THE ZEBRA MUSSEL, DREISSENA POLYMORPHA:

A PHOTOGRAPHIC GUIDE TO THE IDENTIFICATION OF MICROSCOPIC VELIGERS

FEBRUARY 1990

Environment Ontario

Jim Bradley
Minister

ISBN:0-7729-6349-5

THE ZEBRA MUSSEL, DREISSENA POLYMORPHA: A PHOTOGRAPHIC GUIDE TO THE IDENTIFICATION OF MICROSCOPIC VELIGERS

Report and Photographs prepared by:

Gordon J. Hopkins
Limnology Section
Water Resources Branch

FEBRUARY 1990

Forward

This project was initiated in response for assistance from personnel of the Ministry of the Environment Southwestern Regional Office. A photographic guide was needed to assist waterworks personnel and others in the microscopic examination of water supply intakes for the presence of zebra mussel veligers.

TABLE OF CONTENTS

	Page
Forward	i
Table of Contents	ii
Introduction	1
Life History Stages	1
Collection and Observation of Veligers	3
Photography	4
Acknowledgements	4
References	5
List of Figures	7

Introduction

The zebra mussel, Dreissena polymorpha (Pallas, 1771) was first identified in North America by Herbert et al. (1989). In June, 1988 large populations were observed in Lake St. Clair. By the end of the 1989 growing season zebra mussels were reported to be extensively distributed throughout the western basin of Lake Erie and had become established as far east as the Welland Canal in the eastern basin. They have also been sighted in Lakes Superior, Michigan and Ontario and the St. Lawrence River at Cornwall.

The zebra mussel, a native European bivalve (clam), was probably brought to North America in ship ballast water which was discharged in Lake St. Clair. Like other exotic organisms that have been introduced to the Great Lakes they have spread rapidly. Recent surveys of Lakes St. Clair and Erie have shown that the zebra mussel is a prolific breeder and has established dense populations wherever it is found. A literature review of European information was prepared for the Ontario Ministry of the Environment by B.A.R. Environmental in July 1989 (Mackie et al. 1989). Information on distribution and impact on water users in the Great Lakes may be found in Griffiths (1989) and Griffiths et al., (1989).

Life History Stages

The adult zebra mussel uses a byssal apparatus to secrete horny, sticky threads to attach itself firmly to almost any solid surface (e.g. rocks, piers, breakwalls, pipes (internally and externally), buoys, boats, fishing nets and other mussel shells). When water temperatures rise above 12°C egg production occurs and fertilization takes place

within hours (Table 1. J. Leach pers. comm.). The free-swimming larvae called veligers appear in the plankton for about 8 to 15 days as long as the temperature is between 14-24°C. With the aid of cilia the veligers are motile but dispersal at this stage is mainly by water currents.

As the veligers grow developmental changes occur which include the appearance of a rudimentary shell, reduction of the velum and lengthening of the foot. When the shell becomes too heavy the organism is unable to swim and settles onto a suitable substrate where it begins a sedentary life as a postveliger. By the end of the first growing season, the postveliger has the appearance of the adult mussel and uses byssal threads to attach itself to the substrate. The veliger and postveliger are the most sensitive stages in the life cycle of the zebra mussel as temperature shock, anoxia and sedimentation (burial) may cause high mortality rates. By the second year of growth zebra mussels are sexually mature (Mackie et al. 1989).

Veligers may be observed in the plankton of raw water samples collected at water supply intakes. After hatching from the egg they are 40-70 µm in diameter and have the appearance of ciliated protozoa (Fig. 1). They grow rapidly to 150-250 µm in diameter during which time the clam-like shell develops. The muscular internal structure (the velum) of the young veliger is crowned with cilia which beat rapidly to select or reject food particles (mainly small algae). With the development of the shell the veliger becomes less motile. The disappearance of the cilia and development of a foot signal the onset of the postveliger stage. As these two stages are microscopic they may appear in plankton collections of the raw water throughout the summer months when the temperature ranges between 14-24°C. Figure 30 provides a complete cyclic diagram for all stages of the zebra mussel Dreisenna polymorpha (Palla, 1771).

Collection and Observation of Veligers

Observations of live samples are ideal for identification of zebra mussel veligers. A one-litre sample, if allowed to settle for a period of time, will yield specimens in the sediment. Observations can be made at low magnification (4X objective) and details of cilia and velum activity can be observed using 10X objectives. Observations of live organisms should be made within two hours of collection as the veligers are very sensitive to temperature and oxygen changes and will die rapidly after collection.

Veligers are very sensitive to fixatives and preservatives. Most common preservatives cause the body fluids to be expelled from the veliger and postveliger. The cilia either fold against the velum or break off. The velum "explodes" leaving fat globules extruding from the shell. Lugol's solution containing acetic acid is most harmful as the acetic acid dissolves the calcium based shell. A sugar-formalin solution (4% Formaldehyde), buffered to pH 7.0, which is commonly used for preserving zooplankton allows for the identification of veligers which have at least produced a rudimentary shell. This same preservative would probably be suitable for maintaining young adult zebra mussels provided only a few mussels were put in one container. For observation of the soft tissue inside the shell of adult mussels 80% ethyl alcohol should be used as a preservative (Pennak, 1978). It should be stressed that the observation of veligers should be made on living specimens and that the above-mentioned "preservatives" do not maintain veligers in a preserved state but rather destroy the cilia and velum.

Photography

The photographic record provided here was accomplished by observation of organisms collected from a zooplankton haul in the western basin of Lake Erie provided by Dr. Joe Leach, Ministry of Natural Resources, Wheatley, Ontario on August 28, 1989 (pers. comm.). The concentrated zooplankton sample was transferred to a two-litre beaker and aerated while one mL aliquots were observed under the microscope and photographed (Fig. 2-14 and 25-29). Another portion of the sample was preserved with a sugar-formalin or Lugol's solution and additional photographs were taken to observe the distortion and destruction caused by using preservatives (Fig. 15-24).

Veligers with shell development and postveligers greater than 5 days old, may be recognized in preserved samples mainly by their size (>150 µm). Early veligers should be observed in live samples as soon as possible after collection as temperature changes, anoxia and/or preservation causes the organism to disintergrate beyond recognition.

Photographs in this report were taken by the author using a Leitz Dialux compound microscope (Ernst Leitz GMBH Wetzler) and a Nikon Microflex AFX photographic attachment (Nikon Nippon Kogaku K.K) with Kodak colour slide film (ASA 400). These slides were edited and those included in this report were then processed as black and white glossy prints to produce the photoplates (Fig. 1-29). Figure 30 was provided by Dr. Gerry Mackie.

Acknowledgements

I would like to express my appreciation to Ken Nicholls for encouraging me to proceed with this project and for critically reviewing its contents, Dr. Joe Leach for providing live specimens and facilities for taking the photographs. Dr. Gerry Mackie, Ron Griffiths and Rick Turnbull for reviewing the manuscript and to Mrs. M. Barclay for typing. Special thanks to Dr. Mackie for allowing me to use the excellent Life-Cycle photograph.

References

ELLIS, A.E. 1978. British Freshwater Bivalve Mollusca. Keys and notes for identification of the species. Academic Press, London.

GRIFFITH, R.W. 1989. Introduction of Zebra Mussels into the Great Lakes: Truth or Consequences. Monthly Newsletter #45, Feb. 1989, Southwest Region, Ministry of the Environment, London, Ontario.

GRIFFITH, R.W., W.P. KOVALAK and D.W. SCHLOESSER. 1989. The Zebra Mussell, Dreissena Polymorpha (Pallas, 1771), in North America: Impact on Raw Water Users. In Symposium on Service Water System Problems Affecting Safety-Related Equipment. Charlotte, N.C. Nov. 6-8, 1989.

HEBERT, P.D.N., B.W. MUNCASTER and G.L. MACKIE. 1989. Ecological and genetic studies on Dreissena Polymorpha (Pallas): a new mollusc in the Great Lakes. Can. J. Fish. Aq. Sci. 46:1587-1591.

MACKIE, G.L., W.N. GIBBONS, B.W. MUNCASTER and I.M. GRAY, B.A.R. Environmental. 1989. The Zebra Mussel, Dreissena Polymorpha: A synthesis of European Experiences and a Preview For North America. Water Resources Branch, Ontario Ministry of the Environment, Toronto, Ontario. 76p + Append.

PENNAK, ROBERT, W. 1978. Freshwater Invertebrates of the United States, 2nd Edition. John Wiley and Sons, Toronto, Canada. 803p.

Table 1: Life History Stages of Dreissena polymorpha[1,2]

1. Egg	- reproduction commences when water temperature is 12-16°C and lasts 2-8 months; - 30,000 to 40,000 per female; - fertilized externally.
2. Veliger	- motile, planktonic; - about 70-290 μ in length; - about 5-16 days (usually 8-12); - mortality about 20%.
3. Post veliger	- veliger settles at about 200 μ; - velum becomes a siphon; - mortality about 99%; - can move after settling.
4. Adult	- up to 4 cm in length; - up to 5-6 years, (in Europe)[1]; 3-5 years, (in N. America)[2]; - sexually mature at about 1 cm, usually in 2nd year or end of first year; - sex ratio about 1:1, (in Europe)[1]; 2 females: 1 male (in N. America)[2]

[1]personal communication, Dr. Joe Leach, Ministry of Natural Resources, Fisheries Research Station, R.R.#2, Wheatley, Ont.

[2]personal communication, Dr. Gerry Mackie, Dept. of Zoology, University of Guelph, Guelph, Ont.

List of Figures

Fig. 1: Diagramatic representation of Dreissena polymorpha veligers. A-B from Ellis, 1978. C-D redrawn from Ellis (Mackie et al. 1989).

Fig. 2-8: Live Dreisenna polymorpha veligers and postveligers (bar = 100 µm). Rudementary shell development, particularly in Fig. 4. All lateral views. A - Diatom Asterionella formosa;
C - cilia; M - mouth; S - shell; V - velum.

Fig. 9-13: Live Dreisenna polymorpha veligers and postveligers (bar = 100 µm). Fig. 9 and 11 anterior (A) view of postveliger with cilia extended. Fig. 10 anterior (A) view of postveliger with cilia retracted. Fig. 12 and 13 lateral (L) view of postveliger with velum fully extended; C - cilia; S - shell; V - velum.

Fig. 14: Live Dreisenna polymorpha veliger with velum fully extended (bar = 200 µm).

Fig. 15: Preserved plankton sample containing veligers, postveligers and phytoplankton (scale bar = 200 µm).

Fig. 16-18: Veligers "preserved" with Lugol's solution. Note: ruptured velum and dislodged cilia (bar = 100 µm).
A - Asterionella formosa; C - cilia; M - Melosira
Pe - Pediastrum; Po - Polyarthra (a Rotifer);
Pv - postveliger; V - veliger.

Fig. 19-21: Polymorpha dreissena veligers and postveligers, "preserved" with Lugol's solution. Note: ruptured velum with spherical fatty globules extruding from shell (bar = 100 µm).

Fig. 22-24: Plankton sample "preserved" with sugar-formalin containing veligers, postveligers, phytoplankton rotifers and microcrustaceans (bar = 200 µm). A - Asterionella; Bo - Bosmina; C - cilia; Cy - Cyclops; Pe - Pediastrum; Po - Polyarthra; Pv - postveliger; V - veliger.

Fig. 25-28: Postveligers (live specimens). Note: bivalve appearance of shell. Fig. 25 and 28 foot extended. Fig. 26 foot retracted (bar = 200 µm). Fig. 27 (bar = 100 µm). Pv - postveligers; V - Veliger.

Fig. 29: Young-of-the-year Dreissena polymorpha (zebra mussels). Note: postveliger attached to smaller mussel. F - foot; P - postveliger.

Fig. 30: Life-Cycle stages of Dreissena polymorpha (Pallas, 1771). Note: Time period for these stages has not been defined. See text for approximate periods. Photograph courtesy of Dr. Gerry Mackie, University of Guelph.

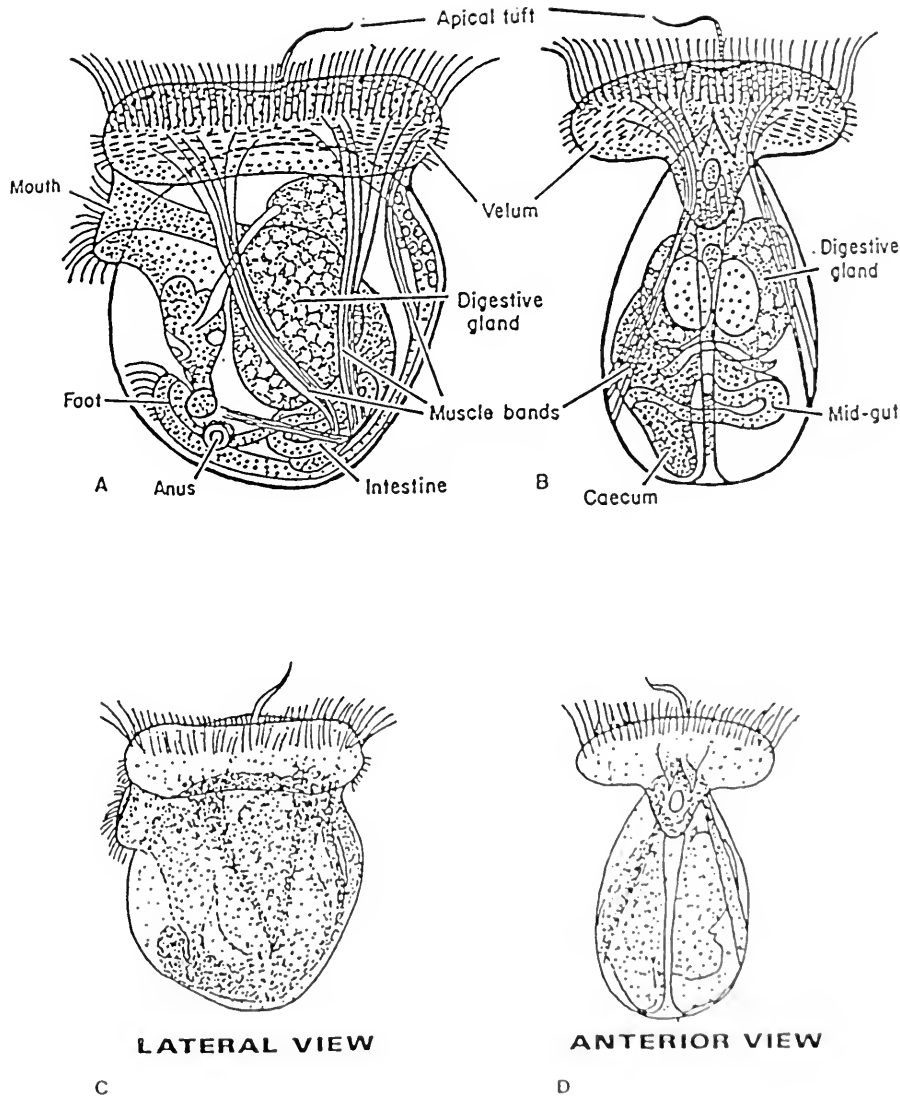
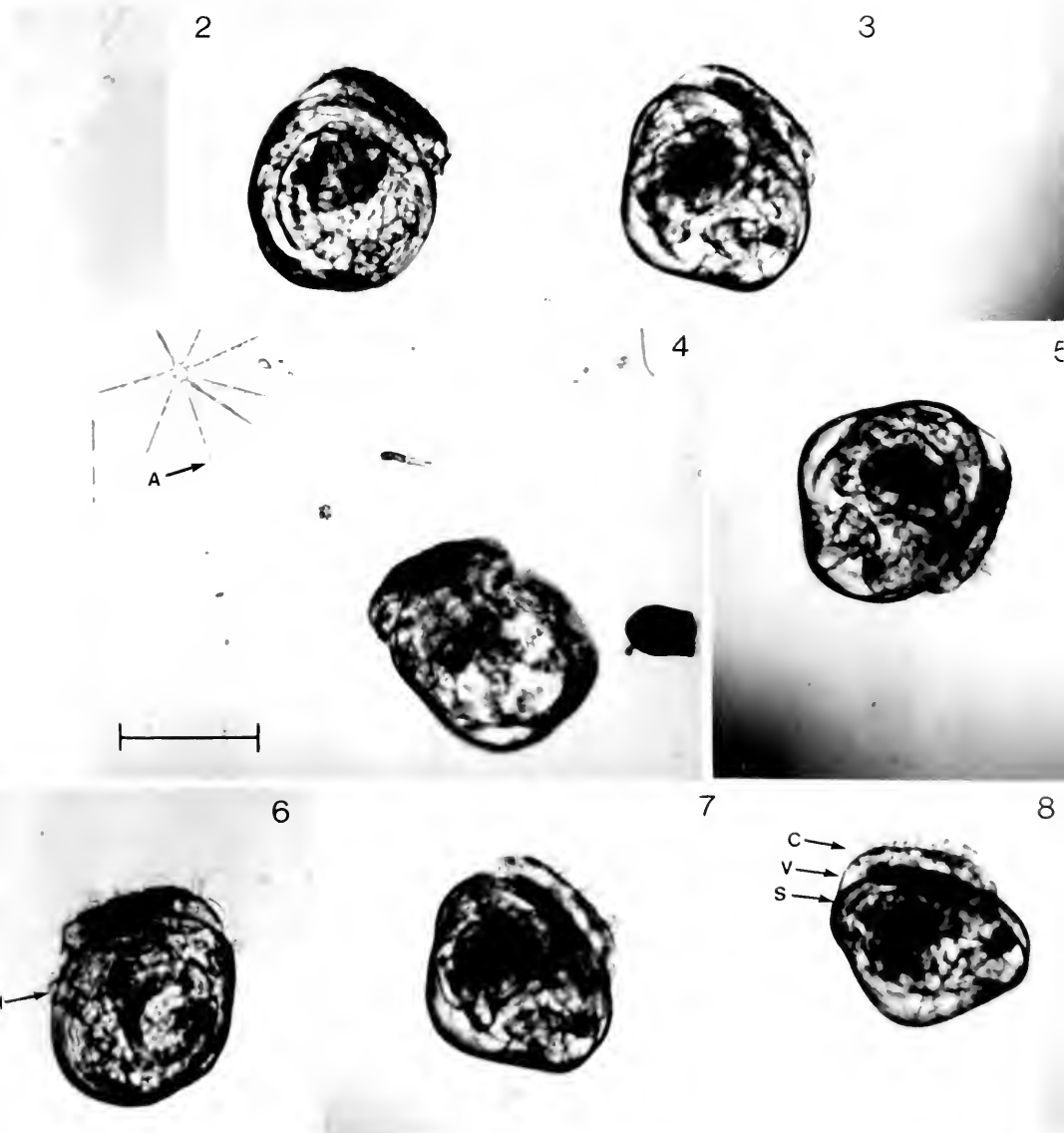
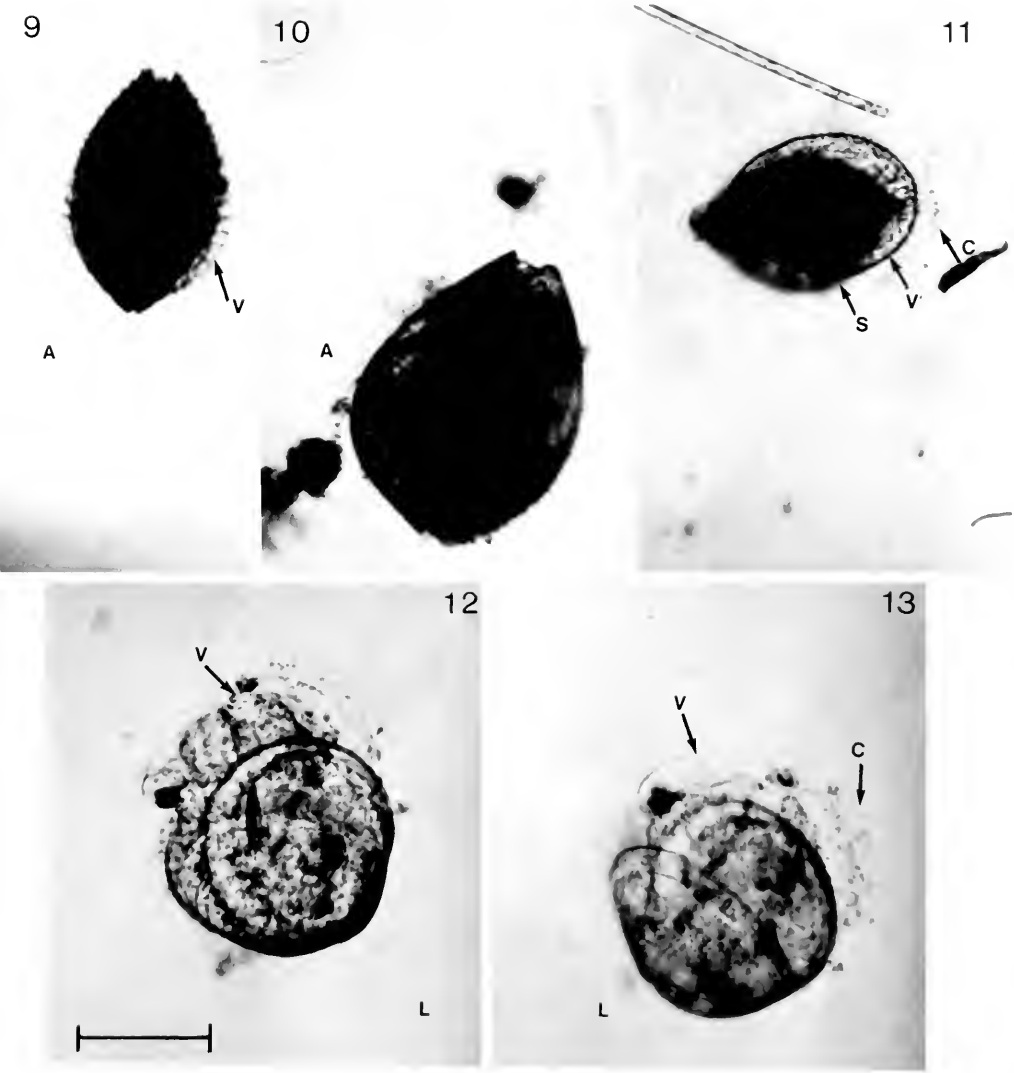
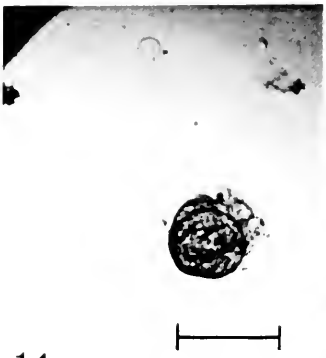

Apical tuft
Mouth
Velum
Digestive gland
Foot
Muscle bands
A
Anus
Intestine
B
Digestive gland
Mid-gut
Caecum
LATERAL VIEW
C
ANTERIOR VIEW
D

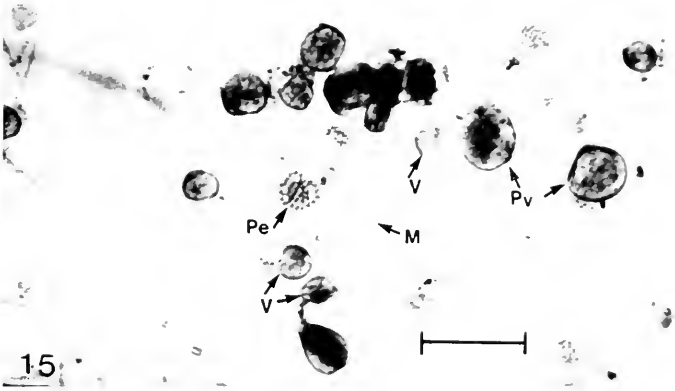
Fig. 1


2
3
4
5
A
6
7
8
C
V
S

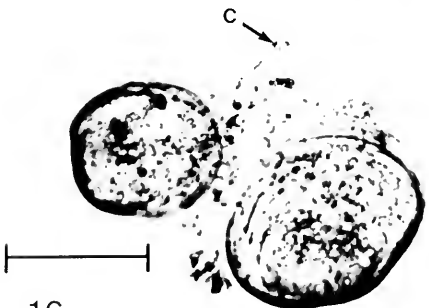

9
V
A
10
A
11
C
V
S
12
V
L
13
V
C
L



14

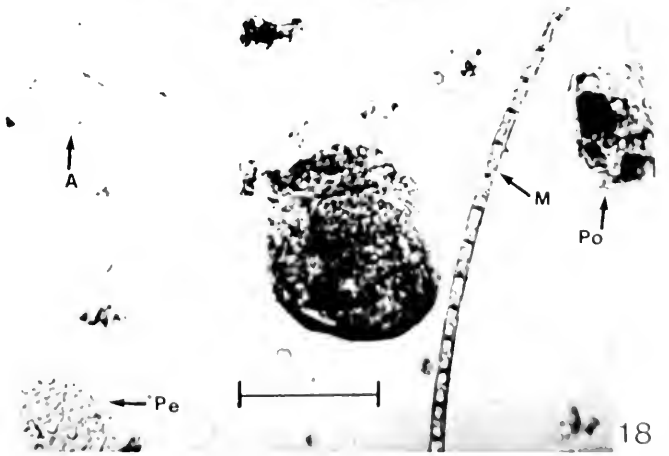


15

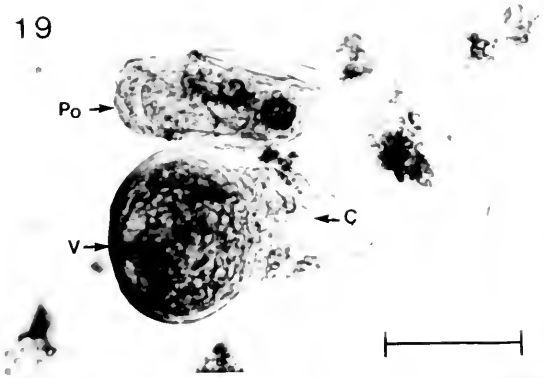


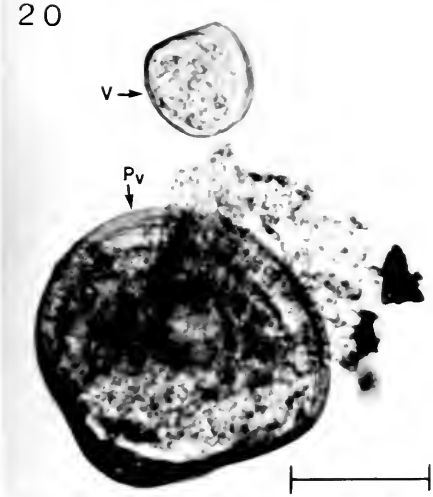
16

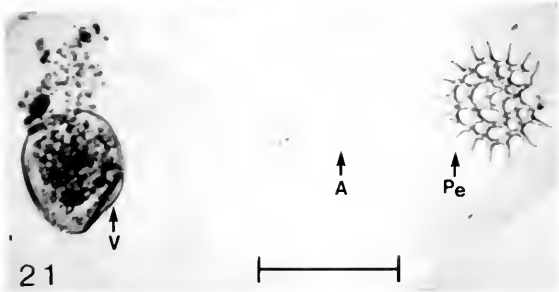
17

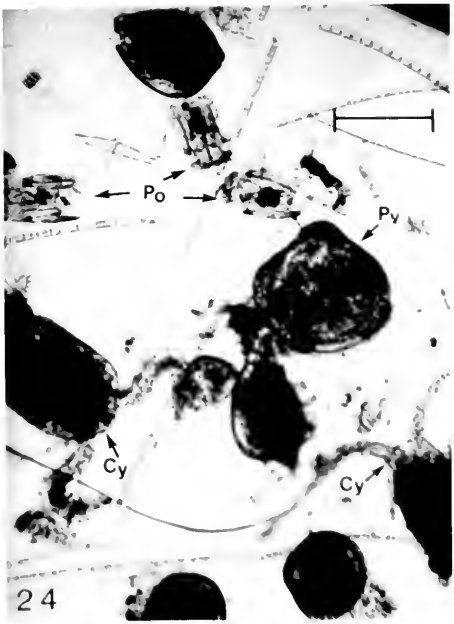


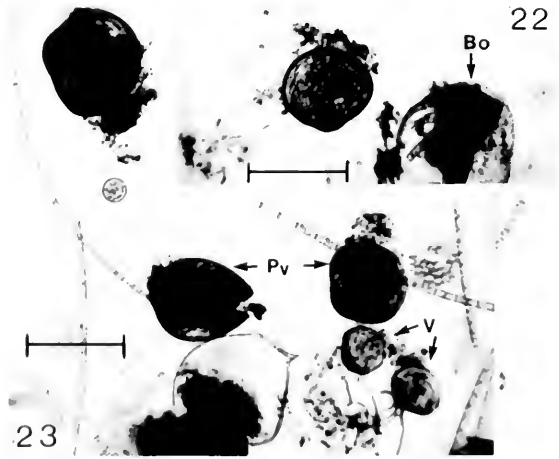
18

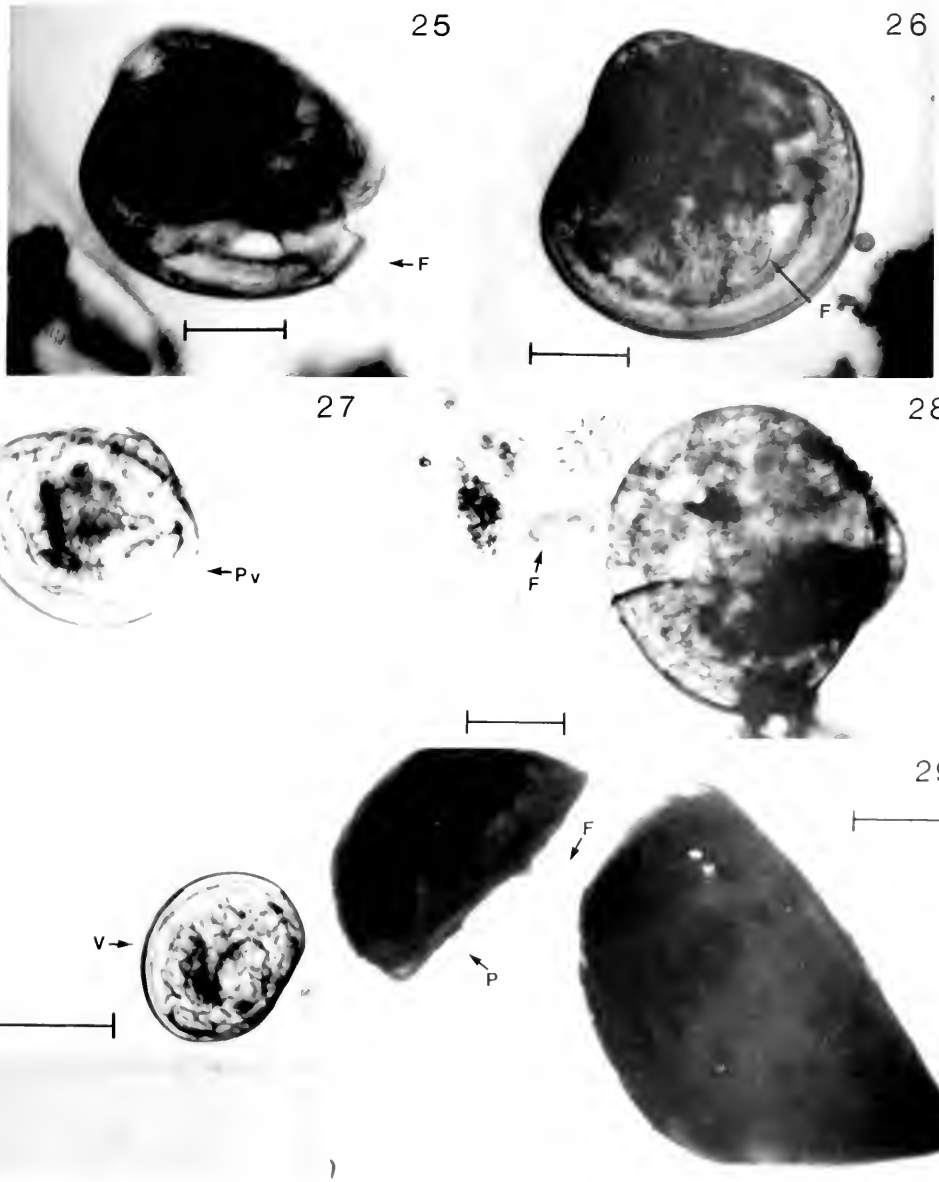

19
Po
C
V


20
V
Pv


V
A
Pe
21


Po
Pv
Cy
Cy
24


22
Bo
Pv
V
23


25
F
26
F
27
Pv
28
F
29
F
P
V

POST-VELIGER STAGE
SETTLING STAGE
ADULT STAGE
EGG STAGE
VELIGER STAGE
UMBONAL STATE
BENTHIC STATE
PLANKTONIC STATE
STRAIGHT-HINGED FORMS
EGG
YOUNG VELIGERS
ADULT FORMS
100
100

Fig.