FRESHWATER ZOOPLANKTON

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If one were asked to name examples of common aquatic organisms, it is most probably that the answer would include such animals as fishes and turtles, and plant names like cattail and moss would most certainly head the list. However, in such instances the term “moss” is probably being applied to any one of several types of plants, ranging from filamentous algae (stringlike colonies of single-celled plants) to rooted flowering plants like the common pondweed, Potamogeton, rather than to a true moss. Regardless of the correctness of the names used, most of the organisms named will probably be large and easily observed. Everyone learns at an early age to recognize a fish or a bird; and anyone who has gone fishing will recall the “darned” moss that fouled the fishing line and the emergent plants, like cattails, which may have served as nesting sites for red-winged blackbirds but made fishing from the shore of some lakes difficult, if not impossible.

Few people are aware of the teeming microscopic life which abounds and plays such a vital role in our ponds, lakes, and streams. This is not surprising because few people have had the opportunity to view a sample of lake water under a microscope, but those that have are frequently amazed at the variety of microscopic organisms found; and the beauty and interesting shapes of such organisms as desmids, diatoms, and rotifers are exciting to behold. (Fig. 1).

TYPES OF AQUATIC LIFE

The aquatic ecologist uses several special terms to characterize different kinds of aquatic organisms, based primarily upon either relative size or place within the lake or stream where they can be found. Nekton are large freely-swimming animals such as fishes and some species of aquatic insects. Members of the nekton are strong enough to navigate against water currents. Neuston consist of organisms which float or swim on the surface or just below the surface film. The tiny duckweeds, water striders, and whirligig beetles are examples of neuston. Benthos live on or in the bottom sediments; clams and animals which burrow through the sediment represent these kinds of organisms. Microscopic plants and animals which are attached to submerged objects make up the periphyton or aufwuchs. Some diatoms, the well-known fresh-water hydra, and sessile protozoans such as Vorticella are examples. Forms of microscopic life which are suspended or floating in the water column are termed plankton. Although many plankters are capable of locomotion,
A. Pediastrum, a desmid.

B. Staurastrum, a desmid.

C. Zygnema, a filamentous green alga.

Fig. 1. Examples of microscopic plants and animals (plankters) found in lakes.

their movements are more or less controlled by water currents. Plankton can be subdivided into zooplankton, or animal plankters, and phytoplankton, or plant plankters. Macrophytes are the larger aquatic plant forms and they include rooted flowering plants, like cattails and water lilies, as well as some forms of macroalgae, such as Spirogyra and Cladophora.

From the above discussion it is obvious that there exists a great variety of plants and animals and microorganisms in our aquatic communities. We will focus our attention upon the major kinds of zooplankters that can be found in Kansas waters. Identifying characteristics, methods of collecting and observing, and life cycles will be discussed. While actual identification of species requires experience, it is possible to learn to recognize some of the common zooplankters on the basis of general body shape.

COLLECTION AND PRESERVATION

Because of their small size (most zooplankters are less than 1-2 mm in length) these animals are most easily collected by straining water through a fine mesh net. Plankton nets can be purchased from any firm selling biological supplies, but commercially constructed nets tend to be very expensive. However, it is relatively easy to construct your own net, the sturdiness of the final product being determined by your imaginative design and the nature of the materials selected from which you construct the net.
Examples of a homemade townet are shown in Fig. 2. Special plankton netting can be purchased from commercial sources, but any fine woven cloth can be used, such as ladies stockings or panty hose. Additional information on constructing nets can be found in previous issues of The Kansas School Naturalist (Life in a Pond, 1957, Vol. 3, No. 3; and Let's build equipment, 1962, Vol. 8, No. 4).

**Use of Nets.** A dipnet works very well if you plan to collect zooplankton from small shallow habitats such as roadside ditches and temporary pools. For larger, deeper bodies of water the townet works best. The net is cast into the lake from the shore or from a boat and then slowly pulled through the water as it is retrieved. If the sample is taken in a deep lake from a boat it is possible to sink the net to the bottom, or some predetermined depth, and then pull the net vertically to the surface. By using a combination of vertical tows from different depths

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Fig. 2. Townets can be thrown into deeper lakes and retrieved with the attached rope.
and horizontal tows from different regions it is possible to obtain some ideas concerning the distribution and abundance of zooplankters in a lake.

The total volume of water strained during each tow can be estimated by calculating the volume of a cylinder whose diameter is equal to the diameter of the mouth of the tow net and whose length equals the distance the net is towed through the water.

Preservation of samples. It is more exciting to observe living zooplankton than looking at preserved materials, since one can see how zooplankters locomote, respond to various kinds of external stimuli, and how they obtain their food. Also, some zooplankters become distorted when preserved so that it is impossible to recognize them. None-the-less, chemical preservatives should be added to zooplankton samples unless the specimens are to be examined immediately.

Formalin and alcohol are the most widely used chemicals for preserving zooplankton. Either a 5% formalin solution or a 70% isopropyl alcohol solution (rubbing alcohol) can be used for most of the common forms of zooplankton, but soft-bodied forms require special handling, and directions for preserving them can be found in the technical literature. An excellent summary of methods for preserving aquatic invertebrates is included in a recent publication of the State Biological Survey of Kansas which is listed with other references at the end of this issue.

**TYPES OF ZOOPLANKTERS**

The majority of species of zooplankters found in Kansas will belong to either the rotifers, copepods, or cladocerans. At times, certain species of single-celled animals, the Protozoa, may also be abundant. However, protozoans will not be included in this discussion of zooplankton.

Rotifers. These tiny animals are classified in the Phylum Rotifera, a name derived from a special ciliated structure near the mouth which in many species looks like a rotating propeller or wheel when it is beating. Although some rotifers, such as Asplanchna, may be several millimeters in length, most species are smaller (1 inch = 25.4 mm). Most planktonic species are solitary, but there are some forms which are colonial. The body of a rotifer is covered by a nonliving cuticle which is thickened in many planktonic forms like Keratella which gives them a rather characteristic and constant shape. Other rotifers, like the large relatively transparent Asplanchna, have a thin cuticle; thus, their body is soft and can change shape.

Identification of rotifers to the species level is difficult, but many of the common genera found in Kansas waters can be recognized by their shape; some common Kansas rotifers are represented in Fig. 3.

The life cycle of rotifers is interesting because these animals are parthenogenetic throughout most of the year. In fact, some species apparently reproduce only by parthenogenesis, since
males of these forms are unknown. In most species of rotifers, males do appear periodically, but the factors which control their appearance are not fully understood. Parthenogenesis is considered as a form of sexual reproduction because an egg, or ovum, is involved. However, the parthenogenic egg, for some reason, undergoes only a single meiotic reduction in the number of chromosomes present in the mature egg; and consequently, this type of egg is diploid (2n) and develops into a diploid female without being fertilized by a male. Females which produce diploid eggs are termed amictic females. Often with the onset of marked changes in environmental conditions some females begin producing eggs which undergo the usual double meiotic reduction in chromosome number. Females which produce these haploid (n) eggs are termed mictic females. The words mictic and amictic are derived from the Greek word "mixis" meaning mixing, which apparently refers to the occurrence of fertilization, i.e. the mixing or combining of chromosomes from two different individuals. If the haploid eggs from a mictic female are not fertilized, as will be the case of the first of these eggs to be produced by the population, they develop parthenogenetically into haploid males. Once males appear in the population and produce sperm, any haploid egg that is fertilized develops into a resting, or winter, egg which is highly resistant to desiccation and temperature changes. Actually, the development of a fertilized egg is arrested for varying periods of time.

Fig. 3. Common rotifers found in Kansas lakes and ponds.
In some cases such an egg may not hatch until the following spring. At any rate, fertilization restores the diploid condition (2n) and when these eggs hatch a diploid parthenogenetic female results. Thus, in rotifers, as in bees and cladocerans, sex is determined by the chromosomal number rather than by specific sex chromosomes. The life cycle of a rotifer is diagrammed in Fig. 4.
**Cladocera**

These microcrustaceans are commonly called water fleas, and most of the more commonly collected species in Kansas will range about 0.5-2.0 mm in length. As members of the Class Crustacea, the Cladocera are therefore taxonomically related to the freshwater crayfish and the marine crab, even though they do not look similar. Cladocera can be found in almost any kind of freshwater habitat, but are usually absent or scarce in rapidly flowing streams. Since these animals are planktonic, they are not capable of swimming against strong currents, hence they are dashed against rocks in the turbulent water or rapids and destroyed. However, the quiet and slowly flowing pool reaches of streams and rivers often support an abundance of these zooplankters. There are only a few marine species of Cladocera.

The life cycle of a cladoceran is similar to that described for rotifers, in that females are parthenogenic throughout all, or most, of their lives. Males appear infrequently, usually after the onset of adverse environmental conditions. The "winter" egg, or fertilized egg, is quite resistant and may not hatch for several months. Such eggs develop into parthenogenic females that in turn will produce several parthenogenic eggs at a time which are retained in a special brood chamber under the exoskeleton. Embryonic development takes place in the brood chamber. There is no larval stage; the parthenogenic egg hatches into a small adultlike parthenogenic female.

Cladocera strain tiny food particles from the water using their five or six pairs of thoracic legs. Each leg is very thin and lobed with numerous hairs along the edges which strain the food particles from the water. Because these animals feed upon phytoplankton and other microscopic particles they play important ecological roles in aquatic communities as primary consumers or herbivores.

The body of the water flea is usually inclosed in a thin carapace which is folded dorsally, giving a bivalved appearance (Fig. 5). The head bears a single compound eye, and a pair of branched appendages, called antennae, extend laterally from the side of the head. These appendages possess numerous long bristles and serve as swimming organs. The thoracic legs extend ventrally toward the opening between the sides of the carapace. The body ends in a special structure called the postabdomen which bears a pair of large claws at its distal end. There may also be numerous small teeth along its lateral and dorsal margins. The postabdomen is apparently used to clean debris from the legs. Examples of different types of cladocerans are represented in Fig. 6.

**Copepoda**

The Copepoda are also members of the Crustacea, and they can be found in virtually any body of freshwater. In addition, many species of copepods are marine; this was not true for rotifers and cladocerans.
Fig. 5. The body plan of a cladoceran.

A. *Daphnia*  
B. *Bosmina*
Copepods can be easily distinguished from rotifers and cladocerans by their general shape (Fig. 7). In general, the copepod body is elongated and tends to taper towards the posterior end. The head and first few thoracic segments are covered dorsally by the carapace, and there is a single pigmented eyespot at the apex of the carapace. Locomotion is by the unbranched but segmented antennae which are inserted along the leading edge of the head. On the ventral side of the thorax are five pairs of segmented legs which bear many small spines and setae. In some species, the fifth pair of these legs is reduced in size and can not be easily seen unless magnified. The abdomen does not bear appendages; the last abdominal segment is branched and each ramus bears numerous spines and long hair-like structures called setae.

Sexes are separate. Females retain the eggs in egg sacs which, when present, are variously attached to the last thoracic segment. In males, the first antennae are modified for clasping the female. The egg hatches into a typical crustacean larval stage called a nauplius. The developing copepod then undergoes a series of molts. Each of the resulting developmental stages becomes larger as the various appendages and adult features develop. The time from hatching to the adult...
stage is highly variable among species.

Some copepods are parasites of fish, but most are free-living, and feeding varies from filtering smaller plankters to actively seizing prey organisms. Most planktonic forms of copepods collected from Kansas waters belong to one of two groups, the calonoids and the cyclopoids. The former tend to be larger than cyclopoids, usually being 1-3 mm in length. In the calonoid forms, each caudal ramus bears five or six stout short setae which give the appearance of the tines of a pitch fork. Their antennae are composed of 22 or more segments and are nearly equal in length to the body.

The cyclopoids are usually smaller than the calonoids. Their antennae are, at most, only slightly longer than the carapace, being composed of 17 or fewer segments. The caudal rami tend to be longer than those of the calonoids, and each ramus bears at least two long setae plus several shorter setae and spines. Examples of some of the common general of copepods are shown in Fig. 8.

A. A female *Cyclops* with egg sacs.

B. A female *Diaptomus* with egg sacs.

C. A member of the Harpacticoids group of copepods which are usually found in the shallow regions of lakes and ponds among the bottom detritus.
REFERENCES


SUGGESTED CLASS ACTIVITIES

There are many class activities and projects that can utilize members of the zooplankton community of a pond or lake to demonstrate various biological processes. The following are examples of activities which can be accomplished with a minimum of time or equipment required. In most instances the only equipment needed are plankton net and microscope, items which generally can be made available in any Kansas high school.

**Constructing a plankton net.** Some students may be interested in constructing their own plankton net. Examples of homemade nets are shown in Figure 2. In general, the diameter of the mouth of the plankton net need not exceed 25-30 cm, or approximately 10-12 inches. The main materials needed for constructing a net are: (a) a rim of relatively rigid material, either round or square; (b) a fine mesh cloth for the net; (c) a small diameter rope or twine to serve as a tow rope; (d) a female hose coupling, and (e) small bottles that will screw in the house coupling.

A commercial source for netting is the Wildo Wildlife Supply Company, 301 Cass Street, Saginaw, Michigan 48602. Commercially constructed nets can also be purchased directly from Wildo or from any Biological Supply Co. such as Turtox/Cambesco, 8200 South Hoyne Avenue, Chicago, Illinois 60620, however, costs will run from approximately $20.00 and more depending upon the size and mesh of the net.

**Heart beat in Daphnia.** The heart is easily seen in *Daphnia*, or any other of the larger cladocerans, so it is possible to observe the heart beating using magnifications of 20x to 40x. One method of doing this is to use a toothpick to draw a ring of vaseline on...
a clean microscope slide. Make the diameter of the ring about that of a dime and then place a small speck of the vaseline in the center of the ring. Now transfer a drop of zooplankton containing Daphnia to the ring and examine with the aid of a dissecting microscope. Using a toothpick or small needle maneuver a large Daphnia onto the speck of vaseline and turn the trapped animal so that the dorsal heart is visible. See Figure 5 for the general morphological features of a Daphnia. If a cover slip is now placed over the ring of vaseline and gently pressed down the preparation can be used for several hours.

One can also use this method to demonstrate the effect of temperature on the heart rate. Simply heat or cool the prepared slide and count heart beats for a given period of time. One could first acclimate the zooplankton to the desired temperatures and then prepare a slide as described above and count the heart beats per unit of time.

Reproductive rates of Cladocera. Since cladocerans reproduce by parthenogenesis most of the time it is possible to analyze a zooplankton sample to determine the proportion of a population which bears parthenogenic eggs and to calculate the average number of such eggs contained in the brood chamber. The brood chamber is located dorsally, just below the carapace and the eggs and embryos therein can be seen and counted (Figure 5). It would be of interest to determine if all species of cladocerans are reproducing at the same time, and to learn if there are apparent differences in the reproductive rates between species and during different seasons.

The same study can be made of the copepods. However, sexes are separate and it is more difficult to distinguish between the females of different species. Still, it would be possible to determine the proportion of all females of one type which carry egg sacs and to calculate the average number of eggs contained in an egg sac. There are many other questions that can be asked and the answers sought. For example, how long does it take for the parthenogenic egg of a cladoceran to develop and the young to be released from the brood chamber? From "hatching," how long does it take the new individual to begin producing eggs? Do old individuals produce more eggs than young ones and how many batches of eggs does an individual usually produce during its lifetime? There are few limits on the number of questions that you might ask, and the fun of science is in finding ways to answer the questions.

Determining abundance of zooplankters in a pond

It is possible to estimate the density of the zooplankton population (number per volume of water) in a pond or lake by the following method. Collect a series of plankton samples from different regions of a pond by allowing the net to sink to the bottom and then slowly raise the net to surface. It is important that the tow net be kept in a vertical position.
Record the actual distance, in meters, the net was pulled through the water. Later, calculate the volume, in liters, of a cylinder whose height is one meter (100 cm) and whose diameter is that of the diameter of the plankton net mouth in cm. The answer (volume) will be in cubic centimeter (cm$^3$ or cc). There are 1000 cc in one liter, so by dividing the volume of the cylinder by 1000, the volume of the cylinder is transformed from cm$^3$ to liters. This answer represents the number of liters of water strained for each meter the net is pulled through the water. Now by multiplying the liter value by the number of meters the net is towed, the total volume of water strained in taking the sample is determined.

\[
\text{volume of a cylinder} = H (\pi r^2)
\]

Where $H$ in this case = 100 cm and $r$ = the radius in cm of the net mouth. The solution is $H$ times 3.142 times $r^2$. Then dividing the solution by 1000, the volume is translated into liters.

The next step is to make each plankton sample to a known, constant volume. For example either add or remove water from the sample until its volume is 50 ml. Now stir the sample to disperse the plankters and withdraw a 1.0 ml subsample. Put this subsample into a small dish or counting cell and count all the individuals present. Repeat this step several times until the accumulative average number of plankters per ml of the concentrated sample remains essentially the same. The accumulative average is found by adding the number of individuals in the first two subsamples and dividing by two, then add the individuals in the first three subsamples and divide by three, and so on.

Once you have calculated the average number of plankters per ml of the concentrated sample you can estimate the total number of individuals contained in the sample and calculate the average number per liter of water by substituting your known values into the following formula:

\[
\text{Number of individuals per liter} = \frac{\text{average number per ml} \times \text{volume in ml}}{\text{number of liters strained}}
\]

It might be interesting to determine if there are more cladocerans than copepods or rotifers present in a sample. It would also be possible to study the fluctuation of a population through time by taking a set of samples from a pond every few days or weeks.

**Identification of Species**

The identification of zooplankters to the species level requires considerable practice, patience and experience. It is possible though to develop sufficient skill to recognize some of the common genera of cladocerans, copepods, and rotifers if one is willing to make careful observations and practice recognizing different genera. Unfortunately, there is no single simple taxonomic key one can turn to for the identification of zooplankters. One must learn the meaning of technical terms used in a key, and finally it is most helpful if someone experienced with identifying plankton is available to verify your results.
MOUNTAIN ECOLOGY COURSE
Summer Session, 1977

The Division of Biological Sciences of Emporia State College is offering a four-credit hour course in Mountain Ecology during the Summer Session of 1977. Dates for the course are 18 July through 6 August and students may earn either graduate credit by enrolling in EN 859A or undergraduate credit by enrolling in EB 459A. Students who will be seniors in high school during the 1977-78 school year may enroll for undergraduate credit.

The course will be conducted in the Pecos Wilderness in northern New Mexico. While the course is conducted students will have a chance to observe and learn about the physical and biological aspects of a montain environment, travel through a relatively undisturbed wilderness area and appreciate the aesthetic qualities of a wilderness experience. Class members will camp out, prepare their own food, backpack, and study under a variety of out-of-doors conditions and in a variety of areas.

For additional information write to:
Dr. Dwight L. Spencer
Division of Biological Sciences
Emporia Kansas State College
Emporia, Kansas 66801

GREAT PLAINS FIELD STUDY

This summer Emporia State College is offering a 3-week course on the Great Plains. This will be a multi-disciplinary approach to the area. While traveling and visiting various sites in the Great Plains, the students will be studying the area from biological, historical and aesthetic viewpoints.

The course will be held from 6 June-24 June for 4 hours of credit. More information on the course can be obtained on request from:
Ms. Leanna Smith
Division of Biological Sciences
Emporia Kansas State College
Emporia, Kansas 66801

The Division of Biology offers an attractive and informative series of courses during the Summer Session, which opens June 6. Information concerning these courses may be obtained by writing to either the Division of Biology or the Office of Admissions, Emporia Kansas State College, Emporia, Kansas 66801.

Do you have trouble remembering scientific names and their meanings? Try the Biological Terminology course! (2 hr. credit, June 27-July 15).