Artemia franciscana

C. Drewes (updated, 2002)
http://www.zool.iastate.edu/~c_drewes/
http://www.zool.iastate.edu/~c_drewes/Artemph.jpg

Taxonomy

Phylum: Arthropoda
Subphylum): Crustacea
Class: Branchiopoda (includes fairy shrimp, brine shrimp, daphnia, clam shrimp, tadpole shrimp)
Order: Anostraca (brine shrimp and fairy shrimp)
Genus and species: *Artemia franciscana* (= the North American version of *Artemia salina*)

[Note: The species commonly referred to as "*Artemia salina"* in much research and educational literature appears, in fact, to consist of several closely related species or subspecies. One of these, *Artemia franciscana,* is the main North American species.]

Reproduction

Typically, sexes are separate and adults are sexually dimorphic. Males have large graspers (modified second antennae) which easily distinguish them from females. In some species and populations of *Artemia* (for example, Europe), males may be rare and females reproduce by parthenogenesis.

During mating, males deposit sperm in the female ovisac where eggs are fertilized and covered with a shell. Eggs are then deposited and stored in a brood sac near the posterior end of the thorax (Figure 1M). Once fertilized, eggs quickly undergo cleavage and development through the gastrula stage (Figure 1A-E). After one or a few days, eggs are then released by the female (oviposition). Multiple batches of eggs may be released at intervals of every few days by the same female.

Two types of eggs may be laid -- (1) thin-shelled "summer eggs" that continue developing and hatch quickly, or (2) thick-shelled, brown "winter eggs" in which development is arrested at about early gastrula stage. Such "winter eggs," in their dried and encysted form, survive in a metabolically inactive state (termed anabiosis) for up to 10 or more years while still retaining the ability to survive severe environmental conditions. For example, *Artemia* eggs may remain viable after heating to 80 °C for 1 hr, cooling to -190 °C for 24 hrs, or reducing air pressure to 0.000001 mm mercury for 6 months!

Embryology

Cleavage of the developing egg is total and yolk is equally distributed among blastomeres. While within the female brood sac, egg development proceeds rapidly though cleavage and blastula stages (Figure 1A-C). Eggs are then deposited in the environment where they may remain encysted, with embryonic development arrested at about early gastrula stage (Figure 1D-C). At this time, there are about 4,000 cells in the embryo and these are highly organized, but no organs are discernible.

When encysted eggs are exposed to more favorable conditions (rehydration), the eggs swell and rapid development of the embryo resumes, resulting in completion of the nauplius stage (Figure 1F-G). Hatching occurs in about 1-2 days, depending on temperature. For the first few hours, the nauplius stays within a hatching membrane that hangs beneath the cyst shell. This is also called the "umbrella stage" in which development of the nauplius is completed

Larval stages and growth

[Note: Larval development of *Artemia* has been described in detail by several authors (see references). Although basic interpretations of development are similar, there are differences between authors regarding the numbering of molts and the naming of various instar stages.]

At hatching, the nauplius larva (= instar #1) emerges as a free-swimming stage (Figure 1H). This stage is about 0.4-0.5 mm in length and brownish-orange in color, due to the presence of yolk material. In a sense, the body of the nauplius larva consists mainly of a head. It has three pairs of "head" appendages -- a pair of small first antennae (antennules), a pair of well-developed second antennae, and a pair of mandibles. There is a large lip-like structure (labrum) covering a ventral mouth. A nauplius eye is present but it is not easily distinguished at this stage.

The posterior end of the nauplius consists of the future trunk -- it is short, undifferentiated, and unsegmented (Figure 1H). The nauplius larva does not have a complete digestive tract and does not immediately feed. It relies on stored yolk as an energy source. Depending on temperature, it swims weakly for about 12-20 hrs and then molts into the metanauplius larva (= second instar).

The metanauplius larva is translucent in color and about 0.6 mm in length (Figure 1I). Its trunk region is noticeably longer, and this region continues to lengthen and differentiate through the next series of molts. The metanauplius swims vigorously using its second antennae which are now better developed. At this stage, it starts filter-feeding. Its food consists mainly of microalgae, bacteria, and detritus.

The next three stages (each terminated by a molt) are also classified as metanauplius stages. Examples are shown in Figure J-K. Some developmental trends during these later metanauplius stages include more developed mouthpart appendages (maxillules and maxillae) and a longer thoracic region, with some definition of thoracic segments.

Next, there are seven postnaupliar stages -- one example is shown in Figure 1L. During these stages, the antennae begin to undergo a reduction in size and paired thoracic appendages begin forming. With each stage, these appendages become more numerous, larger, and functional. In addition, the compound eyes become more fully developed, the labrum is reduced in size, and abdominal segments become defined.

Then, there are a series of five postlarval stages (not illustrated) involving further reduction in the antennae, multiplication of ommatidial facets in the compound eyes, lengthening of the eyestalks, and formation of sexual organs. Completion of the 17th molt marks the end of post-embryonic development and the beginning of the final adult stage (Figure 1M). [Note that some authors recognize only 14-15 molts, rather than 17.]

Brine shrimp grow extremely rapidly. The adult stage is reached about three weeks after hatching. At adult size, biomass is about 500 times more than the nauplius biomass. Adults may live up to about 4 months.

Adults

Adult body size is variable, but typically it is about 8 mm in length. The anterior part of the body is not covered by a shield or carapace. The head has a pair of compound eyes at the end of stalks. Head appendages include a short pair of first antennae (also called antennules), a pair of second antennae, mandibles, and paired maxillules and maxillae -- the latter are greatly reduced in size. In males, the second antennae are enlarged and modified as claspers -- in females, they are short and thickened.

The body has 20 trunk segments (some authors say 19). The first 11 trunk segments are classified as thoracic segments and bear paired, paddle-like appendages, also called phyllopods.

Posterior to the thorax, there are 7 abdominal segments that bear no appendages. The last body segment bears a pair of long tail filaments.

Thoracic appendages are used for swimming and the animal swims ventral side up. During swimming, appendages move in a rhythmic and wave-like pattern, at a frequency of about 5-10 waves per second. Although difficult to see with the naked eye, each wave of movement actually starts out in posterior segments and then, rapidly and sequentially, progresses into more anterior segments. During the "power stroke" of each cycle of movement, the paddle-like appendages push water in a rearward direction, thus smoothly propelling the animal forward. Importantly, such water currents also function in food gathering, as well as in respiration, since thoracic appendages also have gills.

References

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Web Sites for additional background, lab culture methods, and student activities:

http://www.zool.iastate.edu/~c_drewes/ This site provides an new classroom activity entitled: *"Stuck-On Artemia"* [New, simple methods are described for systematically following the developmental fate of individual cysts while quantifying the hatching success of small populations of cysts. The method allows small numbers of cysts to be easily transferred, counted, and kept in the same focal plane for viewing. This technical approach leads to a wide array of open0ended student investigations, as well. Presented by C. Drewes at 1999 NABT]

http://www.zool.iastate.edu/~c_drewes/Artemph.jpg

http://allserv.rug.ac.be/aquaculture/index.htm\

http://www.science.lander.edu/rsfox/artemia.html

http://www.iit.edu/~smile/bi9216.html

http://www.terc.edu/handson/f94/shrimp.html

http://www.terc.edu/handson/f94/spotlight.shrimp.html

Commercial Sources:

Most biological supply companies and tropical fish stores sell small quantities of brine shrimp cysts. Larger quantities may be purchased from:

http:/www.aqualink.com/marine/z-atemia.html
(sells cysts and *includes suggestions for feeding)*

http:/www.aquaticeco.com
(sells cysts and "Dry Brine Shrimp Feed" that supports growth from nauplius to adult (Cat#: E-16; 1.0 lb/$25).

(*Spirulina* powdered algae supports growth from 1-week-old larvae to adult (*Spirulina*, Cat#: SP10; 1 lb/$25).