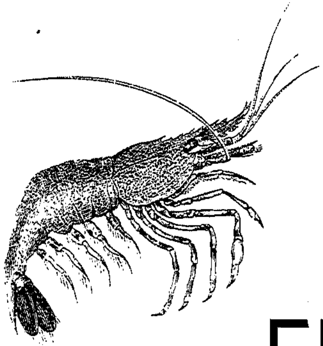
Fourth Edition



PENNAK'S FRESHWATER INVERTEBRATES OF THE UNITED STATES

PORIFERA TO CRUSTACEA

Douglas Grant Smith

To the memory of

C. Juday

4th edition to the memory of
my friends and mentors

David J. Klingener

Herbert E. Pottswald

This book is printed on acid-free paper. ♾

Published simultaneously in Canada.

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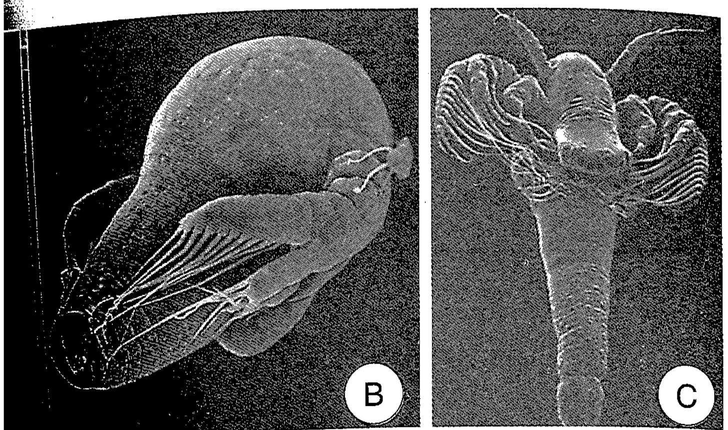

... A, emerging nauplius; B, freshly emerged nauplius; C, metanau- ... et al. 1997.)

while they ... male or ... se, de- ... wer. It ... egins ... the ... era- ... is

instar to the next are gradual, and there is progressive appearance of more segments, more appendages, and increasing complexity of appendages. *Linderiella occidentalis*, for example, has 17 instars in the life history. By the third instar the length averages 1.1 mm and all appendages through the fifth or sixth trunk segments are represented to some degree. By the sixth instar the average length is 2.1 mm and all appendages are present, though most of the most posterior ones are completely developed. Complete development, sexual maturity, and copulation are attained in the 16th instar. *Artemia franciscana* probably has 14 instars, sexual maturity being attained in the 12th instar. *Streptocephalus sealii* has 18 preadult instars. Some investigators have found that the number of ...ars is variable for each species, depending on temperatures and food conditions. ...e active portion of the life cycle may ...pleted in a surprisingly short time. ... history of several species of *Eulim-* ... from hatching until death is complet... 3 weeks. *Lynceus brachyurus* lives ... days and *Cyzicus mexicanus* about 2 ... *franciscana*, on the other

weeks and *Eubranchipus oregonus* has an exceptionally long natural life span, sometimes up to 25 weeks. *Cyclestheria hislopi* dies during the "ovipositing" molt.

In small ponds that contain water for only a few weeks during the spring and early summer, phyllopods usually have one generation per year. The resting eggs hatch early in the spring, and the animals mature rapidly and produce resting eggs that fall to the bottom and do not hatch until the following spring. Some "summer" eggs are usually produced during the short period of activity and, although they may hatch, there is not sufficient time for the second generation to mature. Such immature individuals and any remaining "summer" eggs are presumably destroyed by the adverse conditions accompanying the disappearance of water from the pond. In Great Salt Lake, in permanent ponds, and in ponds that persist for several months, however, there are usually two or more complete generations per year, the summer generations being completed in a short time because the "summer" eggs hatch almost immediately.

Ecology. It seems evident that the development of most phyllopod species in the spring and their sudden disappearance in summer or early autumn are governed largely by temperature conditions. Most species do not appear until water temperatures exceed 4°C; and 13 to 30°C, depending on the species, is the upper limit beyond which individuals die quickly. In Great Salt Lake, *Artemia franciscana* disappears in the autumn when the water temperature drops below 6°C; *Eubranchipus bundyi*, *Eubranchipus serratus*, and *Lynceus brachyurus* are seldom successful in water warmer than 15°C. At the other extreme, phyllopod populations have been recorded from desert ponds where the midday temperatures exceeded 42°C.

Many species exhibit little in the way of specific habitat preferences. The widely distributed *Eubranchipus vernalis*, for example

Branchinecta coloradensis occur only in clear ponds and pools, while many clam shrimps, *Triops*, *Branchinecta gigas*, and *Thamnocephalus platyurus* are almost invariably found in muddy, alkaline waters. I (RWP) have often collected phyllopods in mountain locations in puddles in pothole depressions of a boulder, sometimes where the entire water volume was less than 20 L.

A compelling feature about phyllopod ecology is their almost complete absence from permanent water bodies, either lentic or lotic. Seldom are they collected from bodies of water having areas exceeding one hectare. Phyllopods are almost defenseless, and it is also notable that they are not often abundant in ponds containing carnivorous insects, and are rarely present along with carnivorous fishes. In fact, they attain greatest densities in vernal ponds and prairie pools that are generally lacking in other macrometazoans. A notable exception to this paradigm is *Cyclestheria hislopi* (Fig. 17.18), which is known from permanent, warm, and nutrient-rich ponds and lakes. This species' preference for thick algal mats probably discourages predators.

In keeping with widely fluctuating water levels and the consequent rapid changes in the dissolved salt content of pond waters, phyllopods have highly efficient but poorly known means of making physiological ad-