LITERATURE CITED


USE OF COMMENSAL PROTOZOA AS BIOLOGICAL INDICATORS OF WATER QUALITY AND POLLUTION¹

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Antipa, G. A. 1977. Use of commensal protozoa as biological indicators of water quality and pollution. Trans. Amer. Micros. Soc., 96: 482-489. Commensal ciliated protozoa of fresh-water bivalve molluscs were tested for their ability to detect conditions of organic pollution within a small midwestern stream. Data are presented which demonstrate that one of these ciliates, Heterocinetopsis unionidum, responds rapidly to unfavorable conditions. The further development of sensitive biological indicators and their potential to warn of impending and possibly irreversible environmental change are discussed.

Biological indicators have been used extensively in assays of water quality. This approach has involved broad surveys of the aquatic biota which take into consideration the general ecology of an area and result in the classification of water quality with respect to organic pollution (Goodnight, 1973; Wilber, 1969). While such biological analyses offer certain advantages over chemical and physical methods (e.g., see Egloff & Brakel, 1973), there are three major drawbacks

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to this approach: (1) a significant and long-term change in the biology of the environment is necessary before conditions can be recognized and accurately categorized, (2) indicator organisms are dependent on and limited to the biota present at the locale in question, and (3) considerable expertise is required to make the necessary identifications needed to complete the analysis of water conditions.

Members of almost every group of aquatic plants and animals have been considered useful indicators of water quality. Recently, the protozoa have been added to this burgeoning list (Bick, 1972; Burbank & Spoon, 1967; Cairns & Dickson, 1971; Curds, 1966; Patrick & Cairns, 1967; Sladekova & Sladecek, 1966). The accumulated evidence suggests that the unicellular and fastidious protozoa are more responsive to their environment than multicellular organisms. As a consequence, although they are microscopic and hence difficult to work with, evaluations of water quality based on their presence or absence have been especially accurate; and studies on the effects of specific pollutants on the protozoa will increase the dimension of their utility (Carter & Cameron, 1973; Sudo & Aiba, 1973).

While most studies which have involved the protozoa rely on a multitude of analytical methods for dealing with free-living protozoa, there are two reports which suggest that commensal ciliated protozoa may provide valuable, but as yet untapped, information (Laird, 1959; Thiemenmann, 1950). Thiemenmann suggests that epibiont ciliated protozoa provide a far more accurate indication of water pollution than the invertebrate host amphipods on which they reside. Similarly, Laird suggests that the epicommensal protozoa of mosquito larvae appear with a regular relationship to polluted environments.

I set out to experimentally test these suggestions and present evidence here which indicates that the commensal ciliated protozoa of fresh-water pelecypods (fresh-water mussels or clams) provide not only a critical index of water quality but an indication which may be beyond the resolution of other available methods.

DESCRIPTION OF THE STUDY SYSTEM

The Organisms

I chose to analyze the ciliated protozoa which are obligatory commensals within the mantle cavity of fresh-water bivalve molluscs. Since the fresh-water mussel and its commensals are abundant throughout the Greater Mississippi Valley Drainage System in ponds, lakes, creeks, streams, and rivers, their use as indicators would not be restricted to a specific class of waterway or water body but could be universal for fresh water within the Midwest. Additionally, it is well documented that unionid bivalves, themselves, are rapidly affected by conditions of poor water quality (Coker, et al., 1921; Ingram, 1957; Wurtz, 1956). Their presence has therefore indicated “good water.”

The ciliates are epicommensals which reside either on the surface of the fleshy portions of the mantle or attached to the gills. As a consequence, they are bathed in environmental water which the bivalve mollusc circulates through its mantle cavity. The position of these ciliates within their clam hosts gives them a well-defined microniche; a niche which is not drastically affected by seasonal factors that may change the ecology of the external habitat. Further, the limited territory of the clams allows for the same population, or even the same individual, to be sampled repeatedly.

During this investigation I was specifically concerned with the free-swimming ciliate Conchophthirus curtus and the attached ciliate Heterocinetopsisunionidarum. Both are described in detail elsewhere (Antipa & Small, 1971a,b). Conchophthirus was associated with both unionids Anodonta grandis and
FIG. 1. Map of the study area indicating locations of the Champaign-Urbana Sanitation Plant (*) and sites of the planting experiment on the Saline Ditch (A–C), Salt Fork Vermilion River (D, E), and Spoon River (F). Mileage indicator appears in lower right.

*Lampsilis ventricosa*, while *Heterocinetopsis* was only commensal on *Anodonta grandis*.

**The Approach**

It has been previously established that both *Conchophthirus* and *Heterocinetopsis* are indigenous to unionid bivalves of unpolluted environments (Antipa & Small, 1971b). Mussels known to be infected with *Conchophthirus* and *Heterocinetopsis* were planted in locations of known pollution, recovered, and examined for their relative ciliate abundance.

**The Stream**

The study stream was the Salt Fork of the Vermilion River and its tributaries. The source of organic pollution was the treated wastewater put into the stream by the Champaign-Urbana, Illinois Sanitation District. The Salt Fork is a typical small midwestern stream which shows seasonal fluctuations of flow. At times during the summer months, the sewage effluent may represent as much as 50% of the flow of the Saline Branch of the Salt Fork, and urbanization over the years has continually increased the organic load on this stream. The retreat of mussels from the Saline Branch and in regions of the Salt Fork between St. Joseph and Sydney has been well studied (Baker, 1922; Matteson & Dexter, 1966; Van Cleave, 1940). Documentation of the mussel fauna as well as physico-chemical and biological data available on this stream made it an ideal subject for the planting experiment.
**Planting Experiment**

A number of *Lampsilis ventricosa* and *Anodonta grandis* were gathered from Wilmington strip mine #2 (Antipa & Small, 1971b). Both of these host species normally appear in the Salt Fork of the Vermilion River. All hosts were examined prior to planting for the presence of commensal ciliates, and it was established that all *L. ventricosa* were infected with *Conchophthirus curtus* and all *A. grandis* were infected with both *C. curtus* and *Heterocinetopsis unionidarum*.

Six specimens of *A. grandis* and four specimens of *L. siliquoidea* were planted at each of six locations on the Saline Ditch-Spoon River-Salt Fork Vermilion River.
Fig. 3. Results of the planting experiment for Conchophthirus, Heterocinetopsis, and clams at polluted stations B–D. Symbols are as in Fig. 2.
study area (see A–F, Fig. 1). Planting station B, 0.75 miles downstream from the
Champaign-Urbana sewage disposal plant, is considered to be α-mesosaprobic.2
Planting station C (7.5 miles downstream from the sewage disposal plant) is an
area of β-mesosaprobic condition. Station D (16.5 miles downstream) is an
area of β-mesosaprobic to α-oligosaprobic condition; this is where stream recovery
begins and where unionid bivalves naturally occur; this includes both A. grandis and L. siliquoidea. Stations B–D are thus in locations of differing
pollution. Stations A, E, and F are considered to be control stations; that is,
they are located in areas of so-called “clean water” and have a β-oligosaprobic
index. Station A is 3.75 miles above the sewage disposal plant; Station E is
42.75 miles downstream and apparently relatively unaffected by intervening
pollutants; and Station F, at the headwaters of the Spoon River tributary, is also
considered to be a clean environment.

As there is no way of quantitatively measuring the ciliates present within a
clam without damage to the host, all clams were considered to contain the
subjective “numerous” number at the time of planting. Based on the results
from the control stations and our knowledge of the Wilmington pond clams,
this appears to have been a reasonable approximation.

One mussel of each type was collected on the second and ninth days after
planting. Data from host examinations on the ninth day indicated that mussels
from the polluted Stations B and C were either dead or in a weakened condition;
this prompted examination of remaining mussels from the polluted stations.
Mussels at the control stations were collected individually over a period of 72
days.

The results of host examinations are presented in Figs. 2 and 3. Polluted
stations had a uniformly detrimental effect on the ciliates as well as their clam
hosts, while both hosts and ciliates at the control stations were apparently
unchanged.

Conchophthirus showed somewhat greater sensitivity to water conditions
than did its host. It disappeared from hosts within 10 days at stations B and C;
however, at the slightly polluted station D, no change could be noted during
the 10-day-period of investigation. Data for Conchophthirus from the Anodonta
and Lampsilis hosts did not significantly differ. Conchophthirus appeared at
control stations until the last specimen was examined, some 72 days after
planting.

Heterocinetopsis appeared to be very sensitive to water quality. At the most
highly polluted station, B, they could not be found after two days, the earliest
check; at stations C and D, they could not be found after 10 and 9 days,
respectively. All control stations exhibited uniformly abundant Heterocinetopsis
until the last specimen was examined.

DISCUSSION

The planting experiment was designed to test the potential of molluscan
commensal ciliates as biological indicators capable of discerning traces of
pollutants in the aquatic environment. The experiment successfully demon-
strated that both Conchophthirus and Heterocinetopsis were more sensitive to
water conditions than their molluscan hosts. Under the conditions of the experi-
ment, Conchophthirus was not shown to be a dramatically better indicator than
its host molluscs. However, Heterocinetopsis disappeared from hosts planted

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2 The saprobic index used here is after Bick (1972) and based on extensive surveys of
the free-living protozoa performed on the Salt Fork Vermilion River and its tributaries (Small,
1973; Small, unpublished).
at the α-mesosaprobic Station B in two days, and within 10 days, these ciliates did not appear on hosts planted at either the β-mesosaprobic Station C or at the β-mesosaprobic to α-oligosaprobic Station D. Matteson & Dexter (1966) have previously shown that unionids are present at Station D. Thus, while unionid bivalves are generally accepted indicators of clean water and while they naturally appear upstream from Station D, Heterocinetopsis was excluded from clams planted at this “biologically clean” station within 10 days.

Although it must be emphasized that this was a pilot study, its success does lend support to the notion that commensal ciliates can be utilized as convenient monitors capable of recognizing subtle biological pollutants. For these organisms to be used in a general assay of water quality, further experimentation must be carried out to characterize and quantify their sensitivities. This experiment may only begin to demonstrate the potential indicator value of such ciliates. It is feasible for infected clams to be taken from a “culture” pond and distributed to a fresh-water body of questionable water quality. Following periodic examination of the planted clams, the water quality of the site in question would be determined. Such a system may be more critical than other methods of detecting biologically damaging pollutants. The procedure would provide a simple and more direct biological method of detecting environmental conditions than those in current use. It is likely that such a system would be sensitive enough to allow for appropriate conservation steps to be taken before major and irreversible environmental damage occurs.

**Literature Cited**


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THE APOSTOME FOETTINGERIA AND OTHER CILIATE SYMBIONTS FROM THE SEA ANEMONE BUNODOSOMA CAVERNATA FROM GALVESTON ISLAND, TEXAS

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WELCH, M. P. 1977. The apostome Foettingeria and other ciliate symbionts from the sea anemone Bunodosoma cavernata from Galveston Island, Texas. Trans. Amer. Micros. Soc., 96: 489–496. A member of the genus Foettingeria and various hypotrichous ciliates commonly occur in association with the sea anemone Bunodosoma cavernata from Galveston Island, Texas. The Foettingeria species shows a few differences from specimens of F. actiniarum from Roscoff, France, and apparently depends on the anemone for completion of its life cycle, as determined by Chatton and Lwoff. The hypotrich ciliates observed in association with the same host include Euplotes, Uronychia, Aspidisca, Oxytricha, and Paramecium. The symbionts were observed to undergo variations in occurrence and abundance. The more common forms are described and illustrated.

A member of the apostome ciliate genus Foettingeria was first observed by Claparède (1863), as Plagiotoma actiniarum, from anemones in Saint-Vaast-la-

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