of the enrichment diet per liter of incubation water (assuming 2 g dry cysts per liter of incubation water). After 18 to 24 hours hatching time, add another 0.5 ml of the enrichment diet per liter 2 hours before harvesting. Harvest before *Artemia* become too large for fish larvae.

For use with hatched, separated *Artemia* (in seawater)

Use about 0.5 ml of the enrichment diet per liter of separated *Artemia* (assuming a density of 100 to 150 *Artemia* per ml) for not less than 4 hours. Aerate the *Artemia*/diet mix during the enrichment process. Cooling the water with ice may slow the rate at which the *Artemia* grow during the enrichment process if size is critical to the target larvae.

The drawback to this procedure is that *Artemia* grow very rapidly, metamorphose to second instar metanauplii, and can become too large for some fish larvae to consume. The recommended solution is to use premium quality, newly hatched *Artemia* for the younger stages and then switch to enriched metanauplii *Artemia* as food for older fish larvae. For further information, see Sorgeloos et al., 1986.

There are a number of enrichment products on the market. Artemia Systems I.N.V.E. (Gent, Belgium), Aquafauna Bio-Marine Inc., and Sanders Brine Shrimp Company are among the companies that carry these products. A number of companies are producing algae pastes or concentrates that also can be used as food supplements for *Artemia*.

Most years the demand for quality *Artemia* is greater than the supply. Supplies may vary from year to year. The 2000 harvest at the Great Salt Lake was a record low in terms of quantity. Many companies teamed up to form associations to make their operations more efficient. One such association, called Utah Strategic Alliance, is a group of a dozen companies. They can be reached at *i.goossens@hotmail.com*.

Artemia storage

Artemia can be stored for future use in several ways. They will survive for several days in a refrigerator, but should be warmed up before using. *Artemia* also can be stored in the freezer, but this will kill them. An ice cube tray works well. Freeze them in 7- to 8-ppt saltwater for best results.

Decapsulated cysts also can be stored. For long-term storage, the cysts need to be dehydrated. Transferring 1 gram of decapsulated cysts into a saturated brine solution of 330 g salt to 1 liter water dehydrates the decapsulated cysts. Aerate this for 18 hours, replacing the solution every 2 hours. After 18 hours the cysts will have lost about 80 percent of their cellular water, so the air can be cut, allowing the cysts to settle before being filtered. These cysts can then be placed in a container and topped off with fresh brine solution. Seal the container and store it in the refrigerator or freezer. Cysts with 16 to 20 percent cellular water can be stored for a few months without a decrease in hatching rate. For longer storage, reduce the cellular water content to less than 10 percent.

Artemia substitutes

In some cultures (*P. monodon*, sea bass and other finfish) in Southeast Asia, there is a growing use of *Diaphanosoma celebensis (=aspinosum)* as a substitute for *Artemia*. This is a saline-tolerant (1 to 42 ppt) water flea in the 400- to 800-micrometer range, which has been successfully cultured in backyard hatcheries. Biomasses of up to 1 kg in 1 cubic meter of water every 3 days have been reached. In certain parts of Thailand, this organism has effectively replaced 100 percent of the *Artemia* after the shrimp PL 5 stage. To be effective as a replacement, this organism must be enriched before it is fed. Enrichment is accomplished with a high source of DHA, but usually not one with an oil emulsion base because of problems with gill and water fouling. *Schizochytrium* is the enrichment agent used most often in Thailand. This organism is classified as a golden algae but was once thought to be a fungus. It is spread by culture division because the organism, under current culture conditions, has reproduced only parthenogenetically. Hatchery managers using this organism have reduced their dependency on *Artemia*. References on this organism were cited by Susumu Segawa (Tokyo University of Fisheries) and Won Tack Yang (Marine Biomedical Institute, University of Texas Medical Branch) in 1988. They found that mean densities of 72 to 100 individuals per ml -1 could be maintained on *Tetraselmis chuii* after maximum density was attained (for general culture). In Thailand, culturists are growing *Diaphanosoma* on *Chlorella* sp. In 1998 researchers at SEAFDEC in the Philippines successfully used *Diaphanosoma* as an *Artemia* substitute for Barramundi larvae (*Lates calcarifer*). There are several publications on the enrichment of non-*Artemia* diet sources using high-DHA additives. One such paper is Harel et al., 1998.

Summary

Through the years *Artemia* have proved to be one of the easiest to prepare and most nutritious foods available to hatchery managers for rearing larval finfish and crustaceans. Although expensive, *Artemia* provides good survival and more consistent hatchery production than any other larval food. The ease of feeding *Artemia* and its superior nutritional value ensure that brine shrimp will be used in hatcheries for many years to come if supplies keep up with demand.

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