



United States Department of the Interior

NATIONAL PARK SERVICE
El Morro National Monument
Route 2, Box 43
Ramah, New Mexico 87321-9603

IN REPLY REFER TO:

A

August 14, 1997

FILE COPY

David W. Johnson
Professor of Biology
College of Santa Fe
1600 St. Michael's Drive
Santa Fe, New Mexico 87505-7634

Dear Dave:

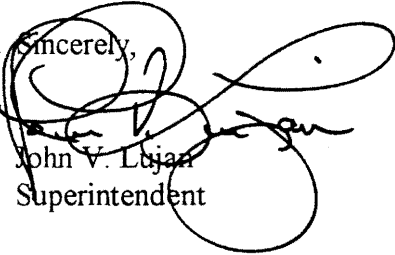
I have completed the review of the draft report of the Biota of the Historic Pool, El Morro National Monument. I found the report quite informative, easy to read, and understandable. Your work will indeed be an asset to our resources management data base.

I have just a few very minor comments. They are as follow:

1. Page 3, second paragraph, seems to be missing a word after very (minimal range of tolerance.)
2. Page 3, fourth paragraph, need a space between "ph of".
3. Page 6, fourth paragraph, not really sure what a water column is as it is referenced here.
4. Page 6, last paragraph, is it possible to include a photo of the tiger salamander?

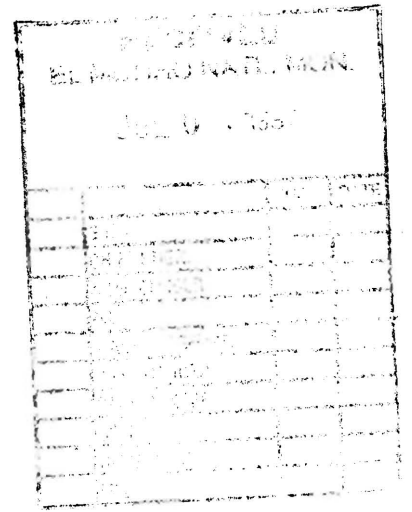
I particularly appreciated the chart identifying the various organisms. I think the interpreters will find that most useful. Thanks again for all your work.

Sincerely,


John V. Lujan
Superintendent

THE COLLEGE OF SANTA FE

Department of Science and Mathematics



3 July 1997

John V. Lujan
El Morro National Monument
Route 2, Box 43
Ramah, NM 87321

Dear John:

Here is a complete copy of the draft report with the figures. I look forward to your comments.

Sincerely,



David W. Johnson
Professor of Biology



Draft Report
Biota of the Historic Pool
El Morro National Monument

David W. Johnson, Ph.D.
Wendy Beers
Danica Brice

Department of Science and Mathematics
The College of Santa Fe
1600 St. Michael's Drive
Santa Fe, NM 87505

30 June 1997

1 June 1997

Draft final report--Biota of the Pool, El Morro National Monument

Introduction

From 25 July 1994 through 21 August 1997, we visited the historic pool at ELMO eight times to collect aquatic specimens to document the common life forms in the pool. In summary, one vertebrate (Tiger salamander), at least 23 invertebrate species, and the cattail are the usual species inhabiting the pool (Table 1). We found no Threatened or Endangered species in the pool, although several species of bats (including *Leptonycteris nivalis*, *Leptonycteris curasoae yerbabuencae*, several *Myotis* species), Spotted Owls, and other species that are currently listed or proposed for listing could potentially occur in the area and visit the site. Further study of those species is needed.

Methods

At each visit, we sampled surface and subsurface waters with a plankton net, collected sedentary species with a Dendy multiple plate sampler, collected sediment samples near shore, and used a hand net to collect large aquatic invertebrates. Salamanders were live-trapped with minnow traps baited with canned sardines. A few specimens were identified on site, the remainder was transported alive to The College of Santa Fe where we conducted identifications. A few specimens (especially, backswimmers and water striders) were preserved in 70% ethanol. Other, more delicate specimens deteriorated in alcohol and instead, if possible, were photographed. Photomicrographs accompany the descriptions of some specimens.

Results

Most of the organisms inhabiting the pool are tiny invertebrates belonging to taxa that are difficult to identify. Most can be identified to species only by expert taxonomists. Therefore, most organisms are here identified to Family or Genus. Each group is listed as common or uncommon. Common indicates species that were usually observed on collecting trips; uncommon species were much less abundant and observed infrequently. Taxonomic names follow Pennak (1989), Barnes (1987), and Porter (1967).

Descriptions of groups

Cattails--Cattails appear to be the only flowering plants living directly in the pool. This species (*Typha latifolia*) is a rhizomatous perennial--it has horizontal,

underwater stems that grow laterally and can produce new stems and roots and can spread as long as the water is not too deep. One ranger suggested that the cattails were planted historically; this needs verification. Because *Typha* is widespread in North America, it is possible that they occur naturally at ELMO.

Protists--Only five of many protists are identified here. These are the most common. Protists include the single-celled organisms--some are photosynthetic (the algae) and some are not. The Euglenids and Dinoflagellates are photosynthetic (Figures 1 and 2). The typical *Euglena* is ovoid in shape, is microscopic in size, and usually has two threadlike flagellae. It reproduces by splitting in two. The Dinoflagellates are also single-cells. Although most are marine, some are freshwater, as in *Ceratium* here. These photosynthetic algae also move with flagellae and tend to spin--their name originates in the Greek word *dinein*, "to whirl." Dinoflagellates often make up a large part of freshwater plankton and are important parts of aquatic food chains.

Roundworms--Roundworms belong to the Phylum Nematoda, and at El Morro, the aquatic nematode probably belongs to the Class Adenophorea (Figure 3). The roundworms are poorly known and at least 1500 freshwater species have been identified from habitats ranging from polar ice, hot springs, stream bottoms, and at great depths in lakes. At least as many more species are terrestrial. Most aquatic nematodes are less than one centimeter long; the specimen identified here is less than one mm in length. The aquatic nematodes are closely tied to the bottom substrate and usually are not free-swimming.

Water mite--The Arachnids include familiar spiders, scorpions, ticks, and mites. The pool at El Morro supports at least one species of aquatic mite (Figure 4). Nearly all of the aquatic mites occur in freshwater; only a few are marine. They occur most frequently in areas with rooted vegetation, like cattails. Water mites are tiny--less than one mm in length--and often very colorful. They superficially resemble spiders, but instead of having a separate cephalothorax and abdomen (as in spiders) water mites have but one body part and no evidence of segmentation. The mite found here is a bright green color with a body texture resembling large rounded granules. Like spiders, most water mites are carnivorous. More than 600 species are known from the U.S., but despite their bright colors and interesting habits, water mites are poorly studied west of the Great Plains.

Crustaceans--Seed shrimp (also called Ostracods), copepods, and water fleas (also called Cladocerans) are all members of the class Crustacea. This group also includes the familiar crayfish, shrimp, and crabs. (At El Morro, several other Crustaceans live in the ephemeral pools of water called potholes--the fairy shrimp, tadpole shrimp, and clam shrimp.) Crustaceans are all Arthropods--they have two pairs of antennae and have jointed appendages. Most Crustaceans are aquatic and breathe with gills.

Seed shrimp are named for their resemblance to seeds--the entire animal is enclosed by a two part carapace or shell and looks like a seed (Figure 5). Most seed shrimp are omnivorous scavengers and eat bacteria, algae, and fine organic debris. As a group, seed shrimp can be found in waters of pH 4 to 8 (acidic to alkaline), but some have only a very range of tolerance.

Copepods are easy to recognize crustaceans--they are tiny (about one mm in length) and have two long antennae extending from the head (Figure 6). But once a copepod has been recognized, it is necessary to use high power microscopy to identify individuals to species because of the necessity of using minute anatomical features, often only after micro-dissection of body parts! Because of these difficulties, the identification here is certainly tentative. At least 10,000 species have been described worldwide.

Cladocerans--The water fleas are the most conspicuous animals in the water column during the spring and summer (Figures 7 and 8). Often there are hundreds of individuals in a cupful of water. Many people will recall water fleas from high school biology class when they studied *Daphnia*. Water fleas are the most abundant of the small, freshwater crustaceans and they are extremely diverse. In addition to the many species, there is remarkable variation within species. During the course of the year, individuals change in appearance so drastically that they may resemble other species. The shape of the head may change from rounded to elongated and peaked and form what is called a helmet (Figure 9). This seasonal change in morphology is called cyclomorphosis and complicates the biologist's job of identification. Like the seed shrimp and copepods, water fleas have eyes and use their light sensing ability to migrate vertically during the course of a day. Most cladocerans inhabit waters with a pH of 6.5 to 8.5, a range that includes the yearly pH changes at El Morro. Some investigators are using water fleas as experimental animals in tests for toxic compounds in water but Pennak (1989) states that none of

the studies has lead to any standardized techniques for analysis.

Reproduction in cladocerans involves interesting patterns. During most of the year, females produce unfertilized eggs that hatch and mature into more females. This is called parthenogenesis. No mating is involved; indeed the females are incapable of mating with males. Ten to twenty eggs are released from the ovary into a brood chamber (a cavity dorsal to the body but within the two valves) where they mature (Figure 10). When the eggs hatch into young similar to the adult, the female allows the young to escape from the cavity into open water (Figure 11). As the water temperature increases, food becomes less abundant, and light intensity changes, the female begins to produce male offspring. The reasons for this change are not clear and are the subject of intensive research. At the same time, some females produce female offspring that are fertile--they are capable of mating with males and producing fertile eggs. Some of these fertile females produce fertilized eggs that occur in pairs in a tough protective cover. This structure is called an ephippium (Figure 12). It is tough, resistant to desiccation and freezing. The ephippia may be carried by the wind or birds to distant pools and can overwinter easily. This reproductive pattern is complex and at any one time, there may be parthenogenetic females, males, unfertilized sexual females, and fertilized sexual females all in the pool at the same time.

Ephemeroptera--Mayflies are common and often very abundant, delicate insects seen flying over streams and ponds. The nymphs (larvae) of mayflies are usually the life-form collected and therefore the nymphs are the biologically best understood generation (Figure 13). Adult mayflies are usually short-lived, perhaps living only a few days. Adults usually lay eggs on the surface of the water. After the eggs hatch, the larvae pass through many molts and may spend several months in the immature form. Often, many nymphs mature into adults at the same time (perhaps because water temperature warms and allows simultaneous maturation) and swarms of mayflies may appear at once. Fly fishers are familiar with these "hatches." Mayfly nymphs are important members of aquatic habitats because they are herbivores--they eat micro-organisms, algae, and plants and are, in turn, fed upon by carnivores. Even the brief adult stage provides food for birds and other vertebrates. The Order name Ephemeroptera derives from the Greek word *emphemer*, meaning short-lived.

Odonata--The dragonflies and damselflies are perhaps the most conspicuous insects around the pool because of their large size, distinctive shape, and often bright

coloration (Figures 13 and 14). Mosquitos form a large part of the diet of adult dragonflies, but other insects also fall prey to this agile flying predator. Some dragonflies perch and foray out to catch insects in a manner similar to the flycatcher birds. Others fly almost constantly, patrolling the air for prey. Dragonflies can cruise at 25-35 kilometers per hour; some may reach speeds over 50 kilometers per hour. Odonata comes from the Greek word *odon*, which means tooth. This refers to the sharp tooth-like structures on the dragonfly's mouthparts. Although dragonflies are excellent insect predators, their bites are harmless (if felt at all) by humans. Like mayflies, dragonfly larvae are important members of aquatic food chains. Females usually lay eggs on the stems of aquatic plants and after 10 - 30 days, the eggs hatch. Most larvae burrow into the substrate or climb onto submerged plant stems. After passing through several developmental stages, the adult emerges. Whereas larval mayflies have lateral gills, larval dragonflies and damselflies do not.

Hemiptera--Water boatmen, water striders, and backswimmers are members of the Order Hemiptera, the true bugs (Figures 13, 15). Water boatman and backswimmers swim underwater, water striders live at the interface of water and air. Surface tension of water keeps the striders from sinking. Whereas the mayflies and dragonflies have biting mouthparts, the Hemiptera have piercing and sucking mouthparts (Figure 16). Terrestrial insects in this order include aphids and cicadas. The water boatmen and backswimmers use their oar-like hind legs to propel themselves. Water striders glide across the water surface by pushing back on the water surface with their legs--the water piles up behind the legs and insect moves forward. Most water bugs overwinter as adults then mate and lay eggs in spring. The eggs hatch and larvae mature during summer. In contrast to mayflies and dragonflies, in which the nymphs are often the most easily collected and observed stage, in water bugs the adults are easiest to see. A casual look at the edge of El Morro pool will reveal all three water bugs.

Water boatmen are extremely common aquatic bugs in North America and occur from below sea level in Death Valley to high mountains. They are omnivorous--they eat plant and animal material. In some areas of Mexico, water boatmen are economically important. They are collected as eggs and adults and processed into pet food.

Water striders are easily observed skating across the surface of El Morro pool.

(Figure 17). Most are prey on aquatic organisms that come to the surface and tiny terrestrial animals that fall on the water. They also scavenge on dead animals. Striders even eat each other. They are especially vulnerable during molting.

Backswimmers are fierce predators. They attack appropriately-sized invertebrates and even tiny fish (except at El Morro where there appear to be no fish). Even people can be bitten; the bite is painful but harmless. As with many water bugs, backswimmers come to the surface to breathe. They hold a "head-down" position with the tip of the abdomen above the surface of the water. Air enters abdominal troughs and diffuses into the body via tiny openings called spiracles. As the name denotes, backswimmers swim by rowing with their legs and their body ventral-side (underside) up.

Trichoptera--Caddisflies form one of the largest groups of aquatic insects (Figure 13, 18, 19). Well over 1300 species occur in North America, north of the Rio Grande. Perhaps the most interesting habit of caddisflies is the larvae's ability to construct and live in a portable house! Using silk produced by a gland near the mouth, caddisfly larvae fasten together tiny stones and bits of plant material to form a tubular, protective case open at one end. At El Morro, the caddisflies belong to a group called tube-case makers. Elsewhere, larvae of other species of caddisflies produce cases in the shapes of purses or saddles. The open-ended tube allows the larvae to move about in a safe, armored house while foraging. Most caddisflies eat a great variety of food including algae they scrape from rocks.

Diptera--Three major groups of flies inhabit the pool. Midges, dixids (Dixidae), and mosquitoes (Culicidae) are uncommon members of the aquatic community here (Figures 13 and 20). The Diptera--the True Flies-- are very diverse; more than 120,000 species have been described. Perhaps the mosquito is the one of interest here because of the effects on humans. Females lay eggs on the water surface. They hatch in a matter of days and the larvae feed throughout the water column. They must however frequently return to the surface for fresh air. Here, they may be preyed upon by several kinds of invertebrate predators.

Caudata--Tiger salamanders appear to be the only vertebrates inhabiting the pool at El Morro. Although these salamanders are widely distributed--from semi-arid playas of New Mexico to elevations over 3,300 m in the Southern Rockies--we are not certain if the El Morro salamanders are naturally occurring or were introduced to

the pool. Retired Ranger Tom Townley suggested to me that the salamanders were introduced to the pool in the 1970s. A search of Monument files might reveal the truth. It is possible that a natural population was supplemented by introduced individuals.

In New Mexico, breeding occurs during the summer rains of July and August. Eggs are usually attached to submerged stems, twigs, and rocks. Eggs hatch 2 - 5 weeks after being laid. The small larvae (about 13 mm long) have external gills and may mature into adults before the first winter. Adults leave the water and migrate to land where they spend the winter in abandoned underground burrows built by other animals. While in the water, the larvae eat larval mayflies, dragonflies, and caddisflies. At times, the larvae don't mature until their second year in the water. Sometimes, the larvae grow and become sexually mature without metamorphosing into the adult form. This phenomenon is called paedomorphosis or neoteny and occurs haphazardly. The salamanders live-trapped at El Morro in September 1995 appeared to be neotenic. They were 25 cm in length and fully aquatic with external gills. Sometimes, neotenes become cannibalistic and grow to lengths of 35 cm. Reasons for this phenomenon are not clear; some authors suggest that low pond temperature and/or substrate qualities are factors. Further study (including live trapping, marking, and retrapping) is needed to determine the characteristics of the El Morro salamanders.

Discussion

The organisms in the pool at El Morro are mostly those expected in clean, oxygenated water with a near neutral pH. Several groups--Ephemeroptera (mayflies), Odonata (dragonflies and damselflies), and Trichoptera (caddisflies), especially--are intolerant of pollution and require a narrow range of pH. McKegay (1992) organized aquatic invertebrates according to their tolerances of pollution. These three groups top the list of invertebrates sensitive to water pollution. Water boatmen (Corixidae) are also indicators of good water quality (Jansson, 1977)

Although in the pool pH is near-neutral, a drop below pH 6 is not tolerated by mayflies and other sensitive species. While change (either excessively acidic or basic) will kill organisms directly, often harm is indirect. For example, as pH becomes more acidic ions of aluminum and other metals will become more available in the water. Aluminum ions interfere with ionic balance in organisms via the gills.

hatch. Clearly, pH is a constituent to monitor.

Only one species (the midge fly larva) is tolerant of pollution. On the whole, the pool is inhabited by organisms intolerant of poor water quality and therefore represent excellent water quality in the pool

Recommendations

Further research--The sources of the salamanders and cattails are not clear. A search of the Monument files and discussions with past employees might yield an answer. A genetic analysis could clarify these populations' relationships with other members of the species in the region. Detailed examination of the invertebrate groups, including identification to species level by experts would increase our understanding of the biogeography of these groups. Both of these projects are suitable graduate studies. A total fecal coliform test is needed to quantify the degree of contamination by *E. coli* bacteria. A test for *Giardia*, a common water parasite is also available but expensive. (CHD Diagnostic, Loveland, Colorado, will test for *Giardia* for \$250. There is also a charge for specialized sampling equipment to obtain the water sample of \$75.)

Monitoring--Increased vehicular traffic, increased activity in fossil-fueled power plants in the region, and increased long-distance transport of air pollution (especially from Los Angeles, Phoenix, and Las Vegas) could increase the levels of acid precipitation and change the pH of El Morro pool. Monitoring of pH on a monthly basis is necessary.

Interpretation--Visitors can often see the salamanders and discussions of the life of an amphibian in a semi-arid land might be rewarding. Nearly year-round, Cladocerans can be captured with a fine-meshed net and kept in a bottle for easy viewing with a magnifying glass. The fact that the pool is dominated by protists (single-celled algae and others), invertebrates (no fish, turtles, or mammals, and just one amphibian) is interesting. Here is an isolated aquatic ecosystem with no spring--the only source of water is rain and snow. Although we did not study them, other animals must use the pool--deer and other animals drink the water, birds and bats fly over its surface for insects, and the cattails especially are tied to the water.

References and literature cited

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- Whitford, L. A., and G. J. Schumacher. 1973. A manual of the fresh-water algae. Sparks Press, Raleigh, NC, 324 pp.

Table 1. Organisms identified in historic pool at El Morro National Monument

Common Name	Class	Order	Family	Genus/Species	Status*
Cattail	Angiospermae	Typhales	Typhaceae	<i>Typha latifolia</i>	c
Protist	Chlorophyceae	Zygnematales	Desmidiaceae	<i>Pleurotaenium</i>	u
Protist	Chlorophyceae	Zygnematales	Zygnemataceae	<i>Spirogyra</i>	c
Protist	Phytomastigophora	Euglenida	Euglenaceae	<i>Euglena</i>	c
Protist	Phytomastigophora	Euglenida	Euglenaceae	<i>Euglena elastica</i>	u
Protist	Phytomastigophora	Dinoflagellida	Ceratiaceae	<i>Ceratium hirundinella</i>	u
Roundworm	Adenophorea				u
Water mite	Arachnida	Hydrocarinae			u
Seed shrimp (Ostracod)	Crustacea	Ostracoda	Candoniidae	<i>Candona</i>	u
Copepod	Crustacea	Copepoda	Cyclopidae	<i>Acanthocyclops</i>	u
Copepod	Crustacea	Copepoda	Cyclopidae	<i>Cyclops</i>	u
Water flea	Crustacea	Cladocera	Daphnidae	<i>Ceriodaphnia</i>	c
Water flea	Crustacea	Cladocera	Daphnidae	<i>Alonella</i>	c
Water flea	Crustacea	Cladocera	Sididae		c
Mayfly larva	Insecta	Ephemeroptera			c
Damselfly larva	Insecta	Odonata			u
Dragonfly larva	Insecta	Odonata			u
Water boatman	Insecta	Hemiptera	Corixidae		c
Water strider	Insecta	Hemiptera	Gerridae	<i>Gerris</i>	c
Backswimmer	Insecta	Hemiptera	Notonectidae	<i>Notonecta</i>	c
Caddisfly larva	Insecta	Trichoptera			u
Midge larva	Insecta	Diptera			u
Fly larva	Insecta	Diptera	Dixidae		u
Mosquito larva	Insecta	Diptera	Culicidae		u
Tiger salamander	Amphibia	Caudata	Ambystomidae	<i>Ambystoma tigrinum</i>	c

* status: c = common (easily observed), u = uncommon (less frequently observed)

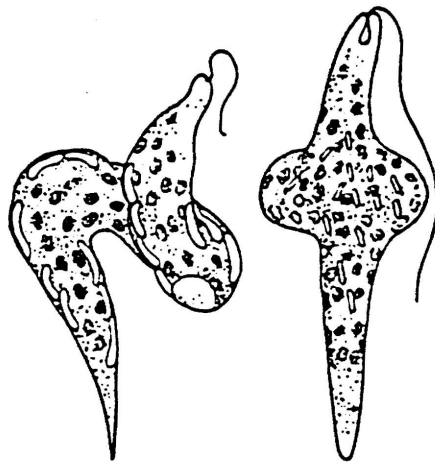


Figure 1. Typical *Euglena*. One on right is *Euglena elastica* (from Prescott, 1954).

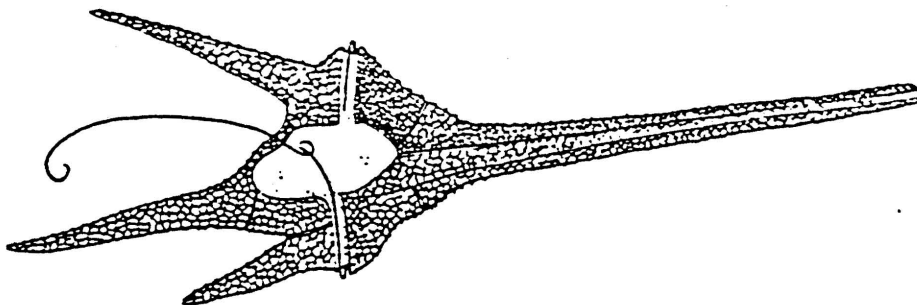
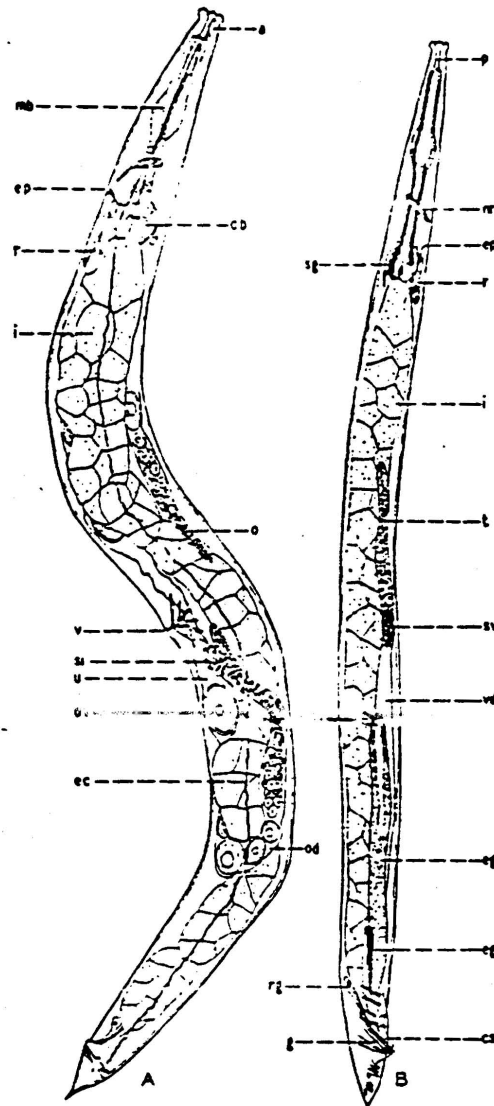


Figure 2. *Ceratium* (from Prescott, 1954.)



—Structure of *Rhabditis*, a typical fresh-water nematode, X95. A, female; B, male. A genital bursa is shown in the male, but this structure is rare in free-living species. a, amphid; cb, cardiac bulb of esophagus; cs, copulatory spicule; ec, excretory canal; eg, ejaculatory gland; ep, excretory pore; g, gubernaculum; i, intestine; mb, middle bulb of esophagus; nr, nerve ring; o, ovary; od, oviduct; ov, mature fertilized ovum; p, pharynx; r, renette; rg, rectal gland; sg, salivary gland (glands and ducts solid black; present in both sexes but shown only in figure of male); sr, seminal receptacle; sv, seminal vesicle; t, testis; u, uterus; v, vulva and genital pore; vd, vas deferens. (Modified from Chitwood, 1937, by permission.)

Figure 3. Nematode (from Pennak, 1989)

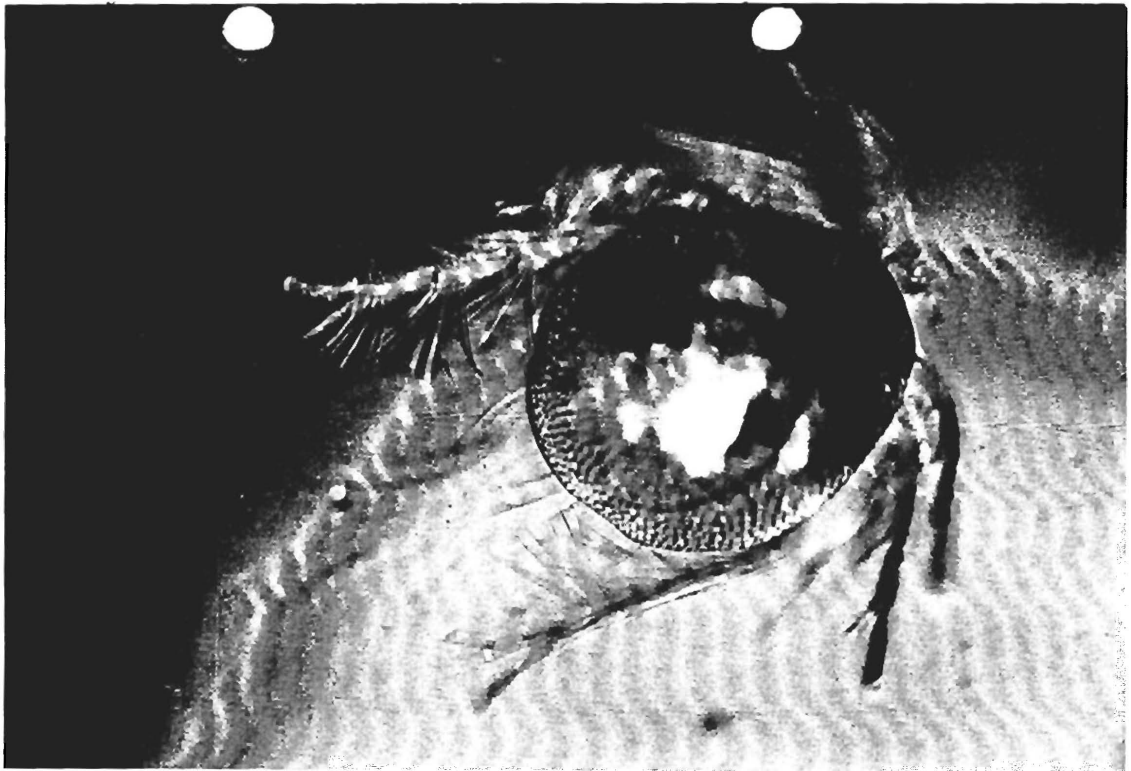


Figure 4. Water mite.

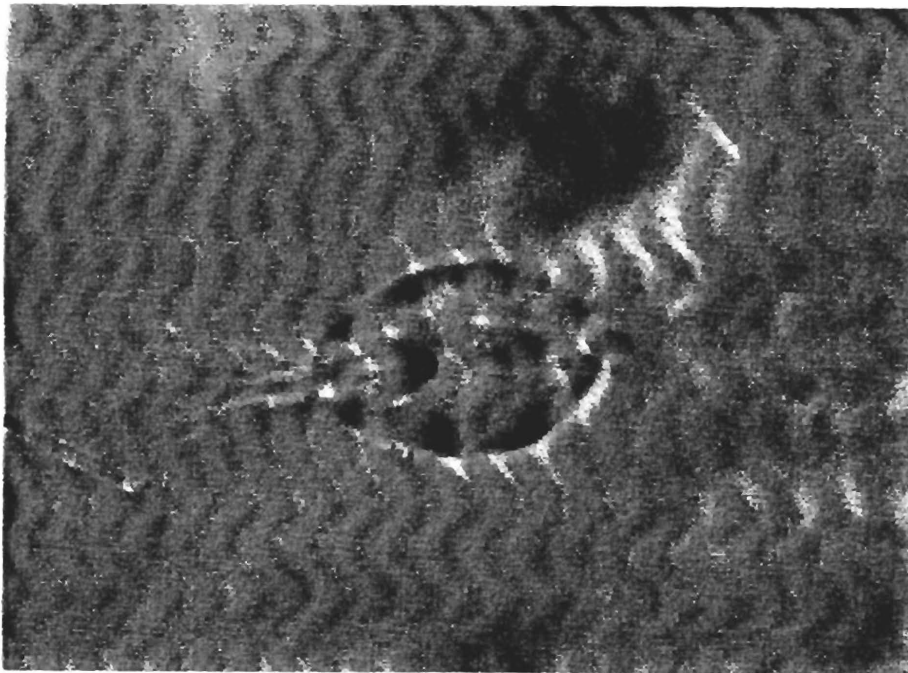


Figure 5. Seed shrimp.

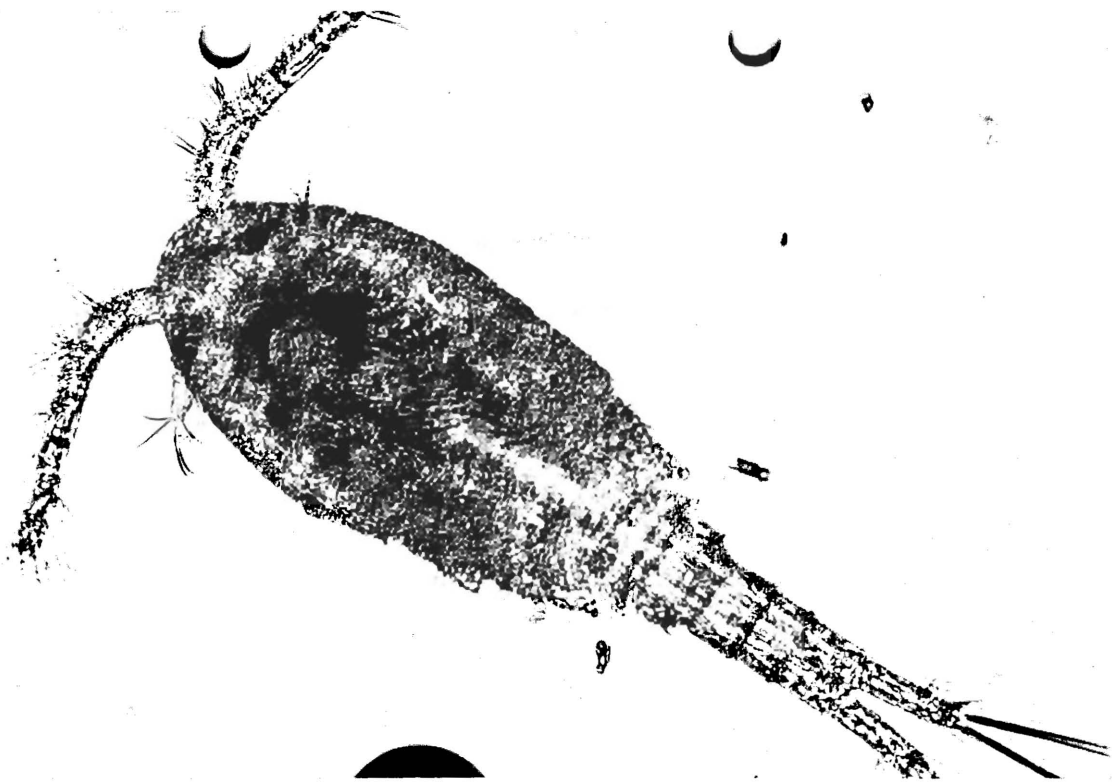


Figure 6. Copepod.

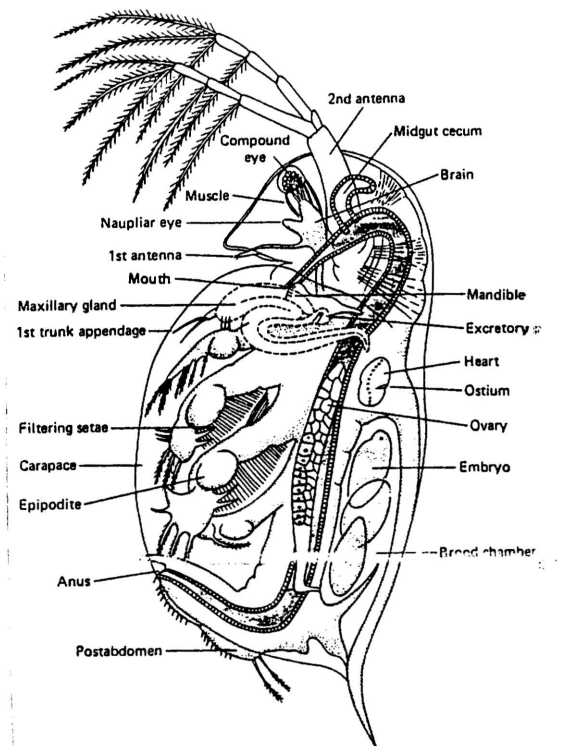


Figure 7. Cladoceran. Diagram on right from Barnes (1987).

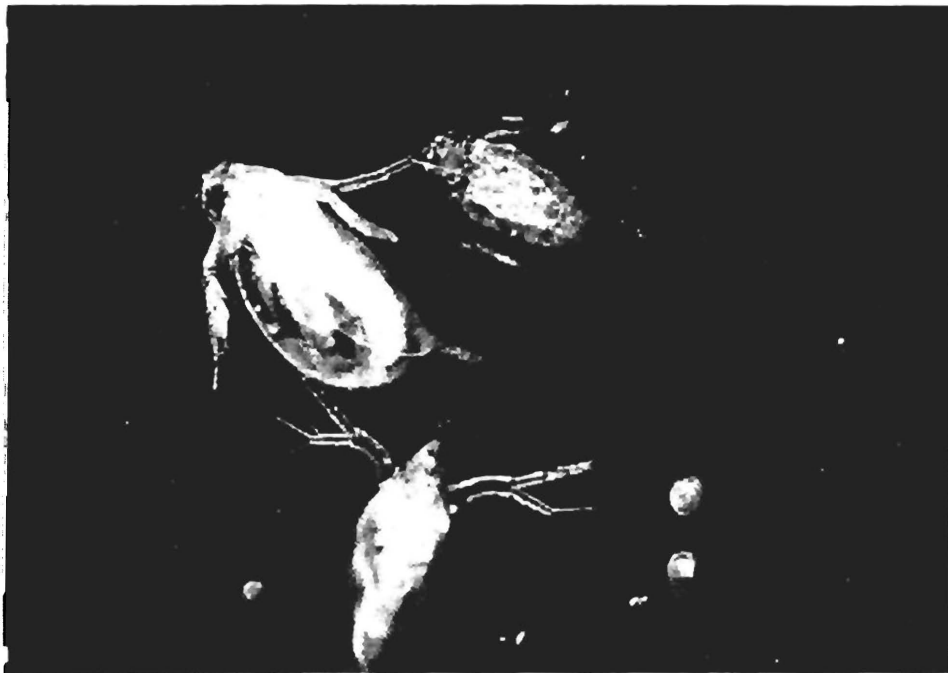


Figure 8. Cladoceran.

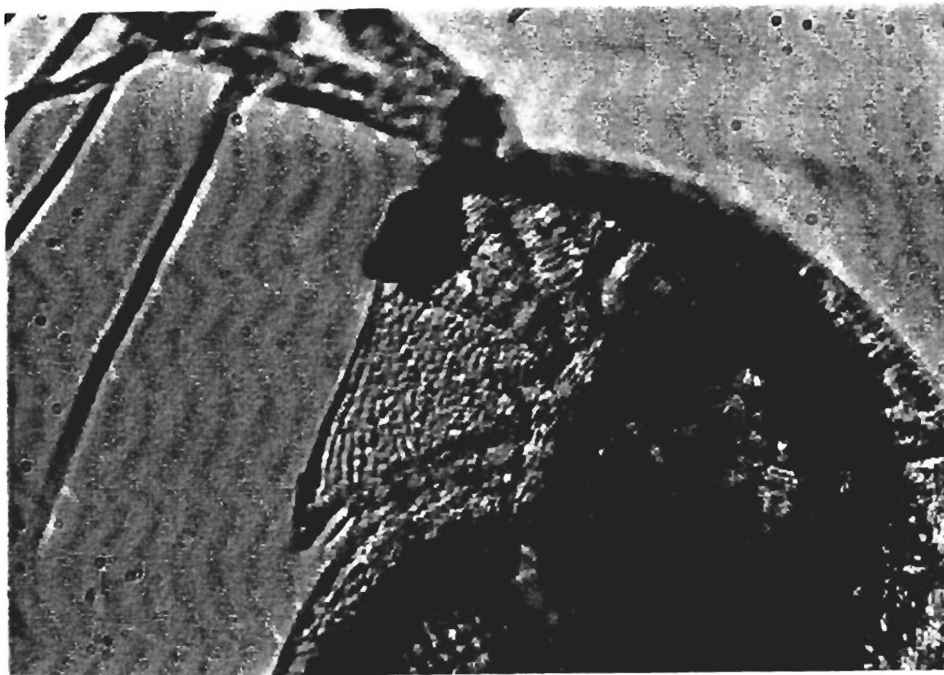


Figure 9. Cladoceran "helmet."

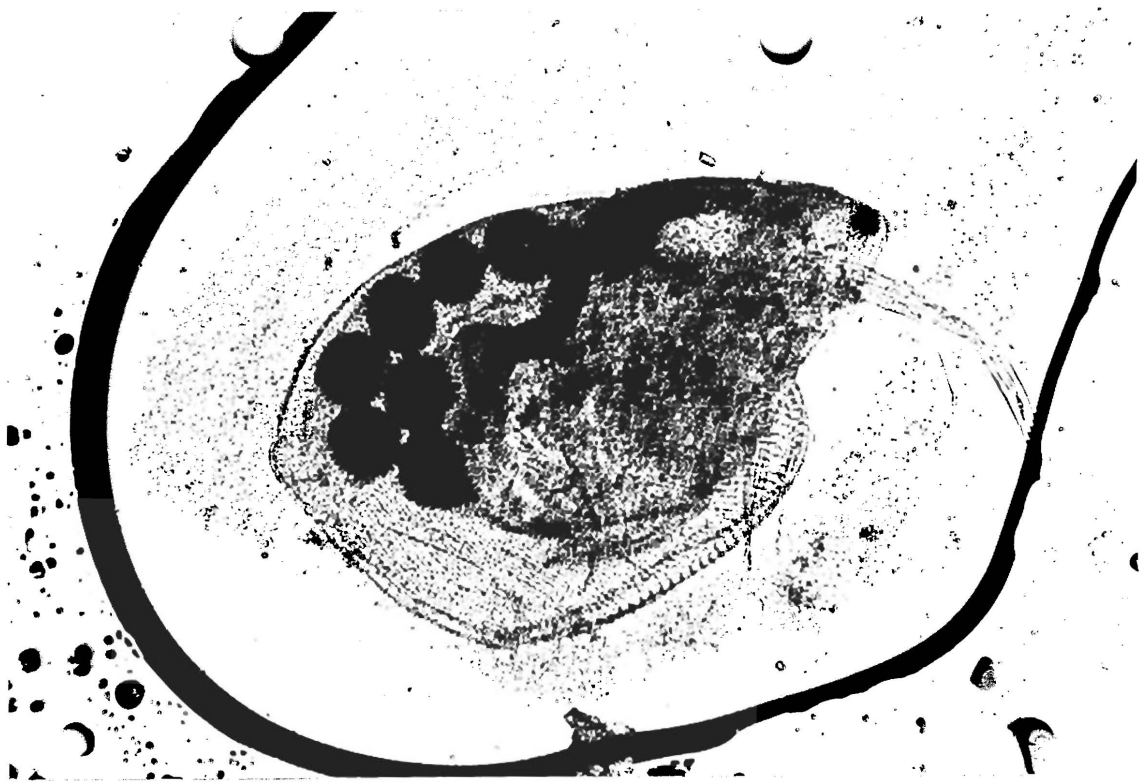


Figure 10. Cladoceran with eggs in brood chamber.

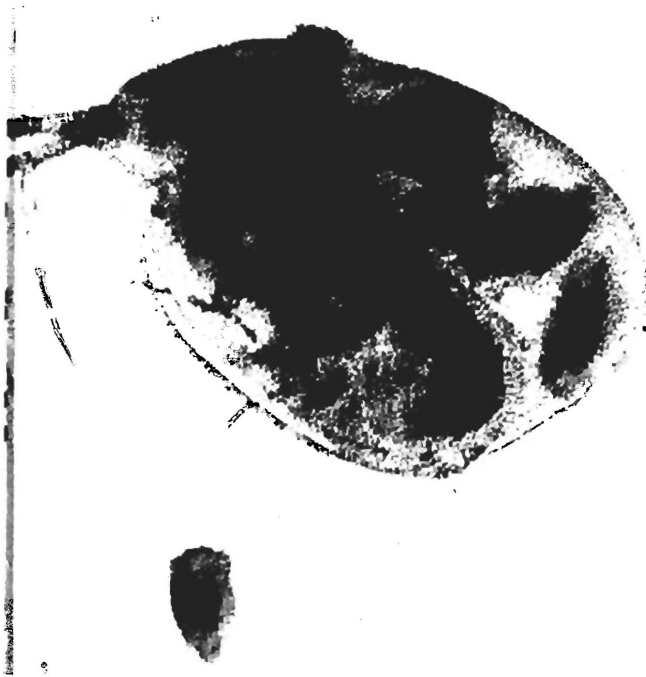
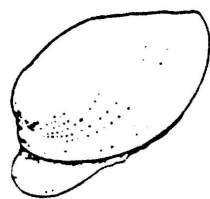


Figure 11. Cladoceran with young ready to leave brood chamber. Note recently released young individual swimming in lower left of photograph.



Figure 12. Ephippium (protective egg case).

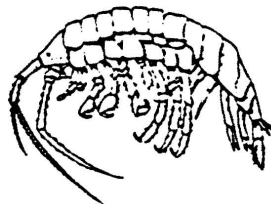
Macroinvertebrates Identification Chart



Fingernail clam



Leech



Scud



Blackfly larvae



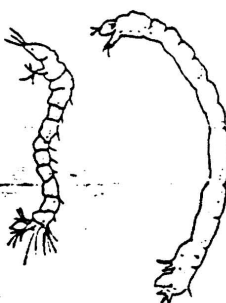
Horsefly larvae



Mosquito larvae



Crane fly



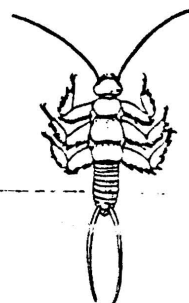
Midges (flies)



Caddisfly



Caddisfly cases



Stonefly



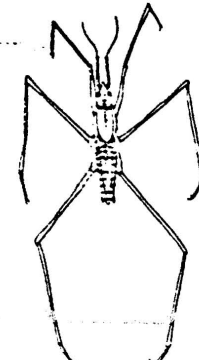
Mayfly



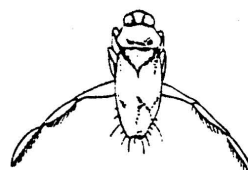
Damselfly



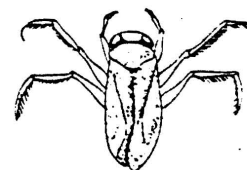
Dragonfly



Water strider



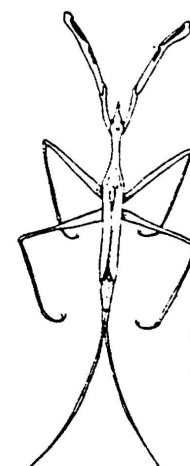
Backswimmers



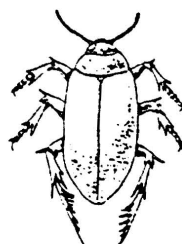
Water boatman



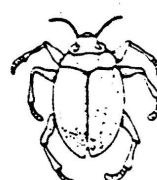
Giant water bug



Water scorpion



Predaceous diving beetle



Rifle beetle

Only the most common organisms are shown as immatures. The actual organisms may be smaller or larger than shown, due to species differences and maturation stage at collection time.

Figure 13. Mayfly nymph (from Enger and Smith, 1995)

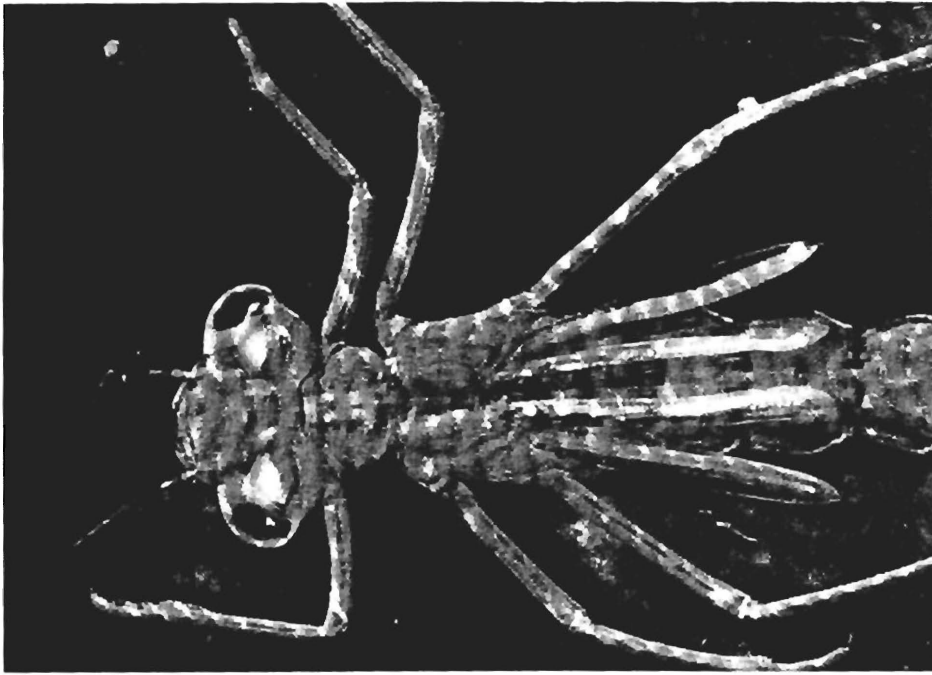


Figure 14. Damselfly nymph.

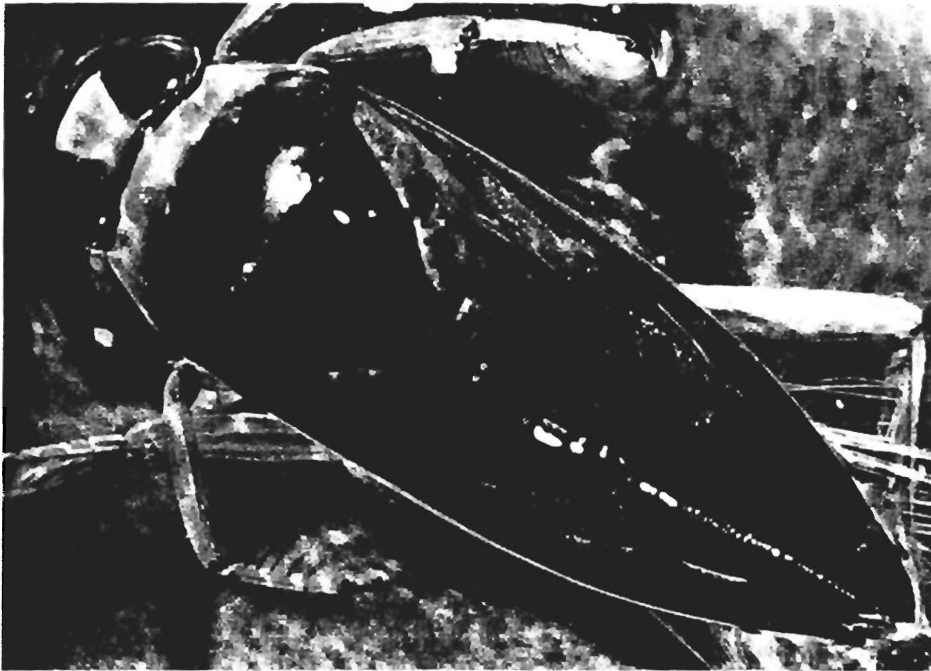


Figure 15. Water boatman.



Figure 16. Water boatman, close up. Note beak for piercing.

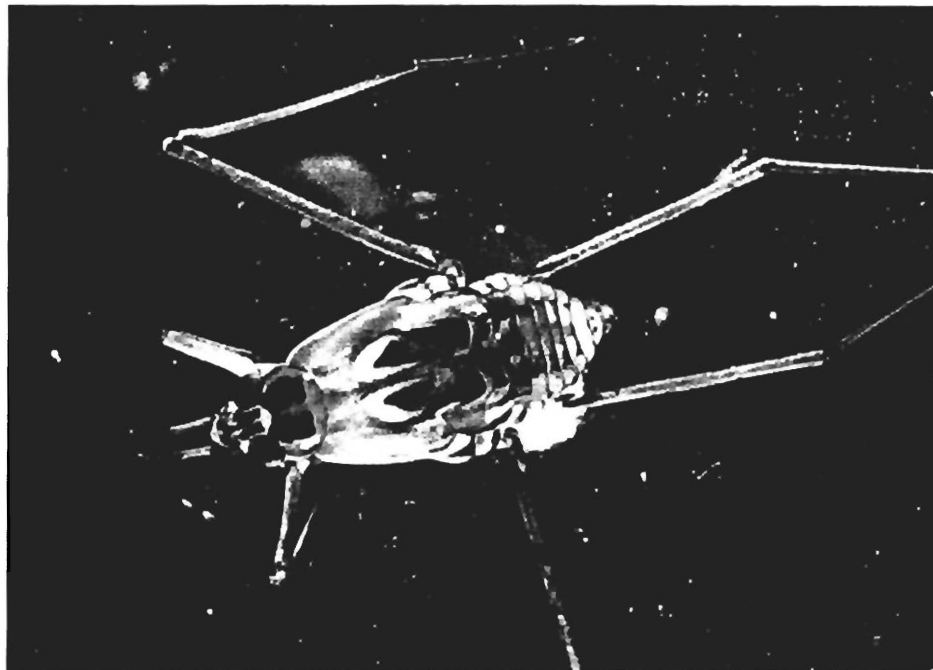


Figure 17. Water strider.



Figure 18. Caddisfly case.



Figure 19. Caddisfly, anterior end.

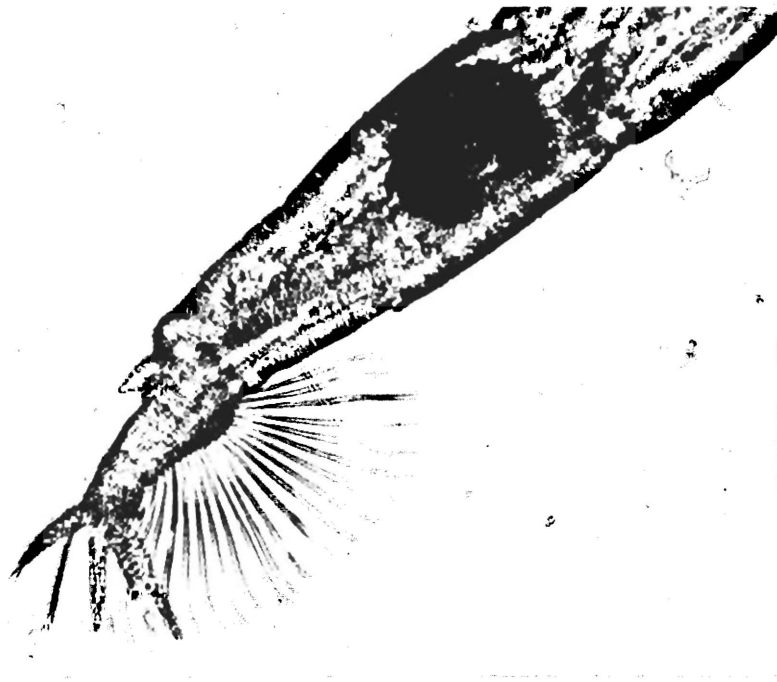


Figure 20. Midge larva.