Bio 25: San Francisco Bay Ecology
Professor Crima Pogge

Brine Shrimp

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Fig 1

Brine Shrimp

Filling a gap in the food chain between the plankton and larger filter feeders, small fish and birds are the brine shrimp. Brine shrimp earn their common name from their fairly unique ability to live in a wide range of salinities, from nearly freshwater to saturated brine (MacGinite 1968). An ability, along with its fast reproduction cycle and their eggs' ability to survive dessication, which allows them to inhabit the very harsh environment of drying salt ponds where it finds little competition and is able to escape some predation by animals who cannot tolerate the high levels of salt (Brown 1960).

The brine shrimp belong to the subclass *Branchiopoda*, from 'branch' meaning gill, and 'poda' meaning feet (Borror 1988), which are characterized by the fact that their appendages which are used for used for locomotion (and feeding as discussed later) are used for respiration.

Habitat

Ranging throughout the Western United States (Henger 425), brine shrimp prefer shallow, saline waters and have adapted to the hypersaline waters of drying saltwater ponds(Pearse 1987) (an adaptation that allows them to thrive in commercial salt ponds (SFBCDC 2005)). Though *Artemia* (the genus in which brine shrimp are found) is the only *Branchiopoda* adapted to salt water, all have adapted to living in seasonal ponds, again an adaptation that allows them to escape predation from populations of aquatic animals who cannot tolerate dessication. (Hickman 1967)

Though wetlands in the San Francisco Bay are threatened and do not exist to the extent that they once did the brine shrimp's continued existence is not threatened because of its fast reproductive cycle. Brine shrimp may be found in any tidal marsh waters in the Bay.

Reproduction and life cycle

Generally reproduction is sexual with the male using his prehensile antennae to clasp onto the female during copulation (Fig. 3) (Hickman 1967), which may last as long as several days, and can

commence each time the female molts which is as frequent as every four to six days.(Brown 1960)

When in the absence of males brine shrimp are known to reproduce by parthenogenesis (Brown 1960), the eggs produced in this way often have thinner shells than their sexually produced counterparts (Borradale 1967) and are typically female.

The female will carry her brood in her ovisac, an extension of the uterus. As the eggs develop they ovisac will inflate into a conspicuous pouch in which the eggs may be seen through its clear walls . (Fig 2) (Hickman 1967)

The eggs, once developed and released by the mother, can survive dessication for up to five years (Pearse 1987), reanimating within just a few hours of re-wetting (MacGinitie 1968), this function allows the population to survive a temporary loss of a lake or salt pond and also allows them to be carried by the wind or on the feet of birds (MacGinitie 1968) to other waters, helping the species populate otherwise inaccessible new habitats. At times, the eggs of brine shrimp may be so abundant that they cover the shores of salt ponds in layers as deep as 7cm (MacGinitie 1968).

Newly hatched brine shrimp bear little resemblance to the mature adults; beginning as nauplius larvae they are ovular in shape with no visible delineation between the segments of the body and have only three pairs of appendages which are used for feeding and locomotion but which develop into the antennules, antennae and mandibles as they progress into adulthood.(Grasse 1975) It may take as many as 17 instars (Hickman 1967), or molting cycles, for the nauplius larvae to pass through stages know as protozoaea, zoaea, mysis before finally becoming reproductively mature adults.(Grasse 1975) As with all crustaceans, brine shrimp continue to grow and molt through their lives, though they grow more slowly with age. (Grasse 1975)

Feeding and Digestion

Brine shrimp are opportunistic filter feeders feeding on detritus scraped up from the bottom of the water column or on unicellular algae and other plankton higher up in the water column. Among

other functions the rhythmic beating of the limbs pumps food and watter through the median gully where the food is strained out by the limbs and retained in the food groove and later moved up to the mouth, broken into smaller pieces or discarded. (Borradale 1967)

Digestion begins with the mandibles reducing the size of food particles and with the addition of a sticky secretion from glands near the mouth. The secretion helps hold the bolus together while secretions all along the digestive tract add digestive enzymes (Brown 1960). The food is passed into the mouth, through esophagus and into the combined stomach and intestine. Nutrients is taken up all along the digestive tract before the waste is passed on through the anus.(Borradale 1967)

Adaptations to Hypersaline Environments

Urine in the brine shrimp is used in osmotic regulation and is hypertonic (Hickman 1967), additionally the exoskeleton, though very thin is quite resistant to osmosis (Brown 1960) and thus helps the animal maintain its salt levels. The brine shrimp is able to absorb water through its digestive tract and to expel salt through special glands in the gills, both of which aid in osmoregulation (Hegner 1968).

As mentioned above the eggs of brine shrimp are capable of dessication and may survive upto five years before reanimation. The eggs respond to salinity levels in the determination of hatching and thus will not hatch when the salinity is too high but will wait until fresher water is present, often from rains a following year (Pearse 1987). This too helps the population to survive extreme salinities.

Other Physiology

The elongated body is covered with a thin exoskeleton and usually consists of 19 segments, the first 11 of which have pairs of appendages, the next two which are often fused together carry the reproductive organs and finally the last lead to the tail (Hickman 1967). Though brine shrimp have a true head, thorax and abdomen, the delineation is often difficult to detect and so the body parts are usually termed as head and trunk (Brown 1960).

The rudimentary, compound eyes, set at the end of short stalks perform little more detecting light direction and intensity, though they may be able to aid in orientation based on the polarization of sunlight and are keen at detecting light movement which might indicate the advancement of predators. (Hickman 1967)

Locomotion is achieved by the rhythmic beating of the appendages acting in pairs. Steering is accomplished by use of the telson (a type of flattened tail). The telson may also be used for rapid movements for escaping prey (Brown 1960).

Respiration occurs on the surface of the legs through fibrous, feather like plates (lamellar epipodites) (Hickman 1967).

In addition to locomotion, feeding and respiration, the legs or appendages serve to aid in the circulation of blood despite the existence of a long tube like heart. The blood which uses hemoglobins as its primary oxygen fixing pigment and lends the brine shrimp its pink color, does not flow through veins but rather flows in the hemocoelic spaces of the head and throughout the trunk and appendages (Brown 1960).

The nervous system consists of two parallel chains leading from a small brain down length of the body and is cross connected (like a ladder) in each segment or somite.(Brown 1960) Many functions, including swimming, digestion and reproduction are not controlled through the brain though the brain may control some regulation or synchronization of these functions. Autonomy, the voluntary shedding or dropping of parts of the body for defense, is controlled locally along the nervous system aswell. (Hickman 1967)

Human interactions

Though human encroachment in the San Francisco Bay has dramatically reduced the amount of wetland habitat and had a dramatic impact on other marine organisms, the adaptability and rapid reproductive cycle of brine shrimp has lead to their continued existence. One of the encroachments

into the Bay is in the form of salt ponds in the South Bay where salt is commercially harvested but doubles as a brine shrimp breading ground and farm. Before the salt is harvested, brine shrimp, being the only animals capable of living in the harsh salty environment, may be harvested and sold for use in research and as tropical fish food. The high densities of the brine shrimp in commercial salt ponds also makes them an abundant food source for many common birds on the bay such as grebes, gulls and sandpipers. (SFBCDC 2005)

Brine shrimp may also find human interactions in the handling of farm and industrial waste in that they may be used to disperse naturally occurring selenium and salts in waste waters. In this case algae is grown in the waters upon which the brine shrimp will feed who will in turn be fed upon by birds, whence the salts and selenium will be redistributed into the environment.(CDWR 2007)

Conclusion

The adaptability, reproduction cycle and ability of the eggs to survive dessication makes the brine shrimp a permanent and healthy fixture in the San Francisco Bay. Bay wetlands are being restored and as birds move into these new habitats they are likely bringing the eggs of brine shrimp along with them. Brine shrimp are an important food source for wild fish and birds, aquaculture and tropical fish in tanks, their populations are not in danger but understanding their niche in the Bay helps to show how all species in this ecosystem are interrelated and dependent on one another.

Images

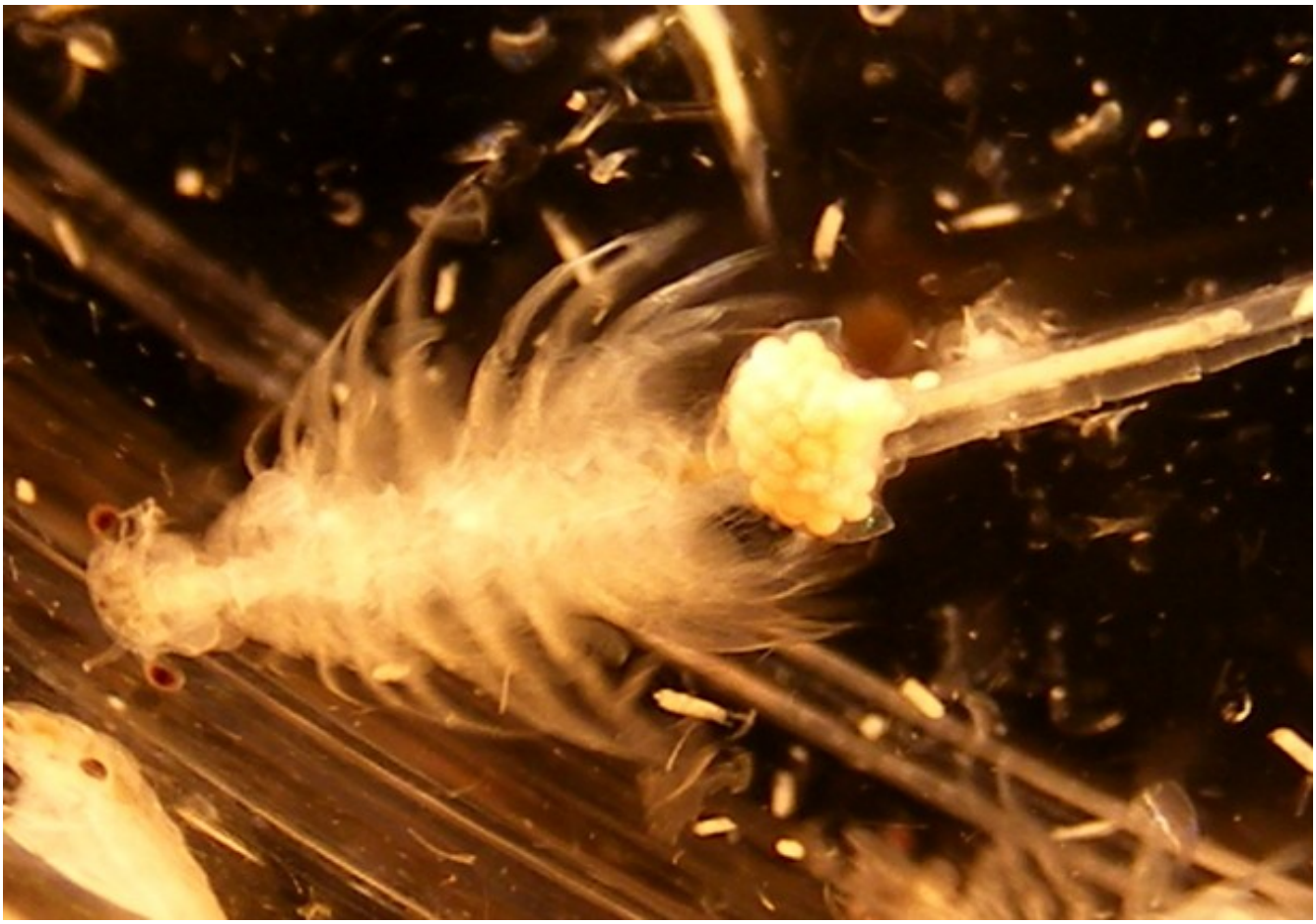

Fig. 2: The eggs that this female are carrying may be seen clearly through the clear walls of the ovisac.

Fig. 3: The male of this mating pair may hold on for several days using his prehensile antenna.

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