Fig. Ap. 2.1. Denton tending his fairy shrimp collection.

# Appendix 3

## *Hatching and Rearing*

Back in the bowels of this book we noted that if one takes dry soil samples from a pool basin, preferably at its deepest point, one can then "just add water and stir". In a day or two nauplii appear if their cysts are present. O.K., so they won't always appear, but you get the idea.

If your desire is to hatch and rear fairy shrimps the hi-tech way, you should get some guidance from Brendonck *et al.* (1990) and Maeda-Martinez *et al.* (1995c). If you merely want to see what an anostracan is like, buy some *Artemia* cysts at the local aquarium shop and follow directions on the container. Should you wish to find out what's in your favorite pool, or gather together sufficient animals for a study of behavior or some other biological phenomenon, then several low-tech approaches are available.

Most any broad and shallow container can serve as a hatching and rearing vessel, but it needs to be compatible with your project and available space. Plastic kiddy wading pools, perhaps 1.0-1.5 m in diameter, serve well outside. Once a thin layer of soil is added, nature is allowed to take its course. When rains come, and conditions are suitable, hatching happens. Obviously, if this method is chosen you are not in control of temperature, timing, or other conditions.

In the kitchen, basement, or lab, "aquaria" holding 1-2 gallons of fluid work fine. They are small enough to move easily from place to place or temperature to temperature as desired or necessary. Spread a thin layer of soil on the aquarium bottom, then add distilled, deionized, or rain water. Remember, most pools initially fill from rain, snow-melt, or flash-floods, sources **low** in TDS. However, salts may leach from soils to ultimately make the water salty, a situation which commonly turns off hatching. Tap water is usually unsatisfactory, either because it has high TDS, or because it contains chlorine or chloramine, disinfectants which may inhibit hatching or kill emerging nauplii.

As you have read time and again in Chapter 5, temperature is an important environmental cue for coaxing larvae from their dormant state. You can guess what temperatures might need to be approximated given the sample's origin. Try incubation at about 3-5°C if it came from the mountains or high desert. If from California grasslands, 10° is a good level at which to start. Should it be a Mojave Desert sample, you might try anywhere from 5-25°C, for cysts of both winter and summer species may be in your soil, and these of course hatch at different temperatures. To play it safe, containers placed at about 5, 10, and 25°C will give you the greatest chance of coaxing forth some larvae.

If you have an aquarium aerator, prudence says use it to keep oxygen at elevated levels. Remember, hatching is a highly energetic process, so emerging larvae need considerable $O_2$.

Growth is rapid, particularly if you raise (slowly) the temperature after hatching, so a continuous food supply is necessary. Powdered yeast and powdered aquarium-fish food both seem to do the job. Do **not** add too much, for an unused excess will decay, putrefy the water, and quite likely kill your developing shrimps.

Just a word to temper unabashed optimism for success. Although the above procedures will re-

sult in hatching cysts and growing larvae of many, if not most, fairy shrimps, individuals of a few species have either not yet been coaxed from their cysts, emerged only grudgingly, or no attempt has been made to get them out and rear them. Should you end up with difficult-to-hatch cysts, we wish you well in finding a simple recipe that cajoles larvae into making their debut. Go for it!

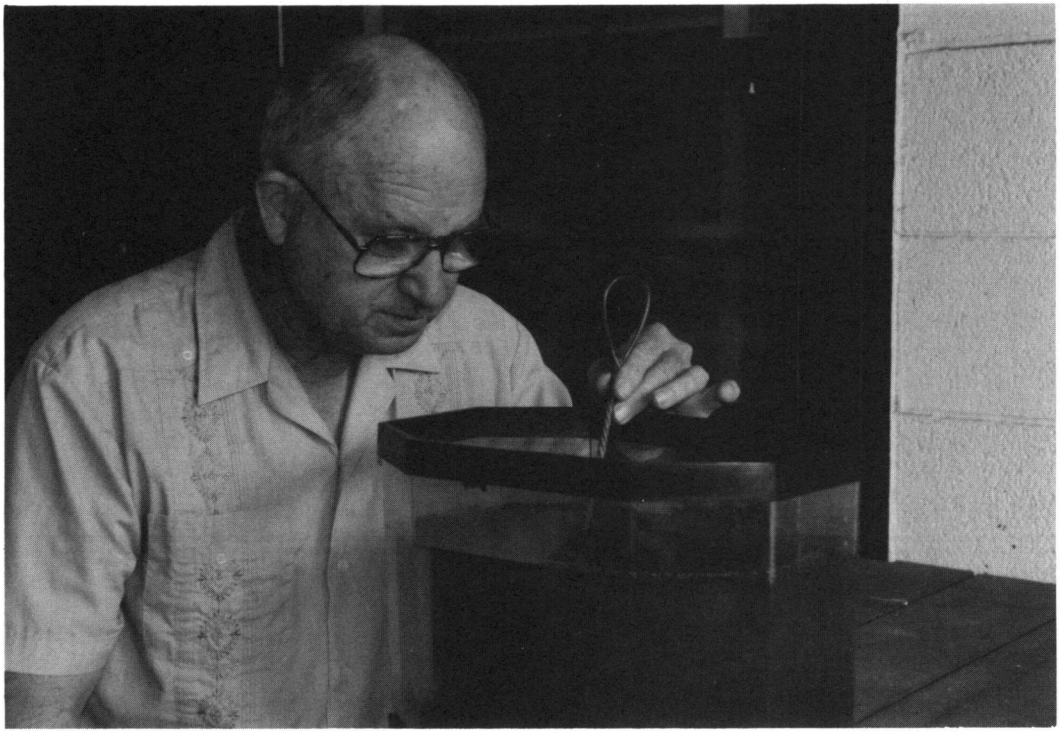

Fig. Ap. 3.1. Denton checking a culture of *Artemia franciscana*.

# Appendix 4

## *Classification of Fairy Shrimps and Some of Their Arthropod Relatives*

Taxonomy is the science of naming species. Classification is the attempt to place these species into ever larger groupings that demonstrate phylogenetic relatedness. Because new information is constantly appearing, there is often an on-going reshuffling in and of these larger categories – a reshuffling that sometimes creates disagreement among specialists (fairy shrimps and their relatives are not immune to this scenario). Although some scientist may have published different names or groupings at one time or another, we use Belk and Brtek's (1995) classification of the Anostraca, with the addition of two newly described genera (Brendonck 1995; Hamer & Brendonck 1995). For Conchostraca, we follow Martin and Belk (1988) and Sassaman (1995). The two genera of Notostraca are well accepted, but the species need considerable reevaluation. For those of you with geographical interests, we have indicated where on this small world of ours these "Large Branchiopods" dwell. The additional categories included are highly selected, and are offered only to give you an idea of where the other arthropods mentioned in this book "fit" into the scheme of things, at least as portrayed by Ruppert and Barnes (1994). Taxa are listed in alphabetical order.

### Phylum: Arthropoda

Sub-phylum: Crustacea
Class: Branchiopoda
Order: Anostraca
Family: Artemiidae
Genus: *Artemia* (Eurasia, the Americas, Africa, Australia)
Family: Branchinectidae
Genus: *Branchinecta* (Eurasia, the Americas, Antarctica)
Family: Branchipodidae
Genus: *Branchipus* (Europe, Africa, Pakistan)
Genus: *Branchipodopsis* (Africa, Asia, Armenia)
Genus: *Metabranchipus* (Somalia)
Genus: *Parartemia* (Australia)
Genus: *Pumilibranchipus* (Namibia)
Genus: *Rhinobranchipus* (South Africa)
Genus: *Tanymastigites* (North Africa)
Genus: *Tanymastix* (Europe, North Africa)

Family: Chirocephalidae
Genus: *Artemiopsis* (Russia, U.S.A. [Alaska], Canada)
Genus: *Branchinectella* (Eurasia, North Africa)
Genus: *Chirocephalus* (Eurasia, North Africa)
Genus: *Eubranchipus* (Eurasia, Japan, North America)
Genus: *Phallocryptus* (Argentina)
Family: Linderiellidae
Genus: *Dexteria* (U.S.A. [Florida])
Genus: *Linderiella* (France, Spain, Morocco, U.S.A. [California])
Family: Polyartemiidae
Genus: *Polyartemia* (arctic & subarctic Eurasia)
Genus: *Polyartemiella* (arctic & subarctic North America, Russia)
Family: Streptocephalidae
Genus: *Streptocephalus* (Africa, North America, Eurasia, Australia)
Family: Thamnocephalidae
Genus: *Branchinella* (Australia, Eurasia, Japan, Africa, U.S.A., Paraguay)
Genus: *Dendrocephalus* (South America, Costa Rica)
Genus: *Thamnocephalus* (U.S.A., Mexico, Venezuela)
Order: Conchostraca
Sub-order: Laevicaudata
Family: Lynceidae
Genus: *Lynceus* (Eurasia, Africa, Japan, the Americas, Australia)
Genus: *Lynceiopsis* (Africa)
Genus: *Paralimnetis* (South America, Mexico, U.S.A. [Texas])
Sub-order: Spinicaudata
Family: Cyclestheriidae
Genus: *Cyclestheria* (tropical and subtropical regions of all continents except Antarctica)
Genus: *Paracyclestheria* (China [Yunnan Province])
Family: Cyzicidae
Genus: *Caenestheria* (Eurasia, Africa, Australia)
Genus: *Cyzicus* (Eurasia, Africa, the Americas, Australia)
Genus: *Eocyzicus* (Eurasia, Africa, North America)
Family: Leptestheriidae
Genus: *Eoleptestheria* (Eurasia, Africa)
Genus: *Leptestheria* (Eurasia, Africa, the Americas)
Genus: *Leptestheriella* (India)
Genus: *Maghrebestheria* (Morocco)
Genus: *Sewellestheria* (India)

Family: Limnadiidae
Genus: *Eulimnadia* (Eurasia, Africa, the Americas, Australia)
Genus: *Imnadia* (Europe)
Genus: *Limnadia* (Eurasia, Africa, the Americas, Australia)
Genus: *Limnadiopsis* (Australia)
Genus: *Limnadiopsium* (Australia)
Genus: *Metalimnadia* (South America)
Order: Notostraca
Family: Triopsidae
Genus: *Lepidurus* (Eurasia, Africa, the Americas, Australia)
Genus: *Triops* (Eurasia, Africa, the Americas, Australia)

**The following list of arthropod relatives is highly selected**

Sub-phylum: Crustacea (included again for clarity)
Class: Branchiopoda
Order: "Cladocera" (water fleas) [for current classification see Fryer 1987]
Class: Cirripedia (barnacles)
Class: Malacostraca
Order: Isopoda (sowbugs, pillbugs, roly-polys)
Order: Decapoda (shrimps, lobsters, crabs)
Sub-phylum: Uniramia
Class: Chilopoda (centipedes)
Class: Insecta (insects)
Sub-phylum: Chelicerata
Class: Arachnida
Order: Scorpiones (scorpions)
Order: Araneae (spiders)

# Last Minute News — Fairy Shrimp Science Swims On

## *And Now There Are 25 Species Found in California*

With ice still on the pools in March of 1998, Christopher Rogers captured an unnamed fairy shrimp in Modoc Co., California. He found the same species in Utah also. The animal turned out to be a new species first discovered in Oregon by Dr. Michael Fugate. Michael and Christopher are working on a co-authored description of this new form they call the winter fairy shrimp.

Early in 1999, Christopher Rogers called Denton to report that the distal segments of the antennae of *Branchinecta dissimilis* he collected in Modoc Co. looked very different from what we were calling *B. dissimilis*. When these two workers got together and examined Lynch's type material borrowed from the Smithsonian, they discovered that they were dealing with two species differing only in the morphology of the distal segment of the antenna. The specimens from Modoc Co. proved to be *B. dissimilis*. Those taken in the mountains from Alpine Co. south to Fresno and Inyo counties are a new species. Denton and Christopher are working on a description of this new anostracan they are calling the mountain fairy shrimp. Use this information as you read about *Branchinecta dissimilis* on pages 87-88 and look at its distribution on Map 5.5, page 121. The dots in Shasta and Lassen counties on Map 5.5 are incorrect and should be ignored. The key will identify both *B. dissimilis* and the mountain fairy shrimp as *B. dissimilis*. So far, *B. dissimilis* is known in California only from Modoc Co.

## Branchinecta lynchi *Now Found in Oregon*

Brent Helm collected *Branchinecta lynchi* near Medford, Jackson County, Oregon in 1998. The area is a vernal pool landscape similar to the Central Valley of California.

## Branchinecta mackini *Not Found East of the Continental Divide*

Detailed comparative studies by Denton revealed that populations east of the Continental Divide that were being called *B. mackini* are in fact an unrecognized new species. Dr. James Lynch, of *B. lynchi* fame, observed that there was something different about the eastern populations when he was ask to look at specimens from Alberta and Saskatchewan by Dr. Richard Hartland-Rowe (1965). Lynch suggested to Hartland-Rowe that the specimens appeared to him to be a distinct subspecies. Richard passed on taking up the challenge of testing this hypothesis and proposing a new subspecies name. Denton studied specimens from British Columbia to Baja California, and from Alberta, Wyoming, and Minnesota. The results are in a nearly completed manuscript naming the eastern alkali fairy shrimp in honor of Canadian naturalist and friend Ken Reading.

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# Index

| Table of conversion factors | | |
|---|---|---|
| 1µm | = | 1/1,000 mm |
| 1 mm | = | 0.04 inches |
| 1 cm | = | 10 mm |
| 1 m | = | 39.37 inches |
| 1 km | = | 0.62 miles |
| 1 ha | = | 2.47 acres |
| 1 mg/L | = | 1 ppm |
| 1 L | = | 1.06 quarts |

µmhos/cm (conductivity) x 0.65 ≈ ppm TDS

mOsm/L (salinity) x 50 ≈ µmhos/cm (conductivity)

mOsm/L (salinity) x 32.5 ≈ ppm TDS

# Cover Pictures

## *Front Cover:*

Upper right. This female *Linderiella occidentalis* is ready to mate; note the cluster of eggs in her left lateral pouch and the enlarged shell glands filling most of her brood pouch. Check Fig. 1.3, p. 3 if you need help in finding these structures. Also, compare her red eyes with the black eyes of the fairy shrimps in the picture below. Photo by Larry Serpa.

Lower left. Explore the internal anatomy of both males and females in this shot of *Branchinecta longiantenna*. Figures 1.2 and 1.3 (pp. 2 & 3) are available to aid in your discovery. Note the exceptionally long antennae on the male; these are the stimulus for the name of this species. Photo by Larry Serpa.

## *Back Cover:*

Upper right. Look closely at the many beautiful colors in this male of *Eubranchipus serratus*. His cercopods just brush the cyst filled brood pouch of a female *E. serratus* in the lower corner of the picture. The two small red animals are copepods. Photo by Richard Hill.

Lower right. This female *Streptocephalus woottoni* is practicing the alternate feeding method of scraping. She has her back toward the water's surface which is upside down for a fairy shrimp. Note the dark blue-green color associated with her reproductive structures. You may read about the limited information we have concerning such color development in the section on "Color" in Chapter 2 (pp. 27-30). Photo by Larry Serpa.

Upper left. Your authors posing beside a created temporary pool at the Bernard Biological Field Station of The Claremont Colleges. Photo by Clyde with the aid of a shutter-release timer, and a lot of running back and forth.