ACHIEVING CONTROL OF DREISSENIDS THROUGHOUT ENTIRE LAKES
(*No, This Is Not Just Wishful Thinking*)

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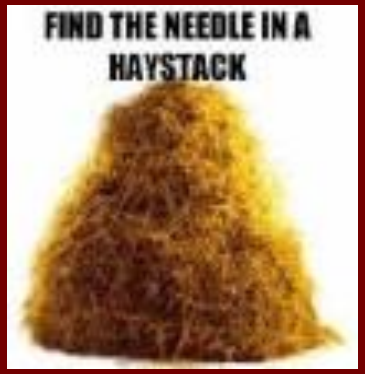
April 11, 2016

International Conference on Aquatic Invasive Species
Winnipeg, Manitoba, Canada

MY RESEARCH BACKGROUND

I’m an aquatic biologist who is attracted to looking for solutions to aquatic pest problems that have been considered by many to be unsolvable

…..to be the equivalent of finding a needle in a haystack



Use my expertise in aquatic invertebrate pathology…
….to develop environmentally safe biocontrol agents

Two parts of my talk today…..

1. Briefly tell you about research projects to develop biocontrol agents for aquatic pests that:
-- have beaten the odds
-- have disproven the doubters
-- have gone all the way to commercialization

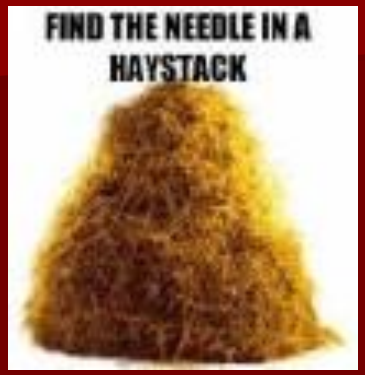
2.Tell you about my ongoing research to develop an OUTSIDE THE SHELL control agent that will achieve lake wide control of dreissenids and be…..
….. economical
….. environmentally safe
….. effective in drastically reducing dreissenid populations

I wouldn’t be surprised if after you hear this talk you think ….

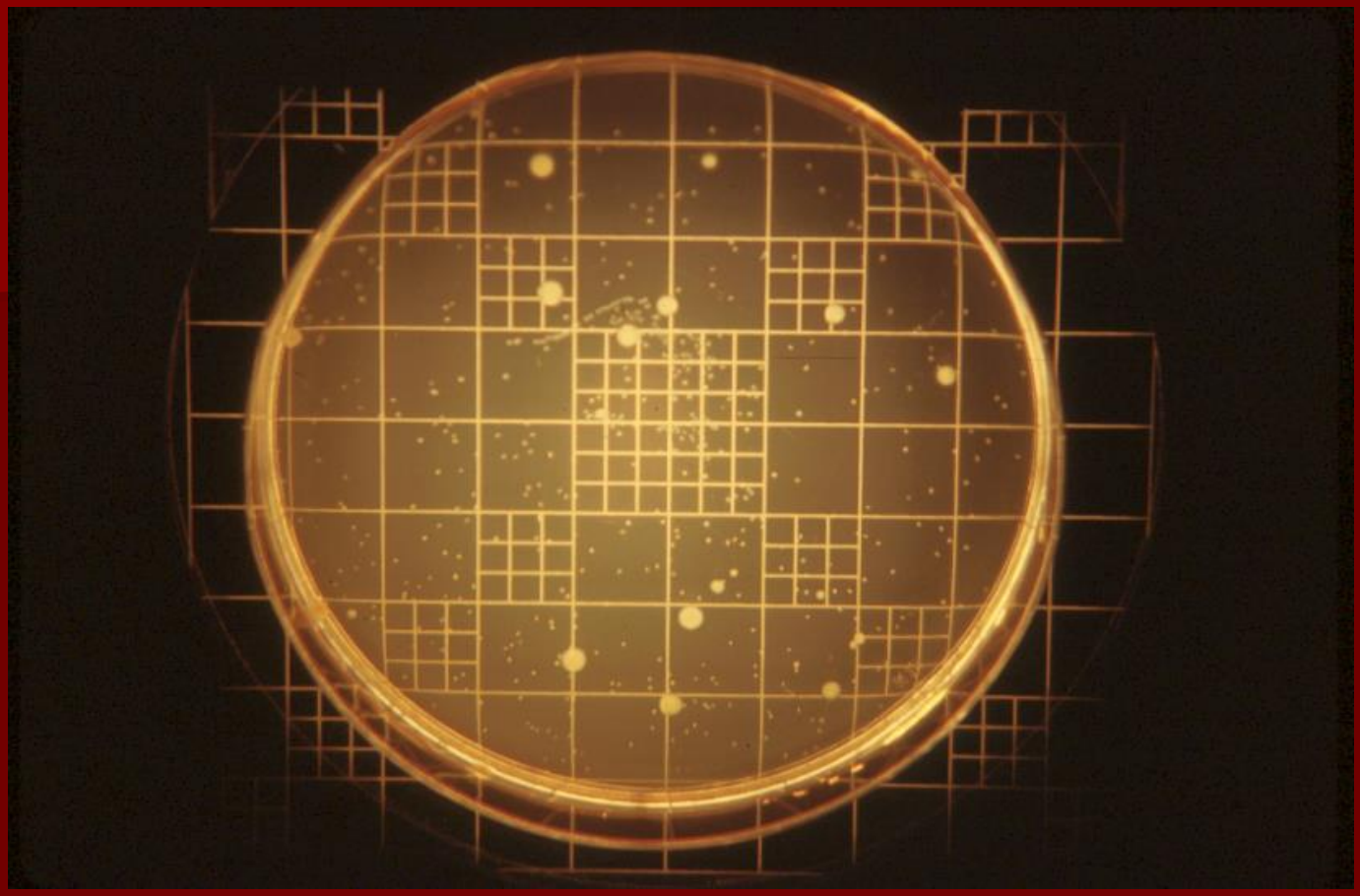
This guy Dan Molloy is a biocontrol idealistic dreamer -- a scientific version of Don Quijote, Man of La Mancha….

Biocontrol Dreamer ?

Nope, not just a dreamer. My lab has had major commercial successes in R&D for the …



Biocontrol of black flies with the bacterium *Bacillus thuringiensis israelensis* (BTI) – a leader in this international effort

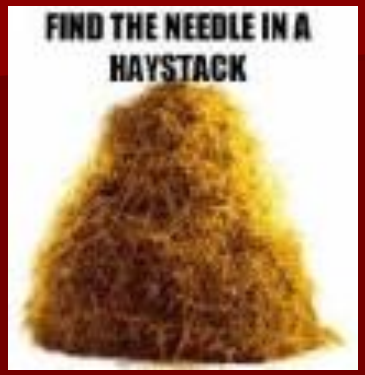


Bacillus thuringiensis israelensis

B t i


VectoBac 12AS

In this regard, my lab has had major commercial successes in R&D for the …



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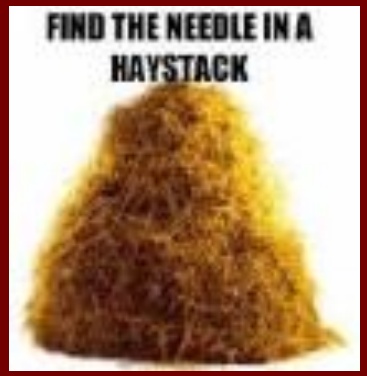
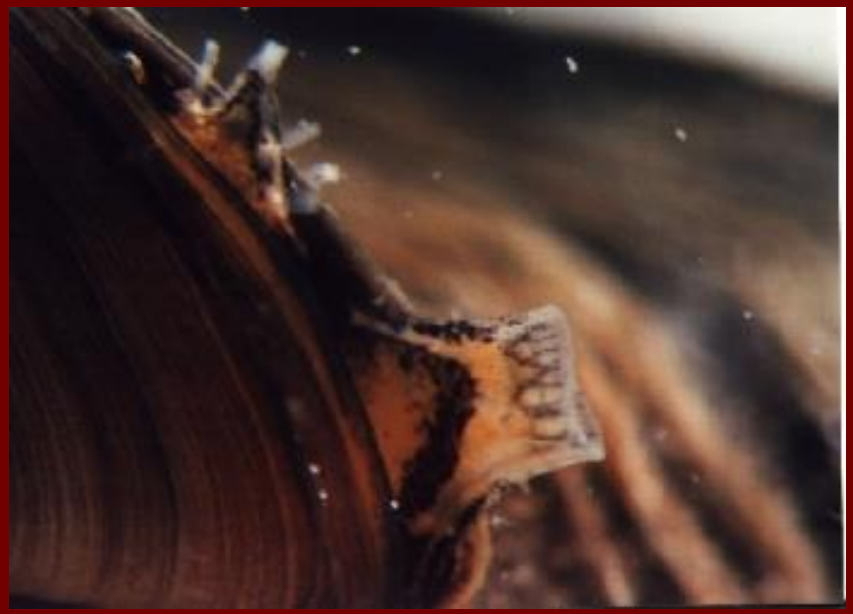
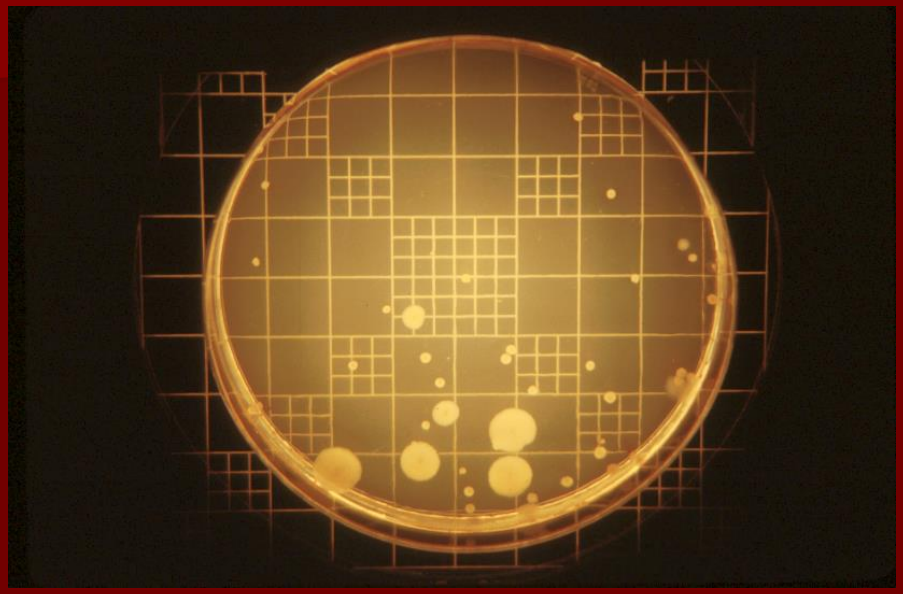
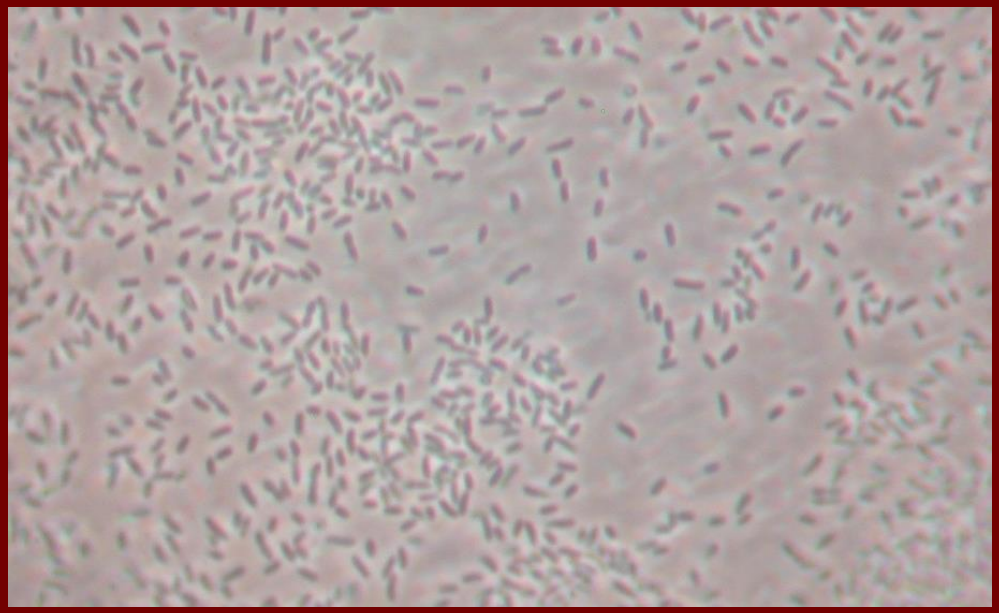


Biocontrol of dreissenids with the bacterium *Pseudomonas fluorescens* (Zequanox®) – patent inventor





Pseudomonas fluorescens
Strain CL145A



Individual cells of *P. fluorescens* strain CL145A

Extensive Ecotox Studies Show No Impact to Other Aquatic Species

FISH

Bluegill sunfish (*Lepomis macrochirus*)
Channel catfish (*Ictalurus punctatus*) †
Chinook Salmon (*Oncorhynchus tshawytscha*)
Coaster brook trout (*Salvelinus fontinalis*)
Common Carp (*Cyprinus carpio*)
Fathead Minnow (*Pimephales promelas*) *
Klamath Suckers (*Catostomus sucker spp*)
Lake sturgeon (*Acipenser fulvescens*) †
Largemouth bass (*Micropterus salmoides*) †
Rainbow Trout (*Oncorhynchus mykiss*) *
Sacramento Splittail (*Pogonichthys macrolepidotus*)
Smallmouth bass (*Micropterus dolomieu*) †
Striped Bass (*Morone saxatilis*)
Walleye (*Sander vitreus*) †
Yellow perch (*Perca flavescens*) †

OTHERS

Mallard Duck *
Midge (*Chironomidae*)
Mayfly (*Baetis*)
Amphipod (*Hyalella azteca*) *
European Freshwater Crayfish (*Austropotatamobius pallipes*)
Freshwater Crustacean (*Asellus aquaticus*)
Freshwater Water Flea (*Daphnia magna*) *

MOLLUSCS

Blue Mussel (*Mytilus edulis*) *
Freshwater Mussel - Duck Mussel (*Anadonta*)
Freshwater Mussel - Black Sandshell (*Ligumia recta*) †
Freshwater Mussel - Fatmucket (*Lampsilis siliquoidea*)
Freshwater Mussel - Pink mucket (*Lampsilis abrupta*)
Freshwater Mussel - Hickorynut (*Obovaria olivaria*) †
Freshwater Mussel - Higgins Eye (*Lampsilis higginsii*) †
Freshwater Mussel - Mucket (*Actinonaias ligamentina*) †
Freshwater Mussel - Paper Pond Shell (*Utterbackia imbecillis*) †
Freshwater Mussel - Plain Pocketbook (*Lampsilis cardium*) †
Freshwater Mussel - Washboard (*Megalonaias nervosa*)
Freshwater Snail (*Lymnaea peregra*)

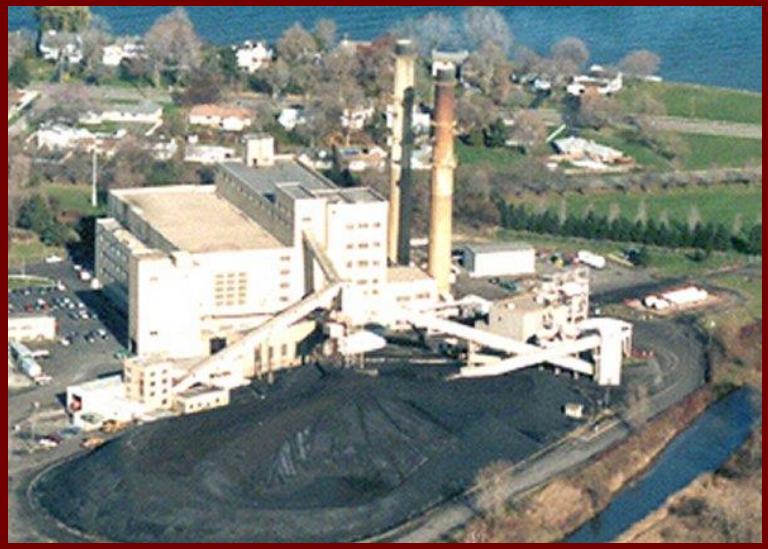
PLANTS AND ALGAE

Algae *
Bindweed (*Convolvulaceae*)
Common Water Plantain (*Alisma subcordatum*)
Curly Dock (*Rumex crispus*)
Mallow (*Malvaceae*)
Nightshade (*Solanaceae*)
Smallflower Umbrella Sedge (*Cyperus difformis*)

** EPA required*
† Final report expected by mid-2013.
Studies conducted by Institute of Technology, Sligo, Ireland; New York State Museum and USGS; U.S. Bureau of Reclamation; Certified Good Laboratory Practices (GLP) Lab; and MBI lab

ZEQUANOX® Invasive Mussel Control

As its patent inventor, I take great pride that we now have the selective, eco-friendly, biocontrol agent Zequanox® for dreissenid control……



Do we really need research on another dreissenid control agent in addition?

Yes, we do…

Here's why….

Unfortunately … IN THE VAST MAJORITY OF CASES…there is currently still no control method capable of drastically reducing dreissenid populations throughout an entire water body.

Why?

With little exception, successfully treating an entire water body with any currently available control agent is either technically unfeasible, economically prohibitive, and/or too environmentally degrading

Yes, there are commercially available control agents capable of reducing dreissenid populations in small, high-value areas within infested water bodies, but these control efforts are so localized that they have little effect on reducing:

1) the continual spread of dreissenids from lake to lake

2) the ecological perturbations in the lake as a whole caused by the vast multitude of dreissenids still thriving elsewhere in the lake

So….We still need a control agent of dreissenids throughout an entire lake

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….. economical

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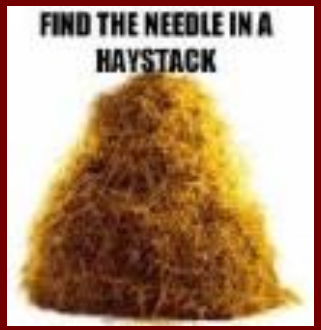
This will not be an easy task….!

These mussels have been in Western Europe for a couple of hundred years and nobody has come up with as effective lake-wide control method

Thus, …..
--- control of dreissenids in entire lakes will be a very daunting challenge
--- another classic NEEDLE IN A HAYSTACK project



No organization has the money for lake-wide treatments and subsequent re-treatments of entire lakes

Thus the control agent ideally must be applied only once in a small area and be:

-- self-perpetuating

&

-- self-spreading

Thus, it must be alive

It must be a biocontrol agent

…..and above all….

it must be extremely selective for killing dreissenids….

…. and among all types of biocontrol candidates, parasites (not predators) are the most specific killing agents

So what is this “outside-the-shell” new bold approach using a LIVE biocontrol agent to drastically reduce dreissenid populations ????

Here are some clues….

What happened to American chestnut trees?

What happened to American chestnut trees?

Fungus : American chestnut blight

What happened to elm trees?

What happened to elm trees?

Fungus: Dutch elm disease

In these two examples of drastic host population decline……

These species were/are "naïve" hosts infected by "novel" lethal parasites

"Novel" parasites are species or strains that the "naïve" host:

-- has not co-evolved with

-- has not developed an immunity to

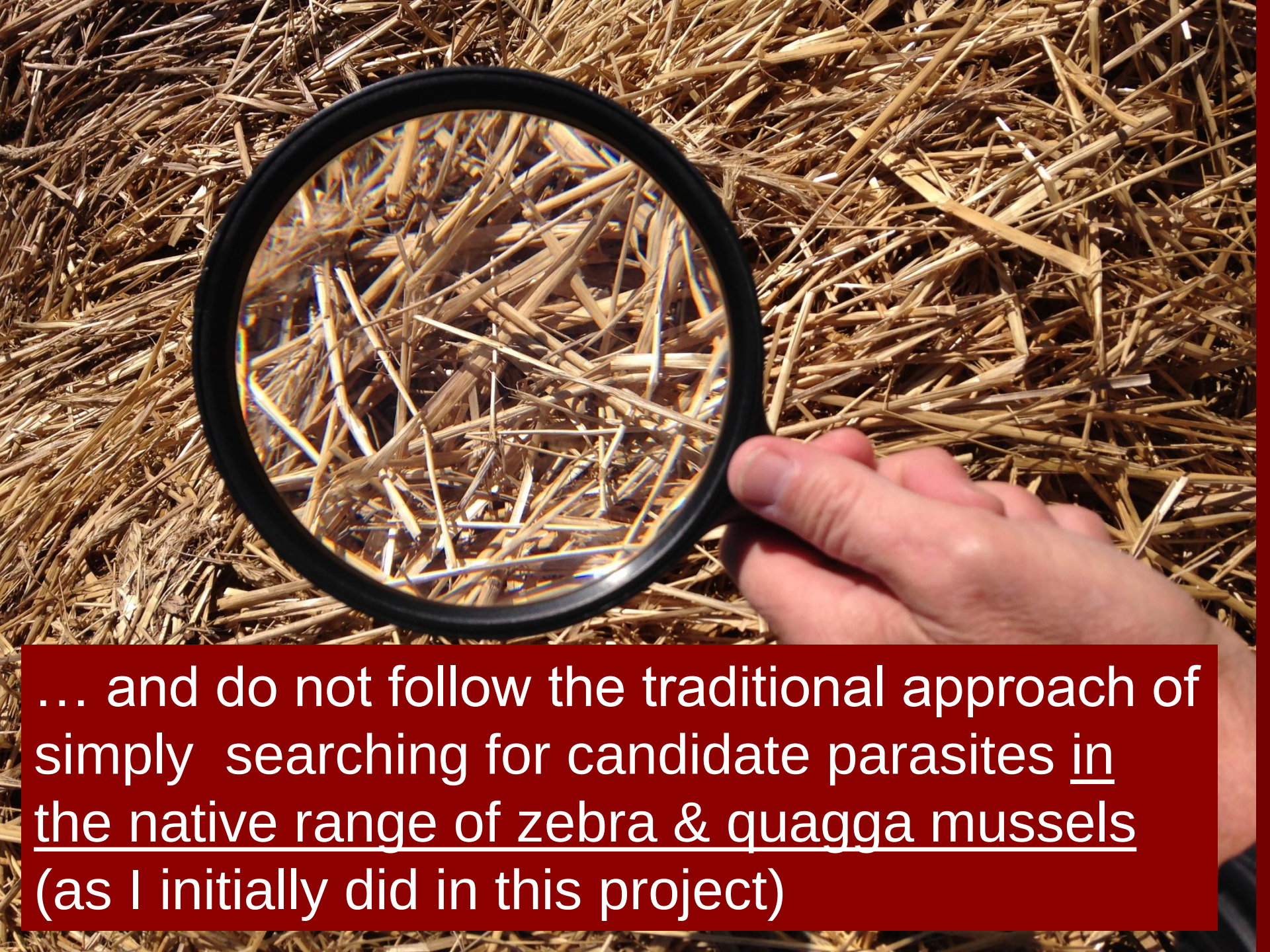
-- has often been geographically separated from for millions of years

But neither of these two “naïve” species examples were bivalves……..

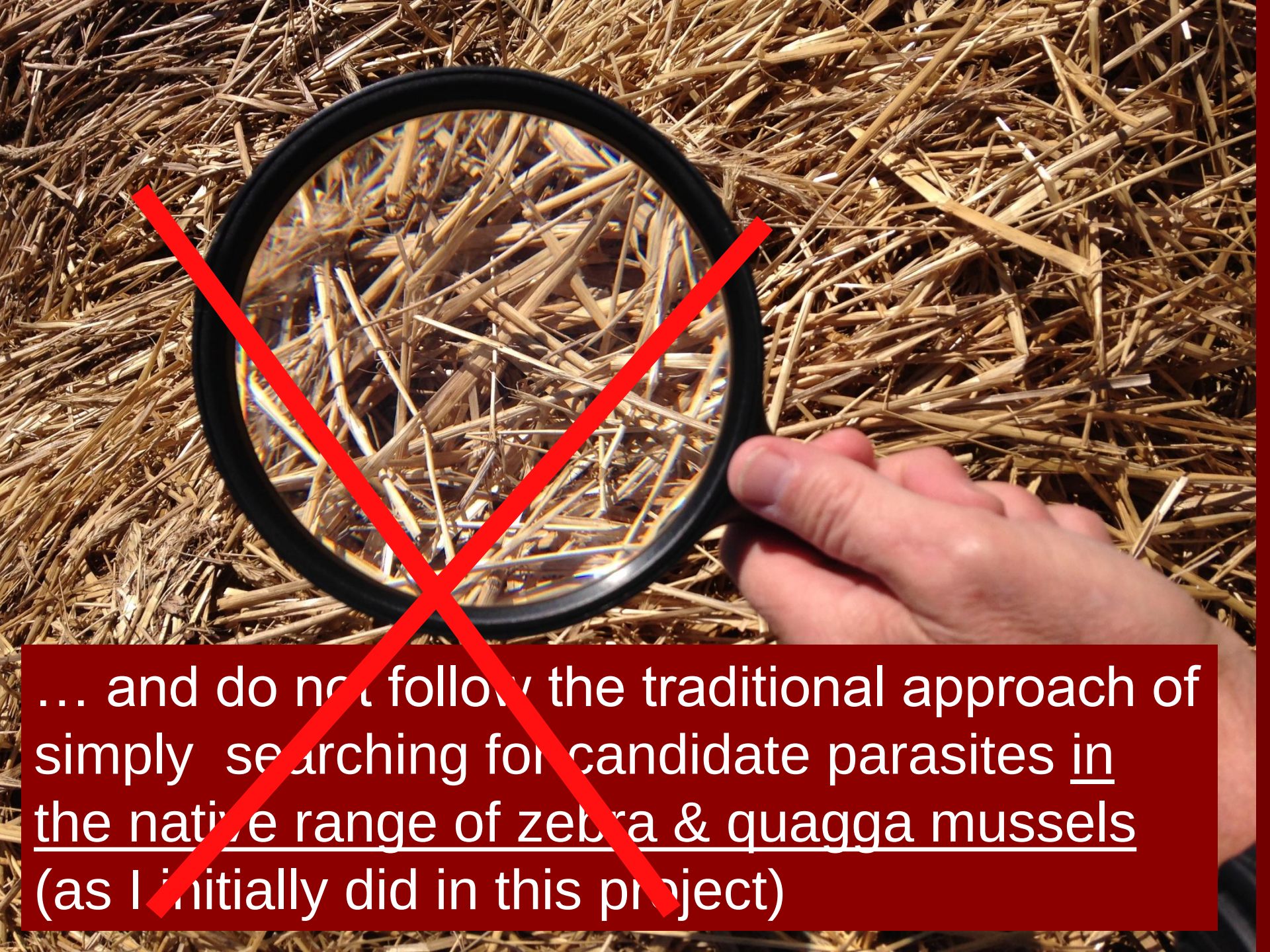
Eastern oyster
Crassostrea virginica

YEP, THAT'S THE BOLD NEW PARADIGM OF THE BIOCONTROL APPROACH

INTRODUCE A NOVEL PARASITE THAT OUR NORTH AMERICAN DREISSENIDS WILL BE NAÏVE TO



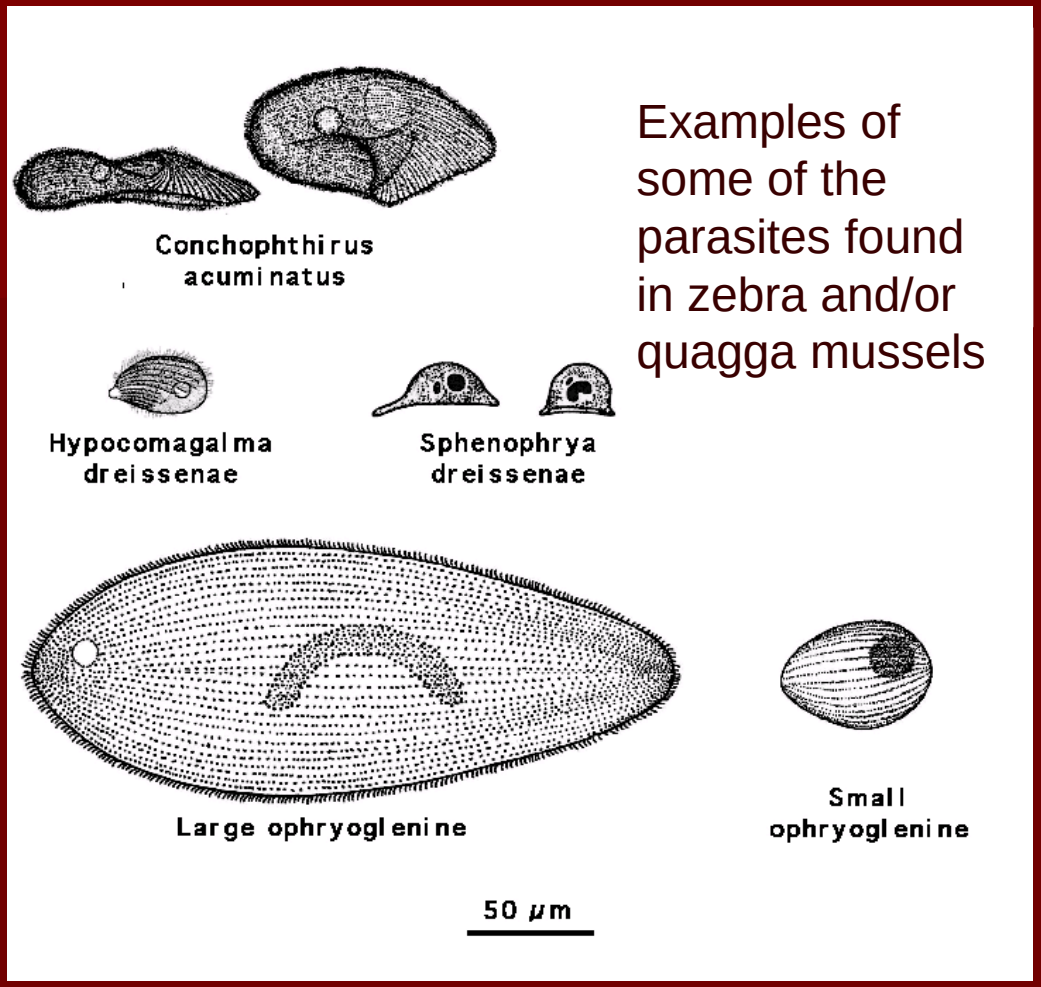
… and do not follow the traditional approach of simply searching for candidate parasites in the native range of zebra & quagga mussels (as I initially did in this project)



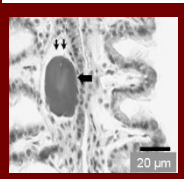
… and do not follow the traditional approach of simply searching for candidate parasites <u>in the native range of zebra & quagga mussels</u> (as I initially did in this project)

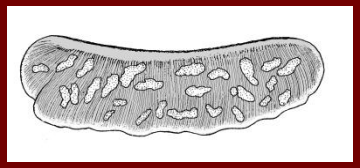
Instead… use an outside-the-shell approach, by searching for candidate parasites in the native range of a geographically-distant closely-related dreissenid species

Over the last 20 years we have found a variety of parasites in zebra and quagga populations… but none with hyper-virulence



Examples of some of the parasites found in zebra and/or quagga mussels





WHERE WE HAVE SEARCHED IN PAST PRIMARILY EXAMINING ZEBRA AND QUAGGA MUSSELS

THIS IS THE NEW FOCUS AREA OF OUR SEARCH EXAMINING PRIMARILY DREISSENID SPECIES OTHER THAN ZEBRAS AND QUAGGA MUSSELS

There are about a half-dozen recognized ***Dreissena*** spp. in Europe and Asia Minor. Some are in saline habitats and will not be initially considered.

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Dreissena presbensis - Macedonia, Albania & Greece

Dreissena blanci - Greece

Dreissena caputlacus - Turkey

Populations of ***Dreissena polymorpha*** (zebra mussels) and ***Dreissena rostriformis bugensis*** (quagga mussels) with evidence of long-term isolation will also be considered.

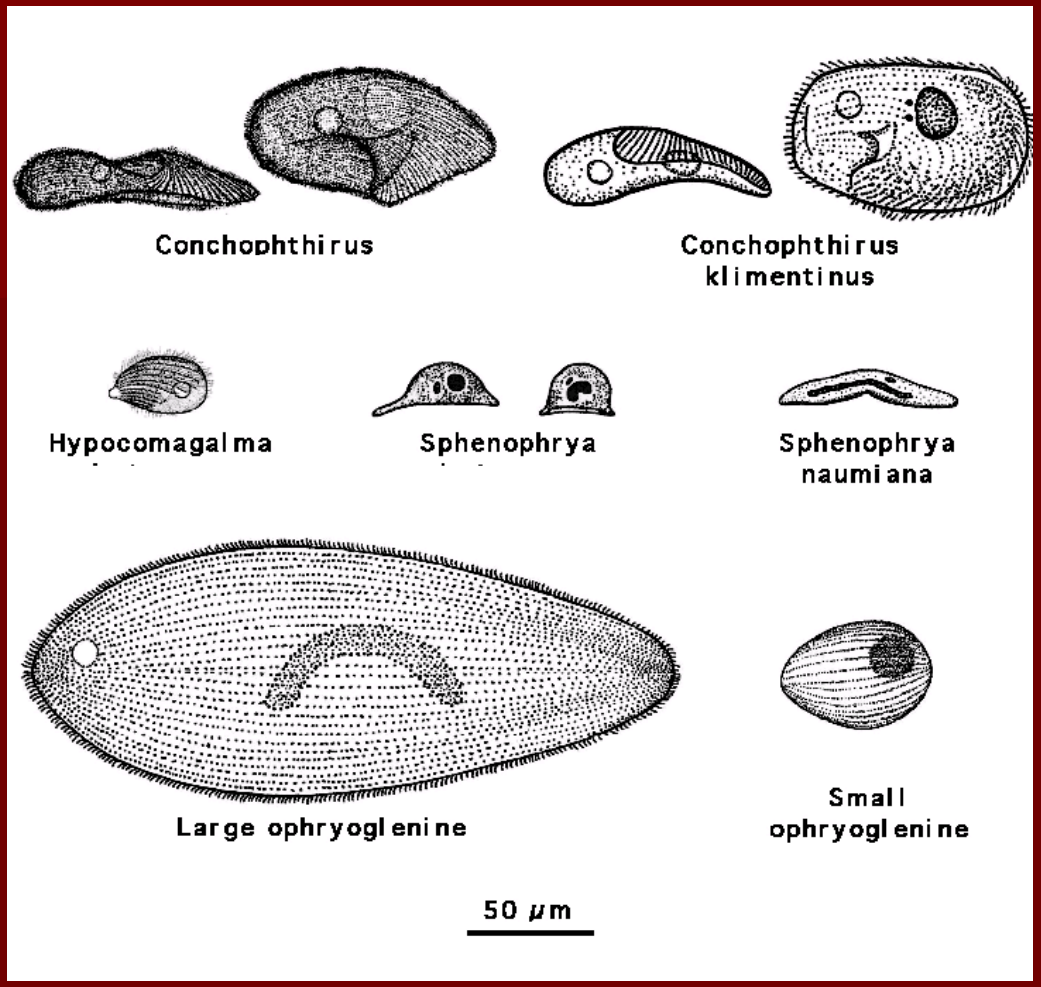
Lake Ohrid in Macedonia -- My favorite place to look for “novel” candidate parasites for controlling our “naïve” North American zebra and quagga mussels

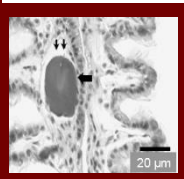
There’s only one dreissenid species in this lake: *D. presbensis*

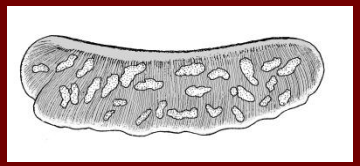
…and we have already found parasites in this dreissenid!

…. and in Lake Ohrid in *D. presbensis* in Macedonia we are finding similar parasites that sequencing indicates are NOT the same species as in zebra and quagga mussels

D. presbensis



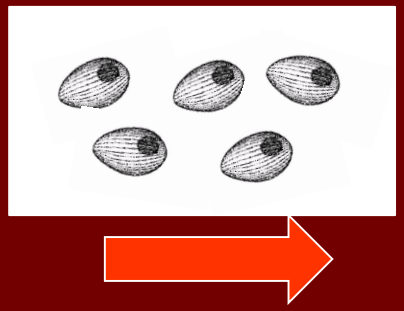




Next logical research step is to try to infect zebra and quagga mussels with parasites that have co-evolved with the Macedonian *D. presbensis*

Could some relatively harmless parasite from *D. presbensis* be hypervirulent to “naïve” zebra/quagga mussels and kill them?

D. presbensis



TAKE HOME MESSAGE

Will there ever be lake-wide biocontrol of dreissenids in North American waterbodies?

Don’t give up on the use of parasites for that purpose, as they can have long-term devastating impacts on naïve host populations.

To achieve this goal, the “outside the shell” solution will likely involve exposing our North American dreissenid populations to a parasite they have never ever encountered before – a parasite from a distant related dreissenid species found outside the native range of the zebra mussel or quagga mussel, as for example from *Dreissena presbensis* in Lake Ohrid, Macedonia