TAXONOMY OF SELECTED SPECIES OF *MYXOBOLUS* (MYXOZOA) FROM FRESHWATER FISHES IN CANADA; APPLICATIONS OF LIGHT MICROSCOPY AND MOLECULAR METHODS

A Thesis

Submitted to the Graduate Faculty

In Partial Fulfillment of the Requirements

for the Degree of

Master of Science

in the Department of Biology

Faculty of Science

St. Mary's University

Halifax, Nova Scotia

Russell H. Easy

Halifax, Nova Scotia

Date: April 22, 2004

Your file Votre référence
ISBN: 0-612-90328-1
Our file Notre référence
ISBN: 0-612-90328-1

CONDITIONS OF USE

PERMISSION TO USE POSTGRADUATE THESIS

Title of thesis: TAXONOMY OF SELECTED SPECIES OF *MYXOBOLUS* (MYXOZOA) FROM FRESHWATER FISHES IN CANADA; APPLICATIONS OF LIGHT MICROSCOPY AND MOLECULAR METHODS

Name of Author: Russell H. Easy

Department: Biology

Degree: Master of Applied Science

Year: 2004

Signature

Date: April 22, 2004

St. Mary's University

Faculty of Science

Halifax

Abstract

Russell H. Easy

Thesis Title: TAXONOMY OF SELECTED SPECIES OF *MYXOBOLUS* (MYXOZOA) FROM FRESHWATER FISHES IN CANADA; APPLICATIONS OF LIGHT MICROSCOPY AND MOLECULAR METHODS

Date: April 22, 2004

Species of *Myxobolus* (Myxozoa) are compared on the basis of spore morphology, site of development, host species and sequence data of the 18S rDNA. The first situation compares the morphology and molecular features of *Myxobolus procerus* from large intercellular and small intracellular cysts in trout-perch (*Percopsis omiscomaycus*) muscle. The data suggests that spores from each cyst type represent a single species of *Myxobolus* with variable cyst phenotypes. Interestingly, spores from the small cysts were shorter than those from the large cysts implying ecophenotypic variation. The fact that the two cyst types did not occur independently of each other suggests that they are a single species. The observed differences in the morphological and molecular data suggest species divergence. The second situation provides a comparison between *Myxobolus neurophilus* from the optic tectum of yellow perch (*Perca flavescens*) and specimens that were tentatively identified as *M. neurophilus* from the tectum of Johnny darter (*Etheostoma nigrum*). Although the morphology of the spores of these samples is very similar, molecular information identifies the latter parasite as a possible new species of *Myxobolus.* The morphological and molecular similarities between these three species are examined on both an individual basis and between other species in the genus *Myxobolus.* Phylogenies are drawn from the molecular data and a phylogenetic tree is constructed that includes sequences presented in the current work which have not been analysed at this level. The validity of traditional taxonomic methods and their use in classification of the myxobolids is discussed. Alternately modern techniques of molecular biology and their role in the taxonomy of these parasites are evaluated.

Acknowledgments

I would like to acknowledge the majority of individuals who have supported my burgeoning interest in the field of parasitology. Dr. David Cone who as my mentor allowed me the freedom to apply my experience to that field he knows so well. Dr. Stewart Johnson who was always willing to lend me an ear providing a wealth of information garnered from his years of experience. To Jeffrey Gallant my “molecular guru” for allowing me to frequently tap into his mind. To Colleen Murphy who gave freely of her time clarifying procedures and concepts and lending a variety of media and reagents when needed. To Jane Osborne who’s quiet demeanor contrasted with my rabid enthusiasm in proportions sufficient to produce an interesting and fruitful collaboration.

I would also like to thank Dr. Laura Brown and Dr. George Iwama of the National Research Council – Institute for Marine Biosciences for their encouragement and support.

I must also joyously acknowledge the loves of my life, my three amazing daughters, Kara, Samantha and Darby who are always ready to let their dad act with utter foolishness and are then willing to listen so attentively when I go on about this fish or that bug. And of course my wonderful wife Dorothy whom I adore, for endless support and for always being there.

And to Emery, our Iguana, who is a constant reminder to me of the beauty and diversity that fills our world.

TABLE OF CONTENTS

PAGE

8. FIGURES

LIST OF FIGURES CONTINUED...

LIST OF FIGURES CONTINUED...

PAGE

9. TABLES

10. APPENDICES

LIST OF ABBREVIATIONS

BLAST	Basic Local Alignment Search Tool
CISTI	Canadian Institute for Scientific and Technical Information
DNA	Deoxyribonucleic Acid
IMB	Institute for Marine Biosciences
ITS	Inter Transcribed Spacer region
NCBI	National Center for Biotechnology Information
NRC	National Research Council
DNTP	deoxyribonucleotide triphosphate
PAUP	Phylogenetic Analysis Using Parsimony
PCR	Polymerase Chain Reaction
PFGE	Pulsed Field Gel Electrophoresis
RAPD	Randomly Amplified Polymorphic DNA
RFLP	Restriction Fragment Length Polymorphism
RNA	Ribonucleic Acid
SSU	Small Subunit
SNPs	Single Nucleotide Polymorphisms
Taq	*Thermus aquaticus*
X-gal	5-bromo-4-chloro-3-indolyl-β-D-galactoside

1.0 Introduction

The phylum Myxozoa is a diverse group of approximately 1350 described species all of which are parasites (Kent et al. 2001). Their hosts include annelids, bony fishes, amphibians and reptiles (Andree et al. 1999 a). They can be considered ubiquitous within a wide range of environments and occupy an even wider range of hosts.

Myxozoans are considered tissue specific in their site of development (Molnár 1994), but as a group they can be found in a variety of organs within individual fish hosts. Numerous species can be found in the lumen of the gall bladder, kidney tubules, and digestive tract (coelozoic species), whereas others are known from sites within tissues of the digestive, reproductive, muscular, circulatory, and skeletal systems including the skin (histozoic species). Although myxozoans are generally not pathogenic there are some major exceptions. For example, Whirling disease in trout is caused by *Myxobolus cerebralis* and enzymatic lysis or soft tissue disease of salmon is caused by *Kudoa* and *Hexacapsula* species.

Until the early 1990's the Myxozoa were usually grouped with the protists (Kent et al. 2001). Pioneering studies into the morphology of myxozoans, however, identified characteristics typical of multicellular animals including structural and developmental patterns similar to those of the phylum Cnidaria (Siddall et al. 1995). Cnidarians are those animals armed with stingers or nematocysts and include the jellyfish and corals. Siddall et al. (1995) identified myxozoan “polar capsules” within “capsulogenic cells” that bore a distinct homology to cnidarian nematocysts. The results appeared to group the Myxozoa within a clade of highly derived parasitic cnidarians (Siddall et al. 1995). In phylogenetic analyses, Siddall et al. (1995) included the cnidarian narcomedusan *Polypodium hydriforme* and considered it essential to the resolution of the myxozoans as cnidarians. However, Hanelt et al. (1996) argued that the small subunit (SSU) 18S ribosomal DNA (rDNA) sequence of *P. hydriforme* is too different to be included in a proper phylogenetic comparison. It was concluded by Hanelt et al. (1996) that data collected through BLAST searches using *Polypodium* 18S rDNA sequences differed from existing 18S sequences to such an extent that its grouping within the myxozoans must be due to “long branch abstraction” (Siddall and Whiting 1999). Conflicts in the molecular data may arise from the long-branch nature of the Myxozoa as well as the low “taxon density” common to most molecular analyses (Zrzavý et al. 1998). Siddall and Whiting (1999), subsequently, concluded that there is no support for the suggestion that myxozoans are unrelated to cnidarians, stating that homology in ontogenetic stages and intercellular parasitism common to myxozoans and cnidarians cannot be due to long-branch abstraction (Siddall and Whiting 1999). Figure 1 illustrates parsimony analysis of SSU 18S rDNA sequences for the phylum Myxozoa as constructed by Siddall and Whiting (1999). Since these molecular lineages have been defined using a single data set, this cannot be the final word on myxozoan origins (Kent et al. 2001).

It has recently been suggested that the Myxozoa originated from a bilaterian ancestor such as *Buddenbrockia*, a nematode-like parasite of freshwater bryozoans (Okamura et al. 2002). Phylogenetic analyses based on SSU 18S rDNA sequences and one on *Hox* gene sequences further supported this hypothesis (Canning et al. 2002). Zrzavý and Hypša (2003) support this relationship of the Myxozoa while allowing at the same time for a homology between polar capsules of the myxozoan and cnidarian nematocysts. Successive clades of nematocyst bearing animals including the Myxozoa, *Polypodium* and Cnidaria, appear to bridge the gap between the animals like *Buddenbrockia* and more primitive animals (Zrzavý and Hypša 2003).

Life cycles are known for only about 25 myxozoans (Oumouna et al. 2002) as summarized in Table 1. Wolf and Markiw (1984) elucidated the biphasic life cycle of *M. cerebralis* including development into an actinosporean (triactinomyxon) within an annelid host prior to infecting the fish host (Wolf and Markiw 1984) (Fig. 2). Spores from salmonid hosts having Whirling disease are not infective to healthy fish. It is only after the spores have been ingested by annelid worms and have gone through a series of complex stages of development does an infective triactinomyxon, or TAM, emerge. Spores are liberated when dead fish decay. Or, if a predator eats a fish the spores are passed out with the predator's feces. The tubificid worms then ingest the spores and the binucleate sporoplasm that emerges from the spores invades the gut epithelium of the host worm (Brinkhurst 1996).

In the majority of cases species have a biphasic cycle involving myxosporean and actinosporean phases. Issues concerning nomenclature of the myxozoans have been raised in response to the respective life stage the organism is presently undergoing. Kent et al. (2001) proposed that based on their interpretation of the International Code of Zoological Nomenclature that the generic names of all actinosporeans should be treated as collective groups (Kent et al. 2001). This would eliminate the discrepancies arising from alternate myxosporean generic names. There is concern over this proposed change, however, because it is uncertain that all species of Actinosporea produce corresponding myxosporean stages in their life cycles (Morris et al. 2002). Those species of *Myxobolus* in which separate life stages have been identified should not be described based solely on their actinosporean forms. Major discrepancies in nomenclature arise from interpretations of the significance of new and unusual actinosporean forms and not simply on the interpretations as defined by the International Code of Zoological Nomenclature (Kent et al. 2001).

Conventional light microscopy provides information that allows significant functional resolution at the species level of the Myxozoa (Oumouna et al. 2002). However, the use of these classical zoological methods is sometimes very difficult to accurately characterize morphologically similar myxozoans inhabiting taxonomically related host species (Molnár et al. 2002). The morphology of myxosporeans is thought to vary significantly with host, environment within which they are found and tissue. However, traditional diagnostic procedures are based solely on these characteristics (Yokoyama et al. 1997).

Species concepts based on traditional morphological variance are continually being modified to include data obtained through analysis of an organism's genotype. There are few homologous morphological characters that can be compared among all living organisms whereas a number of genes with fundamental biochemical functions are found within all species (Hillis and Dixon 1991). The use of rDNA sequences is a well-accepted method to resolve taxonomic relationships at the intrageneric level as well as at higher taxonomic levels (Kent et al. 2001). The SSU 18S rDNA has become the genetic region of choice by researchers and as such was used in this work as well. Sequence data from regions distributed along the ribosomal RNA provide a molecular template that can be used as a tool for identifying relationships among organisms (See Appendix A). This is possible because the rRNA is universally distributed, is functionally equivalent, and occurs in large enough sizes that interspersion patterns of conserved and non-conserved regions allow for statistical analyses that provide valid interpretations of genetic similarities between species (Frasca et al. 1999). The SSU 18S rDNA gene is also the most slowly evolving of the rDNA genes thus it is suitable for addressing questions concerning ancient evolution (Hillis and Dixon 1991). However, a drawback of being the most evolutionarily conserved region of the ribosomal genes is sometimes a concern in that closely related species do not often show significant differences (Hervio et al. 1997). This is a concern when looking for variation within closely related species. The lack of significant variation in the 18S rDNA however, has lead researchers to explore other molecular regions within the genome of the

Myxozoa. Such regions include the internal transcribed spacer regions (ITS1 and ITS2). The ITS regions are under fewer constraints of selective pressure and have shown significant variability which is useful in discriminating both between closely related species and among populations of a chosen species (Andree et al. 1999 b). Generally, highly conserved genes, including the functional ribosomal RNA genes as well as enzymes or structural proteins, are useful for defining ancestral relationships within eukaryotic lineages, whereas rapidly evolving sequences are best suited for more recent phylogenetic groupings (Barta 2001). Further, molecular analysis of the SSU 18S rDNA has been attempted using a series of restriction enzymes to digest the nucleic acid into readily distinguishable profiles. This has proved a quick and easy method to identify species of *Myxobolus* that are otherwise difficult to distinguish by morphology and tissue tropism alone (Eszterbauer et al. 2001). Information acquired through the use of molecular methods provides an independent data set separate from morphological information. Phylogenetic trees generated using molecular data are always open to interpretation; however, phylogenies have shed some light on the branching patterns of descent within many phyla (Collins and Valentine 2001).

The present thesis attempts to address important areas of concern that confront taxonomy of the myxozoans based solely on spore morphology. Spore taxonomy works well when the species being studied have spores with distinct morphological characteristics. However, the system breaks down when species with very similar spores are being compared. My work assesses the reliability of the taxonomy in these situations through the application of modern molecular tools.

The first section of my thesis involves the taxonomy of *Myxobolus procerus* (Kudo 1934), a common parasite of trout-perch (*Percopsis omiscomaycus*) in the Great Lakes region of North America (Kudo 1934; Cone et al. 1997). *Myxobolus procerus* is unusual in that it forms two morphologically distinct cyst types within its host, with each form containing what is reported to be similarly shaped and sized spores (Cone et al. 1997). One cyst is large, oval and intercellular between muscle fibres. The other is small, cigar shaped and intracellular within muscle cells. The questions addressed are 1) is this two sibling species that produce different cyst types but similar spores? or 2) is it a single species with variable spore morphology depending on the cyst type the spore is in?

The second area investigated involves the taxonomy of *Myxobolus neurophilus* (Guilford 1963), a common parasite of the brain of yellow perch (*Perca flavescens*) from central and eastern North America (Dzulinsky et al. 1994). In this case the type host was yellow perch; however, Guilford (1963) reported the same species within the brain of etheostomid darters as well. The question addressed is: based on morphological and molecular data are these the same or different species of parasite? Spores of both *M. procerus* and *M. neurophilus* are themselves very similar in morphology being typically oval in shape. In this thesis I used molecular and morphological data to determine the relationship between the species noted above and other species of *Myxobolus* for which there are sequence data available in GenBank (National Center for Biotechnology Information).

2.0 Materials And Methods

2.1 Collection of Parasites

Trout-perch (*Percopsis omiscomaycus*) (Fig. 3) heavily infected with *Myxobolus procerus* were collected by seine net fishing in the shallows of the St. Lawrence River at Île Dorval (45° 26'N, 72° 44'W) on June 3, 2002 by Dr. David Marcogliese, a fellow collaborator. Fish were transported live to a laboratory at the St. Lawrence Center, Environment Canada, Montreal. Yellow perch (*Perca flavescens*)(Fig. 4) infected with *Myxobolus neurophilus* were collected May 2003 by trap net fishing in Vinegar Lake, Nova Scotia (44° 40' N, 64° 02' W). In both cases, fish were fixed either in 10% formalin (for light microscopy) or 95% ethanol (for molecular studies). Samples of Johnny darter (*Etheostoma nigrum*) (Fig. 5) were collected May 2003 from Mykiss Lake, Algonquin Park, Ontario (45° 40' 05 N, 78° 10' 20 W) and taken to the Harkness Fisheries Research Station on Lake Opeongo. There the fish were necropsied, the spores were photographed live, and the samples were preserved in 95% ethanol.

2.2 Light Microscopy

Formalin-fixed fish were examined for cysts containing mature spores. Cysts were excised and transferred to microscope slides where they were ruptured in 2-3 drops of water. A solution of 1% molten agar on a cover slip was placed over cyst contents, and the resulting preparation used to examine immobilized spores. Digital images of spores of *M. procerus* were obtained using a Zeiss photomicroscope camera and Zeiss morphometric software. Length and width of the spore and of the polar capsules (Fig. 6) were determined to the nearest 0.1 µM from these images. The number of polar filament coils within the capsules were counted where possible and notes made on the presence and form of intercapsular appendices, vacuoles, and sutural ridge folds.

Intense infections of *M. procerus* in trout-perch allowed detailed comparison of spore size within cysts in individual fish, between fish, and between small and large cyst types. Spore length and width, and polar capsule length and width of 25 spores from each of 3 small intracellular and 3 large intercellular cysts from 5 individual fish were compared to assess variation between cysts and among separate hosts.

2.3 Statistical analysis

Morphological data were analysed using SYSTAT. One variable was non-transformable and therefore a Kruskal-Wallace test was completed in lieu of a one-way MANOVA. The statistical analyses are therefore distribution free tests. In order to reduce the chance of a Type 1 error a Bonferoni test was completed.

Note that terms used in this thesis are defined in the glossary in Appendix B.

2.4 Molecular Biology

2.4.1 DNA Extraction

Spores were lysed in 10 mM Tris-Cl pH 8.0, 1 mM EDTA (TE), 1% SDS with proteinase K (200 µg/ml) for 2 hours in a 37°C water bath. Suspensions were extracted twice with phenol: chloroform: isoamyl alcohol (25:24:1) and the DNA was precipitated with cold 100% ethanol and 3 M sodium acetate (pH 7.0) followed by centrifugation at 9,300 g for 10 minutes. The pellet was washed once with 70% ethanol and air dried at room temperature. Genomic DNA was resuspended in 50 µl 10 mM Tris-Cl pH 8.0, 1 mM EDTA (TE) and stored in TE at 4°C. Quantification of DNA was completed using a Beckman Spectrophotometer. An aliquot of each extraction was visualized on a 1% agarose gel against known standards (Fig. 7).

2.4.2 Polymerase Chain Reaction

Small subunit (SSU) 18S rDNA was amplified using myxozoan general and specific primers (Table 2). Primers were re-suspended in ddH_20 to a stock concentration of 10 µM. PCR was performed in 50 µl reaction volumes containing 1.5 mM $MgCl_2$, 0.2 mM dNTP, 1.25 Units *Taq* polymerase, 1 µM of each primer and 300 ng DNA. Amplifications were performed on a Perkin-Elmer Gene Amp 9700 Thermocycler. Cycling parameters were as follows: initial denaturation at 95° C for 5 minutes followed by 35 cycles of 94° C for 1 minute, 55° C for 1 minute, 72° C for 1.5 minutes and a final extension at 72° C for 10 minutes. The

PCR products were excised from the agarose gel and purified. A list of reagents used in this work is given in Appendix C.

2.4.3 Cloning

The purified PCR products were analysed on a 1% agarose gel and 4 μl was used for cloning reactions. PCR products were cloned using the TOPO TA Cloning Kit (see Appendix F). Prior to cloning 4 μl of the "cleaned" PCR product was incubated at 72°C for 15 minutes in a sterile PCR tube containing 1 μl dATP (at 1 μM), 0.25 U *Taq* and 0.5 μl 10X *Taq* buffer. This was to ensure the addition of the poly A tail necessary for a successful TOPO reaction. Chemically competent *Escherichia coli* cells were transformed with the TOPO vector containing the PCR generated inserts. Approximately 150 μl of each transformation was streaked onto LB plates containing carbenicillin to a final concentration of 25 μg/ml + X-gal and grown overnight at 37°C/300 RPM. A representative number of "white" colonies indicating positive clones were transferred into 1 ml LB broth + carbenicillin (25 μg/ml) and grown at 37°C /300 rpm overnight. Glycerol stocks of each colony were prepared by mixing 100 µl of culture with 100 µl of a sterile 50% glycerol solution. The stock cultures were then stored at –80°C.

2.4.4 Screening

2.4.4.a Protoplasting

Protoplasts were generated using a modified chemical treatment assay.

Approximately 3 ml of LB containing carbenicillin (25 μg /ml) were inoculated with a single colony. The tubes were placed at 37°C/300 rpm for 18 hours. After incubation 50 µl of culture was transferred into a sterile 0.6 ml Eppendorf tube and centrifuged at 9,300g for 10 minutes. The supernatant was discarded and the pellet re-suspended in 30 µl sucrose buffer. A further 10 µl of phenol:chloroform:isoamyl alcohol (25:24:1) was added and the tube was vortexed for 1 minute at high speed. The tubes were then centrifuged for 20 minutes at 9,300g.

2.4.4.b Plasmid Preparation

Plasmid DNA was isolated from clones using the Qia-Prep Mini prep isolation procedure or a simple protoplasting technique and transformants were analysed on a 1% agarose gel (Fig. 8). Sizes of the inserts were determined by comparison against a standard of known molecular weight.

2.4.4.c Screening by M13 PCR

To determine the presence and sizes of inserts purified plasmid DNA was amplified using primers M13 F and M13 R (Fig. 9). Reaction conditions are as follows;

PCR Reaction	**Cycling conditions**	
1 X PCR buffer		
dNTP 0.2 mM	1. 95°C	5'
Taq polymerase 1.25 U	2. 95°C	1'
M13F 100 ng	3. 55°C	1'
M13R 100 ng	4. 72°C	1'
ddH_20 to 20 µl	5. Go to 2 for 30 X	
DNA to 300ng	6. 4°C α	

2.4.5 DNA Sequencing

Sequencing reactions were performed using those primers that generated PCR products. Sequence data was also obtained using M13 F and M13 R primers. The following clones were sequenced: three clones each of *M. procerus* spores from intercellular cysts with 18e and MX3 primers, three clones of *M. procerus* spores from intracellular cysts using MX3 primer and two clones using Myxgen2r (18r) primer, and three clones from yellow perch using M13 F and M13 R primers with cloned 18e-Myxgen2r (18r) PCR product, three clones each from Johnny darter using M13F and M13 R primers with cloned 18e-Myxgen2r PCR product and cloned Act3f-MX3 PCR product. In order to obtain more SSU 18S rDNA from *M. procerus*, "walking" primers were designed from those regions containing unambiguous sequence data. Sequencing reactions were performed using ET terminator chemistry and sequencing was done on a MegaBACE 1000 capillary sequencer.

Sequences were aligned against the vector to eliminate any contaminating vector DNA. To further eliminate the presence of any vector sequence a restriction map of the SSU 18S rDNA isolated in this work was constructed. Recognition sites common to the TOPO plasmid were not identified, thereby further confirming the lack of vector contamination.

2.4.6 Sequence and Phylogenetic Analysis

Sequencher (Version 4.0.5) was used to edit sequence data and produce contiguous alignments. Sequences were subjected to BLAST (Altschul et al.

1990) searches against sequences in GenBank (NCBI). Bit scores are listed in the tables along with the corresponding E values. The Bit score indicates the relatedness of the sequence to those against which it aligns. It is also a link to the NCBI database from which the sequence originates. The E value illustrates the number of matches to the current non-redundant database that are expected by chance alone. The lower the E value the more "real" the alignment in question. The higher the bit score the greater the similarity.

Alignment of SSU 18S rDNA sequences is completed using DNA analysis software, termed Clustal X (Thompson et al. 1997) with optimal parameters defined in Hall (2001). Clustal X uses an algorithm that aligns most closely related sequences first then these groups are gradually aligned together retaining the previous alignments (Thompson et al. 1997). The output of the Clustal X alignment is read by the phylogenetic tree-generating program PAUP (Swofford et al. 2001). Algorithms used in the PAUP analysis included parsimony, maximum likelihood, and distance methods and bootstrap analysis with 1000 replicates. Sequences used were; *Ceratomyxa shasta* GenBank AF001579, *Myxidium truttae* GenBank AF201374, *Myxidium* spp. GenBank U13829, *Myxidium lieberkuehni* GenBank X766390, *Henneguya lesteri* GenBank AF306794, *Henneguya* spp. GenBank U13826, *Henneguya doori* GenBank U37549, *Henneguya ictaluri* GenBank AF195510, *Henneguya exilis* GenBank AF021881, *Myxobolus osburni* GenBank AF378338, *Myxobolus spinacurvatura* GenBank F378341, *Myxobolus ichkeulensis* GenBank AF378337, *Myxobolus lentisuturalis* GenBank AY119688, *Myxobolus* KAB-2001B GenBank AF378343, *Myxobolus xiaoi* GenBank AF186843, *Myxobolus portucalensis* GenBank F085182, *Myxobolus cerebralis* GenBank U96492, *Myxobolus insidiosus* GenBank U96494, *Myxobolus neurobius* GenBank AF085180, *Myxobolus elipsoides* GenBank AF085178, *Myxobolus djragini* GenBank AF085179, *Myxobolus arcticus* GenBank AF085176, *Myxobolus bramae* GenBank AF085177, *Myxobolus sandrae* GenBank AF085181, *Myxobolus* spp. KAB2001A GenBank AF378342, *Henneguya zschokkei* GenBank AF378344, *Henneguya salminicola* GenBank AF031411, *Myxobolus pseudodispar* GenBank AF380143, *Myxobolus musculi* GenBank AF380141, *Myxobolus cyprini* GenBank AF380140, *Myxobolus hungaricus* GenBank AF448444, *Myxobolus pendula* GenBank AF378340, *Myxobolus pellicides* GenBank AF378339, *Myxobolus bibullatus* GenBank AF378336, *Myxobolus elegans* GenBank AF448445, *Myxobolus algonquinensis* GenBank AF378335.

3. Situation 1 – Cyst Types of *Myxobolus procerus.*

3.1 Light Microscopy

Microscopic examination of trout-perch during necropsy revealed the presence of both intercellular and intracellular cysts. Cysts exist intercellularly within connective tissue associated with muscle as well as within the outer epidermis between dermal scales. The intercellular cysts were white, oval and approximately 1.5-2 mm in size and concentrated around the head and caudal peduncle regions (Fig. 10). Intracellular cysts inside striated muscle cells were dark grey and cigar shaped structures (up to 1mm long) running the length of the muscle cell (Fig. 11). Intracellular cysts were less prone to rupture and could be handled with greater pressure than the intercellular cysts that were more fragile and had to be handled more delicately. Intercellular and intracellular cysts were treated separately so as to avoid crossover contamination.

Spores of both cyst types were typically pyriform in shape, tapering anteriorly to a knob-like end. The polar capsules were a narrow pyriform shape, with a pore-like intercapsular appendix (Fig. 12). The sutural ridge was thin, with some spores having 3-4 posteriorly located sutural ridge folds.

Table 4 summarizes the statistical comparison of morphometrics obtained from intercellular and intracellular cysts. The histogram in Figure 13 provides an illustration of the distribution of spore length in both cyst types. There were no statistically significant differences in spore morphometrics, and the number of polar filament coils in the spores, from intracellular cysts within individual fish or between the five fish sampled. Similarly, the same applied to spores from intercellular cysts. However, spores from intercellular cysts were significantly longer that spores from intracellular cysts.

3.2 Molecular analysis

Polymerase Chain Reactions using myxozoan general primers produced products of approximately 1.6 Kb (Fig. 14). Primer set 18e-Myxgen2r (18r) was more consistent and therefore PCR products from this primer set were used for further molecular analysis. Subsequent primer sets were used to “walk” the 18S region of *Myxobolus procerus* isolated from both cyst types (Table 2). PCR products were used in TOPO cloning reactions and white colonies indicating possible transformants were screened using the methods discussed above. Positive transformants were sequenced and those clones with “reliable” sequence data were aligned and analysed. Analysing individual clones for sequence heterogeneity provided an indication of variability within different cyst types. Individual clones from each reaction were analysed and regions with poor sequence data removed to provide a reliable region to identify sequence differences. Table 3 shows the number of base pairs of each clone that was compared. As indicated, there were no differences in SSU 18S rDNA sequence between those clones of *Myxobolus procerus* analysed.

3.3 Basic Local Alignment Search (BLAST) Results

Comparison of the consensus sequence (Figs. 15 and 16) for intracellular and intercellular forms of *M. procerus* with myxozoan sequences submitted to GenBank showed that they are indeed myxobolids with a high degree of similarity to *Myxobolus exiguus* (93%) Accession # AF021878.1, *M. muelleri* (93%) Accession # AY129317.1, *Aurantiactinomyxon mississipiens* (90%) Accession # AF021878.1, *Henneguya exilis* (89%) Accession # AF021881.1 and *H. ictaluri* (89%) Accession # AF195510.1 (Table 5). The remaining 8 sequences producing significant alignments with the consensus sequences of *M. procerus* from both intercellular and intracellular cysts types are listed in Figures 17 and 18.

3.4 Clustal X Alignment of SSU 18S rDNA

A total of 989 base pairs from consensus sequences for both intercellular and intracellular cysts types were compared using Clustal X software (Fig. 19). There were 20 base pairs difference (2.1% of total) in SSU18S rDNA sequence between *M. procerus* within the intracellular cysts and *M. procerus* within intercellular cysts. Of these 20 base pair differences 10 were due to base substitutions and the remaining 10 due to the presence or absence of a nucleotide. Differences in sequence could be attributed to *Taq* polymerase error; however, according to the manufacturer the enzyme is responsible for very little error. Error rates for thermal resistant DNA polymerases have been calculated at

1.1 X 10-5 base substitutions/bp (Tindall and Kunkel 1988). This indicates only one error in every 110 Kilobases, a value that is in question in the current work.

4.0 Situation 2 – *Myxobolus neurophllus*

4.1 Light Microscopy

Formalin fixed spores of *M. neurophilus* from the optic tectum of yellow perch (*Perca flavescens*) from Vinegar Lake, Nova Scotia, were pyriform in shape with a bluntly pointed anterior extremity and broadly rounded posterior (Fig. 20). Spores measured 14.40 μm ± 0.77 μm long, 6.96 μm ± 0.24 wide (N=13), with two similarly sized polar capsules 6.50 μm ± 0.24 long and 2.10 μm ±0.21 wide containing 7 – 9 filament coils arranged perpendicular to the capsule length. There was no evidence of an intercapsular appendix, sutural ridge folds, or a mucous coat.

Material collected from the optic tectum of Johnny darter (*Etheostoma nigrum*) from Mykiss Lake, Algonquin Park was tentatively identified by Guilford (1963) as *Myxobolus neurophilus* on the basis of host, developmental site, and morphology of the spores examined and photographed live in the field. Spores were pyriform but with a subtle narrowing at the anterior extremity (Fig. 21). Fresh spores measured 14.40 μm ± 0.72 long and 7.40 μm ± 1.20 wide, with two similarly sized narrowly pyriform polar capsules 7.50 μm ± 0.40 long and 2 μm wide. Some spores had what appeared to be a round intercapsular appendix anteriorly as well as 3 – 4 posteriorly located sutural ridge folds. A large iodinophilous vacuole was present in the sporoplasm. There was no evidence of a mucous coat.

4.2 Molecular Analysis

4.2.1 *Myxobolus neurophilus* from yellow perch (*Perca flavescens)*

Using primer sets Myxgp2f-Act1R and Act3F-MX3 both specific for the Myxozoa, I was able to amplify products of approximately 920bp and 750bp respectively from the neural tissue of yellow perch. Three clones were generated from the 18e-Myxgen2r PCR product only. Each clone was successfully sequenced using M13 forward and reverse primers. After removing unreliable sequence data a total of 723 bp from each of the three clones were aligned and differences between the clones noted (Fig. 22). There were no differences in the consensus sequence from each clone. The resulting 723 bp sequence used for the subsequent BLAST search is illustrated in Figure 23.

4.2.2 *Myxobolus neurophilus* from the Johnny darter (*Etheostoma nigrum*)

Using the same primers as noted above PCR products were generated from the neural tissue of Johnny darter. Products from both primer sets were successfully cloned and sequences from each of three clones from each primer set were compared. Lining up clones 1-3 from the Myxgp2f-Act1r primer set gives 844 bp of sequence with no differences. Lining up clones 1-3 for the Act3F-MX3 primer set gives 750 bp sequence data with two differences in clone 3 sequenced in both forward and reverse directions. Differences were noted at position 429 with C for a T (questionable) and position 575 with G for an A (uncontested). Lining up all clones gives me 1570 bp with the two differences from clone 3 AM (Fig. 24). The resulting consensus sequence Johnny darter (Fig. 25) was used in a Clustal X alignment against the consensus sequence from yellow perch and trout-perch.

4.2.3 Basic Local Alignment Search (BLAST) Results

BLAST results for each consensus sequence from Johnny darter and yellow perch are illustrated in Figures 26 and 27. Sequences obtained from PCR reactions with DNA isolated from yellow perch were most similar to *Henneguya zschokkei* (Accession # AF378344), *Henneguya weishanensis* (Accession # AY165182), *Henneguya ictaluri* (Accession # AF195510) and *Neoactinomyxum* sp. (Accession # AF378353). Sequences obtained from Johnny darter BLAST'ed with a high degree of similarity against *Henneguya weishanensis* (Accession # AY165182), *Henneguya ictaluri* (Accession # AF195510) and *Neoactinomyxum* sp. (Accession # AF378353) and *Tetraspora discoidea* (Accession # AF306793).

4.2.4 Clustal X Alignment of SSU 18S rDNA

Sequences generated by amplification of the SSU 18S rDNA from all of the species of *Myxobolus* studied were aligned using Clustal X. Ambiguous regions were removed and sequences aligned using Clustal X. The alignment between *Myxobolus* species isolated from Johnny darter and the yellow perch resulted in an 8% difference noted (54/690) (Fig. 28). The differences noted were confirmed using the accompanying chromatogram from data generated by the MegaBace sequencer. The results suggest that the species of *Myxobolus* isolated from Johnny darter is a different species from *M. neurophilus* isolated from yellow perch. The consensus sequence from Johnny darter was also compared to the consensus sequences generated from the SSU 18S rDNA from spores within each cyst type of *M. procerus*. A total of 989 base pairs of the SSU 18S rDNA from both the darter and trout-perch were aligned with a 53 base pair difference noted (or 5.3 % sequence difference) between darter and *M. procerus* intracellular cysts and a 56 base pair difference (5.6%) between darter and *M. procerus* intercellular cyst types (Fig. 29). What is interesting is that the sequence variation between the myxozoans from the darter and the trout-perch is less than that between the darter and the yellow perch. The consensus sequence from the yellow perch was aligned against consensus sequences from the trout-perch and the differences were significant at > 25% sequence difference (Fig. 30) and clearly indicates a separate species of *Myxobolus*.

5.0 Phylogenetic tree of species of *Myxobolus* identified in this thesis

In my thesis I have provided a molecular comparison between myxozoan SSU 18S rDNA isolated from yellow perch, trout-perch and Johnny darter. Using these three species their position within the phylogeny of the Myxozoa was determined. The phylogenetic tree confirms the presence of three separate species that have been identified in the present work (Fig. 31).

Using three algorithms of analysis, neighbour-joining, parsimony and maximum likelihood the topology of the trees remained unchanged (See

Appendix E and F). The phylogenetic tree places *Myxobolus* sp. from Johnny darter within a clade that includes *Henneguya lesteri* with strong bootstrap support. *Myxobolus procerus* isolates from intercellular and intracellular cyst types are also closely aligned with *Myxobolus* sp. from Johnny darter, once again with high bootstrap support. However, sequence data from *M. procerus* of trout-perch and *Myxobolus* sp. of Johnny darter remain significantly different suggesting that they are in fact separate species. *Myxobolus neurophilus* from yellow perch occupies an independent position from those species sequenced to date. This sequence is more closely related to *Myxobolus* species KAB 2001A and *Myxidium* species. The position of isolates from Johhny darter and yellow perch in the phylogentic tree suggests that they are in fact different species of *Myxobolus*.

Further information on *Myxobolus* species used in the phylogenetic tree is given in Appendix G. The Clustal X alignment of all the species of *Myxobolus* used in creation of the phylogenetic tree is illustrated in Appendix H.

6.0 Discussion

Of the recent advances in biological research few have created a greater impact than those involving molecular biology. This “so-called” cutting edge technology has created, arguably, a “new” taxonomy based upon information acquired through analysis of the genotype of an organism. The meeting of morphological and molecular data has not come without controversy. On one side are the traditional taxonomists who feel that studies must remain focused on morphology to address issues of diversity, especially in areas in which molecular analysis comes with too great a financial commitment. Indeed funding for molecular based projects is a concern leading researchers to speculate as to where this funding will come from (Mallet and Willmott 2003). Seberg et al. (2003) asks the question "what has the molecular revolution really achieved for taxonomy?" A significant quantity of data has become available for phylogenetic analyses however the practice of using a single specimen as representative of the taxon can create havoc in taxonomy (Seberg et al. 2003). Opponents however, concede that the information to be gained is a welcome and at times essential component to the construction of real taxonomic schemes. A final word on this side of the controversy; questions have been raised concerning the trend towards reducing taxonomy of all organism to this impoverished state by replacing existing methods with a system that uses only a tiny fraction of an organisms genome to classify and identify the organism in question (Lipscomb et al. 2003). On the alternate side there are those more adamant who feel that it is not only advantageous but also compulsory to add molecular information to current taxonomy. Proponents of molecular taxonomy are convinced that all hopes for a reliable classification lie in the incorporation of molecular data to in effect generate a taxon "barcode " (Hebert et al. 2002). The present work is very much a participant in this debate for taxonomic questions are addressed that are explained using both techniques of traditional taxonomy and molecular biology.

The first situation addresses the significance of two cyst types of *M. procerus* in trout-perch. In the original species description of this parasite, Kudo

(1934) described only large intercellular cysts from trout-perch in Illinois. Cone et al. (1997) described what was considered to be a variant of *M. procerus* from Lake Superior involving the majority of the cysts being intracellular in muscle cells with relatively few large intercellular cysts being produced. The present study of host tissue from the St. Lawrence River, Quebec, similarly found both cyst morphotypes co-existing within the single host species. The fact that the two cyst types do not exist independently of each other further suggests polymorphism in cyst development for *M. procerus.*

In contrast to what was reported by Cone et al. (1997) the present morphological comparison of spores from the two cyst types observed that spores from the small, intracellular cysts were shorter than those from the large, intercellular cysts. It appears that site of development has an effect on the morphology of the spores being produced. How does this come about? The life cycle of *M. procerus* is unknown. However, it is assumed that fish acquire infections from invasive actinosporeans released from oligochaetes (Kent et al. 2001). The migrating infective sporoplasm enters individual striated muscle cells and develops or lodges between cells and develops, forming the two cyst types. Implications are that there may be a physical limitation on spore size as a direct effect of the environment within which the spores are located. As might be expected spores contained within the smaller intracellular cysts are indeed shorter than those within the larger intercellular cysts. What the present work suggests is that during development there may be certain physical or chemical limitations in the way of nutrients available to the developing spore that would affect growth. Previous work has suggested that it is possible that spore dimensions could vary due to developmental temperature, site of infection, host fish parameters and spore age (Yokoyama et al. 1997). Morphological examinations of spores of *Myxobolus koi* in the gills of common carp identified large and small cysts correlated with several distinct differences in their seasonality and mode of development (Yokoyama et al. 1997). It is tempting to suggest that the material studied from the two cyst types of *M. procerus* reflects the process of speciation.

The molecular data acquired in the present work supports the conclusion of ongoing ecophenotypic variation in spores of *M. procerus* depending on cyst type. The sequence data suggests a high degree of homology within the region of the genome that was sequenced. As indicated there is only a 2.1% difference in the SSU 18S rDNA between spores contained within each cyst type. The conclusion is that this is a single species with phenotypic variation. The first reported example of two morphologically distinct spore types that were indistinguishable genetically was described for the aurantiactinomyxons by Hallett et al. (2002). The authors examined a small region of the parasite genome near the 5' end and contend that only a 358-bp region was sufficient to provide information on the variability inherent in different species (Hallett et al. 2002.) Their findings indicate a shared homology between morphological distinct aurantiactinomyxons of only 42-44% of their bases (Hallett et al. 2002).

The second hypothesis examined in the present thesis involves a presumed single species of *Myxobolus* occupying the same specific tissue but in separate hosts. Guilford (1967) described *M. neurophilus* in the optic tectum of its parent host the yellow perch. This description is now considered inadequate by present standards because of the lack of accurate photomicrographs of spores in this early work. Guilford (1963) also reported the parasite from the tectum of Johnny darter (*Etheostoma nigrum*) though this was a peremptory conclusion for he failed to provide any morphological information to support the conclusion. Assuming, as Guilford (1963) did, that the species of *Myxobolus* within the neural tissue of Johnny darter was the same as that described for yellow perch, I attempted a detailed analysis of specific genetic regions of the isolates. On a morphological basis the spores of both myxobolids are very similar, however, the SSU 18S rDNA sequence information differs significantly. Using this single genetic region as a taxon criteria places doubt on classifying this particular parasite from Johnny darter as *M. neurophilus.* In fact, it implies that the material collected from Johnny darter is a new species of *Myxobolus.*

Unfortunately we did not have sufficient material for a reliable morphological comparison between spores of *M. neurophilus* from yellow perch and those isolated from Johnny darter. The available material reveals that the spores differ slightly in shape; those of *M. neurophilus* from yellow perch do not have the indent in the shell as it tapers toward the anterior extremity as seen with the presumed new species in Johnny darter. What is interesting is that in this specific feature, spores of *Myxobolus* sp. from Johnny darter are very similar to *M. procerus.* A detailed analysis of the pyriform shape of these myxobolids needs to be completed to reveal the importance of these observations. Recent information from Dr. Mark Ridgeway in Ontario suggests that there may presently not be any yellow perch in Mykiss Lake, thus supporting the conclusion of a separate species of *Myxobolus* in Johnny darter.

DNA extractions were performed on pooled spores and therefore the possibility of variation within individual samples becomes an issue. To address this a representative number of clones generated from PCR reactions using specific and general myxozoan primers were sequenced and aligned to identify any variations that may exist. Table 3 indicates the clones of *M. procerus* that were aligned to identify sample variation. As indicated, within each cyst phenotype there were no sequence variations suggesting there was no variability within samples. Alignment of clones from those species isolated from yellow perch and Johnny darter are illustrated in Figures 68 and 72 respectively. There are no differences within the three clones of SSU 18S rDNA isolated and sequenced from the yellow perch. There was however two differences noted in clone #3 with primers Act3F-MX3 amplified from Johnny darter. Sequence data from this clone was ambiguous and not as “clean” as that obtained from clones 1 and 2 with the same primer. Thus the consensus sequence from clones 1 and 2 of Johnny darter were used for the alignment against the yellow perch sequences. Differences in clone # 3 from Johnny darter can be attributed to mispriming by the *Taq* polymerase or may be sequencing error resulting in base substitutions however infrequently they do occur. Errors due to *Taq* polymerase is statistically low and not considered a reliable source of sequence variation however this manufacturers claim is not always substantiated.

The phylogenetic tree illustrates the taxonomic placement of a series of myxobolids based upon analysis of SSU 18S rDNA. The tree in Figure 31 is very similar to and defines topologies resembling those generated by Dyková et al. (2002) using the same SSU 18S rDNA sequences that I used in my analysis.

Using the phylogenetic tree as a method of classifying the myxobolids raises many interesting questions. Phylogenetic analyses using the 18S rDNA have grouped morphologically distinct organisms into clades of similar species bringing into question the division of parasites into genera based solely on polar capsule numbers (Whipps et al. 2003). The two morphotypes of *Myxobolus procerus* spores from trout-perch are grouped identically with high bootstrap support. The isolate from Johnny darter falls in with *M. procerus* suggesting a genetic link thus supporting the morphological similarities previously noted. This clade is assigned high bootstrap support, which enhances the reliability of the grouping.

It must be noted that BLAST results do not provide the same information as the phylogenetic analysis program. The BLAST program identifies those sequences that are sufficiently similiar to the sequence of interest as compared against the international database at NCBI. The phylogenetic tree program PAUP then provides an illustrated look at the relationships of each of these sequences using a chosen algorithm. This indicates the variability in sequence analysis results that are dependant upon the chosen algorithm.

Myxobolus neurophilus from yellow perch appears independently and more closely aligned to *Myxobolus* sp. in GenBank than to the isolates from

Johnny darter. In fact the yellow perch isolate is not far removed from other brain dwellers including *Myxobolus insidiosus, M. arcticus* and *M. neurobius*, the latter two species isolated from the neural tissue of salmon. *Myxobolus neurobius* is also found in the spinal cord of trout and salmon distributed throughout British Colombia and Newfoundland (Lom and Dyková 1992).

The species examined in this thesis all have classic pyriform shaped spores, a characteristic that traditional taxonomy would use to group them together. The molecular data however draws a different picture by examining the SSU 18S rDNA of those species studied. In a less conserved region this would not appear significant but within highly conserved genetic regions differences are significant.

The present work questions the feasibility of clarifying species based on spore morphology or molecular data alone. In my thesis I have identified what appears to be three separate species of *Myxobolus* based upon comparison of morphological and molecular data. What provides the defining criterion when molecular and morphological data disagree? Research by Whipps et al. (2003) identifies a variant of *Kudoa permulticapsula* that is significantly different in morphology than any species of *Kudoa* previously described. However based on the SSU 18S rDNA sequence the authors contend that assigning the myxozoan to a new species (or family) would be unacceptable (Whipps et al. 2003). This thesis suggests that conclusions based solely on the analysis of a single genetic region place doubt on an accurate classification of species of *Myxobolus*.

A reliable taxonomic division cannot be defined unless data from both methods are thoroughly examined. In cases when the molecular data from a single genetic region seriously contradicts morphological information it is suggested that other regions of the genome be explored. Molecular biology has provided a sensitive tool with which to examine an organism at a level separate from traditional techniques. Targeting either conserved or variable genes allow examinations into the similarities between species at precise levels of molecular differentiation. However molecular techniques like traditional methods are simply tools to be used in taxonomy. If the data is sound both morphological and molecular data should be used synergistically and not competitively.

Certainly more information will become available as new techniques are discovered and existing techniques improved however the present state of taxonomy can only be enriched by inclusion of the methods discussed in the present work.

7. References

Altschul S. F., W. Gish, W. Miller, E. W. Myers and D.J. Lipman. 1990. Basic local alignment search tool. Journal of Molecular Biology 215:403-10.

Andree K.B., C. Székely, K. Molnár, S.J. Gresoviac and R.P. Hedrick. 1999. (a) Relationships among members of the genus *Myxobolus* (Myxozoa:Bivalvidae) based on small subunit ribosomal DNA sequences. Journal of Parasitology 85:68-74.

Andree K. B., M. El-Matbouli, R. W. Hoffman and R. P. Hedrick. 1999. (b) Comparison of 18S and ITS-1 rDNA sequences of selected geographic isolates of *Myxobolus cerebralis*. International Journal of Parasitology 29:771-775. (b)

Barta J. R. 2001. Molecular approaches for inferring evolutionary relationships among protistan parasites. Veterinary Parasitology 101:175-186.

Brinkhurst R. O. 1996. On the role of tubificid oligochaetes in relation to fish disease with special reference to the Myxozoa. Annual Review of Fish Diseases 6:29-49.

Campbell N. A., Biology. 4th ed. Menlo Park, CA: The Benjamin/Cummings Publishing Company, Inc.; 1996. p 379-380.

Canning, E. U., S. Tops, A. Curry, T. S. Wood and B. Okamura. 2002. Ecology, development and pathogenicity of *Buddenbrockia plummatellae* Schröder, 1910 (Myxozoa, Malacosporea) (syn. *Tetracapsula bryozoides*) and establishment of *Tetracapsuloides* n. gen. for *Tetracapsula bryosalmonae*. Journal of Eukaryotic Microbiology 49:280-295.

Collins A. G. and J. W. Valentine. 2001. Defining phyla: evolutionary pathways to metazoan body plans. Evolution and Development 3:432-442.

Cone D., T. Eurell, R. Axler, D. Rau, and V. Beasley. 1997. Intense infections with a variant of *Myxobolus procerus* (Myxosporea) in muscle of trout-perch (*Percopsis omiscomaycus*) in Duluth Harbor, Lake Superior. Folia Parasitologica 44:7-11.

Dzulinsky K., D. K. Cone, G.T. Faulkner, R. Cusack. 1994. Development of *Myxobolus neurophilus* (Guilford, 1963) (Myxosporea) in the brain of yellow perch (*Perca flavescens*) in Vinegar Lake, Nova Scotia. Canadian Journal of Zoology 72:1180-1185.

Dyková I., I. Fiala and P. Nie. 2002. *Myxobolus lentisuturalis* sp. n. (Myxozoa:Myxobolidae), a new muscle-infecting species from the Prussian carp, *Carassius gibelio* from China. Folia Parasitologica 49:253-258.

Eszterbauer E., M. Benkó, A. Dán and K. Molnár. 2001. Identification of fish-parasitic *Myxobolus* (Myxosporea) species using a combined PCR-RFLP method. Diseases of Aquatic Organisms 44:35-39.

Frasca S. Hr., D. R. Linfert, G. J. Tsongalis, T. S. Gorton, A. E. Garmendia, R. P. Hedrick, A. B. West and H. J. Van Kriuningen. 1999. Molecular Characterization of the Myxosporean associated with parasitic encephalitis of farmed Atlantic salmon *Salmo salar* in Ireland. Diseases of Aquatic Organisms 35:221-233.

Guilford H. G. 1963. New species of Myxosporidia found in Percid fishes from Green Bay (Lake Michigan). Journal of Parasitology 49:474-478.

Guilford H. G. 1967. *Myxosoma pendula* n. sp. (Protozoa, Myxosporida) from the creek chub *Semotilus atromaculatus*. Journal of Protozoology 14:196-198.

Hall G. B. 2001. Phylogenetic Trees Made Easy. A How-To-Manual for Molecular Biologists. Sinauer Associates Inc. Publishers. Sunderland, Massachusetts, USA.

Hallett S. L. and A. Diamant. 2001. Ultrastructure and small-subunit ribosomal DNA sequence of *Henneguya lesteri* n. sp. (Myxosporea) a parasite of sand whiting *Sillago analis* (Sillaginidae) from the coast of Queensland, Australia. Diseases of Aquatic Organisms 46(3): 197-212.

Hallett S. L., S. D. Atkinson and M. El-Matbouli. 2002. Molecular characterization of two aurantiactinomyxon (Myxozoa) phenotypes reveals one genotype. Journal of Fish Diseases 25:627-631.

Hanelt B., D. Van Schyndel, C. M. Adema, L. A. Lewis and E. S. Loker. 1996. The phylogenetic position of *Rhopalura ophiocomae* (Orthonectida) based on 18S ribosomal DNA sequence analysis. Molecular and Biological Evolution 13(9):1187-91.

Hebert P. D. N., A. Cywinska, S. L. Ball and J. R. deWaard. 2002. Biological identifications through DNA barcodes. Proceedings of the Royal Society of London 270:313-321.

Hervio D. M. L., M. L. Kent, J. Khattra, J. Sakanari, H. Yokohama, and R. H. Devlin. 1997. Taxonomy of *Kudoa* species (Myxosporea) using small subunit ribosomal DNA sequence. Canadian Journal of Zoology 75:2112-2119.

Hillis D. M. and M. T. Dixon. 1991. Ribosomal DNA: Molecular Evolution and Phylogenetic Inference. The Quarterly Review of Biology 66:411-453.

Hoover C. 1998 July 8. Invitrogen web catalog.

Kent M. L., K. B. Andree, J. L. Bartholomew, M. El-Matbouli, S. S. Desser, R. H. Devlin, S. W. Feist, R. P. Hedrick, R. W. Hoffmann, J. Khattra, S. L. Hallett, R. J. G. Lester, M. Longshaw, O. Palenzuala, M. E. Siddall and C. Xiao. 2001. Recent Advances in Our Knowledge of the Myxozoa. Journal of Eukaryotic Microbiology 48: 395-413.

Kent M. L., J. Khattra, R. P. Hedrick, and R. H. Devlin. 2000. *Tetracapsula renicola* N. sp. (Myxozoa:saccosporidae); The PKX Myxozoan-The cause of proliferative kidney disease of salmonid fishes. Journal of Parasitology 86:103-111.

Kudo R. R. 1934. Studies on some protoxoan parasites of fishes of Illinois. Illinois Biological Monograph 23:1-41.

Lipscomb D., N. Platnick and Q. Wheeler. 2003. The intellectual content of taxonomy: a comment on DNA taxonomy. Trends in Ecology and Evolution 18:65-66.

Lom J., and I. Dyková. 1992. Protozoan parasites of fishes. Developments in Aquaculture and Fisheries Science 26:1-315.

Mallett J and K. Willmott. 2003. Taxonomy: renaissance or tower of Babel? Trends in Ecology and Evolution 18:57-59.

Molnár K. 1994. Comments on the host, organ and tissue specificity of fish myxosporeans and types of their intrapiscine development. Parasitologica Hungarica 27:5-20.

Molnár K., E. Eszterbauer, C. Székely, Á. Dan and B. Harrach. 2002. Morphological and molecular biological studies on intramuscular *Myxobolus* spp. of cyprinid fish. Journal of Fish Diseases 24:643-652.

Morris D. J., D. C. Morris and A. Adams. 2002. Development and release of a malacosporean (Myxozoa) from *Plumatella repens* (Bryozoa: Phylactolaemata). Folio Parasitologica 49:25-34.

Okamura B., A. Curry, T. S. Wood and E. U. Canning. 2002. Ultrastructure of Buddenbrockia identifies it as a myxozoan and verifies the bilaterian origin of the Myxozoa. Parasitology 124:215-223.

Oumouna M., S. L. Hallett, R. W. Hoffman and M. El-Matbouli. 2002. Early developmental stages of two actinosporeans, *Raabeia* and *Aurantiactinomyxon* (Myxozoa), as detected by light and electron microscopy. Journal of Invertebrate Pathology 79: 17-26.

Seberg O., C. J. Humphries, S. Knapp, D. Wm. Stevenson, G. Petersen, N. Scharff and N. Anderson. 2003. Shortcuts in systematics? A commentary on DNA-based taxonomy. Trends in Ecoiogy and Evolution 18:63-65.

Siddall M. E., D. S. Martin, D. Bridge, S. S. Desser and D. K. Cone. 1995. The demise of phylum of protests: phylogeny of Myxozoa and other parasitic Cnidaria. Journal of Parasitology 81:961-967.

Siddall, M. E. and M. F. Whiting. 1999. Long-branch abstractions. Cladistics 15:9-24.

Swofford D. L. 2001. PAUP*. Phylogenetic analysis using parsimony (* and other methods), Version 4. Sinauer Associates, Sunderland, Massachussetts.

Systat Software Inc. 1998. Point Richmond Tech Center, Canal Boulevard, Richmond,. USA.

Thompson J. D., T. J. Gibson, F. Piewniak, F. Jeanmougin, and D. G. Higgins. 1997. The Clustal X windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucleic Acids Research 24: 4876-4882.

Tindall K. R. and T. A. Kunkel. 1988. Fidelity of DNA synthesis by the *Thermus aquaticus* DNA polymerase Assay. Biochemistry 27:6008-6013.

Whipps C. M., R. D. Adlard, M. S. Bryant and M. L. Kent. 2003. Two unusual myxozoans, *Kudoa quadricornis* N. Sp. (Multivalvulida) from the muscle of goldspotted trevally (*Carangoides fulvoguttatus*) and *Kudoa permulticapsula* N. Sp. (Multivalvulida) from the muscle of Spanish mackerel (*Scomberomorus commerson*) from the Great Barrier Reef, Australia. Journal of Parasitology 89(1):168-173.

Wolf K. and M. E. Markiw. 1984. Biology contravenes taxonomy in the Myxozoa: New discoveries show alternation of invertebrate and vertebrate hosts. Science 225:1449-1452.

Yokoyama H., D. Inoue, A. Kumamaru and H. Wakabayashi. 1997. *Myxobolus koi* (Myxozoa:Myxosporea) forms large and small type cysts in the gills of common carp. Fish Pathology 32:211-217.

Zrzavý J., S. Mihulka, P. Kepka, A. Bezděk and D. Tietz. 1998. Phylogeny of the Metazoa based on morphological and 18S ribosomal DNA evidence. Cladistics 14:249-285.

Zrzavý J. and V. Hypša. 2003. Myxozoa, *Polypodium*, and the origin of the Bilateria:The phylogenetic position of "Endocnidozoa" in light of the rediscovery of *Buddenbrockia*. Cladistics 19:164-169.

8. FIGURES

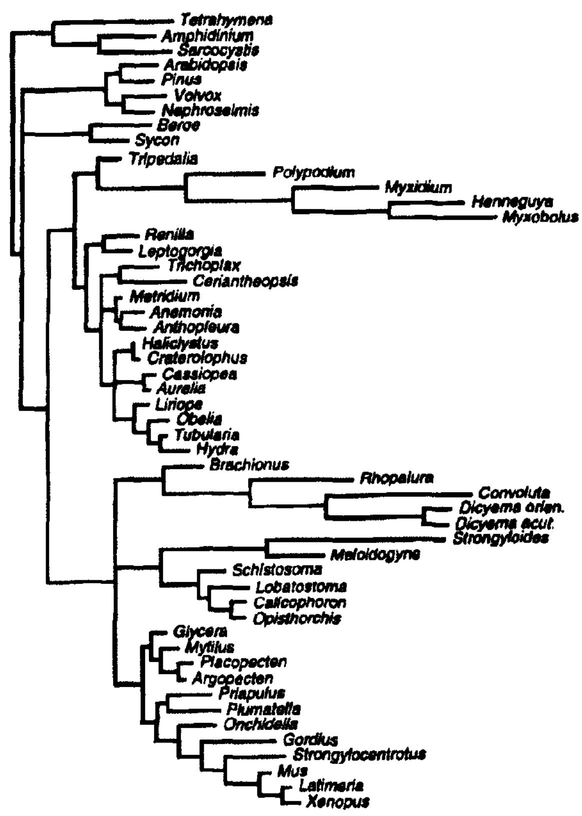


Figure 1. Parsimony analysis of a taxonomically more inclusive molecular data set results in support for the monophyly of the myxozoans with *Polypodium hydriforme* as well as for the phylum Mesozoa (from Siddall and Whiting, 1999).

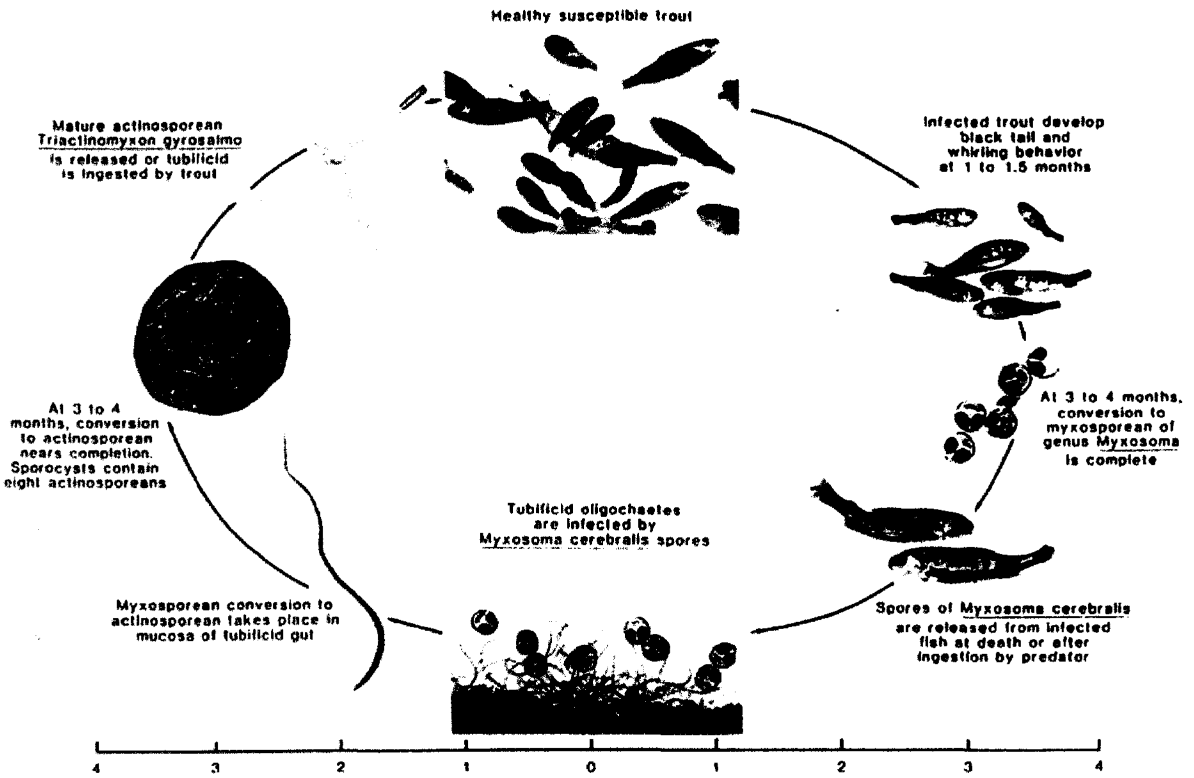


Figure 2. Biphasic life cycle of a myxozoan. From Wolf and Markiw, Science,1984.

Figure 3. Trout-perch (*Percopsis omiscomaycus*)

Figure 4. Yellow perch (*Perca flavescens*)

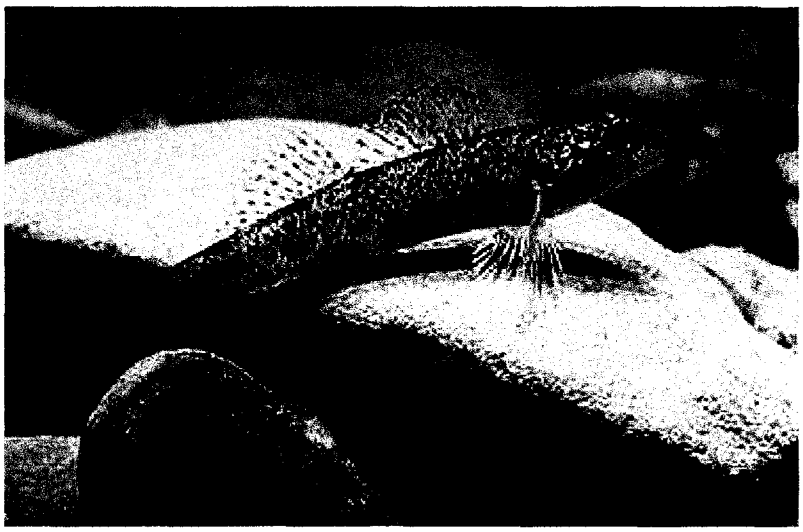


Figure 5. Johnny darter (*Etheostoma nigrum*)

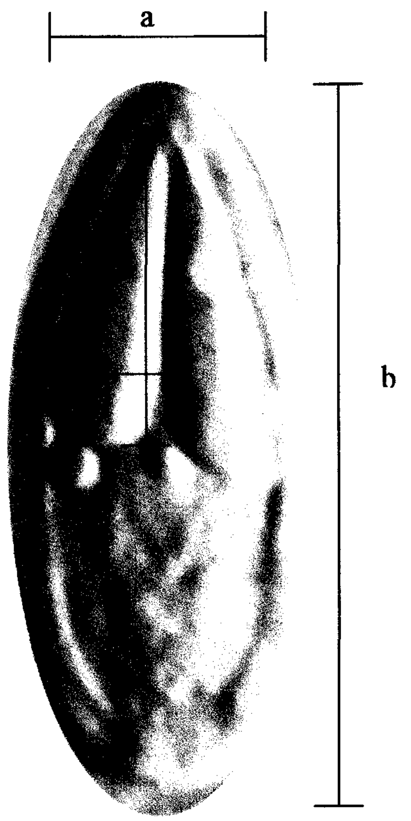


Illustration of spore measurements. a and b indicate width and length respectively. Width of polar capsules inside spores were measured in the same way.

Figure 6. Spore measurement schematic

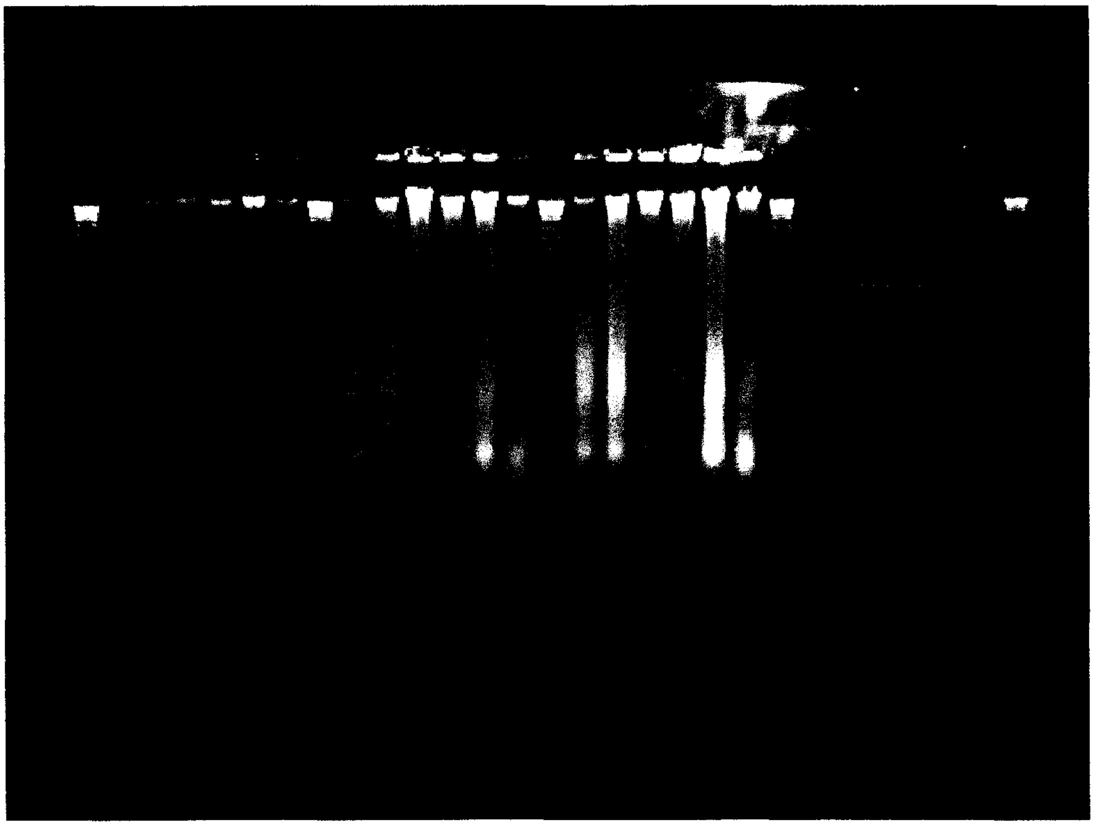


Figure 7. DNA extraction of species of *Myxobolus* using a traditional phenol:chloroform:isoamyl alcohol method. Lanes at right contain pGEM DNA at known concentrations of 10 – 100 nanograms DNA. High molecular weight DNA is evident at the top of the gel with some degradation throughout the lanes. Marker is supercoiled DNA ladder.

Figure 8 a and b. Screening of transformants using Qiagen mini prep kit on left and simple protoplasting method on right. High molecular weight DNA is indicated by comparison with Mass ladder. Inserts are calculated by size of PCR product + Vector. Example: 1.6 kb PCR product + 3.9 kb vector = 5.5 Kb fragment.

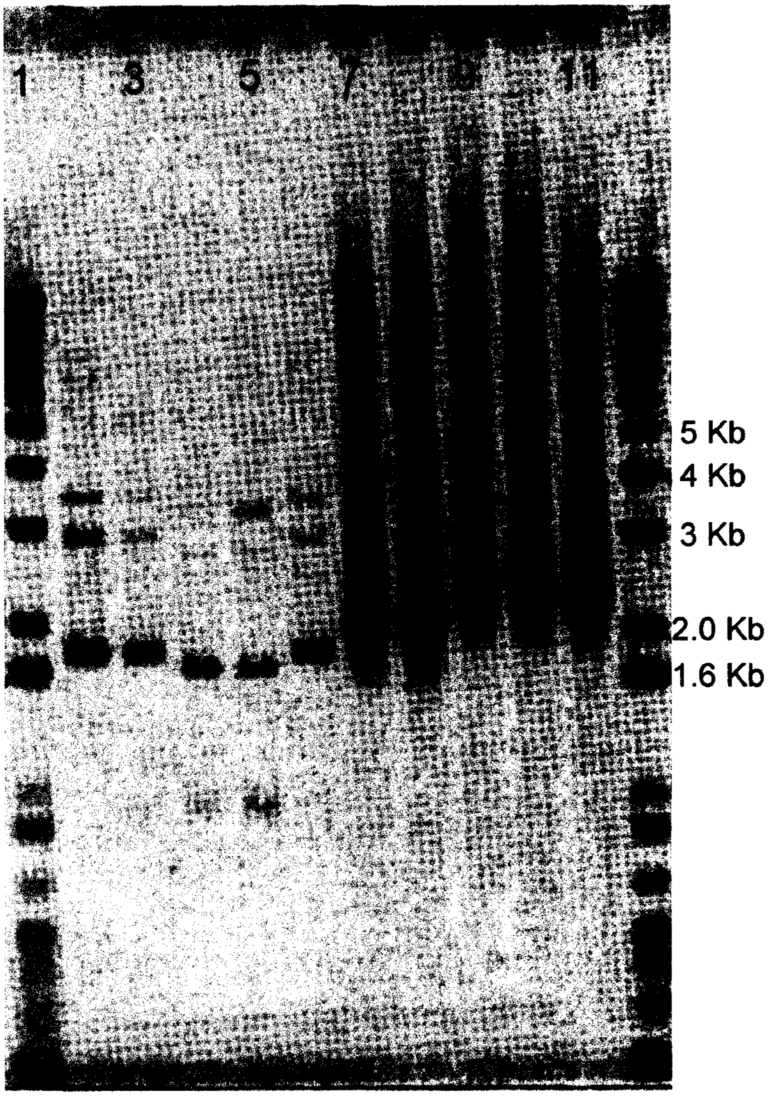


Figure 9. M13 PCR for screening of transformants. Lanes 1 and 12 contain 1 kb+ ladder. The primers amplify regions between M13 forward and reverse and presence of insert is determined by the size of the PCR product + intervening primer sequence. Positive products at between 1.6kb and 2kb are indicated.

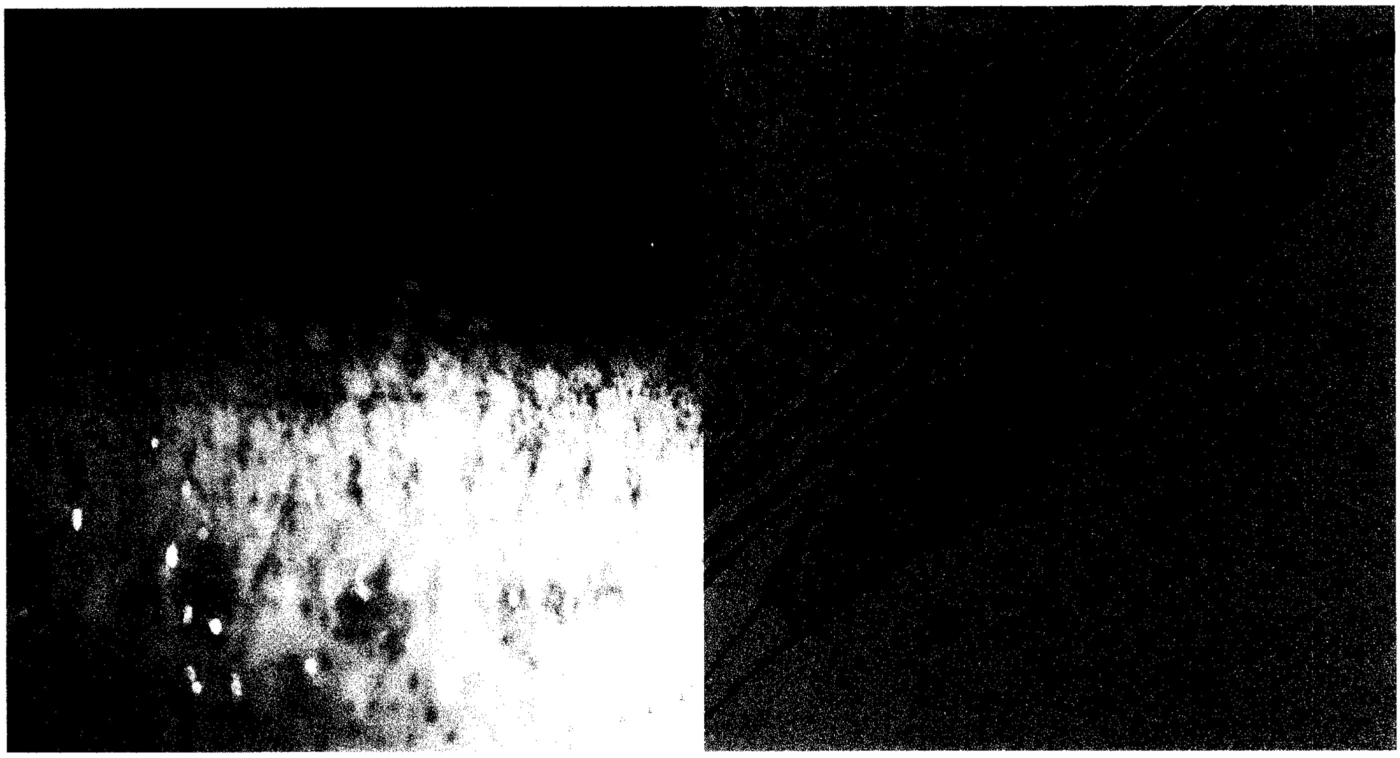


Figure 10. Intercellular cysts of *Myxobolus procerus*. The large cysts containing the parasitic spores in the left illustration are photographed on the surface of the trout-perch alongside the dorsal fin. The picture on the right illustrates a cross-sectional view of the intercellular cysts lying just beneath the epithelium of the host.

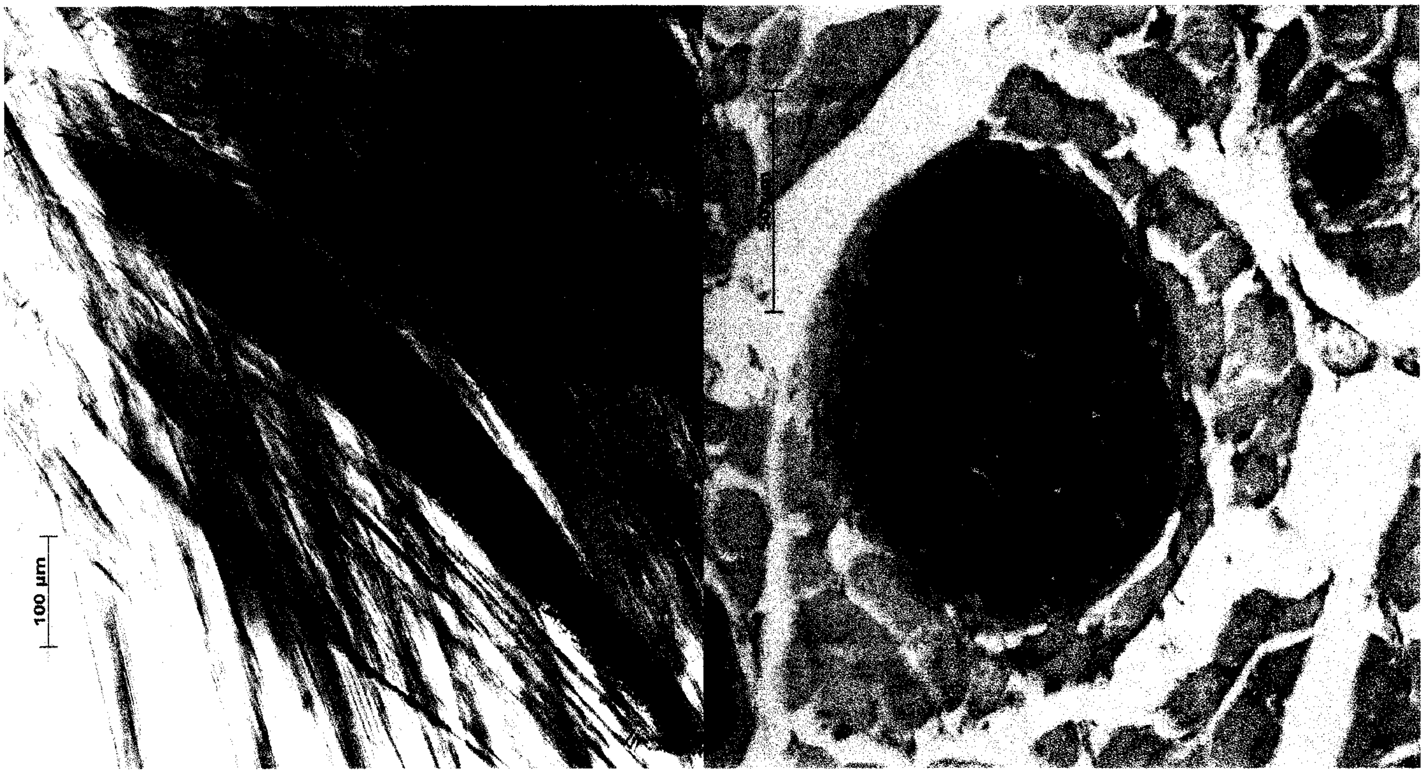


Figure 11. Intracellular cysts of *Myxobolus procerus.* The cyst lies inside of the cell of its host and is clearly fusiform in shape. The picture on the right is a cross sectional view of the developing cyst. Spores are visible as dark oval bodies inside of the cyst.

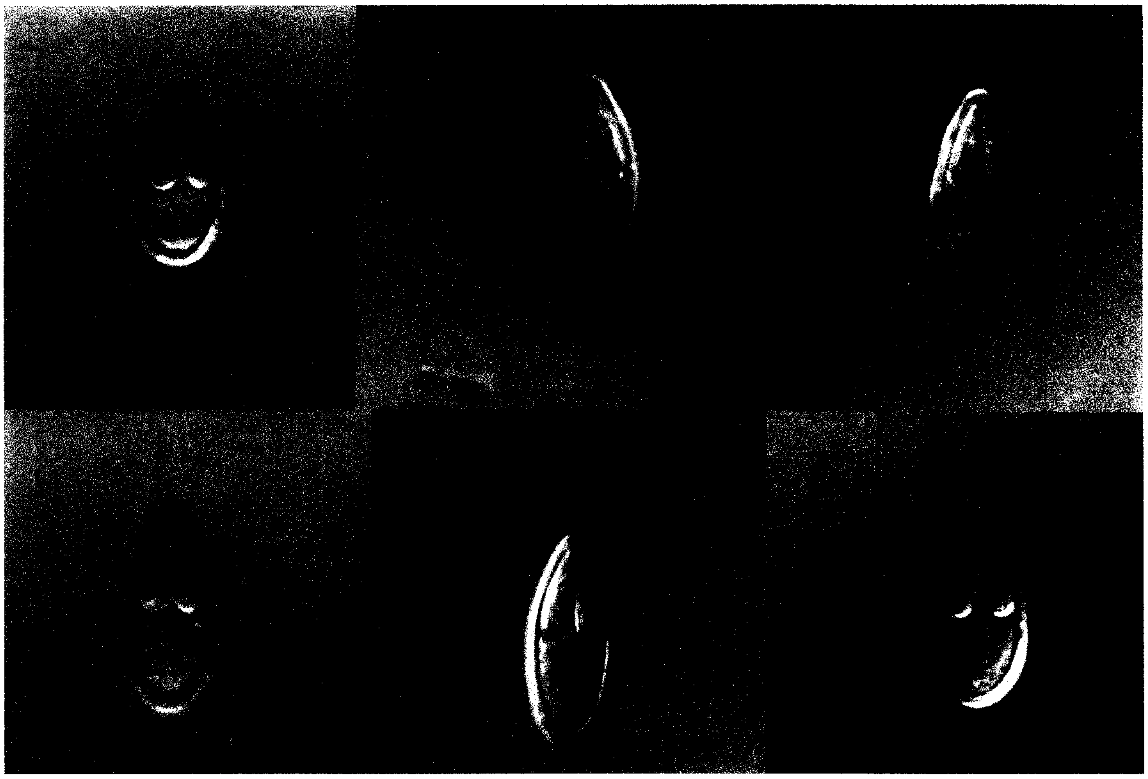


Figure 12. Spores of *Myxobolus procerus*. The top three spores are from the small intracellular cyst. The bottom three from the large intercellular cysts. Note the elongated spore shapes of those from the larger cysts. Scale bar at left is 10 µm.

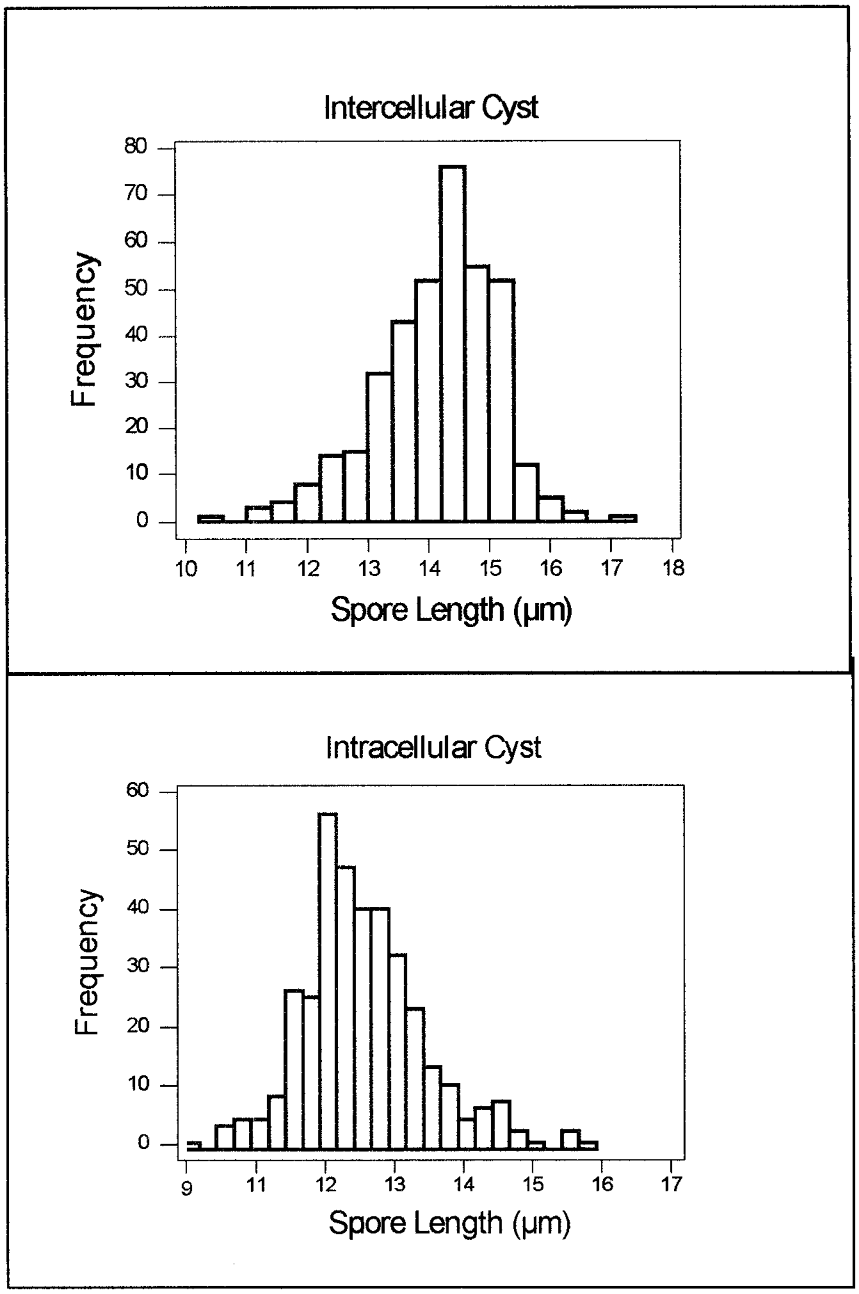


Figure 13. Frequency distributions of spore length within two cyst types of *Myxobolus procerus*. Spores in the larger intercellular cysts have a mean length of 14.5 µm while the smaller intracellular spores have a mean length of 12.0 µm.

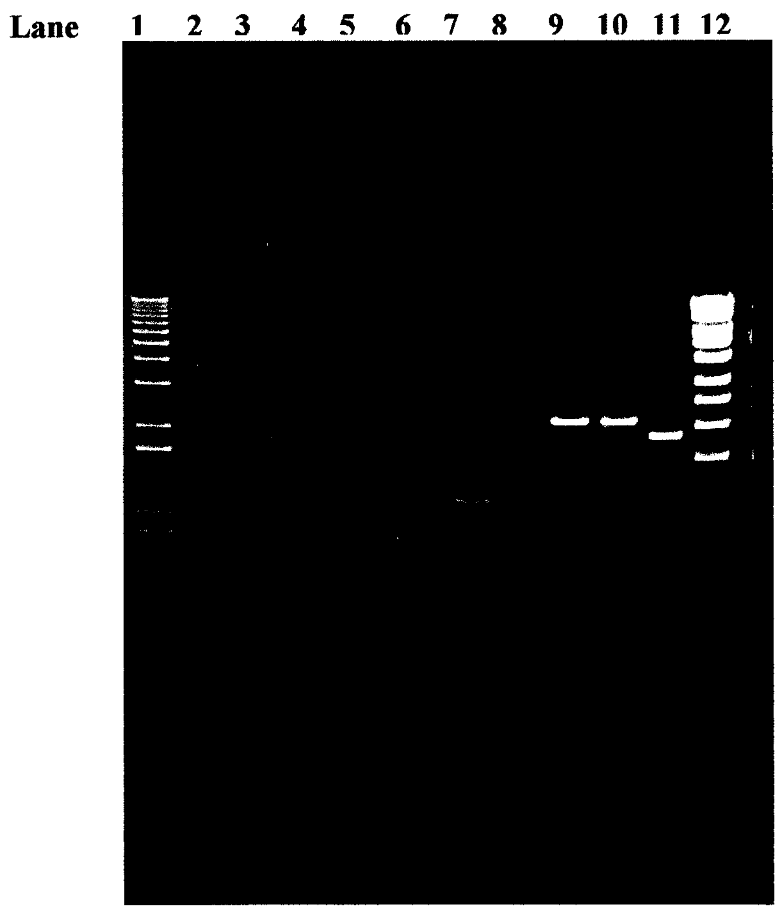


Figure 14. PCR products following amplification of SSU 18S rDNA from species of *Myxobolus*. PCR product using MX3-MX5 primer sets are illustrated in lanes 2-5. Lanes 6-8 with 18e-18m primer set. Lanes 9-11 with primers 18e-Myxgen2r. Lane 1 – 1kb + ladder. Lane - 12 Mass Ladder.

CTGCGGACGGCTCAGTATATCAGTTATAATCTGCTCGATTGTTATGGTTATTGGATAACCGTG
GGAAATCTAGAGCTAATACATGCTATAATGTTGGGTGTGGTTCGCTGCATTCAGCCGCATTT
ATTAGAGAATACCAATCGCATGAGCAATCATGTGTGGTGAATCTAGATAACTTTGCTGATCGC
ATGGCCTTTGAGCCGGCGACATTTCGATTGAGTTTCTGCCCTATCACCTTGATGCTAGTGTA
TTGAACTAGCATGGGAGTAACGGGTAACGGAGGATCAGGTTCGATCCCGGAGAGGGAGCC
TTAGAAACGGCTACCACATCCAAGGAAGGCAGCAGGCGCGCAAATTACCCAATCCAGACAA
TGGGAGGTGGTGACGAAGAGTACCGGATGACTGATATATTATTAGTCAGTCTGGAATGAAAT
CAATTTAAGCAATTGAGTTGAGTAACTACTGGAGGGCAAGTCTGGTGCCAGCAGCCGCGGT
AATTCCAGCTCCAGTAGCGTGTCTCAAAGTTGCTGCGCTTAAAACGCTCGTAGTTGGATGAG
AATCTATATATCGGATAGTTATCTACTAGATTTAAGGCTAATTATTACTTATTTCCGTGATGCT
TATGGTATCCGGACAATATTGATATTGGTTCAGCTAGTGATAACATTAAACTGGTATGTAGTA
ATTGCGTATGAGGATGACCATTGACCTTAAGTGTGTTGAAGGTCGTGTCTCATGGGATGTGC
TTGAGTAAATCAGAGTGCTCAAAGCAGGCGTGATGCCTGAATGTTGATAGCATGGAACGAAC
AATAGTGTAGATGTGTATTGAAGATGGTAGTGTATTATTACAATGTAATAGTATACTACTACAA
TATGCAACACCGACCGCCAATTACGGATGTTGGTTCCGTATTGGGGTACTGATTAAGAGGAG
CGGTTGGGGGCATTGGTATTTGGCAGCGAGAGGTGAAATTCTTGGACCTGCACAAG

Figure 15. *Myxobolus procerus* intercellular SSU 18S rDNA consensus sequence.

CTGCGGACGGCTCAGTAAATCAGTTATAATCTGCTCGATTGTTATGGTTATTGGATAACCGT
GGGAAATCTAGAGCTAATACATGCTATAATGTTGGGTGTGGTTCGCTGCATTCAGCCGCATT
TATTAGAGAATACCAATCGCATGAGCAATCATGTGTGGTGAATCTAGATAACTTTGCTGATCG
CATGGCCTTTGAGCCGGCGACATTTCGATTGAGTTTCTGCCCTATCACCTTGATGCTAGTGT
ATTGAACTAGCATGGGAGTAACGGGTAACGGAGGATCAGGGTTCGATCCCGGAGAGGGAG
CCTTAGAAACGGCTACCACATCCAAGGAAGGCAGCAGGCGCGCAAATTACCCAATCCAGAC
AATGGGAGGTGGTGACGAAGAGTACCGGATGACTGATATATTATTAGTCAGTCTGGAATGAA
ATCAATTTAAGCAATTGAGTTGAGTAACTACTGGAGGGCAAGTCTGGTGCCAGCAGCCGCG
GTAATTCCAGCTCCAGTAGCGTGTCTCAAAGTTGCTGCGCTTAAAACGCTCGTAGTTGGATG
AGAAACTACATATCGGATAGTTATTTACTAGATTTAGGACTAATTATTACATATTTCCGTGATG
CTTATGGTATCCGGATAATAGTGATATTGGTTCAACTAGTGATAACATTAAACTGGTATGTAG
TAATTGCGTATGAGGATGACCATTGACCTTAAGTGTGTTGAAGGTCGTGTCTCATGGGATGT
GCCTTGAGTAAATCAGAGTGCTCAAAGCAGGCGTGATGCCTGAATGTTGATAGCATGGAAC
GAACAATAGTGTAGATGTGTATTGAAGATGGTAGTGTATTATTACAATGTAATAGTATACTACT
ACAATATGCAACACCGACCGCCAATTACGGATGTTGGTTCCGTATTGGGGTACTGATTAAGA
GGAGCGGTTGGGGGCATTGTATTGCAGCGAGAGTGAATTCTGACCTGCCAAG

Figure 16. *Myxobolus procerus* intracellular small subunit 18S rDNA consensus sequence.

Sequences producing significant alignments	Bit Score	E Value
gi|4103271|gb|AF021878.1| *Aurantiactinomyxon mississippiens...*	420	e-114
gi|4103274|gb|AF021881.1| *Henneguya exilis* 18S small subuni...	414	e-112
gi|11066099|gb|AF195510.1| *Henneguya ictaluri* small subunit...	414	e-112
gi|23429474|gb|AY129317.1| *Myxobolus exiguus* 18S ribosomal ...	394	e-106
gi|23429470|gb|AY129314.1| *Myxobolus muelleri* 18S ribosomal...	394	e-106
gi|23429476|gb|AY129318.1| *Myxobolus bizerti* 18S ribosomal ...	391	e-105
gi|23429467|gb|AY129312.1| *Myxobolus episquamalis* 18S ribos...	375	e-100
gi|21729516|gb|AF378341.2| *Myxobolus spinacurvatura* 18S rib...	359	6e-96
gi|13172451|gb|AF306794.1|AF306794 *Henneguya lesteri* 18S ri...	351	1e-93
gi|13172453|gb|AF306791.1|AF306791 *Endocapsa rosulata* 18S r...	323	3e-85

Figure 17. BLAST results for SSU 18S rDNA from spores of *Myxobolus procerus* - Intercellular cyst types of trout-perch.

Sequences producing significant alignments	Bit Score	E Value
gi|4103271|gb|AF021878.1| *Aurantiactinomyxon mississippiens...*	436	e-119
gi|4103274|gb|AF021881.1| *Henneguya exilis* 18S small subuni...	430	e-117
gi|11066099|gb|AF195510.1| *Henneguya ictaluri* small subunit...	430	e-117
gi|23429474|gb|AY129317.1| *Myxobolus exiguus* 18S ribosomal ...	412	e-112
gi|23429470|gb|AY129314.1| *Myxobolus muelleri* 18S ribosomal...	412	e-112
gi|23429476|gb|AY129318.1| *Myxobolus bizerti* 18S ribosomal ...	406	e-110
gi|23429467|gb|AY129312.1| *Myxobolus episquamalis* 18S ribos...	392	e-106
gi|21729516|gb|AF378341.2| *Myxobolus spinacurvatura* 18S rib...	377	e-101
gi|13172451|gb|AF306794.1|AF306794 *Henneguya lesteri* 18S ri...	367	2e-98
gi|13172453|gb|AF306791.1|AF306791 *Endocapsa rosulata* 18S r...	339	6e-90

Figure 18. BLAST results for SSU 18S rDNA from spores of *Myxobolus procerus* - Intracellular cyst types of trout-perch.

Intercellular CTGCGGACGGCTCAGTATATCAGTTATAATCTGCTCGATTGTTATGGTTA
Intracellular CTGCGGACGGCTCAGTAAATCAGTTATAATCTGCTCGATTGTTATGGTTA

Intercellular TTGGATAACCGTGGGAAATCTAGAGCTAATACATGCTATAATGTTGGGTG
Intracellular TTGGATAACCGTGGGAAATCTAGAGCTAATACATGCTATAATGTTGGGTG

Intercellular TGGTTCGCTGCATTCAGCCGCATTTATTAGAGAATACCAATCGCATGAGC
Intracellular TGGTTCGCTGCATTCAGCCGCATTTATTAGAGAATACCAATCGCATGAGC

Intercellular AATCATGTGTGGTGAATCTAGATAACTTTGCTGATCGCATGGCCTTTGAG
Intracellular AATCATGTGTGGTGAATCTAGATAACTTTGCTGATCGCATGGCCTTTGAG

Intercellular CCGGCGACATTTCGATTGAGTTTCTGCCCTATCACCTTGATGCTAGTGTA
Intracellular CCGGCGACATTTCGATTGAGTTTCTGCCCTATCACCTTGATGCTAGTGTA

Intercellular TTGAACTAGCATGGGAGTAACGGGTAACGGAGGATCAGG -TTCGATCCCG
Intracellular TTGAACTAGCATGGGAGTAACGGGTAACGGAGGATCAGGGTTCGATCCCG

Intercellular GAGAGGGAGCCTTAGAAACGGCTACCACATCCAAGGAAGGCAGCAGGCGC
Intracellular GAGAGGGAGCCTTAGAAACGGCTACCACATCCAAGGAAGGCAGCAGGCGC

Intercellular GCAAATTACCCAATCCAGACAATGGGAGGTGGTGACGAAGAGTACCGGAT
Intracellular GCAAATTACCCAATCCAGACAATGGGAGGTGGTGACGAAGAGTACCGGAT

Intercellular GACTGATATATTATTAGTCAGTCTGGAATGAAATCAATTTAAGCAATTGA
Intracellular GACTGATATATTATTAGTCAGTCTGGAATGAAATCAATTTAAGCAATTGA

Intercellular GTTGAGTAACTACTGGAGGGCAAGTCTGGTGCCAGCAGCCGCGGTAATTC
Intracellular GTTGAGTAACTACTGGAGGGCAAGTCTGGTGCCAGCAGCCGCGGTAATTC

Intercellular CAGCTCCAGTAGCGTGTCTCAAAGTTGCTGCGCTTAAAACGCTCGTAGTT
Intracellular CAGCTCCAGTAGCGTGTCTCAAAGTTGCTGCGCTTAAAACGCTCGTAGTT

Intercellular GGATGAGAATCTATATATCGGATAGTTATCTACTAGATTTAAGGCTAATT
Intracellular GGATGAGAAACTACATATCGGATAGTTATTTACTAGATTTAGGACTAATT

Intercellular ATTACTTATTTCCGTGATGCTTATGGTATCCGGACAATATTGATATTGGT
Intracellular ATTACATATTTCCGTGATGCTTATGGTATCCGGATAATAGTGATATTGGT

Intercellular TCAGCTAGTGATAACATTAAACTGGTATGTAGTAATTGCGTATGAGGATG
Intracellular TCAACTAGTGATAACATTAAACTGGTATGTAGTAATTGCGTATGAGGATG

Intercellular ACCATTGACCTTAAGTGTGTTGAAGGTCGTGTCTCATGGGATGTGC -TTG
Intracellular ACCATTGACCTTAAGTGTGTTGAAGGTCGTGTCTCATGGGATGTGCCTTG

Intercellular AGTAAATCAGAGTGCTCAAAGCAGGCGTGATGCCTGAATGTTGATAGCAT
Intracellular AGTAAATCAGAGTGCTCAAAGCAGGCGTGATGCCTGAATGTTGATAGCAT

Intercellular GGAACGAACAATAGTGTAGATGTGTATTGAAGATGGTAGTGTATTATTAC
Intracellular GGAACGAACAATAGTGTAGATGTGTATTGAAGATGGTAGTGTATTATTAC

Intercellular AATGTAATAGTATACTACTACAATATGCAACACCGACCGCCAATTACGGA
Intracellular AATGTAATAGTATACTACTACAATATGCAACACCGACCGCCAATTACGGA

Intercellular TGTTGGTTCCGTATTGGGGTACTGATTAAGAGGAGCGGTTGGGGGCATTG
Intracellular TGTTGGTTCCGTATTGGGGTACTGATTAAGAGGAGCGGTTGGGGGCATTG

Intercellular GTATTTGGCAGCGAGAGGTGAAATTCTTGGACCTGCACAAG
Intracellular - TATT- - GCAGCGAGAG -TGAA -TTCT - - GACCTGC - CAAG

Figure 19. Clustal X alignment of *Myxobolus procerus* small subunit 18S rDNA obtained from spores contained within intercellular and intracellular cysts in trout-perch. Differences are noted in red.

Figure 20. Spores of *Myxobolus neurophilus* from yellow perch. Polar capsules appear as raised oval shaped structures uneven in size. Scale bar at right is 10 µm.

Figure 21. Spores of *Myxobolus* sp. from Johnny darter. Scale bar at right is 10 µm.

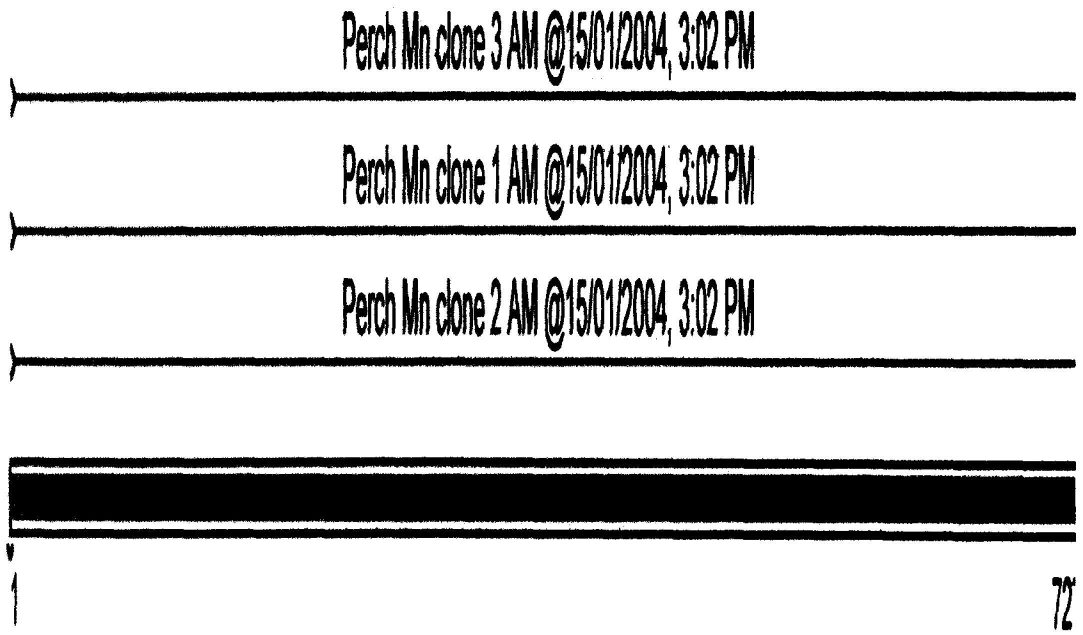


Figure 22. Clones of *Myxobolus neurophilus* from yellow perch. Three clones from a single primer set with ambiguous regions removed. There were no differences.

TGCAATGTTTGACTGGAGGGAAAGTGCAACTTCAACACCCATCCACACCAAGCATGTCATAA
ACACACCCAATGCTTCAGAGTATCTCTTTCACACCTTACCAACAATTCAAATCATATCAATACA
GACCTGTTACAGTCTATAAAGAAGATTTGAATTTACTCCAGCTCGTCAAATGGAGATTGTGAT
CTCGTCCGTTACCGGAATAAACCTGACAAATCACTTCACGAACTAAGAACGGCCATGCACCA
CCAATCACCAGATCATGTAAGATCTTCGGTCTGACAATCCTTTTGATGTCCTGATCCGGTAAG
TTTTCCCGTGTTGAGTCAAATTAAGCCGCAGGCTCCACCCCTGGTGGTGCCCTTCCGTCAAT
TCCTTTAAGTTTCAGCCTTGCGACCATACTCCCCCCGCAACCGAAAAACTTTAGG:TTTCCCA
GGGGGACCAACCCAAGCCGTAATAATAAGGCATAGGACTAATCCCGGGTCGGCATAGTTTA
CAGTGAGAACTAGGACGGTATCTGATCGTCTTCGAACCTCTCACTATCGTTCTTGATTAATG
GATACGGTCTGGACAAATGCCTTCGCATTTGTTAGTCCTTGGCAGGTCCAAGAATTTCACCT
CTCGCTGCCAAATACCAATGCCCCCAACCGCTCCTCTTAATCAGTTACCCCAATACGGAACC
AACATCCGTAATTGGCGGTCGGTGTTGCATATTGAAG

Figure 23. DNA sequence of small subunit 18S rDNA from yellow perch isolates.

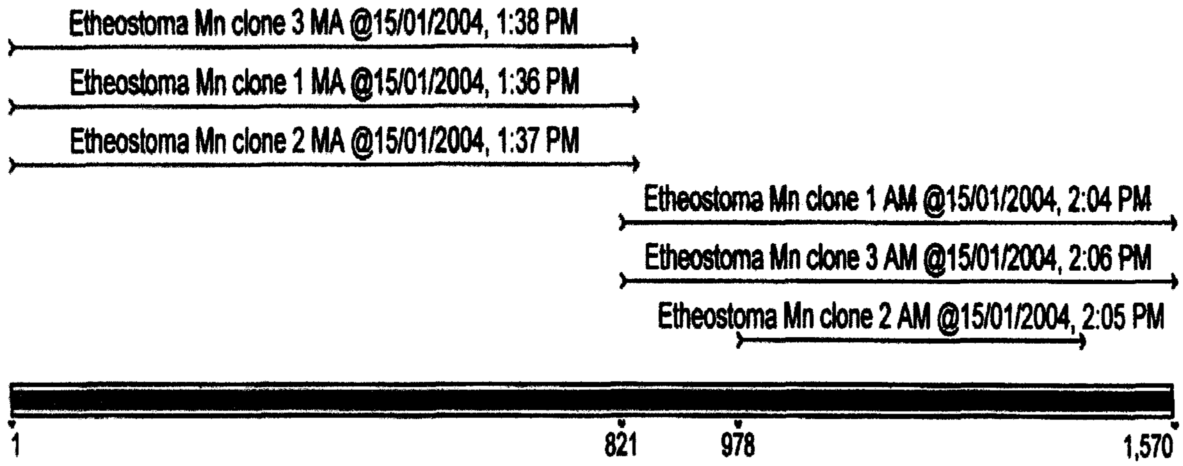


Figure 24. Clones of *Myxobolus* sp. from Johhny darter. Three clones from each of two primer sets with ambiguous regions removed. Differences are noted in text.

CTAACATGCTGGATGTAGCTTGCTACATTTGGCCGCATTTATTAGATAATACCAATCACATGA
GCAATCATGTGTGATGAATCTAGATAACTTTGCTGATCGCATGACCTTGTGTCGGCGACATTT
CGATTGAGTTTCTGCCCTATCACTTGATGCTAGTGTATTGAACTAGCATGGGAGTTACGGGT
AACGGAGGATCAGGGTTCGATCCCGGAGAGGGAGCCTTAGAAACGGCTACCACATCCAAG
GAAGGCAGCAGGCGCGCAAATTACCCAATCCAGACAATGGGAGGTGGTGACGAAGAGTAC
CGGATGACTAAAAAATTTTTTAGTCAGTCTGGAATGAAATCAATTTAAGCAATTGAGTTGAGT
AACTACTGGAGGGCAAGTCTGGTGCCAGCAGCCGCGGTAATTCCAGCTCCAGTAGCGTGTC
TCAAAGTTGCTGCGCTTGAAACGCTCGTAGTTGGATGAGAAACTACACATTGGATAGTTATTA
TCTAGGTTATAGACTACATATTTTCGTATATCTGTGATGCTTTCAGTGTCCAGATAATATGGGT
ATTAGTTGAACTAGTAGTAACATATAACTGGTGTGTAGTAATTGCGTATGAGAATGATCATTG
ACCTTGAGTGTGTTGAAGATCGTGTCTCATGGGATGTGCCTTGAGTAAATCAGAGTGCTCAA
AGCAGGCGTTATGCCTGAATGTTAATAGCATGGAACGAACAATAGTGTAGATGTGTATTGAA
GATGGTAGTATGTTATTATAACTTAATAATATACTACTACAATATGCAACACCGACCGCCAATT
ACGGATGTTGGTTCCGTATTGGGGTACTGATTAAGAGGAGCGGTTGGGGGCATTGGTATTT
GGCAGCGAGAGGTGAAATTCTTGGACCTGCCAAGGACTAACAAATGCGAAGGCATTTGTCC
AGACCGTATCCATTAATCAAGAACGATAGTGAGAGGTTCGAAGACGATCAGATACCGTCCTA
GTTCTCACTGTAAACTATGCCGACCCGGGATTAGTCCTATGCCTTATTTTTACGGCTTGGGTT
GGTCCCCCTGGGAAACCTAAAGTTTTTCGGTTGCGGGGGGAGTATGGTCGCAAGGCTGAAA
CTTAAAGGAATTGACGGAAGGGCACCACCAGGGGTGGAGCCTGCGGCTTAATTTGACTCAA
CACGGGAAAACTTACCGGATCAGGACATCAAAAGGATTGTCAGACCGAAGATCTTACATGAT
CTGGTGACTGGTGGTGCATGGCCGTTCTTAGTTCGTGAAGTGATTTGTCAGGTTTATTCCGG
TAACGGACGAGATCACAATCTCCATTTGACGAACTGGAGTAAATGCAAATAGTCATAATTAAT
TGTAAAAGATTGATTGTGATATGTATTTGCATTGTTGGTAAAATGTGAAAGATATAATCATAAT
GATGAAATATAGGGTAAAAACTATATTGAATTAGAATGAGTATGGAAGTTATATTTTACCTCCA
GTTAAACAGTGTATAGTTAACTTTTAACTGTGTGCTGTATCATGGAGAGACAACGGAAATAAT
AAAAATCGAGGAA

Figure 25. DNA sequence of small subunit 18S rDNA myxobolid sp. from Johnny darter.

Sequences producing significant alignments	Bit Score	E Value
gi|18071158|gb|AF378344.1| *Henneguya zschokkei* 18S ribosoma...	428	e-117
gi|27369410|gb|AY165182.1| *Henneguya weishanensis* 18S ribos...	420	e-114
gi|11066099|gb|AF195510.1| *Henneguya ictaluri* small subunit...	412	e-112
gi|18071167|gb|AF378353.1| *Neoactinomyxum* sp. KAB-2001 18S ...	412	e-112
gi|13172455|gb|AF306793.1|AF306793 *Tetraspora discoidea* 18S...	412	e-112
gi|13172454|gb|AF306792.1|AF306792 *Triactinomyxon* sp. 18S r...	412	e-112
gi|13172451|gb|AF306794.1|AF306794 *Henneguya lesteri* 18S ri...	412	e-112
gi|4103271|gb|AF021878.1| *Aurantiactinomyxon mississippiens...*	404	e-110
gi|13172452|gb|AF306790.1|AF306790 *Sphaeractinomyxon ersei* ...	404	e-110
gi|4103274|gb|AF021881.1| *Henneguya exilis* 18S small subuni...	396	e-107
gi|21729516|gb|AF378341.2| *Myxobolus spinacurvatura* 18S rib...	396	e-107
gi|18071170|gb|AF378356.1| *Aurantiactinomyxon* sp. KAB-2001 ...	391	e-105
gi|18071166|gb|AF378352.1| *Raabeia* sp. KAB-2001 18S ribosom...	391	e-105
gi|18071151|gb|AF378337.1| *Myxobolus ichkeulensis* 18S ribos...	391	e-105
gi|23429476|gb|AY129318.1| *Myxobolus bizerti* 18S ribosomal ...	375	e-101

Figure 26. BLAST results for small subunit 18S rDNA sequence from yellow perch isolates against those sequences available in GenBank.

Sequences producing significant alignments	Bit Score	E Value
gi|27369410|gb|AY165182.1| *Henneguya weishanensis* 18S ribos...	434	e-118
gi|11066099|gb|AF195510.1| *Henneguya ictaluri* small subunit...	426	e-116
gi|18071167|gb|AF378353.1| *Neoactinomyxum* sp. KAB-2001 18S ...	426	e-116
gi|13172455|gb|AF306793.1|AF306793 *Tetraspora discoidea* 18S...	426	e-116
gi|13172454|gb|AF306792.1|AF306792 *Triactinomyxon* sp. 18S r...	426	e-116
gi|13172451|gb|AF306794.1|AF306794 *Henneguya lesteri* 18S ri...	426	e-116
gi|4103271|gb|AF021878.1| *Aurantiactinomyxon mississippiens...*	418	e-113
gi|13172452|gb|AF306790.1|AF306790 *Sphaeractinomyxon ersei* ...	418	e-113
gi|4103274|gb|AF021881.1| *Henneguya exilis* 18S small subuni...	410	e-111
gi|21729516|gb|AF378341.2| *Myxobolus spinacurvatura* 18S rib...	410	e-111
gi|18071170|gb|AF378356.1| *Aurantiactinomyxon* sp. KAB-2001 ...	404	e-109
gi|18071166|gb|AF378352.1| *Raabeia* sp. KAB-2001 18S ribosom...	404	e-109
gi|23429472|gb|AY129315.1| *Myxobolus ichkeulensis* 18S ribos...	404	e-109
gi|23429474|gb|AY129317.1| *Myxobolus exiguus* 18S ribosomal ...	402	e-109
gi|23429470|gb|AY129314.1| *Myxobolus muelleri* 18S ribosomal...	402	e-109

Figure 27. BLAST results for myxobolid small subunit 18S rDNA sequence from Johnny darter against those sequences available in GenBank.

Perch GTTCCGTATTGGGGTACTGATTAAGAGGAGCGGTTGGGGGCATTGGTATT
Etheostoma GTTCCGTATTGGGGTACTGATTAAGAGGAGCGGTTGGGGGCATTGGTATT

Perch TGGCAGCGAGAGGTGAAATTCTTGGACCTGCCAAGGACTAACAAATGCGA
Etheostoma TGGCAGCGAGAGGTGAAATTCTTGGACCTGCCAAGGACTAACAAATGCGA

Perch AGGCATTTGTCCAGACCGTATCCATTAATCAAGAACGATAGTGAGAGGTT
Etheostoma AGGCATTTGTCCAGACCGTATCCATTAATCAAGAACGATAGTGAGAGGTT

Perch CGAAGACGATCAGATACCGTCCTAGTTCTCACTGTAAACTATGCCGACCC
Etheostoma CGAAGACGATCAGATACCGTCCTAGTTCTCACTGTAAACTATGCCGACCC

Perch GGGATTAGTCCTATGCCTTATTATTACGGCTTGGGTTGGTCCCCCTGGGA
Etheostoma GGGATTAGTCCTATGCCTTATTTTTACGGCTTGGGTTGGTCCCCCTGGGA

Perch AACCTAAAGTTTTTCGGTTGCGGGGGGAGTATGGTCGCAAGGCTGAAACT
Etheostoma AACCTAAAGTTTTTCGGTTGCGGGGGGAGTATGGTCGCAAGGCTGAAACT

Perch TAAAGGAATTGACGGAAGGGCACCACCAGGGGTGGAGCCTGCGGCTTAAT
Etheostoma TAAAGGAATTGACGGAAGGGCACCACCAGGGGTGGAGCCTGCGGCTTAAT

Perch TTGACTCAACACGGGAAAACTTACCGGATCAGGACATCAAAAGGATTGTC
Etheostoma TTGACTCAACACGGGAAAACTTACCGGATCAGGACATCAAAAGGATTGTC

Perch AGACCGAAGATCTTACATGATCTGGTGATTGGTGGTGCATGGCCGTTCTT
Etheostoma AGACCGAAGATCTTACATGATCTGGTGATTGGTGGTGCATGGCCGTTCTT

Perch AGTTCGTGAAGTGATTTGTCAGGTTTATTCCGGTAACGGACGAGATCACA
Etheostoma AGTTCGTGAAGTGATTTGTCAGGTTTATTCCGGTAACGGACGAGATCACA

Perch ATCTCCATTTGACGAGCTGGAGTAAATGCAAATCTTCTTTATAGACTGTA
Etheostoma ATCTCCATTTGACGAACTGGAGTAAATGCAAATAGTCATAATTAATTGTA

Perch ACAGGTCTGTAT- TGATATG- ATTTGAATTGTTGGTAAGGTGTGAAAGAG
Etheostoma AAAGATCTGATTGTGATATGTATTTGCATTGTTGGTAAAATGTGAAAGAT

Perch ATACTC-------------TGAAGCATTGGGTGTGTTTATGAC- ATGCTTGGTGTG
Etheostoma ATAATCATAATGATGAAATATAGGGTA----------AAAACTATA TTGAATTAG

Perch GATGGGTGTTGAAGTTGCACTTTCCCTCCAGTCAAACATTGCATGG
Etheostoma AATGAGTATGGAAGTTATATTTTACCTCCAGT TAAACAGTGTATAG

Figure 28. Clustal X alignment of Myxobolus SSU 18S rDNA Isolated from yellow perch and Johnny darter. Data was obtained from sequencing of PCR products using myxozoan specific primers Act3F-MX3. Differences are noted in red.

```
Intercellular   GATAACCGTGGGAAATCTAGAGCTAATACATGCTATAATGTTGGGTG
Intracellular   GATAACCGTGGGAAATCTAGAGCTAATACATGCTATAATGTTGGGTG
Etheostoma      GATAACCGTGGGAAATCTAGAGCTAATACATGCTAACATGCTGGATG

Intercellular   TGGTTCGCTGCATTCAGCCGCATTTATTAGAG-AATACCAATCGCATG
Intracellular   TGGTTCGCTGCATTCAGCCGCATTTATTAGAG-AATACCAATCGCATG
Etheostoma      TAGCTTGCTACATTTGGCCGCATTTATTAGATTAATACCAATCACATG

Intercellular   AGCAATCATGTGTGGTGAATCTAGATAACTTTGCTGATCGCATGGCCTTT
Intracellular   AGCAATCATGTGTGGTGAATCTAGATAACTTTGCTGATCGCATGGCCTTT
Etheostoma      AGCAATCATGTGTGATGAATCTAGATAACTTTGCTGATCGCATGACCTT-

Intercellular   GAGCCGGCGACATTTCGATTGAGTTTCTGCCCTATCACCTTGATGCTAGT
Intracellular   GAGCCGGCGACATTTCGATTGAGTTTCTGCCCTATCACCTTGATGCTAGT
Etheostoma      GTGTCGGCGACATTTCGATTGAGTTTCTGCCCTATCACCTTGATGCTAGT

Intercellular   GTATTGAACTAGCATGGGAGTAACGGGTAACGGAGGATCAGG-TTCGATC
Intracellular   GTATTGAACTAGCATGGGAGTAACGGGTAACGGAGGATCAGGGTTCGATC
Etheostoma      GTATTGAACTAGCATGGGAGTTACGGGTAACGGAGGATCAGGGTTCGATC

Intercellular   CCGGAGAGGGAGCCTTAGAAACGGCTACCACATCCAAGGAAGGCAGCAG
Intracellular   CCGGAGAGGGAGCCTTAGAAACGGCTACCACATCCAAGGAAGGCAGCAG
Etheostoma      CCGGAGAGGGAGCCTTAGAAACGGCTACCACATCCAAGGAAGGCAGCAG

Intercellular   GCGCGCAAATTACCCAATCCAGACAATGGGAGGTGGTGACGAAGAGTAC
Intracellular   GCGCGCAAATTACCCAATCCAGACAATGGGAGGTGGTGACGAAGAGTAC
Etheostoma      GCGCGCAAATTACCCAATCCAGACAATGGGAGGTGGTGACGAAGAGTAC

Intercellular   CGGATGACTGATATATTATT-AGTCAGTCTGGAATGAAATCAATTTAAGC
Intracellular   CGGATGACTGATATATTATT-AGTCAGTCTGGAATGAAATCAATTTAAGC
Etheostoma      CGGATGACTAAAAAATTTTTTAGTCAGTCTGGAATGAAATCAATTTAAGC

Intercellular   AATTGAGTTGAGTAACTACTGGAGGGCAAGTCTGGTGCCAGCAGCCGCGG
Intracellular   AATTGAGTTGAGTAACTACTGGAGGGCAAGTCTGGTGCCAGCAGCCGCGG
Etheostoma      AATTGAGTTGAGTAACTACTGGAGGGCAAGTCTGGTGCCAGCAGCCGCGG

Intercellular   TAATTCCAGCTCCAGTAGCGTGTCTCAAAGTTGCTGCGCTTAAAACGCTC
Intracellular   TAATTCCAGCTCCAGTAGCGTGTCTCAAAGTTGCTGCGCTTAAAACGCTC
Etheostoma      TAATTCCAGCTCCAGTAGCGTGTCTCAAAGTTGCTGCGCTTGAAACGCTC

Intercellular   GTAGTTGGATGAGAATCTATATATCGGATAGTTATCTACTAGATTTAAGG
Intracellular   GTAGTTGGATGAGAAACTACATATCGGATAGTTATTTACTAGATTTAGGA
Etheostoma      GTAGTTGGATGAGAAACTACACATTGGATAGTTATTATCTAGGTTATAGA

Intercellular   CTAATTATTA-CTTATTTCCGTGATGCTTATGGTATCCGGACAATA TTGA
Intracellular   CTAATTATTA-CATATTTCCGTGATGCTTATGGTATCCGGATAATA GTGA
Etheostoma      CTACATATTTTCGTATATCTGTGATGCTTTCAGTGTCCAGATAATATGGG

Intercellular   TATTGGTTCAGCTAGTGATAACATTAAACTGGTATGTAGTAATTGCGTAT
Intracellular   TATTGGTTCAACTAGTGATAACATTAAACTGGTATGTAGTAATTGCGTAT
Etheostoma      TATTAGTTGAACTAGTAGTAACATATAACTGGTGTGTAGTAATTGCGTAT

Intercellular   GAGGATGACCATTGACCTTAAGTGTGTTGAAGGTCGTGTCTCATGGGATG
Intracellular   GAGGATGACCATTGACCTTAAGTGTGTTGAAGGTCGTGTCTCATGGGATG
Etheostoma      GAGAATGATCATTGACCTTGAGTGTGTTGAAGATCGTGTCTCATGGGATG
```

```
Intercellular   TGCCTTGAGTAAATCAGAGTGCTCAAAGCAGGCGTGATGCCTGAATGTTG
Intracellular   TGCCTTGAGTAAATCAGAGTGCTCAAAGCAGGCGTGATGCCTGAATGTTG
Etheostoma      TGCCTTGAGTAAATCAGAGTGCTCAAAGCAGGCGTTATGCCTGAATGTTA

Intercellular   ATAGCATGGAACGAACAATAGTGTAGATGTGTATTGAAGATGGTAGTGTA
Intracellular   ATAGCATGGAACGAACAATAGTGTAGATGTGTATTGAAGATGGTAGTGTA
Etheostoma      ATAGCATGGAACGAACAATAGTGTAGATGTGTATTGAAGATGGTAGTATG

Intercellular   TTATTACAATGTAATAGTATACTACTACAATATGCAACACCGACCGCCAA
Intracellular   TTATTACAATGTAATAGTATACTACTACAATATGCAACACCGACCGCCAA
Etheostoma      TTATTATAACTTAATAATATACTACTACAATATGCAACACCGACCGCCAA

Intercellular   TTACGGATGTTGGTTCCGTATTGGGGTACTGATTAAGAGGAGCGGTTGG
Intracellular   TTACGGATGTTGGTTCCGTATTGGGGTACTGATTAAGAGGAGCGGTTGG
Etheostoma      TTACGGATGTTGGTTCCGTATTGGGGTACTGATTAAGAGGAGCGGTTGG

Intercellular   GGGCATTGGTATTTGGCAGCGAGAGGTGAAATTCTTGGACCTGCACAAG
Intracellular   GGGCATTGGTATTTGGCAGCGAGAGGTGAAATTCTTGGACCTGCACAAG
Etheostoma      GGGCATTGGTATTTGGCAGCGAGAGGTGAAATTCTTGGACCTGC-CAAG
```

Figure 29. Clustal X Alignment of *Myxobolus procerus* SSU 18S rDNA from both cyst types in trout-perch with homologous region isolated from Johnny darter. Differences are noted in red. There are 52 differences out of a total of approximately 989 basepairs or a 5.2% difference.

```
Intercellular  TCAGTTATAATCTGCTCGATTGTTATGGTTA
Intracellular  TCAGTTATAATCTGCTCGATTGTTATGGTTA
Perch          CCA--TGCAAT--GTTTGACTG----GA---

Intercellular  TTGGATAACCGTGGGAAATCTAGAGCTAATACATGCTATAATGTTGGGTG
Intracellular  TTGGATAACCGTGGGAAATCTAGAGCTAATACATGCTATAATGTTGGGTG
Perch          --GGGAAAGTGC---AACTTCAACACCCATCCACACCA--------AGCA

Intercellular  TGGTTCGCTGCATTCAGCCGCATTTATTAGAGAATACCAATCGCA--TGA
Intracellular  TGGTTCGCTGCATTCAGCCGCATTTATTAGAGAATACCAATCGCA--TGA
Perch          TG--TCA-TAAACACACCCA-ATGCTTCAGAGTATCTCTTTCACACCTTA

Intercellular  GCAATCATGTGTGGTGAATCTAGATAACTTTGCTGATCGCATGGCCTTTG
Intracellular  GCAATCATGTGTGGTGAATCTAGATAACTTTGCTGATCGCATGGCCTTTG
Perch          CCAACAATTCAAATCATATCAATACAGACCTGTT------ACAGTCTATA

Intercellular  AGCCGGCGACATTTCGATTGAGTTTCTGCCCTATCACCTTGATGCTAGTG
Intracellular  AGCCGGCGACATTTCGATTGAGTTTCTGCCCTATCACCTTGATGCTAGTG
Perch          AA--GAAGAT-------TTGAATTT----------------ACTCCAGCT

Intercellular  TATTGAACTAGCATGGGAGTAACGGGTAACGGAGGATCAGG-TTCGATCC
Intracellular  TATTGAACTAGCATGGGAGTAACGGGTAACGGAGGATCAGGGTTCGATCC
Perch          CGTCAAA------TGGAGATTGTG-----------ATCTCG-TCCGTTAC

Intercellular  CGGAGAGGGAGCCTTAGAAACGGCTACCAC-ATCCAAGGAAGGCAGCAGG
Intracellular  CGGAGAGGGAGCCTTAGAAACGGCTACCAC-ATCCAAGGAAGGCAGCAGG
Perch          CGGAATA--AACCTGACAAATCACT-TCACGAACTAAGAACGGC--CATG

Intercellular  CGC-GCAAATTACCCAATCCAGACAATGGGAGGTGGT--GACGAAGAGTA
Intracellular  CGC-GCAAATTACCCAATCCAGACAATGGGAGGTGGT--GACGAAGAGTA
Perch          CACCACCAATCACCAGATC------ATGTAAGATCTTCGGTCTGACAATC

Intercellular  CCG--GATGAC-TGATATATTATTAGTCAGTCTGGAATGAAATCAATTTA
Intracellular  CCG--GATGAC-TGATATATTATTAGTCAGTCTGGAATGAAATCAATTTA
Perch          CTTTTGATGTCCTGATCCGGTA--AGTTT-TCCCGTGTTGAGTCAAATTA

Intercellular  AGCAATTGAGTTGAGTAACTACTGGAGGGCAAGTCTGGTGCCAGCAGCCG
Intracellular  AGCAATTGAGTTGAGTAACTACTGGAGGGCAAGTCTGGTGCCAGCAGCCG
Perch          AGCCGCAGGCT----CCACCCCTGG----------TGGTGCC--CTTCCG

Intercellular  CGGTAATTCCAGCTCCAGTAGCGTGTCTCAAAGTTGCTGCGCTTAAAACG
Intracellular  CGGTAATTCCAGCTCCAGTAGCGTGTCTCAAAGTTGCTGCGCTTAAAACG
Perch          T--CAATTCC---TTTAA------GTTTCAGCCTTGCGAC-CATACTCCC

Intercellular  CTCGTAGTTGGATGAGAATCTATATATCGGATAGTTATCTACTAGATTTA
Intracellular  CTCGTAGTTGGATGAGAAACTACATATCGGATAGTTATTTACTAGATTTA
Perch          CCCGCAACCGAA----AAACTTTA----GG-------TTTCCCAGG---G

Intercellular  AGGCTAATTATTACTTATTTCCGTGATGCTTATGGTATCCGGACAATATT
Intracellular  GGACTAATTATTACATATTTCCGTGATGCTTATGGTATCCGGATAATAGT
Perch          GGACCAACC----CAAG---CCGTAATAAT-AAGGCATAGGACTAATCCC

Intercellular  GATATTGGTTCAGCT---AGTGATAACATTAAACTGGTATGTAGTAATTG
Intracellular  GATATTGGTTCAACT---AGTGATAACATTAAACTGGTATGTAGTAATTG
Perch          GG-GTCGGCATAGTTTACAGTGAGAAC--TAGGACGGTATCTG---ATCG
```

```
Intercellular  CGTATGAGGATGACCATTGACCTTAAGTGTGTTGAAGGTCGTGTCTCATG
Intracellular  CGTATGAGGATGACCATTGACCTTAAGTGTGTTGAAGGTCGTGTCTCATG
Perch          TCTTCGA-----ACCTCTCACTAT-----CGTT------CTTGATTAATG

Intercellular  GGATGTGC-TTGAGTAAATCAGAGTGCTCAAAGCAGGCGTGATGCCTGAA
Intracellular  GGATGTGCCTTGAGTAAATCAGAGTGCTCAAAGCAGGCGTGATGCCTGAA
Perch          G-ATACGGTCTGGACAAAT----GCCTTC---GCATTTGTTAGTCCT---

Intercellular  TGTTGATAGCATGGAACGAACAATAGTGTAGATGTGTATTGAAGATGGTA
Intracellular  TGTTGATAGCATGGAACGAACAATAGTGTAGATGTGTATTGAAGATGGTA
Perch          ------TGGCA--GGTCCAAGAAT----------TTCACC----------

Intercellular  GTGTATTATTACAATGTAATAGTATACTACTACAATATGCAACACCGACC
Intracellular  GTGTATTATTACAATGTAATAGTATACTACTACAATATGCAACACCGACC
Perch          ---TCTCGCTGC----CAA----ATACCA-------ATGC--CCCCAACC

Intercellular  GCCAATTACGGATGTTGGTT-CCGTATTGGGGTACTGATTAAGAGGAGCG
Intracellular  GCCAATTACGGATGTTGGTT-CCGTATTGGGGTACTGATTAAGAGGAGCG
Perch          GCTCCTCTTA---ATCAGTTACCCCAATACGGAACC----AACATCCGTA

Intercellular  GTTGGGGGCATTGGTATTTGGCAGCGAGAGGTGAAATTCTTGGACCTGCA
Intracellular  GTTGGGGGCATTG-TATT--GCAGCGAGAG-TGAA-TTCT--GACCTGC-
Perch          ATTGGCGG--TCGGTGTT--GCA--------------TAT------TG--

Intercellular  CAAG
Intracellular  CAAG
Perch          -AAG
```

Figure 30. Clustal X alignment of *Myxobolus procerus* SSU 18S rDNA from both cyst types in trout-perch with homologous region isolated from yellow perch. As is evident there is a marked difference in the sequences. Differences are noted in red.

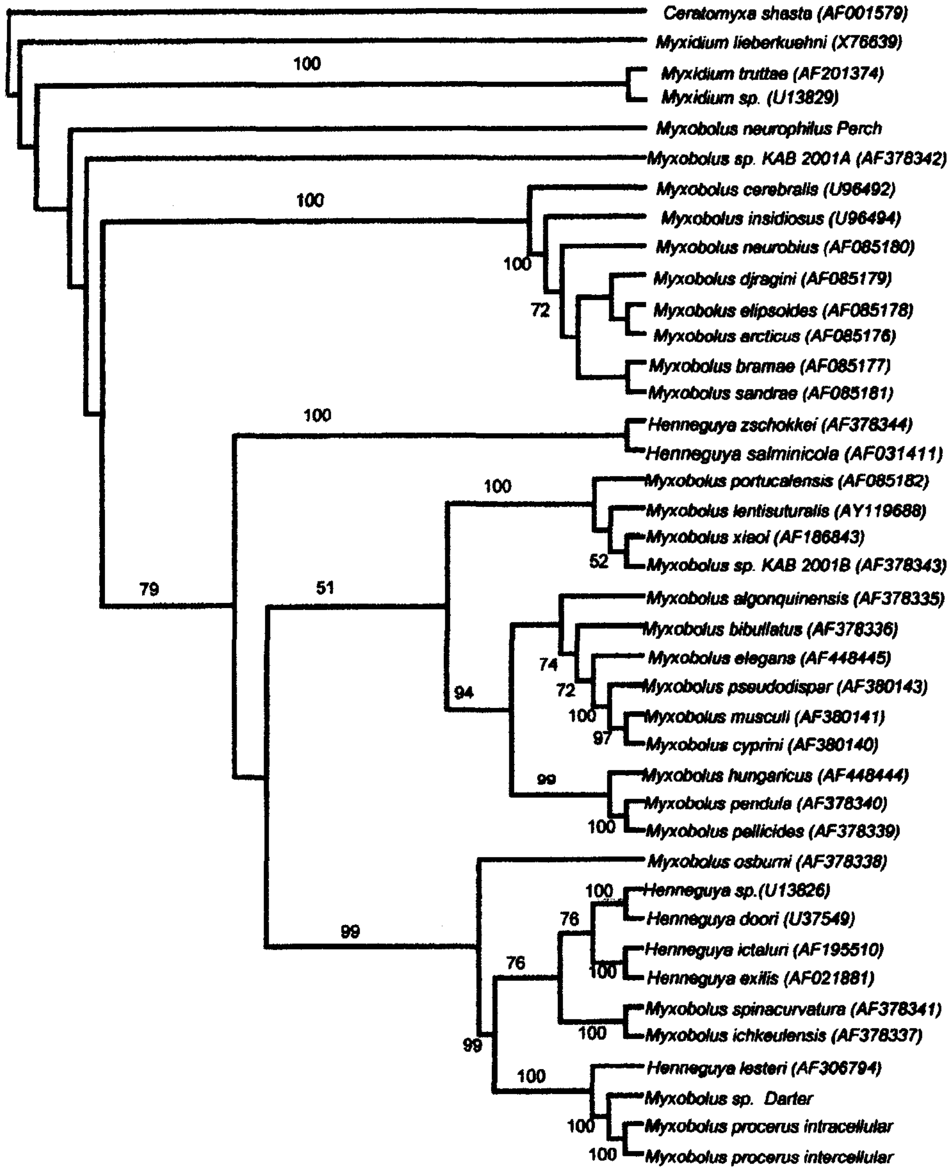


Figure 31. Neighbour-joining tree illustrating SSU 18S rDNA sequences of myxosporeans including data acquired from those species of *Myxobolus* included in the present work. The tree is rooted at *Ceratomyxa shasta*. Bootstrap values and GenBank Accession number (in parentheses) are included.

9. TABLES

Myxosporean	Fish host	Actinosporean	Invertebrate host	References
Myxobolus cerebralis	*Oncorhynchus mykiss*	triactinomyxon	*Tubifex tubifex*	Wolf and Markiw 1984
Myxobolus cotti	*Cottus gobio*	triactinomyxon	mixed oligochaetes	El-Matbouli and Hoffmann 1989
Myxobolus pavlovskii	*Hypophthalmichthys molitrix*	hexactinomyxon	mixed oligochaetes	Ruidisch et al. 1991
Myxobolus cultus	*Carassius auratus*	raabeia	*Branchiura sowerbyi*	Yokoyama et al. 1995
Myxobolus carassii	*Leuciscus idus*	triactinomyxon	*Tubifex tubifex*	El-Matbouli and Hoffmann 1993
Myxobolus arcticus (Canada)	*Oncorhynchus nerka*	triactinomyxon	*Stylodrilus heringianus*	Kent et al. 1993b
Myxobolus arcticus (Japan)	*Oncorhynchus masu*	triactinomyxon	*Lumbriculus variegatus*	Urawa 1994*
Myxobolus drjagini	*Hypophthalmichthys molitrix*	triactinomyxon	*T. tubifex*	El-Mansy and Molnár 1997a
Myxobolus portucalensis	*Anguilla anguilla*	triactinomyxon	*T. tubifex*	El-Mansy et al. 1998a
Myxobolus hungaricus	*Abramis abramis*	triactinomyxon	*T. tubifex, L. hoffmeisteri*	El-Mansy and Molnár 1997b
Myxobolus dispar	*Cyprinus carpio*	raabeia	*T. tubifex*	Molnár et al. 1999a
Myxobolus pseudodispar	*Rutilus rutilus*	triactinomyxon	*T. tubifex, L. hoffmeisteri*	Székely et al. 1999, 2000
Myxobolus bramae	*Abramis brama*	triactinomyxon	*T. tubifex*	Eszterbauer et al. 2000
Henneguya exilis	*Ictalurus punctatus*	*Aurantiactino-myxon janiszewskai*	*Dero digitata*	Lin et al. 1999
Henneguya ictaluri	*Ictalurus punctatus*	aurantiactinomyxon	*D. digitata*	Burtle et al. 1991; Styer et al. 1991; Pote et al. 2000
Hoferellus carassii (Germany)	*Carassius auratus*	aurantiactinomyxon	mixed species	El-Matbouli et al. 1992b
Hoferellus carassii (Japan)	*Carassius auratus*	neoactinomyxum	*B. sowerbyi*	Yokoyama et al. 1993
Hoferellus cyprini	*Cyprinus carpio*	aurantiactinomyxon	*Nais* sp.	Grossheider and Körting 1992
Thelohanellus nikolskii	*Cyprinus carpio*	aurantiactinomyxon	*B. sowerbyi*	Székely et al. 1998
Thelohanellus hovorkai	*Cyprinus carpio*	aurantiactinomyxon	*B. sowerbyi*	Yokoyama 1997; Székely et al. 1998; Anderson et al. 2000
Sphaerospora renicola	*Cyprinus carpio*	undetermined neoactinomyxum	*unknown B. sowerbyi*	Grossheider and Körting 1993; *Molnár et al. 1996b*
Sphaerospora truttae	*Salmo truta*	echinactinomyxon	*L. variegatus*	Özer and Wootten 1999
Ceratomyxa shasta	*Oncorhynchus mykiss*	tetractinomyxon	*Manayunkia speciosa*	Bartholomew et al. 1997
Zschokkella sp.	*Carassius auratus*	echinactinomyxon	*B. sowerbyi*	Yokoyama et al. 1993
Zschokkella nova	*Carassius carassius*	siedleckiella	*T. tubifex*	Uspenkaya 1995
Myxidium giardi	*Anguilla anguilla*	aurantiactinomyxon	*T. tubifex*	Benajiba and Marques 1993
PKX	*Oncorhynchus mykiss*	*Tetracapsula bryosalmonae*	*Plumatella* sp. and *Fredericella sultana*	Longshaw et al. 1999

* Urawa, S. 1994. Life cycle of *Myxobolus arcticus*, a myxosporean parasite of salmonid fishes. In: Program and Abstracts Intl. Symposium, Aquat. Animal Health Seattle, WA. 4–8 Sept. 1994. University of California, Davis. p. W-10.3.

Table 1. A summary of life cycles of myxozoans (Kent et al., 2000).

Primer	Sequence	Annealing Temperature (^{0}C)	Reference
MX5	5' ctgcggacggctcagtaaatcagt 3'	55	Kent et al., 2001
MX3	5' ccaggacatcttagggcatcacaga 3'	55	Kent et al. 2001
18e	5' ctggttgatcctgccagt 3'	55	Hillis and Dixon 1991
18g	5' ggtagtagcgacgggcggtgtg 3'	55	Hillis and Dixon 1991
Myxgen2r	5' caratgcyttcgcwyttgtta 3'	55	Kent et al., 2000
18r	5' ctacggaaaccttgttacg 3'	55	Whipps et al. 2003
MX3-1n	5' tgtatcatggagagacaacg 3'	55	This paper
MX3-3n	5' cattcaggcatcacgcctgc 3'	55	This paper
18M-3n	5' ggtttacacttccctttccg 3'	55	This paper
Myxgp2F	5' tggataaccgtgggaaa 3'	55	Kent et al. 2001
Act1R	5' aatttcacctctcgctgcca 3'	55	Hallet and Diamant 2001
Act3F	5' catggaacgaacaat 3'	55	Hallet and Diamant 2001

Table 2. Primer sequences used to amplify SSU 18S rDNA from isolates of myxobolids.

Myxobolus procerus intercellular	Primer	Number of clones	Differences/base pairs sequenced
	18e	3	0/647
	MX3	3	0/752

Myxobolus procerus intracellular	Primer	Number of clones	Differences/base pairs sequenced
	MX3	3	0/631
	Myxgen2r (18r)	2	0/473

Table 3. Aligning clones of *Myxobolus procerus.* There are no differences within those clones generated for each primer set noted.

In (µM)	*Myxobolus procerus* Intercellular cyst type	*Myxobolus procerus* Intracellular cyst type	Kruskal-Wallace
Spore length	14.13 (0.97)	12.50 (0.91)	0.000
Spore width	6.22 (0.55)	6.22 (0.57)	0.748
Polar Capsule 1 Length	5.94 (0.61)	5.81 (0.62)	0.486
Polar Capsule 1 Width	1.71 (0.30)	1.76 (0.39)	0.573
Polar Capsule 2 length	5.89 (0.62)	5.82 (0.65)	0.329
Polar Capsule 2 Width	1.71 (0.30)	1.73 (0.28)	0.939

Table 4. Statistical analysis for *Myxobolus procerus* spore measurements - ANOVA. *Myxobolus procerus* morphotypes of intercellular and intracellular spores average dimensions. Measurements are of distinct spore types as viewed under light microscopy. The only statistically significant difference between the spores was in spore length.

	Myxobolus exiguus	*Myxobolus muelleri*	*Aurantiactinomyxon mississipiens*	*Henneguya exilis*	*Henneguya ictaluri*
Myxobolus. procerus Intracellular Cyst	276/296 (93%)	276/296 (93%)	353/392 (90%)	356/397 (89%)	356/397 (89%)
Myxobolus procerus Intercellular Cyst	268/287 (93%)	268/287 (93%)	355/397 (89%)	355/397 (89%)	355/397 (89%)

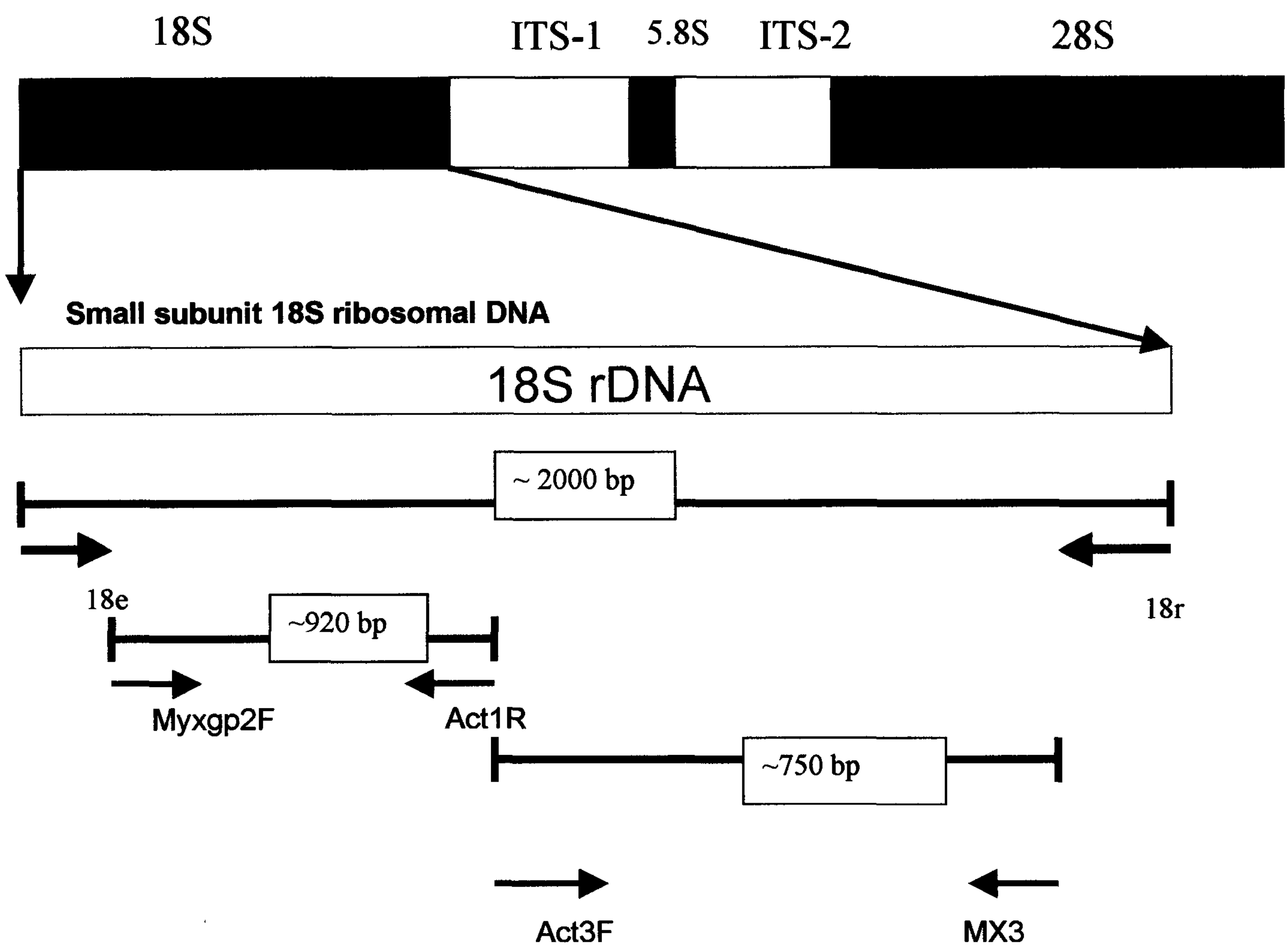
Table 5. BLAST results of SSU 18S rDNA consensus sequences from spores within each cyst type.

Phylum Myxozoa
Class Myxosporea
Order Bivalvulida (marine and freshwater, with two valves to spore)
Suborder Variisporina (marine and freshwater, mostly coelozoic)
Includes *Ceratomyxa, Chloromyxum, Hoferrellus, Myxidium, Myxobilatus, Ortholinea, Parvicapsula, Polysporoplasma, Sinuolinea, Sphaerospora, Zschokkella,*
Suborder Platysporina (marine and freshwater, mostly histozoic)
Includes *Myxobolus, Henneguya, and Thelohanellus*
Suborder Sphaeromyxina (marine, with ribbon-like polar filaments in polar capsules at opposing end of spore)
Sphaeromyxa
Order Multivalvulida (marine, with greater than 2 spores valves)
Includes *Hexacapsula, Kudoa, Trilospora, and Unicapsula*
Class Malacosporea (freshwater, with soft valves, parasites of bryozoans; one order, family and genus)
Order Malacovalvulida
Tetracapsula (with 4 polar capsules)

Table 6. Abbreviated classification of the class Myxosporea based primarily on Lom and Dyková (1992).

10. APPENDICES

Appendix A Ribosomal DNA



Appendix B Glossary

ANOVA (Analysis of variance): Used to uncover the main and interaction effects of categorical independent variables (called "factors") on an interval dependent variable.

Algorithm: A procedure or formula for solving a problem.

Bit-score: An indication of the relatedness of the sequence in question to the sequences it is aligned against. The higher the bit score the greater the similarity.

Bootstrapping: A method in which one takes a sub sample of the sites in an alignment and creates trees based on those sub samples. That process is iterated multiple times (usually 1000) and the results are compiled to allow an estimate of the reliability of a particular grouping.

Capsulogenic: Cells that are to become the polar capsules.

Coelozoic: Cavity dwellers that attach to walls or float freely in cavities such as urinary or gall bladder. Typically invade epithelial cells in early stages.

Ectoparasitic: Parasites that live on the outside of the body of the host.

Endoparasitic: Parasites that live on the inside of the body of the host.

E-Value: The number of matches to the current nonredundant sequence database that are expected by chance alone. The smaller the E value, the more likely that the similarity is "real".

Fusiform: Spindle-shaped; tapering from the middle towards each end

Heterogeneity: Having the characteristic of containing dissimilar constituents.

Heuristic: As an adjective, heuristic pertains to the process of gaining knowledge or some desired result by intelligent guesswork rather than by following some pre-established formula.

Homogeneity: Having the characteristic of containing similar constituents.

Histozoic: Intracellular tissue dwellers, found in solid tissues such as cartilage or Muscle.

***In situ* Hybridization:** A method of detecting the presence of specific nucleic acid sequences within a cytological preparation. A DNA or RNA probe is labeled radioactively or chemically and hybridized to a cytological preparation to detect RNA or to a denatured cytological preparation to detect DNA. The hybridization is detected by autoradiography (for radioactive probes) or by chromomeric reactions or fluorescent (for chemically-labeled probes).

Intercellular: That existing between cells.

Intracellular: That existing inside cells.

Intergenic: taking place or existing between neighboring genes.

Long-Branch Abstractions: An artifact of phylogenetic analyses of taxa with differing evolution rates.

Maximum likelihood: A method of creating phylogenetic trees by maximizing the likelihood of observing the data.

Monophyletic: Derived from a single ancestral line.

Morphology: The comparison of the forms of organisms and their parts in order to identify homologous structures.

Myxosporea: A subphylum of the Kingdom Protista, characterised by the presence of spores of multicellular origin, usually with two or three valves, two or more polar filaments, and an amoeboid sporoplasm; parasitic in lower vertebrates, especially common in fishes. Important genera include *Ceratomyxa, Henneguya, Leptotheca, Myxidium,* and *Myxobolus.*

Neighbour joining: A method of constructing phylogenetic trees by manipulating a distance matrix reducing it in size at each step then reconstructing the tree from that series of matrices.

Ontogeny: The development or course of development, especially that of an individual organism.

p Value: The probability of getting something more extreme than your result, when there is no effect in the population.

Parsimony: In effect, this rule states that if there exists two answers to a problem or a question, and if, for one answer to be true, well-established laws of logic and science must be re-written, ignored, or suspended in order to allow it to be true, and for the other answer to be true no such accommodation need be made, then the simpler-the second-of the two answers is much more likely to be correct.

Phylogeny: The evolution of a genetically related group of organisms as distinguished from the development of the individual organism.

Polar capsule: Apical, thick walled vesicle of a myxozoan spore containing spirally coiled, extrusible polar filament.

Polar filament: Tube-like structure coiled within the polar capsule of myxozoans. Serves as anchor for hatching spore (cf. polar tube of microsporeans).

Polymerase: Any enzyme which catalyses the formation of a polymer, esp. a polynucleotide. For example the enzyme responsible for deoxyribonucleotide incorporation is designated as 'polymerase'.

Polymerase Chain Reaction (PCR): An in vitro DNA synthesis procedure in which two oligonucleotides annealed to a DNA template oriented so that the primers direct DNA synthesis on complementary, opposing strands towards each other. With successive cycles of DNA synthesis, denaturation, and repriming, the region between the primers accumulates exponentially as a double-stranded DNA fragments with the ends consisting of the oligonucleotide primers.

Polyphyletic: Composed of members that originated, independently, from more than one evolutionary line.

Pseudoplasmodium: A plasmodium with vegetative and generative nuclei in the same cell.

Restriction Fragment Length Polymorphism: Restriction fragment length polymorphism is the identification of specific restriction enzymes that reveal a pattern difference between the DNA fragment sizes in individual organisms.

Ribosomal RNA: Ribosomes are the site of protein synthesis in the cell. The sizes of various subunits of the ribosome are given in Svedberg units. In all organisms, the ribosomes are made up of two subunits of unequal size. In eukaryotes, there are 4 segments of rRNAs (18S piece in the smaller subunit and 5.8S and 28S in the larger subunit).

Taxon: A taxonomic group, as a genus or species.

Topology: The way in which constituent parts are interrelated or arranged.

Svedberg Unit (ex.18S): The Svedberg is a unit that measures the rate at which a particle sediments in a sucrose solution during ultra centrifugation..
Taq **Polymerase** - A DNA polymerase that is very stable at high temperatures, isolated from the thermophilic bacterium *Thermus aquaticus*. Very useful in PCR

reactions which must cycle repetitively through high temperatures during the denaturation step.

Triploblast: An organism having three primary germ layers

Vector: A bacteriophage, phage or plasmid that transfers genetic material from one bacterium to another; also, a used to transfer extraneous DNA into a cell.

X-Gal: Chromogenic substrate for the enzyme beta-galactosidase yielding an intense blue colour. Very widely used in blue-white colour selection of bacteria containing recombinant plasmids, and in histochemistry of tissues or cells expressing beta-galactosidase as a reporter gene.

Appendix C List Of Reagents

DNA Extraction

i. Proteinase K (200µg/ml)
ii. Sodium Dodecyl Sulfate (10%)
iii. Sodium Acetate 3 M
iv. Phenol:Chloroform:Isoamyl alcohol 25:24:1
v. TE (Tris 10mM – EDTA 1 mM pH 8.0)
vi. 100% Ethanol
vii. 70% Ethanol

Polymerase Chain Reaction – 50 µL reaction
i. *Taq* Polymerase (1.25U)
ii. Magnesium buffer (1.5mM)
iii. 1 X PCR buffer
iv. dNTP (250 µM each)
v. Primers 1 µM each
vi. ddH_2O to 50 µl
vii. DNA to 300 ng

Gene Clean

i. Sodium iodide
ii. Guanidium hydrochloride
iii. TE (10mM Tris-1mM EDTA pH 8.0)
iv. Glass milk

Cloning

i. X-galactosidase (X-gal)
ii. LB (Luria-Bertani) Broth:
 a. 1% tryptone
 b. 0.5% Yeast extract
 c. 1% NaCl
 d. pH 7.0
iii. Carbenicillin (final concentration at 25 µg/ml)

DNA Sequencing

i. ET dye terminator
ii. PCR primers (see Materials and Methods)

Appendix D TOPO Cloning Vector

Sequence for TOPO Cloning Vector

AGCGCCCAATACGCAAACCGCCTCTCCCCGCGCGTTGGCCGATTCATTAATGCAGCTGGCA
CGACAGGTTTCCCGACTGGAAAGCGGGCAGTGAGCGCAACGCAATTAATGTGAGTTAGCTC
ACTCATTAGGCACCCCAGGCTTTACACTTTATGCTTCCGGCTCGTATGTTGTGTGGAATTGT
GAGCGGATAACAATTTCACACAGGAAACAGCTATGACCATGATTACGCCAAGCTATTTAGGT
GACGCGTTAGAATACTCAAGCTATGCATCAAGCTTGGTACCGAGCTCGGATCCACTAGTAAC
GGCCGCCAGTGTGCTGGAATTCGCCCTTAAGGGCGAATTCTGCAGATATCCATCACACTGG
CGGCCGCTCGAGCATGCATCTAGAGGGCCCAATTCGCCCTATAGTGAGTCGTATTACAATTC
ACTGGCCGTCGTTTTACAACGTCGTGACTGGGAAAACCCTGGCGTTACCCAACTTAATCGCC
TTGCAGCACATCCCCCTTTCGCCAGCTGGCGTAATAGCGAAGAGGCCCGCACCGATCGCCC
TTCCCAACAGTTGCGCAGCCTATACGTACGGCAGTTTAAGGTTTACACCTATAAAAGAGAGA
GCCGTTATCGTCTGTTTGTGGATGTACAGAGTGATATTATTGACACGCCGGGGCGACGGAT
GGTGATCCCCCTGGCCAGTGCACGTCTGCTGTCAGATAAAGTCTCCCGTGAACTTTACCCG
GTGGTGCATATCGGGGATGAAAGCTGGCGCATGATGACCACCGATATGGCCAGTGTGCCG
GTCTCCGTTATCGGGGAAGAAGTGGCTGATCTCAGCCACCGCGAAAATGACATCAAAAACG
CCATTAACCTGATGTTCTGGGGAATATAAATGTCAGGCATGAGATTATCAAAAAGGATCTTCA
CCTAGATCCTTTTCACGTAGAAAGCCAGTCCGCAGAAACGGTGCTGACCCCGGATGAATGT
CAGCTACTGGGCTATCTGGACAAGGGAAAACGCAAGCGCAAAGAGAAAGCAGGTAGCTTGC
AGTGGGCTTACATGGCGATAGCTAGACTGGGCGGTTTTATGGACAGCAAGCGAACCGGAAT
TGCCAGCTGGGGCGCCCTCTGGTAAGGTTGGGAAGCCCTGCAAAGTAAACTGGATGGCTTT
CTCGCCGCCAAGGATCTGATGGCGCAGGGGATCAAGCTCTGATCAAGAGACAGGATGAGG
ATCGTTTCGCATGATTGAACAAGATGGATTGCACGCAGGTTCTCCGGCCGCTTGGGTGGAG
AGGCTATTCGGCTATGACTGGGCACAACAGACAATCGGCTGCTCTGATGCCGCCGTGTTCC
GGCTGTCAGCGCAGGGGCGCCCGGTTCTTTTTGTCAAGACCGACCTGTCCGGTGCCCTGAA
TGAACTGCAAGACGAGGCAGCGCGGCTATCGTGGCTGGCCACGACGGGCGTTCCTTGCGC
AGCTGTGCTCGACGTTGTCACTGAAGCGGGAAGGGACTGGCTGCTATTGGGCGAAGTGCC
GGGGCAGGATCTCCTGTCATCTCACCTTGCTCCTGCCGAGAAAGTATCCATCATGGCTGAT
GCAATGCGGCGGCTGCATACGCTTGATCCGGCTACCTGCCCATTCGACCACCAAGCGAAAC
ATCGCATCGAGCGAGCACGTACTCGGATGGAAGCCGGTCTTGTCGATCAGGATGATCTGGA
CGAAGAGCATCAGGGGCTCGCGCCAGCCGAACTGTTCGCCAGGCTCAAGGCGAGCATGCC
CGACGGCGAGGATCTCGTCGTGACCCATGGCGATGCCTGCTTGCCGAATATCATGGTGGAA
AATGGCCGCTTTTCTGGATTCATCGACTGTGGCCGGCTGGGTGTGGCGGACCGCTATCAGG
ACATAGCGTTGGCTACCCGTGATATTGCTGAAGAGCTTGGCGGCGAATGGGCTGACCGCTT
CCTCGTGCTTTACGGTATCGCCGCTCCCGATTCGCAGCGCATCGCCTTCTATCGCCTTCTTG
ACGAGTTCTTCTGAATTATTAACGCTTACAATTTCCTGATGCGGTATTTTCTCCTTACGCATCT
GTGCGGTATTTCACACCGCATACAGGTGGCACTTTTCGGGGAAATGTGCGCGGAACCCCTA
TTTGTTTATTTTTCTAAATACATTCAAATATGTATCCGCTCATGAGACAATAACCCTGATAAAT
GCTTCAATAATAGCACGTGAGGAGGGCCACCATGGCCAAGTTGACCAGTGCCGTTCCGGTG
CTCACCGCGCGCGACGTCGCCGGAGCGGTCGAGTTCTGGACCGACCGGCTCGGGTTCTCC
CGGGACTTCGTGGAGGACGACTTCGCCGGTGTGGTCCGGGACGACGTGACCCTGTTCATC
AGCGCGGTCCAGGACCAGGTGGTGCCGGACAACACCCTGGCCTGGGTGTGGGTGCGCGG
CCTGGACGAGCTGTACGCCGAGTGGTCGGAGGTCGTGTCCACGAACTTCCGGGACGCCTC
CGGGCCGGCCATGACCGAGATCGGCGAGCAGCCGTGGGGGCGGGAGTTCGCCCTGCGCG
ACCCGGCCGGCAACTGCGTGCACTTCGTGGCCGAGGAGCAGGACTGACACGTGCTAAAAC
TTCATTTTTAATTTAAAAGGATCTAGGTGAAGATCCTTTTTGATAATCTCATGACCAAAATCCC
TTAACGTGAGTTTTCGTTCCACTGAGCGTCAGACCCCGTAGAAAAGATCAAAGGATCTTCTT
GAGATCCTTTTTTTCTGCGCGTAATCTGCTGCTTGCAAACAAAAAAACCACCGCTACCAGCG
GTGGTTTGTTTGCCGGATCAAGAGCTACCAACTCTTTTTCCGAAGGTAACTGGCTTCAGCAG
AGCGCAGATACCAAATACTGTCCTTCTAGTGTAGCCGTAGTTAGGCCACCACTTCAAGAACT
CTGTAGCACCGCCTACATACCTCGCTCTGCTAATCCTGTTACCAGTGGCTGCTGCCAGTGG

CGATAAGTCGTGTCTTACCGGGTTGGACTCAAGACGATAGTTACCGGATAAGGCGCAGCGG
TCGGGCTGAACGGGGGGTTCGTGCACACAGCCCAGCTTGGAGCGAACGACCTACACCGAA
CTGAGATACCTACAGCGTGAGCTATGAGAAAGCGCCACGCTTCCCGAAGGGAGAAAGGCG
GACAGGTATCCGGTAAGCGGCAGGGTCGGAACAGGAGAGCGCACGAGGGAGCTTCCAGG
GGGAAACGCCTGGTATCTTTATAGTCCTGTCGGGTTTCGCCACCTCTGACTTGAGCGTCGAT
TTTTGTGATGCTCGTCAGGGGGGCGGAGCCTATGGAAAAACGCCAGCAACGCGGCCTTTTT
ACGGTTCCTGGGCTTTTGCTGGCCTTTTGCTCACATGTTCTTTCCTGCGTTATCCCCTGATTC
TGTGGATAACCGTATTACCGCCTTTGAGTGAGCTGATACCGCTCGCCGCAGCCGAACGACC
GAGCGCAGCGAGTCAGTGAGCGAGGAAGCGGAAG

The TOPO TA Cloning System

The TOPO TA Cloning System (TOPO Cloning) is a method for cloning polymerase chain reaction (PCR) products into a plasmid vector

PCR is a method, which essentially isolates a specific segment of DNA by amplification. PCR uses specific primers, which allow *Taq* DNA polymerase to make copies of only a specific segment. *Taq* DNA polymerase is used for its ability to withstand the high heat (95C) necessary for the many cycles of PCR. A unique aspect of *Taq* DNA polymerase is that it adds a single deoxyadenosine (A) to the 3' ends of PCR products. The resulting products of PCR are many copies of a specific DNA sequence with 3' A overhangs.

TOPO Cloning ligates the PCR product into the pCR 2.1-TOPO plasmid vector (vector) with topoisomerase I. This can be done quickly and efficiently because of the unique aspects of the vector. The vector has been engineered to be a linearized plasmid with 3' deoxythymidine (T) overhangs that is activated by being covalently bonded to topoisomerase I. The 3' A overhangs of the PCR product complement the 3' T overhangs of the vector and allow for fast ligation with the already present topoisomerase I. The plasmid can then be transformed into competent bacterial cells.

Other useful features of the vector are its ampicillin and kanamycin resistance markers, lacZ reporter gene, T7 promoter, EcoR I sites flanking the PCR insertion site, and the f1 origin of replication. The ampicillin and kanamycin resistance inserts in the plasmid allow for quick selection of bacterial colonies that take up the vector plasmid during transformation. The lacZ gene in bacteria causes colonies to have a blue color. If PCR DNA is inserted in the vector it will insert in the middle of the lacZ gene causing the colonies to be white and easily selected. The T7 promoter region in the vector allows for *in vitro* RNA transcription/translation by the T7 phage. If T7 phage infects the bacteria it will make proteins from the DNA sequence of the vector and insert which allows scientists to sequence the subsequent protein and therefore DNA sequence of the insert. The *Eco*R I sites on either side of the insert enable the insert to be easily removed by *Eco*R I restriction enzymes. The f1 origin of replication is a necessary component of the plasmid and makes single-strand rescue possible.

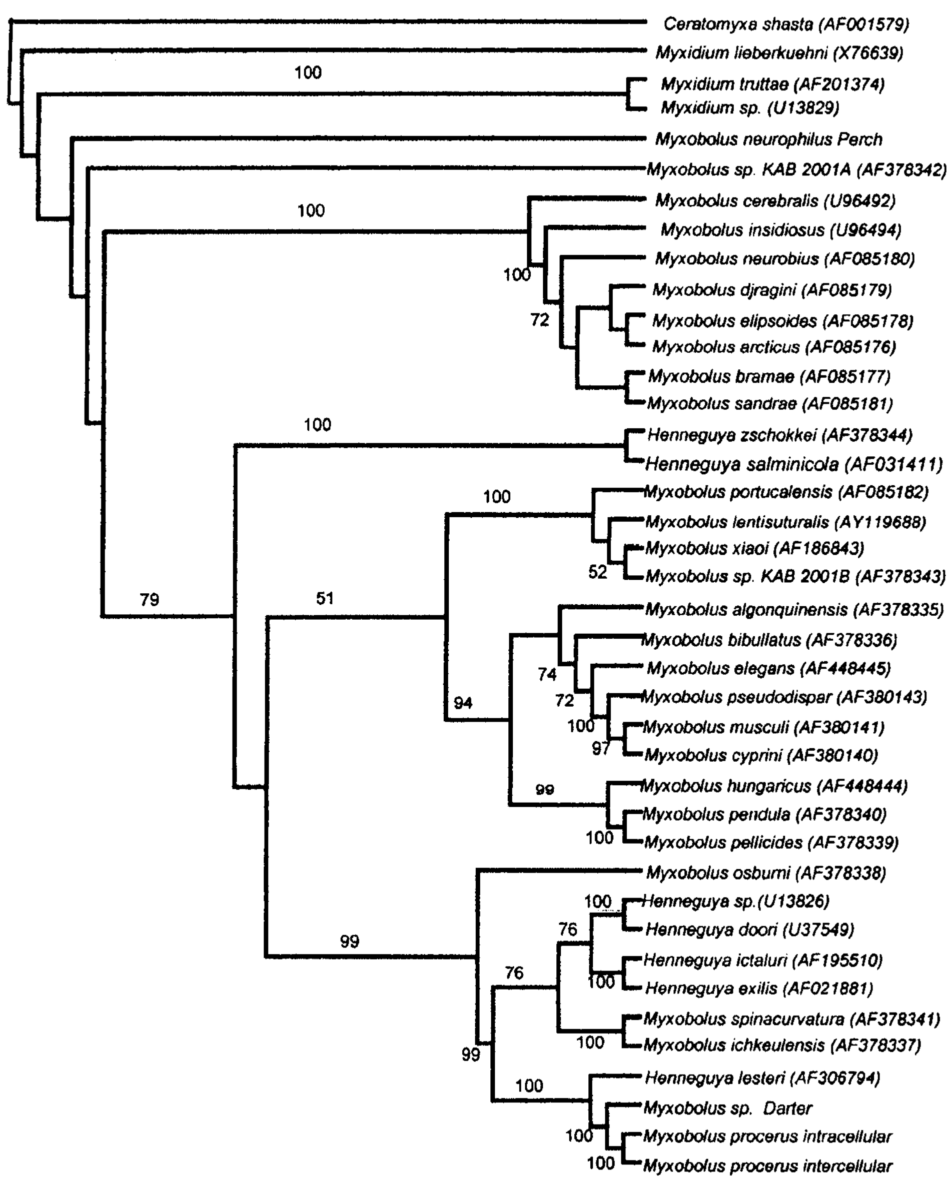
The entire TOPO Cloning process can be done in only five minutes at room temperature with 95% efficiency. This is much faster and less complicated than the PRIME PCR Cloner Cloning System we used in lab and most other cloning procedures. TOPO Cloning system is ideal for scientists that need to quickly clone PCR products into bacteria.

Reference:

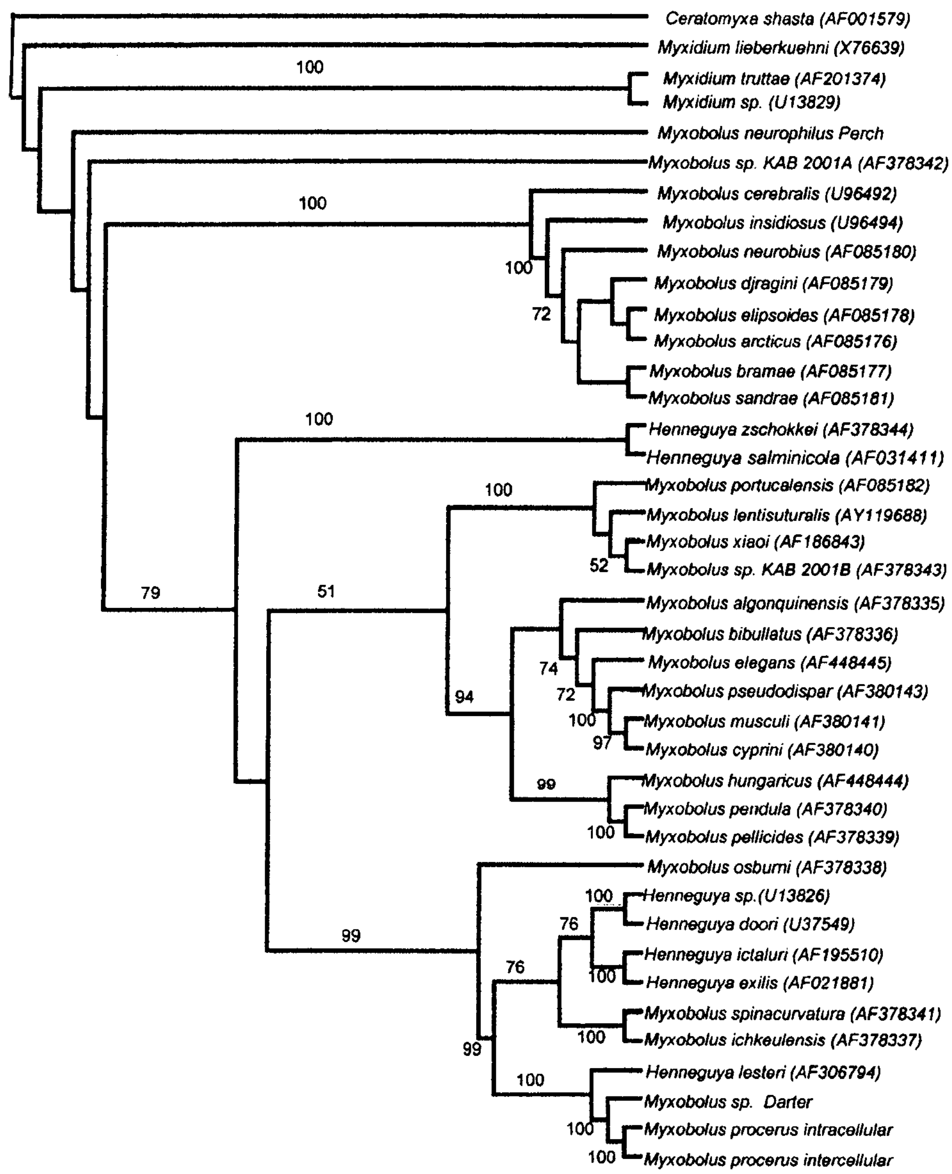
Campbell NA, Biology. 4th ed. Menlo Park, CA: The Benjamin/Cummings Publishing Company, Inc.; 1996. p 379-380.

Hoover C, 1998 July 8. Invitrogen web catalog.

Appendix E Likelihood tree



Appendix F Parsimony Tree



Appendix G Information on *Myxobolus* Sp. used in phylogenetic tree

1. *Myxidium* species

Myxidium truttae GenBank AF201374 *Myxidium* sp. GenBank U13829, *Myxidium lieberkuehni* GenBank X766390,

Host: *Perca flavescens, Melanogrammus aeglifinus, Oncorhynchus*

Site: kidney, intestine, urinary bladder, gall bladder.

Distribution: AB, BC, ON

2. *Henneguya* species

Henneguya sp. GenBank U13826,

Henneguya lesteri GenBank AF306794,

Henneguya doori GenBank U37549,

Henneguya ictaluri GenBank AF195510,

Host: *Coregonus, Luxilis, Oncorhynchus*

Site: gills or not specified

Distribution: AB, ON

3. *Henneguya salminicola* GenBank AF031411

Host: *Oncorhynchus* sp.

Site: muscle cysts

Distribution: BC

4. *Henneguya exilis* GenBank AF021881

Host: *Ameirus, Ictalurus*

Site: gills

Distribution: ON

5. *Henneguya zschokkei* GenBank AF378344

Host: *Coregonus, Cottus, Prosopium, Rhinichthys, Richarsonius, Thymallus*

Site: muscle, gills, kidney

Distribution: BC, ON

6. *Myxobolus osburni* GenBank AF378338

Host: *Lepomis gibbosus*

Site: mesenteries

Distribution: ON

7. *Myxobolus neurobius* GenBank AF085180

Host: *Oncorhynchus, Prosopium, Salmo, Salvelinus*

Site: brain, spinal cord

Distribution: BC, NF

8. *Myxobolus arcticus* GenBank AF085176

Host: *Oncorhynchus* sp.

Site: brain

Distribution: BC

9. *Myxobolus musculi* GenBank AF380141

Host: *Notemigonus crysoleucas*

Site: eye, heart, kidney, muscle, ureters, urinary bladder

Distribution: ON

10. *Myxobolus pendula* GenBank AF378340

Host: *Semotilus atromaculatus, Sematolilus margarita*

Site: gills

Distribution: ON

11. *Myxobolus pellicides* GenBank AF378339

Host: *Semotilus atromaculatus*

Site: gills

Distribution: ON

12. *Myxobolus bibullatus* GenBank AF378336

Host: *Catostomus, Cottus, Mylocheilus, Ptychocheilus*

Site: gall bladder, muscle, kidney

Distribution: BC, NS , ON

13. *Myxobolus* sp.

Myxobolus lentisuturalis GenBank AY119688, *Myxobolus* KAB-2001B GenBank AF378343, *Myxobolus xiaoi* GenBank AF186843, *Myxobolus portucalensis* GenBank F085182,*Myxobolus cerebralis* GenBank U96492, *Myxobolus insidiosus* GenBank U96494, *Myxobolus elipsoides* GenBank AF085178, *Myxobolus djragini* GenBank AF085179, *Myxobolus bramae* GenBank AF085177, *Myxobolus sandrae* GenBank AF085181, *Myxobolus* sp. KAB2001A GenBank AF378342, *Myxobolus pseudodispar* GenBank AF380143, *Myxobolus cyprini* GenBank AF380140, *Myxobolus hungaricus* GenBank AF448444, *Myxobolus elegans* GenBank AF448445, *Myxobolus algonquinensis* GenBank AF378335

Host: All of the above

Site: gills, fins, gall bladder, intestine, heart, kidney, liver, brain, spinal cord, gonads

Distribution: BC, MB, NB, NS, ON

14. *Ceratomyxa shasta* GenBank AF001579

Host: *Oncorhynchus* sp.

Site: pyloric caeca, intestine, gall bladder

Distribution: BC, YT

15. *Myxobolus procerus*

Host: *Percopsis omiscomaycus*

Site: skin, muscle

Distribution: ON

16. *Myxobolus ichkeulensis* GenBank AF378337

Host: ND

Site: gill arches

Distribution: Mugil, Mediterranean Sea: off coast of Tunisia

***17. Myxobolus spinacurvatura* GenBank F378341**

Host: ND

Site: mesenteries and blood

Distribution: Mugil, Mediterranean Sea: off coast of Tunisia

Appendix H Clustal X alignment of species of *Myxobolus*.

```
#NEXUS
BEGIN DATA;
dimensions ntax=49 nchar=2728;
format missing=?
symbols="ABCDEFGHIKLMNPQRSTUVWXYZ"
interleave datatype=DNA gap= -;

matrix
Melipsoides       --------------------------------------------------
Mdjragini         --------------------------------------------------
Mbramae           --------------------------------------------------
Mneurobius        --------------------------------------------------
Marcticus         --------------------------------------------------
Msandrae          --------------------------------------------------
Minsidiosus       --------------------------------------------------
Mcerebralis       ----------------------AGATATACGCTTTTCTCTAAGACTAAGC
Mlentisuturalis   -ACCTGGTTGATCCTGCCAGTGAGCGTACGCTTTTCTCAAGGACTCAGCC
Mxiaoi            ---------------------GAGCGTACGCTTTTCTCAAGGACTCAGCC
Myxo.             --------------------------------------------------
Mportucalensis    --------------------------------------------------
Mmusculi          --------------------------------------------------
Mcyprini          --------------------------------------------------
Mpseudodispar     --------------------------------------------------
Mbibullatus       ---------------------AGAATCATGCTATTCTTGAAGATTAAGCC
Melegans          --------------------------------------------------
Mpendula          -----------CCCTTTGGGAAGAAACATGCTATTCTCAAAGACTAAGCC
Mpellicides       -----------CCCTTTGGGAAGAAA-ATGCTATTCTCAAAGACTAAGCC
Mhungaricus       --------------------------------------------------
Myxiditruttae     --------------------------------------------------
Myxidium          ---------------------TGGCATATGCTCGTCTCTAAGATT-AAGC
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    AACCTGGTTGATCCTGCCAGTAATCATATGCTTGTCTCTAAGCTT-AAGC
Myxosp.           --------------------------------------------------
Hennzschokkei     ---------------------AAACATACGCTGTTTTCTAAGACT-AAGC
Hennsalminicola   ---------------------AAACATACGCTGTTTTCTAAGACTTAAGC
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     --------------------------------------------------
Mprocerus         --------------------------------------------------
Henneguya         -----TTCCGTATTCTGCCAGTGGGCATACGCTCTTTTTAAAGATTTAGC
Hsp.              ----------------------GCGTATACGCTCTTTTTAAAGATTAAGC
Hdoori            ----------------------------ATGC------------------
Hennictaluri      -AACCTGGTTGATCCTGCCAGTGCGTATACGCTCTTTTTAAAGACTAAGC
Hennexilis        -AACCTGGTTGATCCTGCCAGTGCGTATACGCTCTTTTTAAAGATTAAGC
Mspinacurvatura   --------------------------------------------------
Michkeulensis     --------------------------------------------------
Mosburni          ----------------------------ACGCTGTTCTTAAAGATTTAGC
```

```
Muvuliferus        --------------------------------------------------
Ceratomyxa         --------------------------------------------------
Malgonquinensis    ----------------------------------------AAGATTAAGC
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        --------------------------------------------------
Mdjragini          --------------------------------------------------
Mbramae            --------------------------------------------------
Mneurobius         --------------------------------------------------
Marcticus          --------------------------------------------------
Msandrae           --------------------------------------------------
Minsidiosus        ------------------------------------------GYCGGCTC
Mcerebralis        CATGCATGTTNAAGTTCATACGTAGTAAAACGTGAGACTGCGGACGGCTC
Mlentisuturalis    ATGCAAGTGTTAAAGTTCATACGATTTAAAAGTGAGACTGCGGACGGCTC
Mxiaoi             ATGCAAGTGTAAAAGTTCATACGATTTAAAAGTGAGACTGCGGACGGCTC
Myxo.              --------------------------------------------------
Mportucalensis     --------------------------------------------------
Mmusculi           --------------------------------------------------
Mcyprini           --------------------------------------------------
Mpseudodispar      --------------------------------------------------
Mbibullatus        -TGTAGGTGCCAA-GTTCATACAATATTATTGTGAGACTGCGGACGGCTC
Melegans           --------------------------------------------------
Mpendula           ATGCACGTGCCAA-GTTCATACGATCTTATCGTGAGACTGCGGACGGCTC
Mpellicides        -TGCACGTGCCAA-GTTCATACGATCTTATCGTGAGACTGCGGACGGCTC
Mhungaricus        --------------------------------------------------
Myxiditruttae      --------------------------------------------------
Myxidium           CATGCATGTCTGAGTTCATACCTAGTTAA-CGTGAGACTGCGAAAGGCTC
Ethclone1AM        --------------------------------------------------
Ethclone3AM        --------------------------------------------------
Ethclone2AM        --------------------------------------------------
Mdiaphanus         --------------------------------------------------
M.lieberkuehni     CATGCATGTCTAAGTTCAAACAT--TTAA-TGTGAGACTGCGAAAGGCTC
Myxosp.            --------------------------------------------------
Hennzschokkei      CATGCAGGTGCTACAGTACATACGTGAATTCGTGAGACTGCGGAAGGCTC
Hennsalminicola    CATGCAGGTGCTACACTACATACGTGAATTCGTGAGACTGCGGAAGGCTC
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      -------------------------------------CTGCGGACGGCTC
Mprocerus          -------------------------------------CTGCGGACGGCTC
Henneguya          CATGCATGTGCCAG-TTCATACATTAAAAATGTGAGACTGCGGACGGCTC
Hsp.               CATGCAGGTGCTAG-TTCATACATATGTAATGTGAGACTGCGGACGGCTC
Hdoori             ----CAGGTGCTAGCTTCATACATATGTAATGTGAGACTGCGGACGGCTC
Hennictaluri       CATGCATGTGCCAG-TTCATACATATTTAATGTGAGACTGCGGACGGCTC
Hennexilis         CATGCAAGTGCTAG-TTCATACATATTTAATGTGAGACTGCGGACGGCTC
Mspinacurvatura    --------------------------------------------------
Michkeulensis      --------------------------------------------------
Mosburni           CATGCAAGTGAAAG-TTCAAACATTTAAAATGTGAGACTGTGGACGNCTC
Muvuliferus        --------------------------------------------------
Ceratomyxa         ------------------------TTAAATGATGAAACTGCGAAGGCGTC
Malgonquinensis    CATGTATGTGCCAAGTTCATACG--TTAGACGTGAGACTGCGGACGGCTC
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------
```

```
Melipsoides       -----------TATCATCTATTTGATTGTCTA--CCCA-TTGGATAACCG
Mdjragini         -----------TATCATCTATTTGNTTGTCTA--CCCA-TTGGATAACCG
Mbramae           -----------TATCATCTATTTGATTGTCTA--CCCA-TTGGATCCCCG
Mneurobius        -----------TATCATCTATTTGNTTGTCTA--CCCA-TTGGATAACCG
Marcticus         -----------TATCATCTATTTGATTGTCTA--CCCA-TTGGATAACCG
Msandrae          -----------TATCATCTATTTGATTGTCTA--CCCA-TTGGATAACCG
Minsidiosus       AGTAAATCAGTYATCATCTATTTGATTGTCTA--CCCA-TTGGATAACCG
Mcerebralis       AGTAAATCAGTTATCATCTATTTGATTGTCTA--CCCA-TTGGATAACCN
Mlentisuturalis   AGTAAATCAGCAATGATCTATCTGATTGTAGAGACCCA-TTGGATAACCG
Mxiaoi            AGTAAATCAGCGATGATCTATCTGATTGTACAT-CCCA-TTGGATAACCG
Myxo.             -----------GATGATCTATCTGATTGTACAT-CCCA-TTGGATAACCG
Mportucalensis    -----------CATGATCTATCTGATTGTATAG-CCCA-TTGGATAACCG
Mmusculi          -----------GAT-ATCTATTTGATTGTCTAA-CCTA--TGGATAACCG
Mcyprini          -----------GAT-ATCTGTTTGATTGTCTAA-CCTA--TGGATAACCG
Mpseudodispar     -----------GAT-ATCTGTCTGATTGTCTAT-CCTA--TGGATAACCG
Mbibullatus       AGTAAATCAGTGATTATCTGTTTGATTGTATAA-CCCCATTGGATAACCG
Melegans          -----------GAT-ATCTATTTGATTGTCTA--CCCA-TTGGATAACCG
Mpendula          AGTATATCAGTGATTATCTGTTTGATTGTCTTA-CCCA-TTGGATAACCG
Mpellicides       AGTATATCAGTGATTATCTGTTTGATTGTCTTA-CCCA-TTGGATAACCG
Mhungaricus       -----------GAT-ATCTGTTTGATTTTCTTC-GCCA-TTGGATAACCG
Myxiditruttae     --------------------------------------------------
Myxidium          AGTACATCAGTTATAGTTTATTCGATTGT-GAATCCAC-ATGGATAACCG
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    AGTAAATCAGCTATAATCTATTTGATTGTTAACTCCCA-GTGGATAACCG
Myxosp.           -----------------CTATTTGATTGT-ACAGCCCA-ATGGATAACCG
Hennzschokkei     AGTAAATCAGTTATCATCTATTTGATTGT-CTAGCCCA-TTGGATAACCG
Hennsalminicola   AGTAAATCAGTTATCATCTATTTGATTGT-CTAGCCCA-TTGGATAACCG
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     AGTATATCAGTTATAATCTGCTCGATTGTTATGGTTAT--TGGATAACCG
Mprocerus         AGTAAATCAGTTATAATCTGCTCGATTGTTATGGTTAT--TGGATAACCG
Henneguya         AGTATATCAGTTATAATCTGCTCGATTGTTAAGGTTAT--TGGATAACCG
Hsp.              AGTATATCAGTTATAATCTGCTCGATTGTCAAGGTTAT--TGGATAACCG
Hdoori            AGTATATCAGTTATAATCTGCTCGATTGTTGAGGTTAG--TGGATAACCG
Hennictaluri      AGTATATCAGTTATAATCTGCTCGATTGTTAAGGTTAT--TGGATAACCG
Hennexilis        AGTATATCAGTTATAATCTGCTCGATTGTTAAGGTTAT--TGGATAACCG
Mspinacurvatura   --------------------------------------------------
Michkeulensis     -----------TATAATCTGCTCGATTGTATAGGTTAT--TGGATAACCG
Mosburni          AGTAAATCAGTTATAATCTGCTCGATTGTCAAGGTTAT--TGGATAACCG
Muvuliferus       --------------------------------------------------
Ceratomyxa        AGTAAATCAGTTATCGTCTGTTCGATCGATACATGCCA--TGGATAACTG
Malgonquinensis   AGTAAATCAGTGACAATCTATTTGATTTTCTCT-CCCA-TTGGATAACCG
Perchclone1AM     ------CTAGCCATGCAATGTTTGACTG---------------------G
Perchclone2AM     ------CTAGCCATGCAATGTTTGACTG---------------------G
Perchclone3AM     ------CTAGCCATGCAATGTTTGACTG---------------------G

Melipsoides       TGGGNAA-TCTAGNGCTAATAC--ATGCAG-----------TTTTGAGTT
Mdjragini         TGGGNAA-TCTAGNNCTAATAC--ATGCAG-----------TTTTGNANT
Mbramae           TGGGAAA-TCTAGANNTNTTTC--NTNCAG-----------TTTTGAGAT
Mneurobius        TGGGNAA-TCTAGNGCTAATAC--ATGCAG-----------TTTTGAGNT
Marcticus         TGGGAAAATCTAGAGCTAATAC--ATGCAG-----------TTTTGAGAT
Msandrae          TGGGAAA-TCTAGAGCTAATAC--ATGCAG-----------TTTTGAGAT
Minsidiosus       TGGGAAA-TCTAGAGCTAATAC--ATGCAG-----------TCTTGGGAT
```

```
Mcerebralis       NNGGGAAATCTAGAGCTAATAC--ATGCAG-----------TTTTGGG-C
Mlentisuturalis   TGGGAAA-TCTAGAGCTAATAC--ATGCGTTGAAATTACG----TGG---
Mxiaoi            TGGGAAA-TCTAGAGCTAATAC--ATGCGTTGATATAACGATATTGGAGT
Myxo.             TGGGAAA-TCTAGAGCTAATAC--ATGCGTTGATATAATGTATTTGGAG-
Mportucalensis    TGGGAAA-TCTAGAGCTAATAC--ATGCGTTTA-ATCGTACAGGTAGCT-
Mmusculi          TGGGAAA-TCTAGAGCTAATAC--ATGCA----------GTTTATGG---
Mcyprini          TGGGAAA-TCTAGAGCTAATAC--ATGCA----------GTAAATGG---
Mpseudodispar     TGGGAAA-TCTAGAGCTAATAC--ATGCA----------GTTTATGG---
Mbibullatus       TGGGAAA-TCTAGAGCTAATAC--ATGCA----------GTTCATTGGCG
Melegans          TGGGAAA-TCTAGAGCTAATAC--ATGCAA---------GTATTTGGCAG
Mpendula          TGGGAAA-TCTAGAGCTAATAC--ATGCAA---------ATAATTGGCGT
Mpellicides       TGGGAAA-TCTAGAGCTAATAC--ATGCAA---------ATAATTGGCGT
Mhungaricus       TGGGAAA-TCTAGAGCTAATAC--ATGCAG---------TTTATTGGTCT
Myxiditruttae     --------------------------------------------------
Myxidium          TGG-AAA-TCTAGAGCTAATAC--ATGCGAAAAAT----CTTTCAAGGTG
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    TGGGAAA-TCTAGAGCTAATAC--ATGCA-A--------CTAAGCCGTGC
Myxosp.           TGGGAAA-TCTAGAGCTAATAC--ATGCACA--------CTTATTTGAAA
Hennzschokkei     TGGGAAA-TCTAGAGCTAATAC--ATGTAGTTAA------TTGGTGGTGT
Hennsalminicola   TGGGAAA-TCTAGAGCTAATAC--ATGTAGTTAA------TTGGTGGTGT
Ethclone2MA       ---------------------------CTA--------ACATGCTGGATG
Ethclone3MA       ---------------------------CTA--------ACATGCTGGATG
Ethclone1MA       --------------------------------------------------
Myxobprocerus     TGGGAAA-TCTAGAGCTAATAC--ATGCTA--------TAATGTTGGGTG
Mprocerus         TGGGAAA-TCTAGAGCTAATAC--ATGCTA--------TAATGTTGGGTG
Henneguya         TGGGAAA-TCTAGAGCTAATAC--ATGC-A--------GTTTGCGGTGGT
Hsp.              TGGGAAA-TCTAGAGCTAATAC--ATGCA---------CGCCTCGGTT-A
Hdoori            TGGGAAA-TCTAGAGCTAATAC--ATGCAA--------CGCCTCAGTTTG
Hennictaluri      TGGGAAA-TCTAGAGCTAATAC--ATGCA---------CCTCTCGGCGAA
Hennexilis        TGGGAAA-TCTAGAGCTAATAC--ATGCA---------CCTCTCGTCGCG
Mspinacurvatura   ---------------CTAATAC--ATGTA------------ATTTGGGGA
Michkeulensis     TGGGAAA-TCTAGAGCTAATAC--ATGTA------------ATT-GGGAG
Mosburni          TGGGAAA-TCTAGAGCTAATAC--ATGCA----------GTTTGTGAGGG
Muvuliferus       --------------------------------------------------
Ceratomyxa        TGGCAAA-CCTAGAGCTAATAC--ATGCAAA--------ATTCTTTGTTT
Malgonquinensis   TGGGAAA-TCTAAAGCTAATAC--GTGCGG----------TATCTTGGCG
Perchclone1AM     AGGGAAAGTGCAACTTCAACACCCATCCAC--------------------
Perchclone2AM     AGGGAAAGTGCAACTTCAACACCCATCCAC--------------------
Perchclone3AM     AGGGAAAGTGCAACTTCAACACCCATCCAC--------------------

Melipsoides       AG------CGT-AA-GTTGTC----------TCACGGCAT-TTA-TTGG-
Mdjragini         AG------CGT-AA-GTTGTC----------TCACNGCAT-TTA-TTGGG
Mbramae           AG------CGT-AA-GTTGTC----------TCACGGCAT-TTA-TTGG-
Mneurobius        AG------CGT-AA-GTTGTC----------TCACGGCAT-TTA-TTGG-
Marcticus         AG------CGT-NAAGTTGTC----------TCACGTCAT-TTA-TTGG-
Msandrae          AG------CGT-AA-GTTGTC----------TCACGGCAT-TTA-TTGG-
Minsidiosus       AG------CGT-AA-GTTGTC----------TCACGGCAT-TTA-TTGG-
Mcerebralis       AG------CGTTAAAACTGTC----------TCACGGCAT-TTA-TTGG-
Mlentisuturalis   TG---GGTAA--AATCAT-CA---------CGTAAAGCAT-TTA-TTGG-
Mxiaoi            TG---TGTTAGCAATAATGCAATGAATTGTCGTTAAGCAT-TTA-TTAG-
Myxo.             -G---CATTGTAAAAGATGTACTTGAATA-CATTAAGCAT-TTA-TTAG-
Mportucalensis    TG---CGCTGCC-----TGT------------TGAAGCAT-TTA-TTAG-
Mmusculi          -------TCG---GGCTTGCT--------CGGCCAAGCAT-TTA-TTAG-
Mcyprini          -------TCG---GGCTTGCT--------CGGCCAAGCAT-TTA-TTAG-
```

```
Mpseudodispar     -------TCG---GGCTTGCT--------TGGCCAAGCAT-TTA-TTAG-
Mbibullatus       CAAATCTTTG---GGTTTG----------TGTCAAAGCAT-TTA-TTAG-
Melegans          TA--CCCTCG---GG--TGC---------TGTCAAAGCAT-TTA-TTAG-
Mpendula          TG-----CTGCAAGGCGCG------------CCAAAGCAT-TTA-TTAG-
Mpellicides       TG-----CTGCAAGGCGCG------------CCAAAGCAT-TTA-TTAG-
Mhungaricus       TG-----TCGAAAGGCTTGA-----------TCAAAGCAT-TTA-TTAG-
Myxiditruttae     ---------ATC---ATTTC--------AGGGTGATGCAT-TTA-TTAG-
Myxidium          AG------CATC---ATTTTG-------AAGGTGATGCAT-TTAATTAG-
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    CC------TGTC---AAAGGG-------GTGCGGTAGCAT-TTA-TTGG-
Myxosp.           GG------CGTC---AAAACC--------TATCAAGGCAT-TTA-TTAG-
Hennzschokkei     AG------TATTTATATTGTA-------CCACCAATGCAT-TTA-TTAG-
Hennsalminicola   AG------TATTTATATTGTA-------CCACCAATGCAT-TTA-TTAG-
Ethclone2MA       TA-------GCTTGCTACATTT-------GGCC---GCAT-TTA-TTAGA
Ethclone3MA       TA-------GCTTGCTACATTT-------GGCC---GCAT-TTA-TTAGA
Ethclone1MA       --------------------------------------------------
Myxobprocerus     TG-------GTTCGCTGCATTC-------AGCC---GCAT-TTA-TTAGA
Mprocerus         TG-------GTTCGCTGCATTC-------AGCC---GCAT-TTA-TTAGA
Henneguya         TG-------CTTTCGGGCGACT-------GGCGT-GGCAT-TTA-TTAGA
Hsp.              CG-------GTTCC-GCCGTGA-------ACCGAATGCAT-TTA-TTAGA
Hdoori            CG-------GTTC--GCCGCGA-------GCTGAATGCAT-TTA-TTAGA
Hennictaluri      AA-------GCTT--GCTTTTC-------GTCGATTGCAT-TTA-TTAGA
Hennexilis        AA-------GCTT--GCTTTTC-------GTCGATTGCAT-TTA-TTAGA
Mspinacurvatura   TG-------ATTTCGGTCGTT---------CTCGTGGCAT-TTA-TTAGA
Michkeulensis     CG-------GTTTCGGCCGT----------CTCATGGCAT-TTA-TTAGA
Mosburni          CA-------AC-------------------CTCATGGCAT-TTA-TTAGA
Muvuliferus       --------------------------------------------------
Ceratomyxa        CG-------GCAAA-------------------GAAGCAT-TTATCCAG-
Malgonquinensis   TA-------TCTTCGGGTACG----------TCAAAGCAT-TTA-TTAG-
Perchclone1AM     -------------------------------ACCAAGCATGTCA--TAA-
Perchclone2AM     -------------------------------ACCAAGCATGTCA--TAA-
Perchclone3AM     -------------------------------ACCAAGCATGTCA--TAA-

Melipsoides       ACAAAACCAACTAC-CGA-CGTANCAGCTT--GCTGTTGCGACGCGTA--
Mdjragini         ACAAAACCAACTAC-CGA-CGTANCAGCTT--GCTGTTGCGTCGCGTA--
Mbramae           ACAAAACCAACTAC-CGA-CGTANCAGCTT--GCTGTTGCGACGCGTA--
Mneurobius        ACAAAACCAACTAC-CGA-CGTANCAGCTT--GCTGTTGCGACGCGTA--
Marcticus         ACAAAACCAACTAC-CGA-CGTACCAGCTT--GCTGTTGCAACCCGTA--
Msandrae          ACAAAACCAACTAC-CGA-CGTAGCAGCTT--GCTGTTGCGACGCGTA--
Minsidiosus       ACAAAACCYACTAC-CGA-CGTAGCAGTTT--GCTGTTGCGACGCGTN--
Mcerebralis       ACTAAACCAACTAC-CGT-TGCATTGGTTTACGCTGATGTAGCGAGTA--
Mlentisuturalis   TAGAAACCAACTGT-TGG-TGCATGTAACAGTGTG---CCA----ATAT-
Mxiaoi            AATAAACCAACTGC-TAA-TGTATGTGATA-TGCA---TTA----GTGT-
Myxo.             TGTAAACCAACTAT-TGT-AATATGTGATA-TATT---ACA----GTGT-
Mportucalensis    AGCAA-CCAGCCAC-TGTGTGCATGGGTAACTAAACATACA----GTGT-
Mmusculi          TTTTAACCAATTAC-TGC--TT--GCA------------------GTA--
Mcyprini          TTTTAACCAATGAC-TGC--GCAAGCA------------------GTA--
Mpseudodispar     TTTTAACCAATTAC-TGC--GCAAGCA------------------GTA--
Mbibullatus       ACTTTACCAACTAT-TAC--ATGGGCAAC------CATGTA----GTA--
Melegans          ACCAAACCAACTGT-TGT--GCGATCATTG---GTCGTACA----GCA--
Mpendula          ACTTAACCATCTAC-TGT--GTG-GCAAC-------ATACA----GTA--
Mpellicides       ACTTAACCATCTAC-TGT--GTG-GCAAC-------ATACA----GTA--
Mhungaricus       ACTTAACCATCTAC-TGC--GTG-GCAAC-------ACGTG----GTA--
Myxiditruttae     ATTAAGCCAGTCAA-CGATGTGGTA----TTTACG-TATTGCATTGTTGT
```

```
Myxidium          ATTAAACCAATCAT-TGTTTCAATAG---TTTAGGCTATTGTTGCATTGT
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    A--AATACCAACTT-TGGGCGAGTGGGGTTAAACTTGCTCGTCCAGATA-
Myxosp.           ACTAATACCAACTG-TATGTTAGTGG---TTAACGCTTCTGACGTACAA-
Hennzschokkei     ATGAAGCCAA-CTG-GTTGTTGGGGG---TGCAAATCTCCAACTTGTAA-
Hennsalminicola   ATGAAGCCAA-CTG-CTTGTTGGGGG---TGCAAATCTCCAACTTGTAA-
Ethclone2MA       TAA-TACCAAT----CACATGAGCAATCAT---------------GTGTG
Ethclone3MA       TAA-TACCAAT----CACATGAGCAATCAT---------------GTGTG
Ethclone1MA       --------------------------------------------------
Myxobprocerus     GAA-TACCAAT----CGCATGAGCAATCAT---------------GTGTG
Mprocerus         GAA-TACCAAT----CGCATGAGCAATCAT---------------GTGTG
Henneguya         GAA-TACCAATGGCACGTACGAGAGATCGT---------------GCGAG
Hsp.              GCGATACCAATGA--TGTACGTGAGTACAT---------------GT---
Hdoori            GCGATACCAACCA--TGCACGTGAGTGCA---------------------
Hennictaluri      GCGATACCAACCG--TGTGTT---ACACAC---------------GT---
Hennexilis        GCGATACCAACCG--TGTGC----AAACAC---------------GT---
Mspinacurvatura   CAATTACCAATCG--TGGGGC--AACCCAT---------------GT---
Michkeulensis     CAATTACCAATCG--CGGGGC--AACCCGT---------------GT---
Mosburni          TAATTACCAATTGAATGAGAGTAAAATCTC---------------ATTCA
Muvuliferus       --------------------------------------------------
Ceratomyxa        -CTAAACCAATCGG--GCCTTAAAACCCA----------------GTA--
Malgonquinensis   ACTAAACCACTTAC-TATGCTCCGGCATA----------------GTA--
Perchclone1AM     ACACACCCAA----------------------------------------
Perchclone2AM     ACACACCCAA----------------------------------------
Perchclone3AM     ACACACCCAA----------------------------------------

Melipsoides       --AGGTGAATCTAGATAACT-TTGCTGATCGTAT-GGCCTA-ATG--CCG
Mdjragini         --AGGTGAATCTAGNTAACT-TTGCTGATCGTAT-GGCCTA-ATG--CCG
Mbramae           --AGGTGAATCTAGATAACT-TTGCTGATCGTAT-GGCCTA-GTG--CCG
Mneurobius        --AGGTGAATCTAGATAACT-TTGCTGATCGTAT-GGCCTA-NTG--CCG
Marcticus         --AGGTGAATCTAAATAACT-TTGCTNATCGTAT-GGCCTA-TTG--CCG
Msandrae          --AGGTGAATCTAGATAACT-TTGCTGATCGTAT-GGCCTA-NTG--CCG
Minsidiosus       --YGGTGAYTCTAGATAACT-TTGCTGATCGTATTGGCCTA-GTG--CCG
Mcerebralis       --AGGTGAATCTAGATAACT-TTTCTGATCGTAT-GGCCTA-TAG--CCG
Mlentisuturalis   --GGATGAATCTAGATAACT-TTGCTGATCGTAGTGGCGTA-ATA-GCCG
Mxiaoi            --GGGTGAGTCTAGATAACT-TTGCTGATCGTAGTGGCATA-ATA-GCCG
Myxo.             --GGGTGAATCTAGATAACT-TTGCTGATCGTAGTGGCGTA-ATATGCCG
Mportucalensis    --GGGTGAATCTAGATAACT-TGTCTGATCGTAGTGGC-CA-TGAAGCCG
Mmusculi          --AGGTGAATCTAGATAACT-TTGCTGATCGTA-TGGCTTT-G----CCA
Mcyprini          --AGGTGAATCTAGATAACT-TTGCTGATCGCA-TGGCTCT-G----CCA
Mpseudodispar     --AGGTGAATCTAGATAACT-TTGCTGATCGCA-CGGCTTT-G----CCG
Mbibullatus       --AGGCGAATCTAGATAACT-TTGCTGATCGTA-TGGCCTT-GTG--CCG
Melegans          --AGGTGAATCTGGATAACT-TTGCTGATCGTA-TGGCCTA-GAG--CCG
Mpendula          --AGGCGAATCTAGATAACT-TTGCTGATCGTA-TGGCCTA-GTG--CCG
Mpellicides       --AGGCGAATCTAGATAACT-TTGCTGATCGTA-TGGCCTA-GTG--CCG
Mhungaricus       --AGGCGAATCTAGATAACT-TTGCTGATCGTA-TGGCCTT-GTG--CCG
Myxiditruttae     TGTGGTGAGTCTGGATAACT-GTGCCGATCGTA-TGGCCTT-GAG--CCG
Myxidium          TGTGGTGAGTCTGGATAACT-GTGCCGATCGTA-TGGCCTA-GAG--CCG
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    ---GGTGAATCTGGATAACT-G-GCTGATCGTA-TGGCCTT-GTG--CTG
Myxosp.           ---GGTGAATCTAGATAACT-TTGCCGATCGCA-TGGCTTC-GGG--CCG
```

Hennzschokkei	---GGGGAGTCTAGATAACT-GTGCAGATCGTA-TGGCCTT-GTG--CTG
Hennsalminicola	---GGTGAGTCTAGATAACT-GTGCAGATCGTA-TGGCCTT-GTG--CTG
Ethclone2MA	----ATGAATCTAGATAACT-TTGCTGATCGCA-TGACCTT-GTG--TCG
Ethclone3MA	----ATGAATCTAGATAACT-TTGCTGATCGCA-TGACCTT-GTG--TCG
Ethclone1MA	--
Myxobprocerus	----GTGAATCTAGATAACT-TTGCTGATCGCA-TGGCCTTTGAG--CCG
Mprocerus	----GTGAATCTAGATAACT-TTGCTGATCGCA-TGGCCTTTGAG--CCG
Henneguya	CGGGGTGAATCTAGATAACT-GTGCAGATCGCA-TGGCCTT-GAG--CCG
Hsp.	---GGTGAATCTAGATAACT-GTGCAGATCGTA-TGGCCTT-GAG--CTG
Hdoori	-------AATCTAGATAACTCGTGCAGATCGTA-TGGCCTT-GAG--CTG
Hennictaluri	---GGCGAATCTAGATAACT-GTGCAGATCGTA-TGGCCTT-GAG--CTG
Hennexilis	---GGCGAATCTAGATAACT-GTGCAGATCGTA-TGGCCTT-GAG--CTG
Mspinacurvatura	---GGCGAATCTAGATAACTTG-GCAGATCGTA-TGGCCTT-GAG--CCG
Michkeulensis	---GGTGAATCTAGATAACTTA-GCAGATCGTA-TGGCCTA-GTG--CCG
Mosburni	--GGTTGAATCTAGATAACT-ATGCAGATCGTA-CGGCCTC-GTG--CTG
Muvuliferus	--
Ceratomyxa	---GGTGAATCTAGATAACT-GTGCCGATCGTT---GCTTT-ATG---CG
Malgonquinensis	---AGGGAATCTGGATAACT-CTGCTGATCGTA-TGGCCTA-GTG--CCG
Perchclone1AM	-----TGCTTCAGAGTATCTCTTTCACACCTTACCAACAAT------TCA
Perchclone2AM	-----TGCTTCAGAGTATCTCTTTCACACCTTACCAACAAT------TCA
Perchclone3AM	-----TGCTTCAGAGTATCTCTTTCACACCTTACCAACAAT------TCA

Melipsoides	GCGTC-TTTCAATTGAA-TTTCTGCCC-TATT-AACTT--GTTGGTANTA
Mdjragini	GCGNAGTTTCAATTGAA-TTTCTGCCC-TATT-AACTT--GTTGGTAGTA
Mbramae	GCGACGTTTCAATTGAA-TTTCTGCCC-TATT-AACTT--GTTGGTAGTA
Mneurobius	GCGNCNTTTCAATTGAA-TTTCTGCCC-TATT-AACTT--GTTGGTAGTA
Marcticus	GCAACTTTNCAATTGAA-TTNCTGCCC-TATT-AACTT--GTNGGTATTA
Msandrae	GCGACNTTTCAATTGAA-TTTCTGCCC-TATT-AACTT--GTTGGTAGTA
Minsidiosus	GCGACGTTTCAATTGAA-TTTCTGYCCCTATT-AACTT--GTTGGTAGRA
Mcerebralis	GCCACGTTTCAATTGAA-TTTCTGCCC-TATT-AACTA--GTTGGTAGTA
Mlentisuturalis	GCGACATTTCAGTTGAA-TTTCTGCCC-TATC-AATTG--GTTGGTAAGG
Mxiaoi	GCGACATTTCAGTTGAA-TTTCTGCCC-TATC-AATTG--GTTGGTAAGG
Myxo.	GCGACGTTTCAGTTGAA-TTTCTGCCC-TATC-AATTG--GTTGGTAAGG
Mportucalensis	GCGACATTTCAGTTGAAATCTCTGCCC-TATC-AACTT--GTTGGTAAGG
Mmusculi	GCGACATTTCAATTGAG-TTTCTGCCC-TATC-AATTT--GTTGGTAAGG
Mcyprini	GCGACGTTTCAATTGAG-TTTCTGCCC-TATC-AATTT--GTTGGTAAGG
Mpseudodispar	GCGACGTTTCAATTGAG-TTTCTGCCC-TATC-AATTT--GTTGGTAAGG
Mbibullatus	ACGACGTTTCAATTGAG-TTTCTGCCC-TATC-AACTT--GTTGGTAAGG
Melegans	GCGACGTTTCAATTGAG-TTTCTGCCC-TATC-AACTA--GTTGGTAATG
Mpendula	ACGACGTTTCAATTGAG-TTTCTGCCC-TATC-AATTT--GTTGGTAAGG
Mpellicides	ACGACGTTTCAATTGAG-TTTCTGCCC-TATC-AATTT--GTTGGTAAGG
Mhungaricus	ACGACGTTTCAATTGAG-TTTCTGCCC-TATC-AATTT--GTTGGTAAGG
Myxiditruttae	GCGACATTTCGATTAAA-TTTCTGCCC-TATC-AACTT--GTTGGTAAGG
Myxidium	GCGACATTTCGATTAAA-TTTCTGCCC-TATC-AACTT--GTTGGTAAGG
Ethclone1AM	--
Ethclone3AM	--
Ethclone2AM	--
Mdiaphanus	--
M.lieberkuehni	ACGACGTTTCAATTGAA-TTTCTGCCC-TATC-AACTT--GTTGGTAAGG
Myxosp.	GCGACGTTTCAATTGAA-TTTCTGCCC-TATC-AACTT--GTTGGTAAGG
Hennzschokkei	ACGACGTTTCAATTGAA-TTTCTGCCC-TATC-AACTA--GTTGGTAAGG
Hennsalminicola	ACGACGTTTCAATTGAA-TTTCTGCCC-TATC-AACTA--GTTGGTAAGG
Ethclone2MA	GCGACATTTCGATTGAG-TTTCTGCCC-TATC-AC-TT--GATGCTAGTG
Ethclone3MA	GCGACATTTCGATTGAG-TTTCTGCCC-TATC-AC-TT--GATGCTAGTG
Ethclone1MA	--
Myxobprocerus	GCGACATTTCGATTGAG-TTTCTGCCC-TATC-ACCTT--GATGCTAGTG
Mprocerus	GCGACATTTCGATTGAG-TTTCTGCCC-TATC-ACCTT--GATGCTAGTG

```
Henneguya          GCGACATTTCGATTGAG-TTTCTGCCC-TATC-ACCTA--GATGCAAGTG
Hsp.               ACGACGTTTCGATTGAA-TTTCTGCCC-TATC-AACTT-TGTCGACAGTG
Hdoori             ACGACGTTTCGATTGAA-TTTCTGCCC-TATC-AACTCATGTCGACAGTG
Hennictaluri       ACGACATTTCGATTGAA-TTTCTGCCC-TATC-AACTC-TGTTGGCAGTG
Hennexilis         ACGACATTTCGATTGAA-TTTCTGCCC-TATC-AACTC-TGTTGGCAGTG
Mspinacurvatura    GCGACGTTTCGATTGAA-TTTCTGCCC-TATC-AACTATTGTCGGTAGTG
Michkeulensis      GCGACGTTTCGATTGAA-TTTCTGCCC-TATC-AACTATTGTCGGTAGTG
Mosburni           ACGACGATTCGATTGAG-TTTCTGCCT-TATC-AGCTT-TGTCGTGGCGG
Muvuliferus        --------------------------------------------------
Ceratomyxa         GCGATATTTCGATTGAG-TTTCTGCCC-TATC-AACTT--GTTGGTATGG
Malgonquinensis    GCGACGTTTCAATTGAG-TTTCTGCCC-TATCCAACTT--GTTGGTAAGG
Perchclone1AM      A-ATCATATCAATACAG------ACCTGTTAC-AGTCT--ATAAAGAAGA
Perchclone2AM      A-ATCATATCAATACAG------ACCTGTTAC-AGTCT--ATAAAGAAGA
Perchclone3AM      A-ATCATATCAATACAG------ACCTGTTAC-AGTCT--ATAAAGAAGA

Melipsoides        TANTTGCCTAC-CAAGGTTGCGACGGGTGACGGGAATCAGG----GTTC
Mdjragini          TANTTGCCTAC-CAAGGTTGCGACGGGTGACNGGAATCAGG----GTTC
Mbramae            TAGTTGCCTAC-CAAGGTTGCGACGGGTGACCGGAATCAGG----GTTC
Mneurobius         TAGTTGCCTAC-CAAGGTTGCGACGGGTGACGGGAATCAGG----GTTC
Marcticus          TANTTGCCTAC-CACGGTTGCGACGGGTGACGGGAATCAGG----GTTC
Msandrae           TAGTTGCCTAC-CAACGTTGCGACGGGTGACGGGAATCAGG----GTTC
Minsidiosus        TAGTTGCCTAC-CAARGTTCCGACGGGTGACGGGAATCAGG----GTTC
Mcerebralis        TAGAAGCCTAC-CAAGGTTGCGATGGGTAACGGGAATCAGG----GTTC
Mlentisuturalis    TAGTGGCTTAC-CAAGGTTGTAACGGGTAACGGGGATCAGG----GTTC
Mxiaoi             TAGTGGCTTAC-CAAGGTTGTAACGGGTAACGGGGATCAGG----GTTC
Myxo.              TAGTGGCTTAC-CAAGGTTGTAACGGGTAACGGGGATCAGG----GTTC
Mportucalensis     TAGTGGCTTAC-CAAGGTTACAACGGGTAACGGGAATCAGG----GTTC
Mmusculi           TATTGGCTTAC-CAAGGTTGTAACGGGTAACGGGAATCAGG----GTTC
Mcyprini           TATTGGCTTAC-CAAGGTTGTAACGGGTAACGGGAATCAGG----GTTC
Mpseudodispar      TATTGGCTTAC-CAAGGTTGTAACGGGTAACGGGAATCAGG----GTTC
Mbibullatus        TATTGGCTTAC-CAAGGTTGCAACGGGTAACGGGAATCAGG----GTTC
Melegans           TATTGGATTAC-CAAGGTAGCAACGGGTAACGGGAATCAGG----GTTC
Mpendula           TATTGGCTTAC-CAAGGTTGCAACGGGTAACGGGAATCAGG----GTTC
Mpellicides        TATTGGCTTAC-CAAGGTTGCAACGGGTAACGGGAATCAGG----GTTC
Mhungaricus        TATTGGCTTAC-CAAGGTTGCAACGGGTAACGGGAATCAGG----GTTC
Myxiditruttae      TCGTTGCTTAC-CAAGGTGATTACGGGTAACGGGAATCAGG----GTTC
Myxidium           TAGTGGCTTAC-CAAGGTGAT-ACGGGTAACGGGAATCAGG----GTTC
Ethclone1AM        -------------------------------------------------
Ethclone3AM        -------------------------------------------------
Ethclone2AM        -------------------------------------------------
Mdiaphanus         -------------------------------------------------
M.lieberkuehni     TAGTGGCTTAC-CAAGGTTGTAACGGGTAACGGGAATCAGG----GTTC
Myxosp.            TAGATGCTTAC-CAAGGTGGCGACGGGTAACGGGGATCAGG----GTTC
Hennzschokkei      TAGATGCTAAC-CAAGGTTGTGACGGGTAACGGGAATCAGG----GTTC
Hennsalminicola    TAGTAGTCAAC-CAAGGTTGTGACGGGTAACGGGAATCAGG----GTTC
Ethclone2MA        TATTGAACTAG-CATGGGAGTTACGGGTAACGGAGGATCAGG----GTTC
Ethclone3MA        TATTGAACTAG-CATGGGAGTTACGGGTAACGGAGGATCAGG----GTTC
Ethclone1MA        -------------------------------------------------
Myxobprocerus      TATTGAACTAG-CATGGGAGTAACGGGTAACGGAGGATCAGG-----TTC
Mprocerus          TATTGAACTAG-CATGGGAGTAACGGGTAACGGAGGATCAGG----GTTC
Henneguya          TATTGTACTTG-CATGGGGGTCACGGGTGACGGAGGATCAGG----GTTC
Hsp.               TAGTGGACTGC-CGAGGTTTTTACGGGTAACGGGGAATCAGG----GTTC
Hdoori             TAGTGGACTGC-CGAGGTTTTTACGGGTAACGGG-AATCAGG----GTTC
Hennictaluri       TAGTGGACTGC-CAAGGTTTTTACGGGTAACGGGGAATCAGG----GTTC
Hennexilis         TAGTGGACTGC-CAAGGTTTTTACGGGTAACGGGGAATCAGG----GTTC
Mspinacurvatura    TAGTGGACTAC-CGAGGTTTTTACGGGTGACGGGGGATCAGG----GTTC
Michkeulensis      TAGTGGACTAC-CGAGGTTTTTACGGGTGACGGGGGATCAGG----GTTC
```

Mosburni	TGAGGGCCCCA-CGTGGCAGTGACGAGTACGGGTGAATAAGG----GTTT
Muvuliferus	--
Ceratomyxa	TATTGGCCTAC-CAAGGTTTTGACGGGTAACGGGGAATCAGG----GTTC
Malgonquinensis	TATTGGCTTAC-CAAGGTTGCAACGGGTAACGG-GAATCAGG----GTTC
Perchclone1AM	TTTGAATTTACTCCAGCTCGTCA-----AATGGAGATTGTGATCTCGTCC
Perchclone2AM	TTTGAATTTACTCCAGCTCGTCA-----AATGGAGATTGTGATCTCGTCC
Perchclone3AM	TTTGAATTTACTCCAGCTCGTCA-----AATGGAGATTGTGATCTCGTCC

Melipsoides	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCATGGGAAGGC
Mdjragini	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCATGG-AAGGC
Mbramae	GATTCCGGACAGGGAGCCTGAGAAACGGCTACCAC-ATCCATGGNAAGGC
Mneurobius	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCATGGGAAGGC
Marcticus	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCATGG-AAGGC
Msandrae	GATTCCGGAGNGGGAGCCTGAGAAACGGCTACCAC-ATCCATGGGAAGGC
Minsidiosus	GATTCCGGAGAGGGAGCCTGAAAAACGGCTACCAC-ATCCATGG-AAGGC
Mcerebralis	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCATGG-AAGGC
Mlentisuturalis	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Mxiaoi	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Myxo.	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Mportucalensis	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Mmusculi	GATTCCGGAGAGGGAGCTTGAGAATCGGCTACCAC-ATCCAAGG-AAGGC
Mcyprini	GATTCCGGAGAGGGAGCTTGAGAATCGGCTACCAC-ATCCAAGG-AAGGC
Mpseudodispar	GATTCCGGAGAGGGAGCTTGAGAATCGGCTACCAC-ATCCAAGG-AAGGC
Mbibullatus	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Melegans	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Mpendula	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-GAGGC
Mpellicides	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-GAGGC
Mhungaricus	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Myxiditruttae	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-ACGGC
Myxidium	GATTCCGGAGAGGGAGCCTCAGAAACGGCTACCAC-ATCCAAGG-ACGGC
Ethclone1AM	--
Ethclone3AM	--
Ethclone2AM	--
Mdiaphanus	--
M.lieberkuehni	GATTCCGGAGAGGGAGCCTGAGAAATGGCTACCAC-ATCCAAGG-GAGGC
Myxosp.	GATTCCGGAGAGGGAGCCTGAGAAATGGCTACCAC-ATCCAAGG-ACGGC
Hennzschokkei	GATTCCGGAGAGGGAGCTTGAGAATTGGCTACCAC-ATCCAAGG-AAGGC
Hennsalminicola	GATTCCGGAGAGGGAGCTTGAGAATTGGCTACCAC-ATCCAAGG-AAGGC
Ethclone2MA	GATCCCGGAGAGGGAGCCTTAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Ethclone3MA	GATCCCGGAGAGGGAGCCTTAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Ethclone1MA	--
Myxobprocerus	GATCCCGGAGAGGGAGCCTTAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Mprocerus	GATCCCGGAGAGGGAGCCTTAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Henneguya	GATCCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Hsp.	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Hdoori	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Hennictaluri	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Hennexilis	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Mspinacurvatura	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Michkeulensis	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Mosburni	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATNCAAGG-AAGGC
Muvuliferus	--
Ceratomyxa	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-TTCTAAGG-AAGGC
Malgonquinensis	GATTCCGGAGAGGGAGCCTGAGAAACGGCTACCAC-ATCCAAGG-AAGGC
Perchclone1AM	GTTACCGGAAT--AAACCTGACAAATCACT-TCACGAACTAAGA-ACGGC
Perchclone2AM	GTTACCGGAAT--AAACCTGACAAATCACT-TCACGAACTAAGA-ACGGC
Perchclone3AM	GTTACCGGAAT--AAACCTGACAAATCACT-TCACGAACTAAGA-ACGGC

Melipsoides	AGCAGGCGC-GCAAATTACCCAATCC-AGACACTGGGGAGGTGGTGACGA
Mdjragini	AGCAGGCGC-GCAAATTACCCAATCC-ANACACTGGGGAGGTGGTGACGA
Mbramae	AGCAGGCGC-GCAAATTACCCAATCC-AG-CACTGGGG-GGTGGTGACGA
Mneurobius	AGCAGGCGC-GCAAATTACCCAATCC-AGACACTGGGGAGGTGGTGACGA
Marcticus	AGCAGGCGC-GCAAATTACCCAATCC-AGACACTGGGGAGGTGGTAACGA
Msandrae	AGCAGGCGC-GCAAATTACCCAATCC-AGACACTGGGGAGGTGGTGACGA
Minsidiosus	AGCAGGCGC-CCAAATTACCCYATCCYAGANACCGGG-AGGTGGTGACGA
Mcerebralis	AGCAGGCGC-GCAAATTACCCAATCC-AGACACTGGG-AGGTGGTGACGA
Mlentisuturalis	AGCAGGCGC-GCAAATTACCCAATCC-AGACAGTGGG-AGGTGGCGACGA
Mxiaoi	AGCAGGCGC-GCAAATTACCCAATCC-AGACAGTGGG-AGGTGGCGACGA
Myxo.	AGCAGGCGC-GCAAATTACCCAATCC-AGACAGTGGG-AGGTGGCAACGA
Mportucalensis	AGCAGGCGC-GCAAATTACCCAATCC-AGACACTGGG-AGGTAGTAACGA
Mmusculi	AGCAGGCGC-GCAAATTACCAAATCT-AGACAGTAGG-AGGTGGTGAAGA
Mcyprini	AGCAGGCGC-GCAAATTACCAAATCT-AGACAGTAGG-AGGTGGTGAAGA
Mpseudodispar	AGCAGGCGC-GCAAATTACCAAATCT-AGACAGTAGG-AGGTGGTGAAGA
Mbibullatus	AACAGGCGC-GCAAATTACCCAATCT-AGACAGTAGG-AGGTGGTGAAGA
Melegans	AACAGGCGC-GCAAATTACCCAATCT-AGACAGTAGG-AGGTGGTGAAGA
Mpendula	AGCAGGCGC-GCAAATTACCCAATCT-AGACAGTAGG-AGGTGGTGAAGA
Mpellicides	AGCAGGCGC-GCAAATTACCCAATCT-AGACAGTAGG-AGGTGGTGAAGA
Mhungaricus	AGCAGGCGC-GCAAATTACCCAATCT-AGACAGTAGG-AGGTGGTGAAGA
Myxiditruttae	AGCAGGCGC-GCAAATTACCCAATCC-AGACACTGGG-AGGTGGTGACGA
Myxidium	AGCAGGCGC-GCAAATTACCCAATCC-AGACACTGGG-AGGTGGTGACGA
Ethclone1AM	--
Ethclone3AM	--
Ethclone2AM	--
Mdiaphanus	--
M.lieberkuehni	AGCAGGCGC-GCAAATTACCCAATCC-ACAATGTGGG-AGGTGGTGACGA
Myxosp.	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Hennzschokkei	AGCAGGCGC-GCAAATTACCCAATTC-AGACAGTGAG-AGGTGGTGACGA
Hennsalminicola	AGCAGGCGC-GCAAATTACCCAATTC-AGACAGTGAG-AGGTGGTGACGA
Ethclone2MA	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Ethclone3MA	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Ethclone1MA	--
Myxobprocerus	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Mprocerus	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Henneguya	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Hsp.	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGG--AGGTGGTGACGA
Hdoori	AGCAGGCGC-GCAAATTACCCAATCC-AGACGATGGG-AGGTGGTAACGA
Hennictaluri	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Hennexilis	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Mspinacurvatura	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Michkeulensis	AGCAGGCGC-GCAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Mosburni	AGCAGGCGC-GAAAATTACCCAATCC-AGACAATGGG-AGGTGGTGACGA
Muvuliferus	--
Ceratomyxa	AGCAGGCGC-GCAAATTACCCAATCC-AGACATTGGG-AGGTAGTGACGA
Malgonquinensis	AACAGGCGC-GCAAATTACCCAATCT-AGACAGTAGG-AGGTGGTGAAGA
Perchclone1AM	--CATGCACCACCAATCACCAGATC-------------ATGT-------A
Perchclone2AM	--CATGCACCACCAATCACCAGATC-------------ATGT-------A
Perchclone3AM	--CATGCACCACCAATCACCAGATC-------------ATGT-------A

Melipsoides	NAA-GTACTAAGTGGTGGCCCT-TA-GGGTC--GCTAGC-TTGGAATGG-
Mdjragini	GAA-GTACTAAGTGGTGGCCCC-TA-GGGTC--GCTAGC-TTGGAATGG-
Mbramae	NAA-GTACTAAGTGGTGGCCCT-TA-GGGTC--GCTAGC-TTGGAATGG-
Mneurobius	NAA-GTACTAAGTGGTGGCCCT-TA-GGGTC--GCTAGC-TTGGAATGG-
Marcticus	NAA-GTACTAAGTGGTGGCCCT-TA-GGGTC--GCTAGC-TTGGAATGG-
Msandrae	GAA-GTACTAAGTGGTGGCCCT-TA-GGGT---GCTAGC-TTGGAATGG-

Minsidiosus	GNAAGTACTAAGTGGTGGCCCT-TA-GGGTC--GCTAGC-TTGGRATGG-
Mcerebralis	GAA-GTACTAAGTGGTGGCCCT-TA-GGGTC--GCCAGC-TTGGAATGG-
Mlentisuturalis	GAA-TTACTGAGTGGTAGCCAT-AATGG-TT--ATCGAC-TTAGAATGA-
Mxiaoi	GAA-TTACTAAGTGGTAGCCTT-TATGG-TT--ATCGAC-TTAGAATGA-
Myxo.	GAA-TTACTGGGTGGTAGCCTT-TATGG-TT--ATCGAC-TTAGAATGA-
Mportucalensis	GAA-TTACTGAGTAGTGGTCCG-AATGGGCT--ACTAGT-TTGGAATGA-
Mmusculi	GAA-GTACTAAGTGGTGGTT----ATTTACT--ACCAGC-TTGGAATGG-
Mcyprini	GAA-GTACTAAGTGGTGGTT----ATTTACT--ACCAGC-TTGGAATGG-
Mpseudodispar	GAA-GTACTAAGTGGTGGTT----ATTTACT--ACCAGC-TTGGAATGG-
Mbibullatus	GAA-GTACTAAGTAGTGGTCC--AATGGATT--ACTAGC-TTGGAATGA-
Melegans	GAA-TTACTAAGTGGTGGCCT--TATG-GCT--ACCAGC-TTGGAATGA-
Mpendula	GAA-GTACTTAGTGGTGACC----AAATGGT--CCCAAC-TTGGAATGA-
Mpellicides	GAA-GTACTTAGTGGTGACC----AAATGGT--CCCAAC-TTGGAATGA-
Mhungaricus	GAA-GTACCGGGTGGTGGTC----AATGACT--ACCAAC-TTGGAATGA-
Myxiditruttae	GAA-ATACCAGGTCGTTCCC---AAAAGGAT--TCGACA-CTGGAATGA-
Myxidium	GAA-ATACCAGGTCGTTCCC---AAAAGGAT--TCGACA-CTGGAATGA-
Ethclone1AM	--
Ethclone3AM	--
Ethclone2AM	--
Mdiaphanus	--
M.lieberkuehni	GAA-ATATTAGGTCGTTTTCCCTCAGGGAAT--GCGATA-CTGAAATGA-
Myxosp.	GAA-ATACTAGTCAGTGTCTC--AAAAGGAC--GCTGAT-CTGGAATGG-
Hennzschokkei	GAA-TTACCAAGTGGTGACC---ATAAGGTT--GCCAAT-TTGGAATGA-
Hennsalminicola	GAA-TTACCAAGTGGTGACC---ATAAGGTT--GCCAAT-TTGGAATGA-
Ethclone2MA	AGA-GTACCGGATGACTAAA---AAATTTTTTAGTCAGT-CTGGAATGA-
Ethclone3MA	AGA-GTACCGGATGACTAAA---AAATTTTTTAGTCAGT-CTGGAATGA-
Ethclone1MA	--
Myxobprocerus	AGA-GTACCGGATGACTGAT---ATATTATT-AGTCAGT-CTGGAATGA-
Mprocerus	AGA-GTACCGGATGACTGAT---ATATTATT-AGTCAGT-CTGGAATGA-
Henneguya	AAA-GTACCGAATAAC-GCC---AAATGGTT--GTTAGT-TCAGAATGGG
Hsp.	AAA-GTACCAAATGACGCCC---TAACGGGT--GTCAGT-TTGGAATGA-
Hdoori	AAA-GTACCAAATGACGCCC---TAACGGGT--GTCAGT-TTGGAATGA-
Hennictaluri	AAA-GTACCGAATGGCAGCT---TA-TTGTT--GCCAGT-TTGGAATGA-
Hennexilis	AAA-GTACCGAATGGCAGCT---TA-TTGTT--GCCAGT-TTGGAATGA-
Mspinacurvatura	AAA-GTACCAGATGACGATC---TAA-GATT--GTCAAT-TTGGAATGG-
Michkeulensis	AAA-GTACCAGATGACGGTC---AAA-GACT--GTCAAT-CTGGAATGG-
Mosburni	AAA-GTACCGAATCTGGCCC---TAGTGGTT--AG-AGT-TTGGAATGG-
Muvuliferus	--
Ceratomyxa	GAA-ATACCGGACTGGATCT-----TACGAT---CCAGTACTGGAATGA-
Malgonquinensis	GAA-TTACTAAATGGTGGTCT--TATTGATC--ATTTGT-TTGGAATGA-
Perchclone1AM	AGATCTTCGGTCTGACAATCC--------TT---------TTG--ATGT-
Perchclone2AM	AGATCTTCGGTCTGACAATCC--------TT---------TTG--ATGT-
Perchclone3AM	AGATCTTCGGTCTGACAATCC--------TT---------TTG--ATGT-

Melipsoides	ACGTAAT-TTAAGTAATTCG-ATGAGTAACAACTGGAGGGCAA-GTC-TG
Mdjragini	ACGTAAT-TTAAGTAATTCG-ATGAGTAACAACTGGAGGGCAA-GTC-TG
Mbramae	ACGTAAT-TTAAGTAATTCG-ATGAGTAACAACTGGAGGGCAA-GTC-TG
Mneurobius	ACGTAAT-TTAAGTAATTCG-ATGAGTAACAACTGGAGGGCAA-GTC-TG
Marcticus	ACGTAAT-TTAAGTAATTCG-ATGAGTAACAACTGGAGGGCAA-GTC-TG
Msandrae	ACGTAAT-TTAAGTAATTCG-ATGAGTAACAACTGGAGGACAA-GTC-TG
Minsidiosus	ACGTAYT-TTAAGTAATTCG-ATGAGTAACAACTGGAGGGCAA-GTC-TG
Mcerebralis	ACGTAAT-TTAAGTAATTCG-ATGAGTAACAACTGGAGGGCAA-GTC-TG
Mlentisuturalis	ACGTGATATTAAGAAATCCG-TTGAGTAACAACTGGAGGGCAA-GTC-TG
Mxiaoi	ACGTGAT-TTAAGAAATCCG-TTGAGTAACAACTGGAGGGCAA-GTC-TG
Myxo.	ACGTGAT-TTAAGAAATCCG-TTGAGTAACAACTGGAGGGCAA-GTC-TG
Mportucalensis	ACGTGAT-TTAGTACATCCG-ATGAGTAACAACTGGAGGGCAA-GTC-TG
Mmusculi	ACGTAAT-TTAAGCAATTCG-ATGAGTAACTACTGGAGGGCAA-GTCCTG

```
Mcyprini           ACGTAAT-TTAAGCAATTCG-ATGAGTAACTACTGGAGGGCAA-GTCCTG
Mpseudodispar      ACGTAAT-TTAAGCAATTCG-ATGAGTAACTACTGGAGGGCAA-GTCCTG
Mbibullatus        ACGTAAT-TTAAGCAATTCG-ATGAGTAACTACTGGAGGGCAAAGTCCTG
Melegans           ACGTAAT-TTAAGCAATTCG-ATGAGTAACAACTGGAGGGCAA-GTCCTG
Mpendula           GGCCAAT-TTAAGAAATTCG-TCGAGTAACTACTGGAGGGCAA-GTCCTG
Mpellicides        GGCCAAT-TTAAGAAATTCG-TCGAGTAACTACTGGAGGGCAA-GTCCTG
Mhungaricus        ACGTAAT-TTAAGCAATTCG-ATGAGTAACTACTGGAGGGCAA-GTCCTG
Myxiditruttae      GTGCAAT-TTAAAAATTTCA-ACGAGTAACAACTGGAGGGCAA-GTC-TG
Myxidium           GTGCAAT-TTAAAAATTTCA-ACGAGTAACAACTGGAGGGCAA-GTC-TG
Ethclone1AM        --------------------------------------------------
Ethclone3AM        --------------------------------------------------
Ethclone2AM        --------------------------------------------------
Mdiaphanus         --------------------------------------------------
M.lieberkuehni     GCACAAT-TTAGAACATTTG-TCGAGTAACAACTGAAGGGCAA-GTC-TG
Myxosp.            ACGCAAT-TTAAGCAATTCG-ATGAGTAACAACTGGAGGGCAA-GTC-TA
Hennzschokkei      ACGTAAT-TTAAGAAATTCG-ATGAGTAGCAACTGGAGGGCAA-GTC-CG
Hennsalminicola    ACGTAAT-TTAAGAAATTCG-ATGAGTAACAACTGGAGGGCAA-GTC-CG
Ethclone2MA        AATCAAT-TTAAGCAATTGAGTTGAGTAACTACTGGAGGGCAA-GTC-TG
Ethclone3MA        AATCAAT-TTAAGCAATTGAGTTGAGTAACTACTGGAGGGCAA-GTC-TG
Ethclone1MA        --------------------------------------------------
Myxobprocerus      AATCAAT-TTAAGCAATTGAGTTGAGTAACTACTGGAGGGCAA-GTC-TG
Mprocerus          AATCAAT-TTAAGCAATTGAGTTGAGTAACTACTGGAGGGCAA-GTC-TG
Henneguya          AATCAAT-TTAAGCAATTGA-TTGAGTAACGACTGGAGGGCAA-GTC-TG
Hsp.               AAACAAT-TTAGGAATTTGAATTGAGTAACGACTGGAGGGCAA-GTC-TG
Hdoori             AAACAAT-TTAGGAATTTGAATTGAGTAACGACTGGAGGGCAA-GTC-TG
Hennictaluri       AAACAAT-TTAAGTAATTGAATTGAGTAACGACTGGAGGGCAA-GTC-TG
Hennexilis         AAACAAT-TTAAGTAATTGAATTGAGTAACGACTGGAGGGCAA-GTC-TG
Mspinacurvatura    AATCAAT-TTAAGCAATTGA-TTGAGGAACGACTAGAGGGCAA-GTC-TG
Michkeulensis      AATCAAT-TTAAGCAATTGA-TTGAGGAACGACTAGAGGGCAA-GTC-TG
Mosburni           A--CGAT-ANATAAACATGATCGAGAATTCAACTGGAGGGCAA-GTC-TG
Muvuliferus        --------------------------------------------------
Ceratomyxa         ACGATAT-GTAATCATTTCG-ATGAGGATCTACTGGAGGGCAA-GTC-TG
Malgonquinensis    ACGTAAC-TTAAGAAATTCG-TTGAGAAACAACTGGAGGGCAA-GTCCTG
Perchclone1AM      -CCTGAT-CCGGTAAGTTTTCCCGTGT------TGA--GTCAA-------
Perchclone2AM      -CCTGAT-CCGGTAAGTTTTCCCGTGT------TGA--GTCAA-------
Perchclone3AM      -CCTGAT-CCGGTAAGTTTTCCCGTGT------TGA--GTCAA-------

Melipsoides        GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATTTTAAA-G
Mdjragini          GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATTTTAAA-G
Mbramae            GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATTTTAAA-G
Mneurobius         GTGCCAGCAGTC-GCGGTAATTCCAGCTCCA-GTAGC-GTATTTTAAA-G
Marcticus          GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATTTTAAA-G
Msandrae           GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATTTTAAA-G
Minsidiosus        GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATTTTAAA-G
Mcerebralis        GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATTTTAAA-G
Mlentisuturalis    GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTACCTCAAA-G
Mxiaoi             GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTACCTCAAA-G
Myxo.              GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTACCTCAAA-G
Mportucalensis     GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTGGC-GTACTTTAAA-G
Mmusculi           GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTGGC-GTGATTTAAA-G
Mcyprini           GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTGGC-GTGATTTAAA-G
Mpseudodispar      GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTGGC-GTGATTTAAA-G
Mbibullatus        GTGCCAACAGCCCGCGGTAATTCCAGCTCCAAGTTGT-GTGATTTAAAAG
Melegans           GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTGAT-CTCGTTTAAA-G
Mpendula           GTGCCAGCAGCCCGCGGTAATTCCAGCTTC-AGTGGCCGTGATTTAAA-G
Mpellicides        GTGCCAGCAGCCCGCGGTAATTCCAGCTTCCAGTGGCCGTGATTTAAA-G
Mhungaricus        GTGCCAGCAGCC-GCGGTAATTCCAGCTCC-AGTGGC-GTGATTTAAA-G
```

```
Myxiditruttae     GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGT-GTATTCAAAC-G
Myxidium          GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGT-GTATCCAAAC-G
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    GTGCCAGCAGCC-GCGGTAATTCCAGCTTCA-GTAGT-GTATATTAAT-G
Myxosp.           GTGCCAGCAGCC-GCGGTAATTCTAGCTCCA-GTGGT-GTATTTTAAT-G
Hennzschokkei     GTGCCAGCAGCC-GCGGTAATTCCGGCTCCA-GTAGC-GTATTTTAAA-A
Hennsalminicola   GTGCCAGCAGCC-GCG-TAATTCCGGCTCCA-GTAGC-GTATTTTAAA-A
Ethclone2MA       GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTGTCTCAAA-G
Ethclone3MA       GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTGTCTCAAA-G
Ethclone1MA       --------------------------------------------------
Myxobprocerus     GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTGTCTCAAA-G
Mprocerus         GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTGTCTCAAA-G
Henneguya         GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATCTCAAA-G
Hsp.              GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATCTCAAA-G
Hdoori            GTGCCAGCAGCC-GCCGTAATTCCAGCTCCA-GTAGC-GTATCTCAAA-G
Hennictaluri      GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATCTCAAA-G
Hennexilis        GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATCTCAAA-G
Mspinacurvatura   GTGCCAGCAGCC-GCGGTAATTCCAGCTCTA-GTAGC-GTATCCCAAA-G
Michkeulensis     GTGCCAGCAGCC-GCGGTAATTCCAGCTCTA-GTAGC-GTATCCCAAA-G
Mosburni          GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGC-GTATCGCAAA-G
Muvuliferus       --------------------------------------------------
Ceratomyxa        GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGT-GTATATCAAC-A
Malgonquinensis   GTGCCAGCAGCC-GCGGTAATTCCAGCTCCA-GTAGT-TTGCTTTAAA-G
Perchclone1AM     --ATTA--AGCC-GCAG--GCTCCACCCCTG-GTGGT-GCCCTTCC---G
Perchclone2AM     --ATTA--AGCC-GCAG--GCTCCACCCCTG-GTGGT-GCCCTTCC---G
Perchclone3AM     --ATTA--AGCC-GCAG--GCTCCACCCCTG-GTGGT-GCCCTTCC---G

Melipsoides       TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGTGTAA---GT
Mdjragini         TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGTGTAA---GT
Mbramae           TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGTGTAA---GT
Mneurobius        TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGTGTAA---GT
Marcticus         TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGTGTAA---GT
Msandrae          TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGTGTAA---GT
Minsidiosus       TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGTGTAA---GT
Mcerebralis       TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGTGTAA---GT
Mlentisuturalis   TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACATG--GTTG-GGTC
Mxiaoi            TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACATG--GTTAAGGAT
Myxo.             TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACATG--GTTAGGTAT
Mportucalensis    TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCGATGTCA---GT
Mmusculi          TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCAAGCGGTGACA---GT
Mcyprini          TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCATGCGGTGACA---GC
Mpseudodispar     TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCAAGCGGTGTCA---GT
Mbibullatus       TTGTTGCGTTTAAAACGCTCGTAG--TTGG-ATCACCCAGTGACA---GT
Melegans          TTGTTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGCATCA---TC
Mpendula          TTGCTGCGTT-AAAACGCTCGTAG--TTGGGATCATGCAGTGATA---TT
Mpellicides       TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCATGCAGTGATA---TT
Mhungaricus       TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGTAGTA---TT
Myxiditruttae     TTGCTGCGGTTAAAACGCTCGTAG--TTGG-ACAAGAGAGTAACTTGATG
Myxidium          TTGCTGCGGTTAAAACGCTCGTAG--TTGG-ACAAGAGAGTAGCTTGGAG
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    CTGCGGCGGTTAAAACGCTCGTAG--TTGA-ATGAC---GAAGCTCGGGA
```

```
Myxosp.           TTGCTGCGTTTAAAACGCTCGTAG--TTGG-ATTAC---GCAGTGTGAGT
Hennzschokkei     TTGTTGCGCTTAAAACGCTGGTAG--TTGG-ATGAC---ACAGTCATGAT
Hennsalminicola   TTGTTGCGCTTAAAACNCTCGTAG--TTGG-ATGAC---ACAGTCATGAT
Ethclone2MA       TTGCTGCGCTTGAAACGCTCGTAG--TTGG-ATGAGAAACTACAC---AT
Ethclone3MA       TTGCTGCGCTTGAAACGCTCGTAG--TTGG-ATGAGAAACTACAC---AT
Ethclone1MA       --------------------------------------------------
Myxobprocerus     TTGCTGCGCTTAAAACGCTCGTAG--TTGG-ATGAGAATCTATAT---AT
Mprocerus         TTGCTGCGCTTAAAACGCTCGTAG--TTGG-ATGAGAAACTACAT---AT
Henneguya         TTGCTGCGCTTAAAACGCTCGTAG--TTGG-ATCATTAACTGTGT---GT
Hsp.              TTGCTGC-CTTAAAACGCCCGTAG--T-GG-A-CACGCACTGTGT---GT
Hdoori            TTGCTGCGCTTAAAACGCTCGTAG--TTGG-ATCACGCACTGTGT---GT
Hennictaluri      TTGCTGCGCTTAAAACGCTCGTAG--TTGG-ATCACGCACTATGC---AT
Hennexilis        TTGCTGCGCTTAAAACGCTCGTAG--TTGG-ATCACGCACTATGC---AT
Mspinacurvatura   TTGCTGCGCTTAAAACGCTCGTAG--TTGG-ATCACAAACTATAC---GC
Michkeulensis     TTGCTGCGCTTAAAACGCTCGTAG--TTGG-ATCACAAACTATAT---TC
Mosburni          NTGCTGCGCTTAAAACGNTCGTAAGTTGGG-ATCACAGTCTGTGT---GT
Muvuliferus       --------------------------------------------------
Ceratomyxa        TTGTTGCGGTTAAAACGCTCGTAG--TTGG-ATAACGAG-----------
Malgonquinensis   TTGTTGCGTTTAAAACGCTCGTAG--TTGG-ATCACGCAGTGATG---TT
Perchclone1AM     TCAATTCCTTTAAG----TTTCAGCCTTGCGACCA---------------
Perchclone2AM     TCAATTCCTTTAAG----TTTCAGCCTTGCGACCA---------------
Perchclone3AM     TCAATTCCTTTAAG----TTTCAGCCTTGCGACCA---------------

Melipsoides       TGGTAAGCTGATTG---AATGGTGCT-------CCAACTGTTTTG--GTG
Mdjragini         TGGTAAGCTGATTG---AATGGTGCT-------CCAACTGTTTTG--GTG
Mbramae           TGGTAAGCTGATTG---AATGGTGCT-------CCAACTGTTTTG--GTG
Mneurobius        TGGTAAGCTGATTG---AATGGTGCT-------CCAACTGTTTTG--GTG
Marcticus         TGGTAAGCTGATTG---AATGGTGCT-------CCAACTGTTTTG--GTG
Msandrae          TGGTAAGCTGATTG---AATGGTGCT-------CCAACTGTTTTG--GTG
Minsidiosus       TGGTAAGCTGATTG---AATGGTGCT-------CCAACTGTTTYG--GTG
Mcerebralis       TGGTAGGCTGATCG---AATGGTGCTA------CTAACTGCTCCA--GCG
Mlentisuturalis   TAGTGAAAAAACGT---GTTAGTACGCT-AAATCCTCAAGTGTAGATGTG
Mxiaoi            CAGTGAATTGGCAT---GTAGGTACAAT-AAATCCTCAAGTGTAGATGTA
Myxo.             CAGTGAATTACCAT---GTTGGCACAAA-AAATCCTCAAGTGTAGGTGTG
Mportucalensis    CAGTGGAATGGCGC---AAT-GTGCAAT-AAACCCTCACCGGTTGATGTG
Mmusculi          TTGTAGTCTGCGGT---TG----GC------ATTTGGCTGCTTC----AG
Mcyprini          CTGTAGTCTGCGGC---TT----GC------ATTTGGCTGCTTC----AG
Mpseudodispar     TTGTAGTCTGCGAT---TA----GT------ATCTGACTGCTTC----AG
Mbibullatus       CGGTTATTTTCGGT---TAT-ACGCT-----AACTGTCGATTTT----TG
Melegans          TGGTAATCT-TGAT---AGT-GAGCATA-AAAGCTG--CACTTTGAGGAG
Mpendula          CAGTGACCATAAAT---GGT-ACAT-------GTATACGATTTT----CT
Mpellicides       CAGTGACAATAAAT---GGT-ACAT-------GTATACCATTTTT---CT
Mhungaricus       CAGTAATCTAGGCC---AAT-GTAT-------GCTGACGATTG-----CC
Myxiditruttae     CGGGCGGGGAGTGT---AATTACGCTAT-GTGTTCACTCGTTGGG--TGA
Myxidium          CGG--CGGGAGTGT---AAT-GCTCTGT-GTGATCACTGATTAAG--GAA
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    CGATACTTTAACGT---A--TGCTACAT-CAAACCG------------TG
Myxosp.           CGGTCAATTAGCAG---AGCTTCACATT-AAAACCG------------AG
Hennzschokkei     CAGTTGATTGTCAT---GGTTATACATT-AAACTTT--------------
Hennsalminicola   CAGTTGATTGTCAT---GGTTATACATT-AAACTTT--------------
Ethclone2MA       TGGATAGTTATTATCTAGGTTATAGACT-ACATATTTTCGTATATCTGTG
Ethclone3MA       TGGATAGTTATTATCTAGGTTATAGACT-ACATATTTTCGTATATCTGTG
Ethclone1MA       -----------------GGTTATAGACT-ACATATTTTCGTATATCTGTG
Myxobprocerus     CGGATAGTTATCTACTAGATTTAAGGCT-A-ATTATTACTTATTTCCGTG
```

```
Mprocerus          CGGATAGTTATTTACTAGATTTAGGACT-A-ATTATTACATATTTCCGTG
Henneguya          GGGGTAAGTTGGAACGATGTT-TGCCCT-ACACCG----ACATGGCCGCG
Hsp.               TGGTGGATGTGCAA---T-C-GTGCTAT-GACCCTCTTCTTCCAGGCACG
Hdoori             TGGTGGATGCGCAT---TGC-GTGCTATTGACCCTCTTCTTCTGGGCGCG
Hennictaluri       TGGTGTACTCAAGTGTTTGC-ATGGTA--AACCTAG-GCT--CGGTTTTC
Hennexilis         TGGTGTATCCAAGTTGTTGC-ATGGTA--AGCTTTGTGCT--CAGACT-C
Mspinacurvatura    GAGTTGGTGTGG-----TGCTGTATCAA-ATTTATGAA---TCATGCAAG
Michkeulensis      GAGTTGGTGTGG-----TGCTGTGTCAA-AATTTTAAAGATTTTCCCGGG
Mosburni           GTGTGAATCGGAA----TGGCGTGCGTTCAACTTTTATAATTTACATGCT
Muvuliferus        --------------------------------------------------
Ceratomyxa         -GGTAAAAT--------AATTATATGA-----------------------
Malgonquinensis    CAGTAATCTTTAG----AGGGGTGTCGTCAAATGTATCCGTC--------
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        ATA-A------------ATTTCTA--TTTATTACTAAAACAGTGT-----
Mdjragini          ATA-A------------ATTTCTA--TTTATTACTAAAACAGTGT-----
Mbramae            ATA-A------------ATTTCTA--TTTATTACTAAAACAGTGT-----
Mneurobius         ATA-A------------ATTTCTA--TTTATTACTAAAACAGTGT-----
Marcticus          ATA-A------------ATTTCTA--TTTATTACTAAAACAGTGT-----
Msandrae           ATA-A------------ATTTCTA--TTTATTACTAAAACAGTGT-----
Minsidiosus        ATA-A------------ATTTCTA--TTTATTACTAAAACAGTGT-----
Mcerebralis        TTG-A------------ATTTCAAA-TTCAGTGTTGGAGTAGTGT-----
Mlentisuturalis    ACG-GTGTGTTATCACCGTTGCAA--TTTATATGT--TGTGGAGT-----
Mxiaoi             GTG-GGGTCTTATCCCTACTACAA--TTTATATGT--TGTGGAGT-----
Myxo.              ACG-GTGTGCTATCACCGTTGCAA--TTTATATAT--TGTGGAGT-----
Mportucalensis     TCT-ACGTTCTACCGTGGACACAT--TCAATTGACG-TGAGGAGT-----
Mmusculi           TC---------------GATG-----CTGATC------GTGG--------
Mcyprini           TC---------------GATG-----C-AGCC------GTGG--------
Mpseudodispar      TC---------------GATG-----CTTTTC------GTAG--------
Mbibullatus        TCC-AGATATGCAAATAGATGGCA--CTAATCTGATGGGTAG--------
Melegans           TT-------TTCACGTAAGTGTAAGGCCGATT-AAAGTGTAGTGCT----
Mpendula           CCA-C----------CGAGTTTAT--TGAATC-----TGTNCC-------
Mpellicides        CCA-A----------CGAGTTTAT--TGAATC-----TGTACC-------
Mhungaricus        TCA--------------GGCGTAT--CGGATC-----TTCATT-------
Myxiditruttae      -TG--CGTTTGCTGTTTTGCGAAAGTGAAGCAGTTGCGAGGAGCC-TTTC
Myxidium           GTG-TCGCTCGCTAT----CGAAAGTTA-GCAAGTACTATTGACTATTCC
Ethclone1AM        --------------------------------------------------
Ethclone3AM        --------------------------------------------------
Ethclone2AM        --------------------------------------------------
Mdiaphanus         --------------------------------------------------
M.lieberkuehni     CTG-TAGTATTGCGAAGCAGACCACGTCTGTCTA-GTGGTGCTGCAGTAC
Myxosp.            GCG-TTGTCTTCATGAAAACACGGTTACCGTGAACGTGACTCAGCGTCTT
Hennzschokkei      -GA-CTCTTTACTGTAGATGTCTAACGACGTATATGGTGTTGAGT-----
Hennsalminicola    -GA-CTCTCTACTGTAGATGTCTAACGACGTATATG-TGTTGAGT-----
Ethclone2MA        ----ATGCTTTCA--GTGTCCAGATAATATGGGTATTAGTTGAAC-----
Ethclone3MA        ----ATGCTTTCA--GTGTCCAGATAATATGGGTATTAGTTGAAC-----
Ethclone1MA        ----ATGCTTTCA--GTGTCCAGATAATATGGGTATTAGTTGAAC-----
Myxobprocerus      ----ATGCTTATG--GTATCCGGACAATATTGATATTGGTTCAGC-----
Mprocerus          ----ATGCTTATG--GTATCCGGATAATAGTGATATTGGTTCAAC-----
Henneguya          TTGCATGTTCTCAT-GTTTCGTGACA-TGTTGG--TTGGCGGAAC-----
Hsp.               ----GTATCATA--CGTGCACTGGAGCTGAGGGAGTGCGTAATG------
Hdoori             ----GTATCATTACCGTGCACTGGGGCTGGGGGAGTGCGTAGTG------
Hennictaluri       ----GTTCTACG---ATTCTCCGCAGTAAAGG---TGTGTAAGGC-----
Hennexilis         ----GTTCCACG---ATGTTCTGCAGCTAAGG---TGTGCAGCAC-----
Mspinacurvatura    ----GTGTCCAC-----ATTTTGT--ATGATTCT-TATGTGGTGCA----
```

```
Michkeulensis      ----GTGTCATC-----ACTTCGGTAATGATT---TATGTGGTGCA----
Mosburni           ----ATGTAAAA---------TGTGAAAGAGTGCGTCTATTATTC-----
Muvuliferus        --------------------------------------------------
Ceratomyxa         --------------------------------------GCAAA-------
Malgonquinensis    ------------------ACGTACGGCCATTTGACGTCACCCGCT-----
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        -----GC-TTCTTTCAGTTATT-CGCC-AATT-------TACACTACTTA
Mdjragini          -----GC-TTCTTTCAGTTATT-CGCC-AATT-------TACACTACTTA
Mbramae            -----GC-TTCTTTCAGTTATT-CGCC-AATT-------TACACTACTTA
Mneurobius         -----GC-TTCTTTCAGTTATT-CGCC-AATT-------TACACTACTTA
Marcticus          -----GCCTTCTTTCAGTTATT-CGCC-AATT-------TACACTACTTA
Msandrae           -----GC-TTCTTTCAGTTATT-CGCC-AATT-------TACACTACTTA
Minsidiosus        -----GCCTTCTTTCAGTTATT-CGCC-AATT-------TACACTACTTA
Mcerebralis        -----GCCGTCTTTCAGTTATT-CGCC-AATT-------TACACTACTTA
Mlentisuturalis    -----ACTGCACGTTTTTGTTA-GCT-AGGC-------CCAACTGATTG
Mxiaoi             -----ACTGCATGTCGATTGTTA-GCT-GAAC-------TTAACTGATTG
Myxo.              -----GCTGCATGTTGATTGTTA-GCT-GAGC-------CTAACTGATTG
Mportucalensis     -----ACATTGTGTCTATTGTAA-GCT-GATT-------GACATTACTTG
Mmusculi           -----AT------T-AA----AACGCA-AGCT-------GTCACTATTTA
Mcyprini           -----AT------TTAA----AGCGCA-GGCT-------GTCACTATTTA
Mpseudodispar      -----AT------T-AA----AACGCA-AACT-------GTCACTATTTA
Mbibullatus        -----ACCGTAAATAAA----AACGCC-GAAT-------GTTACTATTTG
Melegans           ----CACCG---ATGGATATTAACGCC-AGGT-------GTTGCTAGTTG
Mpendula           -----ATTT----TGCGTGTTTATGCTTGAAT-------GTTACTATTTG
Mpellicides        -----ATTT----TGCGTGTTTATGCT-GAAT-------GTTACTATTTG
Mhungaricus        -----GGCT----CAGATGTTTATGCT-GAAT-------GCTACTATTTG
Myxiditruttae      AGGATGATGCATAGTTGTATCACTTGTCGACCATGCTGCCAGGTTACTTG
Myxidium           TTGTTGTAGCATAGTAGTAGCACTTGTCGACCATGCT-CCAGGCTACTTG
Ethclone1AM        --------------------------------------------------
Ethclone3AM        --------------------------------------------------
Ethclone2AM        --------------------------------------------------
Mdiaphanus         --------------------------------------------------
M.lieberkuehni     GGCGTGGCGTATGTTAATA--AACAGTCGTTC-------CGGGCTACTAG
Myxosp.            GGTGTGCTGCATGTTGATT--ATCAGCCGGCC-------CACACTACTTG
Hennzschokkei      ---TGAAAGTATAACTATGGCAATTGTGTGCTGAATG---TGACTAGTTG
Hennsalminicola    ---TGAAAGTATAACTATGGCAATTGTGTGCTGAATG---TGACTAGTTG
Ethclone2MA        --------------TAGTAGTAACATATAACTG---GTGTGTAGTAATTG
Ethclone3MA        --------------TAGTAGTAACATATAACTG---GTGTGTAGTAATTG
Ethclone1MA        --------------TAGTAGTAACATATAACTG---GTGTGTAGTAATTG
Myxobprocerus      --------------TAGTGATAACATTAAACTG---GTATGTAGTAATTG
Mprocerus          --------------TAGTGATAACATTAAACTG---GTATGTAGTAATTG
Henneguya          --------------GCGTAACAACACATAACCG---ACATGCAGTAATTG
Hsp.               ------------------TGC-ATCGTAAGCTG---ATACACAGTAATTT
Hdoori             ------------------TGC-GTCGTAAGCCG---ATACACAGTAATTT
Hennictaluri       -----------------TTGA-GTAATTAGCCA---GTGCATAGTAATTG
Hennexilis         -----------------TTGG-GTAAATAGCCA---GTGTGTAGTAATTG
Mspinacurvatura    --------------GTGCTGCTACCGTAAGCTA---GTGTATAGTAATTG
Michkeulensis      --------------GTGTTGCTAC-GTAAGCTA---GTGTATAGTAATTG
Mosburni           --------------------TGATTGGAAGCGC---GCGCACAGTAATTG
Muvuliferus        --------------------------------------------------
Ceratomyxa         --------------------TGCTCATTGATTA-----TTTTGCTCTTTT
Malgonquinensis    -------------TCAGATATCATGCTGGACG--------TCGCTAGTTG
Perchclone1AM      -----------------------------------------TACTCCCCC
Perchclone2AM      -----------------------------------------TACTCCCCC
```

```
Perchclone3AM     -----------------------------------------TACTCCCCC

Melipsoides       CG------CGTAAGGATGGCAGTTGACCTTTAGTGCGTCGATTGCCG-TG
Mdjragini         CG------CGTAAGGATGGCAGTTGACCTTTAGTGCGTCGATTGCCG-TG
Mbramae           CG------CGTAAGGATGGCAGTTGACCTTTAGTGCGTCGATTGCCG-TG
Mneurobius        CG------CGTAAGGATGGCAGTTGACCTTTAGTGCGTCGATTGCCG-TG
Marcticus         CG------CGTAAGGATGGCAGTTGACCTTTAGTGCGTCGATTGCCG-TG
Msandrae          CG------CGTAAGGATGGCAGTTGACCTTTAGTGCGTCGATTGCCG-TG
Minsidiosus       CG------CGTAAGGATGGCAGTTGACCTTTAGTGCGTCGATTGCCG-TG
Mcerebralis       CG------CGTAAGGATGGCAGTTG-CCTTTAGTGCGTCGATTGCCG-TG
Mlentisuturalis   CG------TATGGGGATGGCAATTGACCTTAAGTGAGTCGATTGTTG-TG
Mxiaoi            CA------TATGGGGATGGTAATTGACCTTAAGTGTGTCGATTATTG-TG
Myxo.             CA------TATGGGGATGGTGATTGACCTTTAGTGAGTCGATCATCG-TG
Mportucalensis    CA------CGTGGGAATGGTCATTGACCTTAGTTGAGTTGACGATTG-TG
Mmusculi          AT------CGCAAATATGTTGGTTGGCCTTTAGTGAGTCGAGCATCA-TA
Mcyprini          AT------CGCAAATATGTTGGTTGGCCTTTAGTGAGTCGAGCATCA-TA
Mpseudodispar     AT------CGCAAATATGTTAGTTGACCTTTAATGAGTTGACTATCA-TA
Mbibullatus       CA------CGCAAGTATGATAGTTGACCTTAAATGCGTTGAGTGTCA-TG
Melegans          CA------CGCGAGGATGTCAGTTGGTCTTTAGTGTACTGAGTGTCA-TA
Mpendula          CA------CACAAGTATGGCATTTGGCCTTTAGTGAGTTGAGTGTCA-TG
Mpellicides       CA------CACAAGTATGGCATTTGGCCTTTAGTGAGTTGAGTGTCA-TG
Mhungaricus       CA------CACAAGTGTGGTATTTGGCCTTAAGTGAGTTGAGTATCA-TG
Myxiditruttae     TAATGTTTCGTGAGAATGGTACATGGTCTTTATTGTACTGTGTGCTT-TG
Myxidium          TAATGTTTCGTGAGAATGGTATATGGTCTTCATTGTACTGTGTATTA-TG
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    AT------TGTGAGAATGGTGAATGGTCTTTACCGACT--GCTCATCGTG
Myxosp.           TA------CGTGAGGATGGCGGTTGACCTTTAGTGCGTTGACTGTTCGTG
Hennzschokkei     CA------CGTGAGGATGATGGTTGACCTCTGGTGCGTTGACTGTTA-TG
Hennsalminicola   CA------CGTGAGGATGATGGTTGACCTTTAGTGCGTTGACTGTTA-TG
Ethclone2MA       CG------TATGAGAATGATCATTGACCTTGAGTGTGTTGA-AGATCGTG
Ethclone3MA       CG------TATGAGAATGATCATTGACCTTGAGTGTGTTGA-AGATCGTG
Ethclone1MA       CG------TATGAGAATGATCATTGACCTTGAGTGTGTTGA-AGATCGTG
Myxobprocerus     CG------TATGAGGATGACCATTGACCTTAAGTGTGTTGA-AGGTCGTG
Mprocerus         CG------TATGAGGATGACCATTGACCTTAAGTGTGTTGA-AGGTCGTG
Henneguya         CG------CGTGGGGATGGCCTTTGACCTTAAGTGCGTTGA-GGGCCGTG
Hsp.              CA------CGTGAGGATGATCGCTGACCTTGAGTGTGTCGG-TGATCGTG
Hdoori            CA------CGTGAGGATGATCGCTGACCTTGAGTGTGTCGGGTGATCGTG
Hennictaluri      CA------CGTGGGGATGGCCGTTAGCCTTTAGTGCGCTGA-TGGTCGTG
Hennexilis        CA------CGTGGGGATGGTCGTTAGCCTTTAGTGCGCTGA-TGATCGTG
Mspinacurvatura   CA------CGTGAGGATAGACATTAGCCTTGAATGAGTAGA-TGTTTGTG
Michkeulensis     CA------CGTGAGGATAGACATTCGCCTTGAATGAGTAGA-TGTTTGTG
Mosburni          CA------CGCGAGGATGACCATTGACCTTTGGTGTGTTGG-TGGTGGTG
Muvuliferus       --------------GA--ACTA---------------------------G
Ceratomyxa        TA-----TTACAAGGGTCAATACTTTGCTTAATTGAATTG--TATTG-AA
Malgonquinensis   CA------CGTGAGATAGATTGTTGGCCTTGAATGTGCCGG-TATTCTTG
Perchclone1AM     CG--------------CAACCGAAAAACTTTAG----------------G
Perchclone2AM     CG--------------CAACCGAAAAACTTTAG----------------G
Perchclone3AM     CG--------------CAACCGAAAAACTTTAG----------------G

Melipsoides       T-CTTACGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
Mdjragini         T-CTTACGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
Mbramae           T-CTTACGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
Mneurobius        T-CTTACGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
Marcticus         TACTTACGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
```

```
Msandrae            T--TTACGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
Minsidiosus         T-CTTACGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
Mcerebralis         T-CTTACGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
Mlentisuturalis     T-CCCATGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
Mxiaoi              T-CCCATGGAGT-GTGCG-TTGAATAAAACAG------------------
Myxo.               T-CCCATGGAGT-GTGCC-TTGAATAAAACAGAGTGCTTAAAGCAGGC-T
Mportucalensis      T-CTCACGGGGT-GTGCC-TTGAATAAATCAGAGTGCTTAAAGCAGGC-T
Mmusculi            T-TTTGCGGAGTTGTGCC-TTGAATAAAACAGAGTGCTCAAAGCAGGC-G
Mcyprini            T-TTTGCGGAGTTGTGCC-TTGAATAAAACAGAGTGCTCAAAGCAGGC-G
Mpseudodispar       T-TTTGCAGAGTTGTGCC-TTGAATAAAACAGAGTGCTCAAAGCAGGC-G
Mbibullatus         T-CTTGCGGAGT-GTGCC-TTGAATAAANCAGAGTGCTTAAAGCAGGC-T
Melegans            T-CTTGCGGAGT-GTGCC-TTGAATAAAACAGAGTGCTCAACGCAGGC-A
Mpendula            T-CTTGTGGAGT-GTGCC-TTGAATAAAACAGAGTGCTCAAAGCAGGC-G
Mpellicides         T-CTTGTGGAGT-GTGCC-TTGAATAAANCAGAGTGCTCAAAGCAGGC-G
Mhungaricus         C-CTTGTGGAGT-GTGCC-TTGAATAAAACAGAGTGCTCAAAGCAGGC-G
Myxiditruttae       T-CTTACGTAGT-GTGCC-TTGAATAAATCAGAGTGCTCAATGCAAGC--
Myxidium            T-CTTACGTAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAAGC--
Ethclone1AM         --------------------------------------------------
Ethclone3AM         --------------------------------------------------
Ethclone2AM         --------------------------------------------------
Mdiaphanus          -------------------------------------TTAACGGCGCGA-A
M.lieberkuehni      T-CTCGCAGAGT-GTGCC-TTGAATAAACCAGAGTGCTCAAAGCAGGC-A
Myxosp.             T-CTTACGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC--
Hennzschokkei       T-CTCACGGAGT-GTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
Hennsalminicola     T-CTCACGGAGG-TTGCC-TTGAATAAATCAGAGTGCTCAAAGCAGGC-T
Ethclone2MA         T-CTCATGG-GATGTGCC-TTGAGTAAATCAGAGTGCTCAAAGCAGGC-G
Ethclone3MA         T-CTCATGG-GATGTGCC-TTGAGTAAATCAGAGTGCTCAAAGCAGGC-G
Ethclone1MA         T-CTCATGG-GATGTGCC-TTGAGTAAATCAGAGTGCTCAAAGCAGGC-G
Myxobprocerus       T-CTCATGG-GATGTGC--TTGAGTAAATCAGAGTGCTCAAAGCAGGC-G
Mprocerus           T-CTCATGG-GATGTGCC-TTGAGTAAATCAGAGTGCTCAAAGCAGGC-G
Henneguya           T-CTCACGG-GATGTGCC-TTGAGTAAATCAGAGTGCTCAAAGCAGGC-A
Hsp.                T-CTCACGG-G-TGTGCC-TTGAGTAAATCAGAGTGCTTAAAGCAGGC--
Hdoori              T-CTCACGG-G-TGTGCCGTTGAGTAAATCAGAGTG--------------
Hennictaluri        T-CTCACGG-GGTGTGCC-TTGAGTAAATCAGAGTGCTTAAAGCAGGC--
Hennexilis          T-CCCACGG-GGTGTGCC-TTGAGTAAATCAGAGTGCTTAAAGCAGGC--
Mspinacurvatura     T-CTCACGG-AGTGTGCC-TTGAATAAATCAAAGTGCTTAAAGCAGGC-T
Michkeulensis       T-CTCACGGGAGTGTGCC-TTGAATAAATCAAAGTGCTTAAAGCAGGCCT
Mosburni            T-CTCGCGG-GGTGTGCC-TTGAGTAAATCAGAGTGCTTAATGCAAGC--
Muvuliferus         T-CCTGCAG-GTT---------AACGAATC----TCCTT-----------
Ceratomyxa          TACTTGTATAGC-GTGCC-TTGAATAAAGCACAGTGCTCAAAGCAAGC-G
Malgonquinensis     T-CTTGCGGGGT-GTGCC-TTGAATAAAACAGAGTGCTTAAAGCAGGT--
Perchclone1AM       T-------------TTCC-----------CAGGGGGACCAACCCAAGC--
Perchclone2AM       T-------------TTCC-----------CAGGGGGACCAACCCAAGC--
Perchclone3AM       T-------------TTCC-----------CAGGGGGACCAACCCAAGC--

Melipsoides         -TTTGCTTGAATGTTAATAGCATGGAACGAACAATTGTGTA-GTAGTATG
Mdjragini           -TTTGCTTGAATGTTAATAGCATGGAACGAACAATTGTGTA-GTAGTATG
Mbramae             -TTTGCTTGAATGTTAATAGCATGGAACGAACAATTGTGTA-GTAGTATG
Mneurobius          -TTTGCTTGAATATTAATAGCATGGAACGAGCAATTGTGTA-GTAGTATG
Marcticus           -TTTGCTTGAATGTTAATAGCATGGAACGAACAATTGTGTA-GTAGTATG
Msandrae            -TTTGCTTGAATGTTAATAGCATGGAACGAACAATTGTGTA-GTAGTATG
Minsidiosus         -TTTGCTTGAATGTTAATAGCATGGAACGAACAATTGTGTA-GTAGTATG
Mcerebralis         -TTTGCTTGAATGTTAATAGCATGGAACGAANAATTGTGTA-GTAGTGTG
Mlentisuturalis     TGATGCCTGAATGTTAACAGCATGGAACGAACAATTGTGGA-AACATGAT
Mxiaoi              --------------------------------------------------
Myxo.               TGACGCCTGAATGTTAACAGCATGGAACGAACAATTGTGGC-AACATGAT
Mportucalensis      CT-TGCCTGAATGTTGATAGCATGGAACGAACAGTTGTGTT-AACGTGCA
```

```
Mmusculi          -AACGCTTGAATGTT-GTAGCATGGAACGAACAAACGTGTA-TTCGCACA
Mcyprini          -AACGCTTGAATGTT-GTAGCATGGAACGAACAAACGTGTA-TTGGCACA
Mpseudodispar     -AACGCTTGAATGTT-GTAGCATGGAACGAACAAACGTGTA-TTCGCATA
Mbibullatus       -AAAGCTTGAATGTT-ATAGCATGGAACGAACAAACGTGTG-ACAGTACG
Melegans          -AAAGCTTGAATGTT-ATAGCATGGAACGAACAAACGTGTT-AACGTGCA
Mpendula          -TATGCTTGAATGTT-ATAGCATGGAACGAACAAACGTGTA-TTTGTGTA
Mpellicides       -TATGCTTGAATGTT-ATAGCATGGAACGAACAAACGTGTA-TTTGNGTA
Mhungaricus       -AAAGCTTGAATGTT-ATAGCATGGAACGAACAAACGTGTA-TTTGCGTA
Myxiditruttae     AATTGCTTGAATGTTAATAGCATGGAACGAATG--TATAGTGAAAGTGTG
Myxidium          TATCGCTTGAATGTTAATAGCATGGAACGAATG--TATAGTGTATGTGCG
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        TCGCCCTT------------CATGGASTGAACAATAGTGTA-GATGTGTA
M.lieberkuehni    TGTTGCTTGAATGTTAATAGCATGGAACGAACAAATGTGAT-TTCGTGTA
Myxosp.           TTACGCTTGAATGTTAATAGCATGGAACGAACAATTGTGTTATACGTGTC
Hennzschokkei     TTAAGCTTGAATGTTAATAGCATGGAACGAACAAACGTGTT-TATGTATA
Hennsalminicola   TTAAGCTTGAATGTTAATAGCATGGAACGAACAAACGTGTT-TATGTATA
Ethclone2MA       TTATGCCTGAATGTTAATAGCATGGAACGAACAATAGTGTAGA-TGTGTA
Ethclone3MA       TTATGCCTGAATGTTAATAGCATGGAACGAACAATAGTGTAGA-TGTGTA
Ethclone1MA       TTATGCCTGAATGTTAATAGCATGGAACGAACAATAGTGTAGA-TGTGTA
Myxobprocerus     TGATGCCTGAATGTTGATAGCATGGAACGAACAATAGTGTAGA-TGTGTA
Mprocerus         TGATGCCTGAATGTTGATAGCATGGAACGAACAATAGTGTAGA-TGTGTA
Henneguya         TTGCGC-TGAATGTTGATAGCATGGAACGAACAATCGTGTACAGTGCGCG
Hsp.              GTAAGCTTGAATGTTGATAGCATGGAACGAACAATCGTGTATGGTGTGTA
Hdoori            -TAAGCTTGAATGTTGATAGCATGGAACGAACAATCGTGTATGGTGTGTA
Hennictaluri      GTTAGCTTGAATGTTGATAGCATGGAACGAACAATCGTGTATGGTGTGTG
Hennexilis        GTTAGCTTGAATGTTGATAGCATGGAACGAACAATCGTGTATGGTGTGTG
Mspinacurvatura   GTACGCTTGAATGTTAA-AGCATGGAACGAACAATCGTGTAGGGTGCATG
Michkeulensis     TTNCGCTTGAATGTTAA-AGCATGGAACGAACAATCGTGTAGGGTGCATG
Mosburni          GTGTGCTTGAATGTTGATAGCATGGAACGAACAATAGTGTATGGTGTGTG
Muvuliferus       --------------------CATGGAACGAACAATAGTGTATGGTGTGTG
Ceratomyxa        TAACGCTAGAATGTT-ATAGCATGGAACGAATAGAT-TGAC---------
Malgonquinensis   TATCGCCTGAATGTT-ATAGCATGGAACGAACAATCGTGTA-TATGTGTG
Perchclone1AM     ---CGT---AATAATAA-GGCATAGGACTAA-------------------
Perchclone2AM     ---CGT---AATAATAA-GGCATAGGACTAA-------------------
Perchclone3AM     ---CGT---AATAATAA-GGCATAGGACTAA-------------------

Melipsoides       -TTGTGACAC-ATAGCGATCGGTCTTTGA-CTGAATGTTATT-------G
Mdjragini         -TTGTGACAC-ATAGCGATCGGTCTTTGA-CTGAATGCTATT-------G
Mbramae           -TTGTGACAC-ATAGCGATCGGTCTTTGA-CTGAATGCTATT-------G
Mneurobius        -TTGTGACAC-ATAGCGATCGGTCTTTGA-CTGAATGCTATT-------G
Marcticus         -TTGTGACAC-ATAGCGATCGGNCTTTGA-CTGAATGCTATT-------G
Msandrae          -TTGTGACAC-ATAGCGATCGGTCTTTGA-CTGAATGCTATT-------G
Minsidiosus       -TTGTGACAC-ATAGCGATCGGTCTTTGA-CTGAATGCTATT-------G
Mcerebralis       -TTGTGACAA-ATAGCGATCGGTCTTTGA-CTGAATGTTATT--------
Mlentisuturalis   ATTATCTCCACTGG-CAATGTGCTTATTTGTATGTTGTCATG-------T
Mxiaoi            --------------------------------------------------
Myxo.             GTCGTGCTGATTGGGCGATATACTTTTATGTGTGTCGTTTCA-------A
Mportucalensis    ATGGTTGTATTGGTATCGCGAAGCTTTGAGCCTAGCGT-----------G
Mmusculi          --TGTCGTGCGAAGTGGATGTGCTTCTGGTGCGTCTGCT-TT-------G
Mcyprini          --CGTCGTGCGAAGTGGGTGCGCTTCTGGTGCGTCTGCT-TT-------G
Mpseudodispar     --CGTCGTGCGAAGCGGATGTGCTTCTGGTGTGTCTGCT-TT-------G
Mbibullatus       --TGTTTGGCAACGGCGATGAGCTCATGGTTTAT-TGCTGTT-------G
Melegans          --CGTCGAGT-ACAGCGGTATTCTTATGGATTGC-CATTGTA-------T
Mpendula          --TGNTTGGTGGTAATCAGAGGCAACT---CTATTTACT----------G
Mpellicides       --TGTTTGGTGGTAATCAGAGGCAACT---CTATTTACT----------G
```

```
Mhungaricus        --TGTTTAGTGATGATTGGGGGCAACT---CTGATTGTT----------G
Myxiditruttae      -ATGGTGATGG-------------------CAATTCGTTGT---------
Myxidium           -CTAGTAAGCA-------------------TCATTCGTGGT---------
Ethclone1AM        --------------------------------------------------
Ethclone3AM        --------------------------------------------------
Ethclone2AM        --------------------------------------------------
Mdiaphanus         -TTGGTAA-TGGTAGACG-----TTACAA-CGTAATGTTCT---------
M.lieberkuehni     -CTGACAAGTAATGCACAATGATTTACAT-TGTTGTGCACT---------
Myxosp.            -TATACTTACAGTTGA-ATGGATTTATTT-TGTCTAGCTGT---------
Hennzschokkei      -AT-ATAATTGATTTTGATTTGTCTATGA-TAGATTATTAT--------G
Hennsalminicola    -AT-ATAATTGATTTTGATTTGTCTATGA-TAGATTATTGTT-------G
Ethclone2MA        TTGAA---GATGGTAGTATGTTATTATAACTTAATAATA---------TA
Ethclone3MA        TTGAA---GATGGTAGTATGTTATTATAACTTAATAATA---------TA
Ethclone1MA        TTGAA---GATGGTAGTATGTTATTATAACTTAATAATA---------TA
Myxobprocerus      TTGAA---GATGGTAGTGTATTATTACAATGTAATAGTA---------TA
Mprocerus          TTGAA---GATGGTAGTGTATTATTACAATGTAATAGTA---------TA
Henneguya          CTGATATCGGTGCTGGTGTGT-GCTGGCGTGCAAAAGTCGCGTCGCCCCA
Hsp.               TTGAGTACGGTGT--GTGTGGCGTTACTGCGCA-----------------
Hdoori             TTGAGTACGGTGT--GTGTGGCGTTACTGCGCA-----------------
Hennictaluri       TTGATAACGGCGT--GT-TGGATCT-TCCTTCA-----------------
Hennexilis         TTGGTAACGGGGT--GT-TGGATTCGTCCTTCA-----------------
Mspinacurvatura    TTGGTCAATGGGT--GTGAGGCCTAGTCTTGCA-----------------
Michkeulensis      TTA-TTTATGGGT--GCAGGGCCTAGCCAGGCA-----------------
Mosburni           TTGGCCAAGATGT--GA-------TGCAAATTG-----------------
Muvuliferus        TTGGCAAAGATGT--AA-------TTT--ATTG-----------------
Ceratomyxa         --------------------------------------------------
Malgonquinensis    --CGTCTCTGGCAGTTGTGAACCTTTGGTTTACA---------------G
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        CTGTTGCA---GCATACAGCACCAACCACCAATAACGGATGTTGGTT-CC
Mdjragini          CTGTTGCA---GCATACAGCACCAACCACCAATAACGGATGTTGGTT-CC
Mbramae            CTGTTGCA---GCATACAGCACCAACCACCAATAACGGATGTTGGTT-CC
Mneurobius         CTGTTGCA---GCATACAGCACCAACCACCAATAACGGATGTTGGTT-CC
Marcticus          CTGTTGCA---GCATACAGCACCAACCACCAATAACGGATGTTGGTT-CC
Msandrae           CTGTTGCA---GCATACAGCACCAACCACCAATAACGGATGTTGGTT-CC
Minsidiosus        CTGTTGCA---GCATACAGCACCAACCACCAATAACGGATGTTGGYT-CC
Mcerebralis        CAGTTACA---GCATACAGCACCAACCACCAATAACGGATGTTGGTT-CC
Mlentisuturalis    GGGGGCAG---TATCATAGCACCAACCACCAATATCGGATGTTGGTT-CC
Mxiaoi             --------------------------------------------------
Myxo.              TTAGTCGA---GATCATAGCACCAACCACCAATATCGGATGTTGGTT-CC
Mportucalensis     CTGGTCCC---ATGCACAGCACCAACCACCAATATCGGATGTTGGTT-CC
Mmusculi           CTGAC------GTGTGTATCACCCGCCAA-AATA-CGATTGTTGGTTATC
Mcyprini           CTGAT------GTGTGTATCACCCGCCAA-AGTA-CGATTGTTGGTTATC
Mpseudodispar      CTGAT------GTATGCATCACCCGCCAA-AGTA-CGATTGTTGGTTATC
Mbibullatus        TCGAT------GCGTACAGCACCTACCAA-AATA-TGGATGTTGGTT-CC
Melegans           TAGAT------GTGCACAGCACCTACCAA-AATA-TGGATGTTGGTT-CC
Mpendula           TCGGC------ATATGCAGCACCCGCCAA-AATA-CGGATGTTGGTTTTC
Mpellicides        TCGGC------ATATGCAGCACCCGCCAA-AATA-CGGATGTTGGTTTTC
Mhungaricus        CTGGC------ATACGCAGCACCCACCAA-AATA-CGGATGTTGGTTTTC
Myxiditruttae      CATTGCTG---TTACACAGCACCAACCGCGAAGCG-GAGCATTGGTTGCC
Myxidium           GTTTGCTA---GTACATAGCACCAACCGCGAAGCG-GAACATTGGTTACC
Ethclone1AM        --------------------------------------------GTT-CC
Ethclone3AM        --------------------------------------------GTT-CC
Ethclone2AM        --------------------------------------------------
Mdiaphanus         ACT--ACA---ATATGCAACACCGACCGCCAATTACGGATGTTGGTT-CC
```

M.lieberkuehni	AACTGGCA---GTACATAGCACCAACCACCAAG-GCGGATGTTGGTTTCC
Myxosp.	GGGT-GTA---GTTCACATCACCAACCGCCAATAACGGATGTTGGTTTCC
Hennzschokkei	TTTTTGTG---TTGTACTGCACCAACCACCAATAACGGACGTTGGTT-CC
Hennsalminicola	TTTTTGTG---TTGTACTGCACCAACCACCAATAACGGACGTTGGTT-CC
Ethclone2MA	CTACTACA---ATATGCAACACCGACCGCCAATTACGGATGTTGGTT-CC
Ethclone3MA	CTACTACA---ATATGCAACACCGACCGCCAATTACGGATGTTGGTT-CC
Ethclone1MA	CTACTACA---ATATGCAACACCGACCGCCAATTACGGATGTTGGTT-CC
Myxobprocerus	CTACTACA---ATATGCAACACCGACCGCCAATTACGGATGTTGGTT-CC
Mprocerus	CTACTACA---ATATGCAACACCGACCGCCAATTACGGATGTTGGTT-CC
Henneguya	GTGCTGCA---GTGCGCGACACCGACCACCATGTACGGATGTTGGTT-CC
Hsp.	-CATTTCA---ATGCATGACACCGACCACCAATTACGGATGTTGGTTTCC
Hdoori	-CATTTCA---ATGCATGACACCGACCACCAATTACGGATGTTGGTTTCC
Hennictaluri	-CACTGCA---ACACACGACACCGACCGCCAATTACGGATGTTGGTT-CC
Hennexilis	-CACTGCA---ACACACGACACCGACCGCCAGTTACGGATGTTGGTT-CC
Mspinacurvatura	-TCCATCA---ACATGTGACACCGACCGCCAATAACGGATGTTGGTTCC-
Michkeulensis	-TTCATCA---ACATGTGACACCGACCACCAATAACGGATGTTGGTTCCC
Mosburni	-CGTCTCA---ACACATGACACCGACCACCAATTACGGATGTT-GGTTCC
Muvuliferus	-CGTCTCA---ACACATGACACCGACCACCAATTACGGATGTTTGGTTCC
Ceratomyxa	CTGAATCA---GTTTGT-----TGGTAAAAAGTTACGCAAGTAACTAACC
Malgonquinensis	TTGTTCGAGATGCGCACGGCACCCACCA--AAATATGGCTGTTGGTT-CC
Perchclone1AM	--TCCC
Perchclone2AM	--TCCC
Perchclone3AM	--TCCC

Melipsoides	GTATTGGGGTGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGC
Mdjragini	GTATTGGGGTGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGC
Mbramae	GTATTGGGGTGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGC
Mneurobius	GTATTGGGGTGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGC
Marcticus	GTATTGGGGTGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGC
Msandrae	GTATTGGGGTGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGC
Minsidiosus	GTATTGGGGTGATYAATTAAAARGAGCGGNTGGGGGCATTGGTATTTGGC
Mcerebralis	GTATTGGGGTGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGC
Mlentisuturalis	GTATTGGGGTGAT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTTGC
Mxiaoi	--
Myxo.	GTATTGGGGTGAT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTTGC
Mportucalensis	GTATTGGGGTGAT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTCGG
Mmusculi	GTATTAGG-TGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGA
Mcyprini	GTATTAGG-TGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGA
Mpseudodispar	GTATTAGG-TGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGA
Mbibullatus	ATATACGG-TGAT-GATTAAAAGGAGCGGTTGGGGGCATTGGTATTTGGC
Melegans	ATATACGG-TGAT-GATTAAAAGGAGCGGTTGGGGACATTAGTATTTGAC
Mpendula	GTATCAGG-TGAT-GATTAACAGGAGCGGTTGGGGGCATTGGTATTTGGC
Mpellicides	GTATCAGG-TGAT-GATTAACAGGAGCGGTTGGGGGCATTGGTATTTGGC
Mhungaricus	GTATCAGG-TGAT-GATTAACAGGAGCGGTTGGGGGCATTGGTATTTGGC
Myxiditruttae	GACTTCGGGTGAG-GATTAAGAGGGGCATTTGGGGGCATTAGTATTTGGT
Myxidium	GACTTCGGGTGAG-GATTAAGAGGNGCNATTTGGGGCATTAGTATTTGGC
Ethclone1AM	GTATTGGGGTACT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTGGC
Ethclone3AM	GTATTGGGGTACT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTGGC
Ethclone2AM	--
Mdiaphanus	GTATTGGGGTACT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTGGC
M.lieberkuehni	GTTTTGGGGTGAT-GATTAAAAGGGGCGGTTGGGGGCATTGGTATTTGGC
Myxosp.	GTATTGGGGTGAT-GATTAAAAGGAGCGATTGGGGGCATTGGTATTTG-C
Hennzschokkei	GTATTGGGGTGAT-GATTAAAAAGAGCGGTTGGGGGCATTGGTATTTGTC
Hennsalminicola	GTATTGGGGTGAT-GATTAAAAAGAGCGGTTGGGGGCATTGGTATTTGTC
Ethclone2MA	GTATTGGGGTACT-GATTAA------------------------------
Ethclone3MA	GTATTGGGGTACT-GATTAA------------------------------
Ethclone1MA	GTATTGGGGTACT-GATTAA------------------------------

```
Myxobprocerus     GTATTGGGGTACT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTGGC
Mprocerus         GTATTGGGGTACT-GATTAAGAGGAGCGGTTGGGGGCATTG-TATT--GC
Henneguya         GTATTGGGGTACT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTGGC
Hsp.              GTATTGGGGTACT-GATTAAGAGGAGCGGTTGGGGACATTGGTATTTGGC
Hdoori            GTATTGGGGTACT-GATTAAGAGGAGCGGTTGGGGACATTGGTATTTGGC
Hennictaluri      GTATTGGGGTACT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTGGC
Hennexilis        GTATTGGGGTATT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTGGC
Mspinacurvatura   GTATTGGGGTATT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTGGC
Michkeulensis     GTATTGGGGTATT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTGGC
Mosburni          GTATTGGGGTACT-GATTAAGAGGAGCGGTTGGGGGCATTGGTATTTGGC
Muvuliferus       GTATTGGGGTACT-GATTAAGAGGAG-GTTTGGGGGCATTGGTATTTGGC
Ceratomyxa        TGAAACGGGTCCT-GATTAAAAGGGGCATTTGAGGATGTTAGTACTTGGT
Malgonquinensis   ATATACGG-TGAT-GATTAACAGGAGCGGTTGGGGGCATCGGTATTTGGC
Perchclone1AM     GGGTCGGCATAGT---TTACAGTGAG-AACTAGGA----CGGTATCTGAT
Perchclone2AM     GGGTCGGCATAGT---TTACAGTGAG-AACTAGGA----CGGTATCTGAT
Perchclone3AM     GGGTCGGCATAGT---TTACAGTGAG-AACTAGGA----CGGTATCTGAT

Melipsoides       -CGCGAG-AGGTGAAA-TTTTTAGACCGG--CCAAGGACTAACGGAATGC
Mdjragini         -CGCGAG-AGGTGAAA-TTCTTAGACCGG--CCAAGGACTAACGGAATGC
Mbramae           -CGCGAG-AGGTGAAA-TTCTTAGACCGG--CCAAGGACTAACGGAATGC
Mneurobius        -CGCGAG-AGGTGAAA-TTCTTAGACCGG--CCAAGGACTAACG-AATGC
Marcticus         -CGCGAG-AGGTGAAA-TTCTTAGACCGG--CCAAGGACTAACG-AATGC
Msandrae          -CGCGAG-AGGTGAAA-TTTTTAGACCGG--CCAAGGACTAACGGAATGC
Minsidiosus       -CNCGAG-AGGTGAAA-TTCTTAGACCGG--CCAAGGACTAACG-AATGC
Mcerebralis       -CGCGAG-AGGTGAAA-TTCTTAGACCGG--CCAAGGACTAACG-AATGC
Mlentisuturalis   -CGCGAG-AGGTGAAA-TTCTTGGACCGG--CAAAGGACTAACA-AATGC
Mxiaoi            --------------------------------------------------
Myxo.             -CGCGAG-AGGTGAAA-TTCTTGGACCGG--CAAAGGACTAACA-AATGC
Mportucalensis    ACGCGAGGAGGTGAAA-TTCTTGGACCGTTCCCAAGGACTAACA-AATGC
Mmusculi          -CGCGAG-AGGTGAAA-TTCAAAGACCGT--CCAAGGACTAACA-AATGC
Mcyprini          -CGCGAG-AGGTGAAA-TTCAAAGACCGT--CCAAGGACTAACA-AATGC
Mpseudodispar     -CGCGAG-AGGTGAAA-TTCAAAGACCGT--CCAAGGACTAACA-AATGC
Mbibullatus       -CGCGAG-AGGTGAAA-TTCTTAGACCGG--CCAAGGACTAACA-AATGC
Melegans          -CGCGAG-AGGTGAAA-TTCTAGAACCGG--TCAAGGACTAACA-AATGC
Mpendula          -CGCGAG-AGGTGAAA-TTCTTGGACCGG--CCAAGGACTAACA-GATGC
Mpellicides       -CGCGAG-AGGTGAAA-TTCTTGGACCGG--CCAAGGACTAACA-GATGC
Mhungaricus       -CGCGAG-AGGTGAAA-TTCTTGGACCGG--CCAAGGACTAACA-GATGC
Myxiditruttae     -CGCGAG-AGGTGAAA-TTCTTGGACCGG--CCAAGGACTAACA-AGTGC
Myxidium          -CGCGAG-AGGTGAAA-NTCTTGGACCGG--CCAAGGACTAACA-AGTGC
Ethclone1AM       -AGCGAG-AGGTGAAA-TTCTTGGACCTG--CCAAGGACTAACA-AATGC
Ethclone3AM       -AGCGAG-AGGTGAAA-TTCTTGGACCTG--CCAAGGACTAACA-AATGC
Ethclone2AM       --------------------------------------------------
Mdiaphanus        -AGCGAG-AGGTGAAA-TTCTTGGACCTG--CCAAGGACTAACA-AATGC
M.lieberkuehni    -CGCGAG-AGGTGAAA-TTCTTGGACCGG--CCAAGGACTAACA-AATGC
Myxosp.           -CGCGAG-AGGTGAAA-T-CTTGGACCGG--CCAAGGACTAACA-AATGC
Hennzschokkei     -CGCGAG-AGGTGAAA-TTCTTGGACCGG--ACAAGGACTAACA-AATGC
Hennsalminicola   -CGCGAG-AGGTGAAA-TTCTTGGACCGG--ACAAGGACTAACA-AATGC
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     -AGCGAG-AGGTGAAA-TTCTTGGACCTG--CACAAG-------------
Mprocerus         -AGCGAG-AG-TGAA--TTCT--GACCTG--C-CAAG-------------
Henneguya         -AGCGAG-AGGTGAAA-TTCTTGGACCTG--CCAAGGACTAACA-AATGC
Hsp.              -AGCGAG-AGGTGAAA-TTCTTGGACCTG--TCAAGGACTAACA-AATGC
Hdoori            -AGCGAG-AGGTGAAA-TTCTTGGACCTG--TCAAGGACTAACA-AATGC
Hennictaluri      -AGCGAG-AGGTGAAA-TTCTTGGACCTG--CCAAGGACTAACA-AATGC
Hennexilis        -AGCGAG-AGGTGAAA-TTCTTGGACCTG--CCAAGGACTAACA-AATGC
```

```
Mspinacurvatura   -AGCGAG-AGGTGAAA-TTCTTGGACCTG--TCAAGGACTAACA-AATGC
Michkeulensis     -AGCGAG-AGGTGAAA-TTCTTGGACCTG--TCAAGGACTAACA-AATGC
Mosburni          -AGCGAG-AGGTGAAA-TTCTTAGACCTG--CCAAGGACTAACA-AATGC
Muvuliferus       -AGCGAG-AGGTGAAAATTCTTAGACCTG--CCAAGGACTAACA-AATGC
Ceratomyxa        -GGCGAG-AGGTGAAA-TTCTTAGACCCA--CCAAAGACTCACT-ATTGC
Malgonquinensis   -CGCGAG-AGGTGAAA-TTCTTAGACCGG--CCAAGGACTAACA-AATGC
Perchclone1AM     ---CG------------TCTTCGAACCT----------CTCACT------
Perchclone2AM     ---CG------------TCTTCGAACCT----------CTCACT------
Perchclone3AM     ---CG------------TCTTCGAACCT----------CTCACT------

Melipsoides       GGAAGGCATTTGTCTA-GACCGCNTCG-CTTAATC-AAGAACGA-TAGTG
Mdjragini         GGAAGGCATTTGTCTA-GACCGCNTCG-CTTAATC-AAGAACGA-TAGTG
Mbramae           GGAAGGCATTTGTCTA-GACCGCNTCG-CTTAATC-AAGAACGA-TAGTG
Mneurobius        G-AAGGCATTTGTCTA-GACCGCCTCG-CTTAATC-AAGAACGA-TAGTG
Marcticus         G-AAGGCATTTGTCTA-GACCGCNTCG-CTTAATC-AAGAACGA-TAGTG
Msandrae          GGAAGGCATTTGTCTA-GACCGCNTCG-CTTAATC-AAGAACGA-TAGTG
Minsidiosus       G-AAGGCATTGTCCTA-GACCCCCTCG-CTTAATC-AAGAACGA-TAGTG
Mcerebralis       G-AAGGCATTTGCCCA-GACCGCCTCG-CTTAATC-AAGAACGA-TAGTG
Mlentisuturalis   G-AAGGCATTTGCCTA-GACCGTATCC-ATTAATC-AAGAACGA-TAGTG
Mxiaoi            --------------------------------------------------
Myxo.             G-AAGGCATTTGCCTA-GACCGCATCC-ATTAATC-AAGAACGA-TAGTG
Mportucalensis    GGAAGGCATTTGCCCAAGACNGTATCC-ATTAATC-AAGAACGA-AAGTG
Mmusculi          -GAAGGCATCTGTCCA-GACCGTATCC-ATTAATC-AAGAACGA-AAGTG
Mcyprini          -GAAGGCATCTGTCCA-GACCGTATCC-ATTAATC-AAGAACGA-AAGTG
Mpseudodispar     -GAAGGCATCTGTCCA-GACCGTATCC-ATTAATC-AAGAACGA-AAGTG
Mbibullatus       -GAAGGCACTTGTCTA-GACCGTTTCC-ATTAATC-AAGAACGA-AAGTG
Melegans          -GAAGGCACTTGTCTA-GACCGTTTCC-ATTAATC-AAGAACGA-AAGTG
Mpendula          -GAAGGCGTTTGTCTA-GACCGTTTCC-ATTAATC-AAGAACGA-AAGTG
Mpellicides       CGAAGGCGTTTGTCTA-GACCGTTTCC-ATTAATC-AAGAACGA-AAGTG
Mhungaricus       -GAAGGCGTTTGTCTA-GACCGTTTCC-ATTAATC-AAGAACGA-AAGTG
Myxiditruttae     -GAAAGCATTTGCCAA-GTATGTTCCC-TTTAATC-AAGAACGA-AAGTG
Myxidium          -GAAAGCATTTGCCAA-GTATTGTTCC-CTTAATC-AAGAACGA-AAGTG
Ethclone1AM       -GAAGGCATTTGTCCA-GACCGTATCC-ATTAATC-AAGAACGA-TAGTG
Ethclone3AM       -GAAGGCATTTGTCCA-GACCGTATCC-ATTAATC-AAGAACGA-TAGTG
Ethclone2AM       --------------------------------------------------
Mdiaphanus        -GAAGGCATTTGTCCA-GACCGTATCC-ATTAATC-AAGAACGA-TAGTG
M.lieberkuehni    -GAAGGCATCTGCCAA-GACCGTTCCC-GTTGATC-AAGAGCGA-TAGTG
Myxosp.           -GAAGGCAATTGCCAA-GATCGTTTCC-ATTAATC-AAGAACGA-CAGTC
Hennzschokkei     -GAAGGCATTTGCCTA-GACCGTCTCT-ATTAATC-AAGAACGA-TAGAG
Hennsalminicola   -GAAGGCATTTGCCTA-GACCGTCTCT-ATTAATC-AAGAACGA-TAGAG
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     --------------------------------------------------
Mprocerus         --------------------------------------------------
Henneguya         -GAAGGCATCTGTCCA-GACCGTATCC-ATTAATC-AAGAACGA-TAGTG
Hsp.              -GAAGGCATCTGTCCA-GACCGTACC--ATTAATTCAAGAACGA-TAGTG
Hdoori            -GAAGGCATCTGTCCA-GACCGTATCCGATTAATCGAAGAACGAATAGTG
Hennictaluri      -GAAGGCATCTGTCCA-GACCGTATCC-ATTAATC-AAGAACGAA-AGAG
Hennexilis        -GAAGGCATCTGTCCA-GACCGTATCC-ATTAATC-AAGAACGAA-AGAG
Mspinacurvatura   -GAAGGCATCTGTCCA-GACCGTATCC-ATTAATC-AAGAACGA-TAGTG
Michkeulensis     -GAAGGCATCTGTCCA-GACCGTATCC-ATTAATC-AAGAACGA-TAGTG
Mosburni          -GAAGGCATCTGTCCA-GACCGTATCC-ATTGATC-AAGAGCGAA-AGTG
Muvuliferus       -GAAGGCATCTGTCCA-GACCGTATCC-ATTGATC-AAGRGCGAA-AGTG
Ceratomyxa        -GAAGGCATTCATCAA-GAATGTTTTC-ATTAATC-AAGAGCGA-AAGTT
Malgonquinensis   -AAAGGCACTTGTCTA-GACCGTTTCC-ATTAATC-AAGAACGA-AAGTG
Perchclone1AM     ------------------ATCGTTCTTGATTAAT--GGATACGG------
```

Perchclone2AM	-------------------ATCGTTCTTGATTAAT--GGATACGG-----
Perchclone3AM	-------------------ATCGTTCTTGATTAAT--GGATACGG-----

Melipsoides	GGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCC-CACTGT-AA
Mdjragini	GGAGG-TTCGAAGACG---ATCAGATACCGNCCTAGTNCC-CACTGT-AA
Mbramae	GGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCC-CACTGT-AA
Mneurobius	GGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCC-CACTGT-AA
Marcticus	GGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCC-CACTGT-AA
Msandrae	GGAGG-TTCGAAGACG---ATCAGATACCGACCTAGTNCC-CACTGT-AA
Minsidiosus	GGAGG-TTCGAAGACG---AACAGATACCGTCCTAGTTCC-CACTGT-AA
Mcerebralis	G-AGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCC-CACTGT-AA
Mlentisuturalis	GGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCC-CACCGT-AA
Mxiaoi	--
Myxo.	GGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCC-CACCGT-AA
Mportucalensis	GAAGG-TTCCAAGTCG---ATTAGATACCGCCGTAGTTTC-CACTGT-AA
Mmusculi	GGAGG-TTCGAAGACG---ATTAGATACCGTCGTAGTTCC-CACTGT-AA
Mcyprini	GGAGG-TTCGAAGACG---ATTAGATACCGTCGTAGTTCC-CACCGT-AA
Mpseudodispar	GGAGG-TTCGAAGACG---ATTAGATACCGTCGTAGTTCC-CACTGT-AA
Mbibullatus	GGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCC-CACTGT-AA
Melegans	AGAGG-TTCGAAGACG---ATCAGATACCGTCGTAGTTCT-CACCGT-AA
Mpendula	GGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CACTAT-AA
Mpellicides	GGAGG-TTCGAAGACG---ATCAGATNCCGTCCTAGTTCT-CACTAT-AA
Mhungaricus	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CACCGT-AA
Myxiditruttae	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CACCGT-AA
Myxidium	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CACCGT-NA
Ethclone1AM	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CACTGT-AA
Ethclone3AM	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CACTGT-AA
Ethclone2AM	---------------G---ATCAGATACCGTCCTAGTTCT-CACTGT-AA
Mdiaphanus	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CACTGT-AA
M.lieberkuehni	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CACTGT-AA
Myxosp.	CGAGG-TTCGAAGTCG---ATCAGATACCGACTTAGTTCG-GACCGT-AA
Hennzschokkei	GAAGGATC-GAAGAGG---ATCAGATACCCTCGTAGTTTC-CTCCGT-AA
Hennsalminicola	GAAGGATNCGAAGAGG---ATCAGATACCCTCGTAGTTTC-CTCCGTTAA
Ethclone2MA	--
Ethclone3MA	--
Ethclone1MA	--
Myxobprocerus	--
Mprocerus	--
Henneguya	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CACTGT-AA
Hsp.	AGAGG-TTCGAAGACG-GATTCAGATACCGTCCTAGTTCT-CACCGT-AA
Hdoori	AGAGG-TTCGAAGAGACGAGTCAGATACCGTCCTAGTTCT-CACCGT-AA
Hennictaluri	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CTCTGT-AA
Hennexilis	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CTCTGT-AA
Mspinacurvatura	AGAGG-TTCGAAGACG---ATCAGATACCG-CCTAGTTCT-CACTGT-AA
Michkeulensis	AGAGG-TTCGAAGACG---ATCAGATACCGTCCTAGTTCT-CACTGT-AA
Mosburni	CGGGG-ATCGAAGATG---ATCAGATACCATCCTAGTCCG-CACCCT-AA
Muvuliferus	CGGGG-ATCGAAGATG---ATCAGATACCATCCTAGTCCG-CACCCT-AA
Ceratomyxa	GGAGA-ATCGAAGACG---ATCAGATACCGTCCTAGTTCCATACAGT-AA
Malgonquinensis	GGAGG-TTCGAAGACG---ATCAGATACCGTCATAGTTCC-CACCGT-AA
Perchclone1AM	------TCTGGA---------CAAATGCCTTCGCATTT------------
Perchclone2AM	------TCTGGA---------CAAATGCCTTCGCATTT------------
Perchclone3AM	------TCTGGA---------CAAATGCCTTCGCATTT------------

Melipsoides	ACTA--TGC-CGACCCGGGATCAGCAT-GA-AGCNCTATAT--A-TGCTT
Mdjragini	ACTA--TGC-CGACCCGGGATCAGCAT-GA-AGCNCTATAT--A-TGCTT
Mbramae	ACTA--TGC-CGACCCGGGATCAGCAT-GA-AGNTCTATAT--A-TGCTT
Mneurobius	ACTA--TGC-CGACCCGGGATCAGCAT-GA-AGCTCTATAT--A-TGCTT

Marcticus	ACTA--TGC-CGACCCGGGATCAGCAT-GA-AGNTCTATAT--A-TGCTT
Msandrae	ACTA--TGC-CGACCCGGGATCAGCAT-GA-AGNNCTATAT--A-TGCTT
Minsidiosus	ACTA--TGC-CGACCCAGGATCAGCATCGA-AGCTCTATAT--A-TGCTT
Mcerebralis	ACTA--TGC-CGACCCGGGATCAGCAT-GA-AGCTCTTTAT--A-CGCTT
Mlentisuturalis	ACTA--TGC-CGACTCGGGATCAGTTTGGT-GCTATTACCA--A-CGCTC
Mxiaoi	--
Myxo.	ACTA--TGC-CCACTCGGGATCAGTTTGGT-GCTAATACTA--AACGCTC
Mportucalensis	ACTA--TGC-CAACTCGGGATCAGTTTGGT-GTTA-TACCA--A-CGCTC
Mmusculi	ACTA--TGC-CGACTAGGGATCAGCTTGGT-GATATTACAA--G---CAT
Mcyprini	ACTA--TGC-CGACTAGGGATCAGCTTGGT-GATATTACAA--G---CAT
Mpseudodispar	ACTA--TGC-CGACTAGGGATCAGCTTGGT-GATATTACAA--G---CAC
Mbibullatus	ACTA--TGC-CGACCTGGGATCAGTTTGGA-GATATTACAA--G---CTT
Melegans	ACTA--TGC-CGACCTGGGACCAGTTTGG---ATACTACAA--A---CTC
Mpendula	ACTA--TGC-CGACCTGGGATCAGCTTAGT-GAT-TTACAA--G---CTC
Mpellicides	ACTA--TGC-CGACCTGGGATCAGCTTAGT-GAT-TTACAA--G---CTC
Mhungaricus	ACTA--TGC-CGACCTGGGATCAGCTTAGT-GAT-TTGCAA--G---CAC
Myxiditruttae	ACAA--TGC-CAACCCGGGATCAGTTCGGATGATTTTGTT-----GGATC
Myxidium	ACGA--TGC-CAACCCGGGATCAGTTCGGATGATTTTATTT----GGATC
Ethclone1AM	ACTA--TGC-CGACCCGGGATTAGTCCTAT--GCCTTATTTTTACGGCTT
Ethclone3AM	ACTA--TGC-CGACCCGGGATTAGTCCTAT--GCCTTATTTTTACGGCTT
Ethclone2AM	ACTA--TGC-CGACCCGGGATTAGTCCTAT--GCCTTATTTTTACGGCTT
Mdiaphanus	ACTA--TGC-CGACCCGGGATTAGTCCTAT--GCCTTATTGTTACGGCTT
M.lieberkuehni	ACTA--TGC-CAACCCGGGATCAGTTTTGA--GCTAAAT----AACGCTC
Myxosp.	ACTA--TGC-CGACCCGAGATCAGTTTTGA--GC-TAATTA--AACGCTC
Hennzschokkei	ACTA--TGC-CAACCCGGGATGAGTTTAGA--GC-TAATTAT-AACGCTC
Hennsalminicola	ACTCACTGCGCAACCCGGGATGAGTTTAGA--GC-TAATTAT-AACGCTC
Ethclone2MA	--
Ethclone3MA	--
Ethclone1MA	--
Myxobprocerus	--
Mprocerus	--
Henneguya	ACTA--TGC-CGACCCGGGATCAGCTTGGA--GTTATATACTCA-TGCTC
Hsp.	ACTA--TGC-CGACCCGGGATCAGTTTGGA--GCAGTGTATCCA-CGCTC
Hdoori	ACTA--TGC-CGACCCGGGATCAGTTTGGA--GCAGTGTATCCA-CGCTC
Hennictaluri	ACTA--TGC-CGACCCGGGATCAGTTTGGA--GT-ATATTTCCA-CGCTC
Hennexilis	ACTA--TGC-CGACCCGGGATCAGTTTGGA--GTTATATATCCA-CGCTC
Mspinacurvatura	ACTA--TGC-CGACCCGGGATCAGTTTGGA--GCTCTAT-TCCA-TGCTC
Michkeulensis	ACTA--TGC-CGACCCGGGATCAGTTTGGA--GCTCTAT-TCCA-TGCTC
Mosburni	ACTA--TGC-CAACTCGGGATCAGTTTGGA--GCACAGTATCCA-GGCTC
Muvuliferus	ACTA--TGC-CAACTCGGGATCAGTTTGGA--GTACAATTTCCA-AGCTC
Ceratomyxa	ACTA--TGC-CAGCTTGAGATTAGCTCGGT------------AAACGAGC
Malgonquinensis	ACTA--TGC-CGACCTGGGATCAGTTTAGA-GATGTTACAA-----GCTC
Perchclone1AM	--
Perchclone2AM	--
Perchclone3AM	--

Melipsoides	GATGTTGGNCCCCCTGGGAAA--CCTCAAGTTTTTCGG-TTACGGGGAGA
Mdjragini	GATGTTGGACCCCCTGGGAAA--CCTCAAGTTTTTCGG-TTACGGGGAGA
Mbramae	GATGTTGGNCCCCCTGGGAAA--CCTCAAGTTTTTCGG-TTACGGGGAGA
Mneurobius	GATGTTGGTCCCCCTGGGAAA--CCTCAAGTTTTTCGG-TTACGGGGAGA
Marcticus	GATGTTGGNCCCCCTGGGAAA--CCTCAAGTTTTTCGG-TTACGGGGAGA
Msandrae	GATGTTGGACCCCCTGGGAAA--CCTCAAGTTTTTCGG-TTACGGGGAGA
Minsidiosus	GATGTTGGTCCCCCTGGGAAA--CCTCAAGTTTTTCGG-TTACGGGGAGA
Mcerebralis	TATGTTGGTCCCCCTGGGAAA--CCTCAAGTTTTTCGG-TTACGGGGAGA
Mlentisuturalis	GAAGTTGATCCCCCTGGGAAA--CCTGAAGTTTTTCGG-TTACGGGGGGA
Mxiaoi	--
Myxo.	GAAGTTGCTCCCCCTGGGAAA--CCTTAAGTTTTTCGG-TTACGGGGGGA

```
Mportucalensis    TAAGTTGGTCCCCCTGGGAAA--CCTTAAGTTTTTGGG-TTACGGGGGGA
Mmusculi          CAAGTTGGTCTCCAAGGGAAA--CCATAAGTTTTTCGG-TTACGGGGAGA
Mcyprini          CAAGTTGGTCTCCAAGGGAAA--CCATAAGTTTTTCGG-TTACGGGGAGA
Mpseudodispar     CAAGTTGGTCTCCAAGGGAAA--CCATAAGTTTTTCGG-TTACGGGGAGA
Mbibullatus       CAGATTGGTCCCCCTGGGAAA--CTTCAAGTTTTTCGG-TTACGGGGAGA
Melegans          TAGGTTGGTCCCCCTGGGAAA--CCTCAAGTCTTTAGG-TTACGGGGAGA
Mpendula          TAGGTTGGTCCTCCTGGGAAA--CCTCAAGTTTTTCGGGTTACGGGGAGA
Mpellicides       TAGGTTGGTCCTCCTGGGAAA--CCTCAAGTTTTTCGG-TTACGGGGAGA
Mhungaricus       TAAGTTGGTCCCCCTGGGAAA--CCTCAAGTTTTTCGG-TTACGGGGAGA
Myxiditruttae     CAGGTTGGTCCCCCTGG-AAA--CCTTGAGTTTTTAGG-TTCCGGGGGGA
Myxidium          CAGGTTGTTCCCCCTGG-AAA--CCTTGAGTTTT-AGG-TTCCGGGGGNA
Ethclone1AM       G-GGTTGGTCCCCCTGGGAAA--CCTAAAGTTTTTCGG-TTGCGGGGGGA
Ethclone3AM       G-GGTTGGTCCCCCTGGGAAA--CCTAAAGTTTTTCGG-TTGCGGGGGGA
Ethclone2AM       G-GGTTGGTCCCCCTGGGAAA--CCTAAAGTTTTTCGG-TTGCGGGGGGA
Mdiaphanus        G-GGTTGGTCCCCCTGGGAAA--CCTAAAGTTTTTCGG-TTGCGGGGGGA
M.lieberkuehni    GTGGTTGGTCCCCCTGGGAAA--CCTTAAGTTTTTAGG-TTCCGGGGGGA
Myxosp.           GAGGTTGCTCTCCCTGGGAAA--CCTCAAGTTTTTAGG-TTACGGGGGGA
Hennzschokkei     TAGGTTGGTCCCCCTGGGAAA--CCTGAAGTTTTTCGG-TTGCGGGGGGA
Hennsalminicola   TAGGTTGGTCCCCCTGNGAGATACCTGAAGTTTTTCGG-TTGCGGGGGGA
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     --------------------------------------------------
Mprocerus         --------------------------------------------------
Henneguya         GAGGTTGGTCCCCCTGGGAAA--CCTGAAGTTTTTCGG-TTGCGGGGGGA
Hsp.              GAGGTTGGTCCCCCTGGGAAA--CCTAAAGTTTTTCGG-TTGCGGGGGGA
Hdoori            GAGGTTGGTCCCCCTGGGAAA--CCTAA-GTTTTTCGG-TTGCGGGGGGA
Hennictaluri      GAGGTTGGTCCCCCTGGGAAA--CCTGAAGTTTTTCGG-TTGCGGGGGGA
Hennexilis        GAGGTTGGTCCCCCTGGGAAA--CCTGAAGTTTTTCGG-TTGCGGGGGGA
Mspinacurvatura   GGAGTTGGTCCCCCTGGGAAA--CCTAAAGTTTTTCGG-TTGCGGGGGGA
Michkeulensis     GGAGTTGGTCCCCCTGGGAAA--CCTAAAGTTTTTCGG-TTGCGGGGGGA
Mosburni          GAGATTGGTCCCCCTGGGAAA--CCTGAAGTTTTTCGG-TTGCGGGGGGA
Muvuliferus       GAGATTGGTCCCCCTGGGAAA--CCTAAAGTCTTTCGG-TTGCGGGGGGA
Ceratomyxa        CAAGTTGGTCTCTCCGTGAAA----ACAAGCTTTCGGG-TTCCGGGGGGA
Malgonquinensis   TAGATTGGTCCCCCTGGGAAA--CCTAAAGTTTTTCGG-TTACGGGGAGA
Perchclone1AM     ---GTTAGTC--CTTGGCAGG---TCCAAGAATTTCACCTCTCGCTGCCA
Perchclone2AM     ---GTTAGTC--CTTGGCAGG---TCCAAGAATTTCACCTCTCGCTGCCA
Perchclone3AM     ---GTTAGTC--CTTGGCAGG---TCCAAGAATTTCACCTCTCGCTGCCA

Melipsoides       -GTATGG--NCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mdjragini         -GTATGG--NCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mbramae           -GTATGG--NCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mneurobius        -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Marcticus         -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Msandrae          -GTATGG--NCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Minsidiosus       -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mcerebralis       -GTATGG--TCACAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mlentisuturalis   -GTATGG--TTGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mxiaoi            --------------------------------------------------
Myxo.             -GTATGG--TTGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mportucalensis    -GTATGG--TCGCAAGTCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mmusculi          -GTATGG--TCGCAAGGCT-GAAATTT--AAAGGAATTGACGGAAGGGCA
Mcyprini          -GTATGG--TCGCAAGGCT-GAAATTT--AAAGGAATTGACGGAAGGGCA
Mpseudodispar     -GTATGG--TCGCAAGGCT-GAAATTT--AAAGGAATTGACGGAAGGGCA
Mbibullatus       -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Melegans          -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mpendula          AGTATGG--TCGCAAGTCT-GAAACTTTAAAGGAATTGACGGAAGGGCA
```

```
Mpellicides       -GTATGG--TCGCAAGTCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mhungaricus       -GTATGG--TCGCAAGTCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Myxiditruttae     -GTATGG--TTGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Myxidium          -GTATGG--TTGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Ethclone1AM       -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Ethclone3AM       -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Ethclone2AM       -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mdiaphanus        -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
M.lieberkuehni    -GTATGG--TTGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Myxosp.           -GTATGG--TTGCAAAGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Hennzschokkei     -GTATGG--TTGCAAAGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Hennsalminicola   -GTATGGGGTTGCAAAGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     --------------------------------------------------
Mprocerus         --------------------------------------------------
Henneguya         -GTATGG--TCGCAAGGCTGAAACTTT--AAAGGAATTGACGGAAGGGCA
Hsp.              -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGNAGGGCA
Hdoori            -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Hennictaluri      -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Hennexilis        -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Mspinacurvatura   -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Michkeulensis     -GTATGG--TCGCAAGGCTTGAAACTT--AAAGGAATTGACGGAAGGGCA
Mosburni          -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Muvuliferus       -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Ceratomyxa        -GTACGG--TCGCAAGTCT-GAAACTT--AAAGAAATTGACGGAAGGGCA
Malgonquinensis   -GTATGG--TCGCAAGGCT-GAAACTT--AAAGGAATTGACGGAAGGGCA
Perchclone1AM     AATAC-------CAATGCC-----CCC---------------------AA
Perchclone2AM     AATAC-------CAATGCC-----CCC---------------------AA
Perchclone3AM     AATAC-------CAATGCC-----CCC---------------------AA

Melipsoides       CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACNCAACACGGGAAAA
Mdjragini         CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACNCAACACGGGAAAA
Mbramae           CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Mneurobius        CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Marcticus         CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Msandrae          CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Minsidiosus       CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Mcerebralis       CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Mlentisuturalis   CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Mxiaoi            --------------------------------------------------
Myxo.             CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Mportucalensis    CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Mmusculi          CCACC-AGGGGTGGAACCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Mcyprini          CCACC-AGGGGTGGAACCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Mpseudodispar     CCACC-AGGGGTGGAACCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Mbibullatus       CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Melegans          CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Mpendula          CCACC-AGGGTGGAAGCCTGCGGCTTAATT--TGACTTAACACGGGGAAA
Mpellicides       CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCANCACGGGGAAA
Mhungaricus       CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Myxiditruttae     CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Myxidium          CCACC-AGGGGTNNNACCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Ethclone1AM       CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Ethclone3AM       CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Ethclone2AM       CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
```

Mdiaphanus	CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
M.lieberkuehni	CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Myxosp.	CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Hennzschokkei	CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Hennsalminicola	CCACC-AGGAGTGGAG--TGCGGCTTAATT--TGACTCAACACGGGAAAA
Ethclone2MA	--
Ethclone3MA	--
Ethclone1MA	--
Myxobprocerus	--
Mprocerus	--
Henneguya	CCACCCAAGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Hsp.	CCACC-AGGGGTGGAGC-TGCGGCTTAATT--TGACTCAACACGGGAAAA
Hdoori	C-ACC-AGGGGTGGCAT-GGCGGCTTAATT--TGACTCAACACGGGAAAA
Hennictaluri	CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Hennexilis	CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Mspinacurvatura	CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Michkeulensis	CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Mosburni	CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Muvuliferus	CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGAAAA
Ceratomyxa	CCACC-AGGAGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGGCAA
Malgonquinensis	CCACC-AGGGGTGGAGCCTGCGGCTTAATT--TGACTCAACACGGGGAAA
Perchclone1AM	CCGCT-----------CCT----CTTAATCAGTACCCCAATACGG---AA
Perchclone2AM	CCGCT-----------CCT----CTTAATCAGTACCCCAATACGG---AA
Perchclone3AM	CCGCT-----------CCT----CTTAATCAGTACCCCAATACGG---AA

Melipsoides	CTTACCAGGNCCGGACANCAATAGGATAGACA-GACTGATAGANCT--TT
Mdjragini	CTTACCAGGNCCGGACANCAATAGGATAGACA-GACTGATAGANCT--TN
Mbramae	CTTACCAGGNCCGGACATCAATAGGATAGACA-GACTGATAGGCTT--NN
Mneurobius	CTTACCAGGTCCGGACATCAATAGGATAGACA-GACTGATAGATCT--TT
Marcticus	CTTACCAGGTCCGGACATCAATAGGATAGACA-GACTGATAGATCT--TT
Msandrae	CTTACCAGGNCCGGACATCAATAGGATAGACA-GACTGATAGNC----TT
Minsidiosus	CTTACCAGGTCCGGACATCAATAGGATAGACA-GACTGATAGATCT--TT
Mcerebralis	CTTACCAGGTCCGGACATCAATAGGATAGACAAGACTGATAGATCT--TT
Mlentisuturalis	CTCACCCGGTCCGGACATCGAAAGGATAGACA-GATTGATAGATCT--TT
Mxiaoi	--
Myxo.	CTCACCCGGTCCGGACATCGAAAGGATAAACA-GATTAA-AGGTCT--TT
Mportucalensis	CTCACTTGGGCAAGATGTCAAAAGGATGGCCA-GACTGA-AGTTCT--TG
Mmusculi	CTTACATGGTCCAGACATCGATAGGATAAACA-GACTGATAGATCT--TT
Mcyprini	CTTACATGGTCCAGACATCGATAGGATAAACA-GACTGATAGATCT--TT
Mpseudodispar	CTTACATGGTCCAGACATCGATAGGATAAACA-GACTGATAGATCT--TT
Mbibullatus	CTTACCTGGTCCGGACATCGATAGGATAGACA-GACTGATAGATCT--TT
Melegans	CTTACCTGGTCCGGACATCGATAGGATAGACA-GACTGATAGATCT--TT
Mpendula	CTTACTCGGTCAGGACATCGAAAGGATAGACA-GACTGATAGATCT--TT
Mpellicides	CTTACTCGGTCAGGACATCGAAAGGATAGACA-GACTGATAGATCT--TT
Mhungaricus	CTTACCTGGTCCGGACATCGAAAGGATAGACA-GACTGATAGATCT--TT
Myxiditruttae	CTCACCTGGTCCGGACATCGATAGGATTGACA-GACTAATAGATCT--TT
Myxidium	CTCACCTGGTCCGGACATCGATAGGATTGACA-GACTAATAGATCT--TT
Ethclone1AM	CTTACCGGATCAGGACATCAAAAGGATTGTCA-GACCGA-AGATCT--TA
Ethclone3AM	CTTACCGGATCAGGACATCAAAAGGATTGTCA-GACCGA-AGATCT--TA
Ethclone2AM	CTTACCGGATCAGGACATCAAAAGGATTGTCA-GACCGA-AGATCT--TA
Mdiaphanus	CTTACCGGATCAGGACATCAAAAGGATTGTCA-GACCGA-AGATCT--TA
M.lieberkuehni	CTCACCCGGTCCGGACATCGATAGGATCGACA-GACTGATAGATCT--TT
Myxosp.	CTCACCTGGTCCGGACATCGAAAGGATAGACA-GACTGATAGATCT--TT
Hennzschokkei	CTTACTCGGTTCGGACATTGACAGGATAAACA-GTTTGATAGAACT--TT
Hennsalminicola	CTTACTCGGTTCGGACATTGACAGGATAAACA-GTTTGATAGNACT--TT
Ethclone2MA	--
Ethclone3MA	--

```
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          CTTACCTGGTCCGGACATCCGAAGGATACTCA-GACCTAAGATCT----T
Hsp.               CTTACCTGGTCCGGACATCGAAAGGATAAACC-GACCAAAAGATC---GT
Hdoori             CTTACCTGGTCCGGACATCGAAAGGATAAACC-GACCAAAAGATC---GT
Hennictaluri       CTTACCTGGTCCGGACATCAAAAGGATAGACA-GACTGCCAGATC---TT
Hennexilis         CTTACCTGGTCCGGACATCAAAAGGATAGACA-GACTGCCAGATC---TT
Mspinacurvatura    CTTACCTGGTCCGAACATCCGAAGGATACACA-GACTAATAGATC---TT
Michkeulensis      CTTACCTGGTCCGAACATCCGAAGGATACACA-GACTAATAGATC---TT
Mosburni           CTTACCTGGTCCGGACATAAAAAGGAGTTACC-GAGTGCC-GCTCGAATT
Muvuliferus        CTTACCTGGTCCGGACATAAAAAGGAGTTACC-GAGTGCC-GCTCGAATT
Ceratomyxa         CTCACCAGGTCCGGACATTGAAAGGATTGACA-GACTGATAGATCT---T
Malgonquinensis    CTTACCTGGTCCGGACATCGATAGGATAAACA-GATCAATAGCTCT---T
Perchclone1AM      CC-----------AACATCG------------------------------
Perchclone2AM      CC-----------AACATCG------------------------------
Perchclone3AM      CC-----------AACATCG------------------------------

Melipsoides        -CTTGATATGATGGATAGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Mdjragini          -CTTGATATGATGGATAGTGGTGCATGGCC-GTTCTTAGTTTGNGGAGTG
Mbramae            -CTTGATATGATGGATAGTGGGGCATG-CC-CTTTTTAATTCGGGGAG-G
Mneurobius         TCTTGATATGATGGATAGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Marcticus          -CTTGATATGATGGATAGTGGTGCATG-CC-GTT-TTAGTTCGTGG-GTG
Msandrae           ACTTGATATGATGGATAGTG-CGCANN-CC-TTTCNNATTTCGGGGAGAN
Minsidiosus        -CTTGATATGATGGATAGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Mcerebralis        -CTTGATATGATGGATAGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Mlentisuturalis    -CTTGATACGGTGATTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Mxiaoi             --------------------------------------------------
Myxo.              -TTTGATACGGTGATTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Mportucalensis     -CCAGATATGACAAAAGGTGGTGCATGGCC-GTTCTTAGTTCGTGAAGTG
Mmusculi           -TTTGATGCGGTGAGTGGTGGTGCATGGCC-GTTCCTAGTTCGTGGAGTG
Mcyprini           -TTTGATGCGGTGAGTGGTGGTGCATGGCC-GTTCCTAGTTCGTGGAGTG
Mpseudodispar      -TTTGATGCGGTGAGTGGTGGTGCATGGCC-GTTCCTAGTTCGTGGAGTG
Mbibullatus        -CTTGATGCGATGAGTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Melegans           -CTTGATGCGATGAGTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Mpendula           -CTTGATGCGGTGAGTGGTGGTGCATGGCC-GTTCTTAGTTCGTGAAGTG
Mpellicides        -CTTGATGCGGTGAGTGGTGGTGCATGGCC-GTTCTTAGTTCGTGAAGTG
Mhungaricus        -CTTGATGCGGTGAGTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGCG
Myxiditruttae      -CATGATACGGTGGGTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGCG
Myxidium           -CATGATACGGTGGGTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Ethclone1AM        -CATGATCTGGTGACTGGTGGTGCATGGCC-GTTCTTAGTTCGTGAAGTG
Ethclone3AM        -CATGATCTGGTGACTGGTGGTGCATGGCC-GTTCTTAGTTCGTGAAGTG
Ethclone2AM        -CATGATCTGGTGATTGGTGGTGCATGGCC-GTTCTTAGTTCGTGAAGTG
Mdiaphanus         -CATGATCTGGTGATTGGTGGTGCATGGCC-GTTCTTAGTTCGTGAAGTG
M.lieberkuehni     -CGTGATACGGTGTATGGTGGTGCATGGCC-GTTCTTAGTTCGTGAAGTG
Myxosp.            -CTTGATACGTTGGTTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Hennzschokkei      -TTTGATACGGTGAATGGTGGTGCATGGCCCGTTTTTAGTTCGTGGAGTA
Hennsalminicola    -TTTGATACGGTGAATGGTGGTGCATGGCC-GTTTTTAGTTCGTGGAGTA
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          ATTTGATCTGGTGATTGGTGGTGCATGGCC-GTTCTTAGTTCGTGAAGTG
Hsp.               TTTTGATACGATGATTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Hdoori             TTTTGATACGATGATTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Hennictaluri       TCTTGATATGGTGATTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
```

```
Hennexilis         TCTTGATATGGTGATTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Mspinacurvatura    TGTTGATGGGGTGAAAAGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Michkeulensis      TGTTGATGGGTTGAAAAGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Mosburni           TAACGATATTATGAGTAGTGGTGCATGGCC-GTTCTTAGTGCGTGGAGTG
Muvuliferus        TAACGATATTATGAGTAGTGGTGCATGGCC-GTTCTTAGTGCGTGGAGTG
Ceratomyxa         TCATGATACAGTGATTGGTGGTGCATGGCC-GTTCTTAGTTGGTGGAGTG
Malgonquinensis    TTTTGATCCGATGAGTGGTGGTGCATGGCC-GTTCTTAGTTCGTGGAGTG
Perchclone1AM      ---TAAT-TGGCGGTCGGTGTTGCATA---------------TTGAAG--
Perchclone2AM      ---TAAT-TGGCGGTCGGTGTTGCATA---------------TTGAAG--
Perchclone3AM      ---TAAT-TGGCGGTCGGTGTTGCATA---------------TTGAAG--

Melipsoides        ATCTGTCAGGCTAATCCCGGT--AACG-AACGAGATCTTATTCTCCATTT
Mdjragini          ATTTGTCAGGCTAATCCCGGT--AACG-NACGAGANTTTATTTTCCATTT
Mbramae            ATN-GTCAGG-TAATCCCGGT--AACG-AACGAGATNTTATTNTCCATTT
Mneurobius         ATCTGTCAGGCTAATCCCGGT--AACG-AACGAGATCTTATTCTCCATTT
Marcticus          ATCTGTCAGG-TAATCCCGGT--AACGGAACGAGAA-TTATTCTCCATTT
Msandrae           ATCTGTCAGGNANATCCCGGA--ANCG-AACGANATCTTATTCTCCATNA
Minsidiosus        ATCTGTCAGGCTAATCCCGGT--AACG-AACGAGATCTTATTCTCCATTT
Mcerebralis        ATCTGTCAGGCTAATCCCGGT--AACG-AACGAGATCTTATTCTCCATTT
Mlentisuturalis    ATCTGTCAGGCCAATTCCGGT--AACG-AACGAGACCACAATCTTCATTT
Mxiaoi             --------------------------------------------------
Myxo.              ATCTGTCAGGCCTATCCCGGT--AACG-AACGAGACCACAATCTTCATTT
Mportucalensis     ATTTGTCGGGTCGATTCCGAT--AACG-GACGAGACTGCATTCTCCATTT
Mmusculi           ATCTGTCAGGTTTATTCCGGT--AACG-AACGAGACTACAACCTTCATTT
Mcyprini           ATCTGTCAGGTTTATTCCGGT--AACG-AACGAGACTACAACCTTCATTT
Mpseudodispar      ATCTGTCAGGTTTATTCCGGT--AACG-AACGAGACTACAACCTTCATTT
Mbibullatus        ATCTGTCAGGTTTATTCCGGT--AACG-AACGAGACCACATTCTCCATTT
Melegans           ATCTGTCAGGTTAATTCCGGT--AACG-AACGAGACCACAGTCCCCATTT
Mpendula           ATTTGTCAGGTCGATTCCGGT--AACG-GACGAGACCACTGTCTCCATTT
Mpellicides        ATTTGTCAGGTCGATTCCGGT--AACG-GACGAGACCACTGTCTCCATTT
Mhungaricus        ATCTGTCAGGTTTATTCCGGT--AACG-AACGAGACCACCTTCTCCATTT
Myxiditruttae      ATCTGTCAGGTTTATTCCGGT--AACG-AACGAGACCACGTTCTTCATTT
Myxidium           ATCTGTCAGGTTGATTCCGGT--AACG-AACGAGACCATTGTCTTCATTT
Ethclone1AM        ATTTGTCAGGTTTATTCCGGT--AACG-GACGAGATCACAATCTCCATTT
Ethclone3AM        ATTTGTCAGGTTTATTCCGGT--AACG-GACGAGATCACAATCTCCATTT
Ethclone2AM        ATTTGTCAGGTTTATTCCGGT--AACG-GACGAGATCACAATCTCCATTT
Mdiaphanus         ATTTGTCAGGTTAATTCCGGT--AACG-GACGAGATCACAATCTCCATTT
M.lieberkuehni     ATTTGTCAGGTTTATTCCGGT--AACG-AACGAGACCATATTCTCCATTT
Myxosp.            ATCTGTCAGGTTGATTCCGGT--AACG-GACGAGACCATATTCTCCATTT
Hennzschokkei      ATCTGTCAGGCTAACCCCGGT--AACG-AACGAGATCAGCGTCTCCATTT
Hennsalminicola    ATCTGTCAGGCTAACCCCGGT--AACG-AACGAGATCAGCGTCTCCATTT
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          ATTTGTCAGGTTTATTCCGGT--AACG-GACGAGACTGCGTTCTCCATTT
Hsp.               ATCTGTCAGGCTAATCCCGGT--AACG-AACGAGACCACATTCTCCATTT
Hdoori             ATCTGTCAGGCTAATCCCGGT--AACG-AACGAGACCACATTCTCCATTT
Hennictaluri       ATCTGTCAGGCCAATCCCGGT--AACG-AACGAGACCACATTCTCCATTT
Hennexilis         ATCTGTCAGGCCAATTCCGGT--AACG-AACGAGACCACTTTCTCCATTT
Mspinacurvatura    ATCTGTCAGGCCAATTCCGGT--AACG-AACGAGACTACGTTCTCCATTT
Michkeulensis      ATCTGTCAGGCCAATCCCGGT--AACG-AACGAGACTACAGTCTCCATTT
Mosburni           ATCTGTTTCCCTTAT--CGGTTAAACG-CGCGAGATGCCGGTCTTCATTT
Muvuliferus        ATCTGTGTCCCTTAT--CGGATAAACG-CGCGAGATGCCAGTCTTCATTT
Ceratomyxa         ATCTGTCAGGTCTATTCCGGT--AACG-AGCGAGACCACGATCTCTATTT
Malgonquinensis    ATCTGTCAGTTTAATTACGGT--AACG-AACGAGACCACAGTCCCCATTT
```

```
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        -------------------------------------------GATGAGC
Mdjragini          -------------------------------------------GATGAGC
Mbramae            -------------------------------------------GATGAGC
Mneurobius         -------------------------------------------GATGAGC
Marcticus          -------------------------------------------GATGAGC
Msandrae           -------------------------------------------GATGAGC
Minsidiosus        -------------------------------------------GATGAGC
Mcerebralis        -------------------------------------------GATGAGC
Mlentisuturalis    -------------------------------------------GAGAAGC
Mxiaoi             --------------------------------------------------
Myxo.              -------------------------------------------GAGTAGC
Mportucalensis     -------------------------------------------GGTGAGC
Mmusculi           -------------------------------------------AAGAGGC
Mcyprini           -------------------------------------------AAGAGGC
Mpseudodispar      -------------------------------------------AAGAGGC
Mbibullatus        -------------------------------------------AAGGCAT
Melegans           -------------------------------------------AAGAAAC
Mpendula           -------------------------------------------AAGAATC
Mpellicides        -------------------------------------------AAGAATC
Mhungaricus        -------------------------------------------AGGATAC
Myxiditruttae      -------------------------------------------GGGGAAC
Myxidium           -------------------------------------------GGGGAAC
Ethclone1AM        -------------------------------------------GACGAAC
Ethclone3AM        -------------------------------------------GACGAAC
Ethclone2AM        -------------------------------------------GACGAAC
Mdiaphanus         -------------------------------------------GACGAAC
M.lieberkuehni     ACGGAGTCGATGCAGCATCAGCCTGCCAGGGGCAACTCTGTCAGACGAAG
Myxosp.            -------------------------------------------GAGGAA-
Hennzschokkei      --------------------------------------------GGGGTG
Hennsalminicola    --------------------------------------------GGGGTG
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          -------------------------------------------GACGAGC
Hsp.               -------------------------------------------GACGAGC
Hdoori             -------------------------------------------GACGAGC
Hennictaluri       -------------------------------------------GACGAGC
Hennexilis         -------------------------------------------GACGAGC
Mspinacurvatura    -------------------------------------------GACGCGC
Michkeulensis      -------------------------------------------GACGCAC
Mosburni           -------------------------------------------GATGAGT
Muvuliferus        -------------------------------------------GATGAGT
Ceratomyxa         ------------------------------------------------TC
Malgonquinensis    -------------------------------------------GAGAGAT
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        GGAA-GCAGATGGTG-----------------------------------
Mdjragini          GGAA-GCAGATGGTG-----------------------------------
Mbramae            GGAA-GCAGATGGTG-----------------------------------
```

```
Mneurobius       GGAA-GCAGATGGTG-----------------------------------
Marcticus        GGAA-GCAGATGGTG-----------------------------------
Msandrae         GGAA-GCAGATGGTG-----------------------------------
Minsidiosus      GGAA-GCAGATGGTG-----------------------------------
Mcerebralis      GGAA-GAAGATAGTGT----------------------------------
Mlentisuturalis  AGCAGAATTCGA--------------------------------------
Mxiaoi           --------------------------------------------------
Myxo.            AACAGAATTCAA--------------------------------------
Mportucalensis   AAAAGATATTGC--------------------------------------
Mmusculi         AGAA-GCAGGT---------------------------------------
Mcyprini         AAAA-GCAGGT---------------------------------------
Mpseudodispar    AAAA-GCAGGT---------------------------------------
Mbibullatus      GGAA-GTAGGCGGCTGGATTAATACTTTAGGGTATTGATTTGGTTGCTGG
Melegans         GAAA-GTAGAG---------------------------------------
Mpendula         AGTAAGCAAAAGG-------------------------------------
Mpellicides      AGTA-GCAAAAGG-------------------------------------
Mhungaricus      GGTA-GCAGGAGG-------------------------------------
Myxiditruttae    CAG---AGGACAGCTA------TTGTG-----------------------
Myxidium         TAT---AAGAC-----------TTGTG-----------------------
Ethclone1AM      TG----GAGTAAAT----------GCA-----------------------
Ethclone3AM      TG----GAGTAAAT----------GCA-----------------------
Ethclone2AM      TG----GAGTAAAT----------GCA-----------------------
Mdiaphanus       TG----GAGTAAAT----------GTA-----------------------
M.lieberkuehni   TGCGACGATTAAATTGGTTGTTTAGCA-----------------------
Myxosp.          TGCAAAAACTCAGT-----------CA-----------------------
Hennzschokkei    TACAAGAAATCTATCGGTAGTGCTGCATT---------------------
Hennsalminicola  TACAAGAAATGTATCGGTAGTGCTGCATT---------------------
Ethclone2MA      --------------------------------------------------
Ethclone3MA      --------------------------------------------------
Ethclone1MA      --------------------------------------------------
Myxobprocerus    --------------------------------------------------
Mprocerus        --------------------------------------------------
Henneguya        TGAAGTTTGTGCGTTC----------------------------------
Hsp.             CGTAGAAGGCGTTGGC----------------------------------
Hdoori           CGTAGAAGGCGTTGGC----------------------------------
Hennictaluri     CGGAGAAGGCCGTGGT----------------------------------
Hennexilis       CGGAGAAGGCGTTGGT----------------------------------
Mspinacurvatura  CAAAGAACGCACT-------------------------------------
Michkeulensis    TGAAGAATGCAGG-------------------------------------
Mosburni         CAGAGAGGGCGTGGAT----------------------------------
Muvuliferus      CAGAGATGGCGTCGAT----------------------------------
Ceratomyxa       TTTCAGTAGCAT--------------------------------------
Malgonquinensis  GAAAGTAGGCGTCGA-----------------------------------
Perchclone1AM    --------------------------------------------------
Perchclone2AM    --------------------------------------------------
Perchclone3AM    --------------------------------------------------

Melipsoides      ------GCTTGAAAATTGTCT-CG----------------------ATGA
Mdjragini        ------GCTTGAAAATTGTCTTCG----------------------ATGA
Mbramae          ------GCTTGAAAATTGTCT-CG----------------------ATGA
Mneurobius       ------GCTTGAAAATTGTCT-CG----------------------ATGA
Marcticus        ------GCTTGAAAATTGTCT-CG----------------------ATGA
Msandrae         ------GTTTGAAAATTGTCT-CG----------------------NNGA
Minsidiosus      ------GCTTGAAA-TTGTCT-CG----------------------ATGA
Mcerebralis      -----AGCTCGATGATTGTTT-CG----------------------GCGA
Mlentisuturalis  --------CAAACGATTGCCG-----------------------------
Mxiaoi           --------------------------------------------------
```

```
Myxo.              --------CAAGCACTCTCTGAT---------------------------
Mportucalensis     --------CACGTG-TCACCGGTA----------------------ACGG
Mmusculi           --------TTCGCGATTGACTGTG--------------------CTTCG-
Mcyprini           --------TATGCGAGAG---GTG--------------------CTTCGC
Mpseudodispar      --------TTCGCGATTGACTATA--------------------CTT---
Mbibullatus        TGGTAAAATTAGTGATCCATTGTAAATTTAGCAAAGGGAGCAATCTTGAT
Melegans           --------TGTGCAAGAACGGGTA--------------------TTTCG-
Mpendula           --------CTGGTGTGGTACCGC----------------------TTTT-
Mpellicides        --------CTGGTGTGGTACCGC----------------------TTTT-
Mhungaricus        --------CCAG---GAGGCGGT----------------------TTCG-
Myxiditruttae      ---GG--TTGTAGTGTTTTGAATA---------------------AGTGG
Myxidium           ---GT--TTATATTGTTGTTTATC---------------------ATTGA
Ethclone1AM        ---A-------ATAGTCATAATTA---------------------ATTG-
Ethclone3AM        ---A-------ATAGTCATAATTA---------------------ATTG-
Ethclone2AM        ---A-------ATAGTCATAATTA---------------------ATTG-
Mdiaphanus         ---A-------AGCATC-TATGTG---------------------TTTGG
M.lieberkuehni     ---GTACTTGTATTGCTGAATTTCCTTTTTC-------------CATTGA
Myxosp.            ---G-------GGTGTGTTAGTTC------------------------GC
Hennzschokkei      ---GTTTCGACAGTGTCACATTTA----------------------TTGA
Hennsalminicola    ---GTTTCGACAGTGTCACATTTA----------------------TTGA
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          -------GCACACAGTCATTGGCAACGGTGACTGCGTTGTGACCGTATGG
Hsp.               -------TATGAAAGTTTTTCTTCGGGAGAGAGTTTGT-------GGTCA
Hdoori             -------TATGAGTGCTCTC-----GGAGAGAGTTTGT-------GGTCA
Hennictaluri       -------AATGGAAATTTTTGTTTACAAAAGTTTCTGC-------TATCA
Hennexilis         -------ATTGAGGATTTTTGCTTGCAAGGGTCCCCGG-------TGCTA
Mspinacurvatura    --------------------------------------------------
Michkeulensis      --------------------------------------------------
Mosburni           -------CAGTTCAATTTTTGGCAACAAGAGTTGTTCT-------TTTCT
Muvuliferus        -------CAGTTCAATTTTTGGCAACAGAGATTGTACT-------TTTTG
Ceratomyxa         ---------------TTGTCGTTC--------------------------
Malgonquinensis    --------TTCACTCTGCCTCACAGTGGAGCGA------------ATCGG
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        AA-------------------------------------------TTCAA
Mdjragini          AA-------------------------------------------TTCAA
Mbramae            AA-------------------------------------------TTCAA
Mneurobius         AA-------------------------------------------TTCAA
Marcticus          AA-------------------------------------------TTCAA
Msandrae           AA-------------------------------------------TTCAA
Minsidiosus        AA-------------------------------------------TYCAA
Mcerebralis        TT-------------------------------------------CTCAA
Mlentisuturalis    -------------------------------------------------G
Mxiaoi             --------------------------------------------------
Myxo.              -------------------------------------------------G
Mportucalensis     TG-------------------------------------------TATGG
Mmusculi           ------------GTG---------------CTTTC----------TTTCG
Mcyprini           G-----------GTG---------------CCTTG----------TT-CG
Mpseudodispar      ------------GTG---------------TAGTT----------TTTCG
Mbibullatus        GCGAAGATTTATGTGGGGTAATTAGTTTTCCCTTCCATTTAGCAGTTTCT
Melegans           ------------GTA----------------TTTGT---------TTTTG
```

```
Mpendula           ------------GTAG---------------TATC----------TCATT
Mpellicides        ------------GTAG---------------TATC----------TCATT
Mhungaricus        ------------GCCG---------------TTTC----------CC--T
Myxiditruttae      ---------------------------------------------TGAGC
Myxidium           ---------------------------------------------TGAGA
Ethclone1AM        ---------------------------------------------TAAAA
Ethclone3AM        ---------------------------------------------TAAAA
Ethclone2AM        ---------------------------------------------TAAAA
Mdiaphanus         ---------------------------------------------TAAAA
M.lieberkuehni     CTAA----------------------------GCACTGTGTAGCCTCAAA
Myxosp.            ---------------------------------------------TAATA
Hennzschokkei      TAG------------------------------------------TTAGA
Hennsalminicola    TAG------------------------------------------TTATA
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          CTG------------------------------------------CCGGT
Hsp.               ACG------------------------------------------TCGAA
Hdoori             ACG------------------------------------------TCGAA
Hennictaluri       TTG------------------------------------------TTGAA
Hennexilis         ATT------------------------------------------CTGTA
Mspinacurvatura    --------------------------------------------------
Michkeulensis      --------------------------------------------------
Mosburni           GCG------------------------------------------TCGTA
Muvuliferus        GCG------------------------------------------TTGCA
Ceratomyxa         --------------------------------------------------
Malgonquinensis    CG-------------------------------------------CTGTA
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        GTTAT-C-----------ATCGAAGGC-----------------------
Mdjragini          GTTAT-C-----------ATCGAAGGC-----------------------
Mbramae            GTTAT-C-----------ATCGAAGGC-----------------------
Mneurobius         GTTAT-C-----------ATCGAAGGC-----------------------
Marcticus          GTTAN-C-----------ATCGAAGGC-----------------------
Msandrae           GTTAT-CT----------ATNGAAGGC-----------------------
Minsidiosus        GTTAT-C-----------ATCGAAGGC-----------------------
Mcerebralis        GTTATTCT----------ATCGTAGGC-----------------------
Mlentisuturalis    CATGG--------------TAAAA--C-----------------------
Mxiaoi             --------------------------------------------------
Myxo.              GGTGG--------------CAACA--C-----------------------
Mportucalensis     GGTAA--------------AAATAGGC-----------------------
Mmusculi           TGTCT--------------CTGTAAGA-----------------------
Mcyprini           TGTCT--------------CTGTAAGA-----------------------
Mpseudodispar      TGTCT--------------CTTCAAGA-----------------------
Mbibullatus        TACCT--------------CGGTAGGACGCTGTCTTATGGAGAGA-----
Melegans           GATAC--------------TTGTAGGT-----------------------
Mpendula           AGCCT--------------TTATAGGT-----------------------
Mpellicides        AGCCT--------------TTATAGGT-----------------------
Mhungaricus        GGTCT--------------TTGCAGGT-----------------------
Myxiditruttae      AATC--------------ATTGTGAG------------------------
Myxidium           AATCTCG-----------GTTTTAAG------------------------
Ethclone1AM        GATTG-------------ATTGTGA-------------------------
Ethclone3AM        GATTG-------------ATTGTGA-------------------------
```

```
Ethclone2AM       GATTG-------------ATTGTGA-------------------------
Mdiaphanus        CAAAG-------------ATGTAGA-------------------------
M.lieberkuehni    AACTGCATAGTGCG--CTATGGAGAGACAACCGGGTATATCCAAAGCCGG
Myxosp.           TGTTCTG----------TCTGTAGC-------------------------
Hennzschokkei     GGCTGTGTGGGTGTGCTGTTGCCGATGGTAATGT----------------
Hennsalminicola   GGCTGTGTGAGTGTGCTGTTGTTGATGGTTGTAC----------------
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     --------------------------------------------------
Mprocerus         --------------------------------------------------
Henneguya         GGTGGTGGGCGT-----TGTTGTGCGGCT---------------------
Hsp.              GGTTTAATGAGA-----CGGGGAGGTGCC---------------------
Hdoori            GGTTTAATGAGA-----CGGGGAGGTGCC---------------------
Hennictaluri      GGCAT------------CGTATAGTTGCC---------------------
Hennexilis        GGTAC------------TGTGGGGAAGCT---------------------
Mspinacurvatura   -----------------CGTAGGG--------------------------
Michkeulensis     -----------------CGTACGG--------------------------
Mosburni          GGCAATGTCCG------TTTGGTGAGTTT---------------------
Muvuliferus       GGCAATGTCCG------TGTGGTGTGGTT---------------------
Ceratomyxa        -------------------TACTGA-------------------------
Malgonquinensis   GGCAT------------AGTTGTGGAA-----------------------
Perchclone1AM     --------------------------------------------------
Perchclone2AM     --------------------------------------------------
Perchclone3AM     --------------------------------------------------

Melipsoides       ----------------------------AGTGCTTGCGAGTTTATTGT--
Mdjragini         ----------------------------AGTGCTTGCGAGTTTATTGT--
Mbramae           ----------------------------AGTGCTTGCGAGTTTATTGT--
Mneurobius        ----------------------------AGTGCTTGCGAGTTTATTGT--
Marcticus         ----------------------------AGTGCTTGCGAGTTTATTGT--
Msandrae          ----------------------------AGTGCTNGCGAGTTTATTGTG-
Minsidiosus       ----------------------------AGTGTTTTCGAGTTTATTGT--
Mcerebralis       ----------------------------AGTGTTTGTGAATTTAGTGT--
Mlentisuturalis   -----------------------------ATGTCGGTATATTGTTT----
Mxiaoi            --------------------------------------------------
Myxo.             -----------------------------TTATCAG-AGGGTGTTT----
Mportucalensis    -----------------------------AGATTGGGCGCGCAATT----
Mmusculi          ---------------------------AAGAATATGCGAGTTC-------
Mcyprini          ---------------------------A-GAATATGCAAATTC-------
Mpseudodispar     ---------------------------A-GAATATTCAAGTTC-------
Mbibullatus       ----------------------CAACGGGGAATATATAAGCTCGAGGAAG
Melegans          -------------------------------ATA-GCTGGTTAGC-----
Mpendula          ----------------------------AAAAT-ATCAAATTCTG-----
Mpellicides       ----------------------------AAAAT-ATCAAATTCTG-----
Mhungaricus       ----------------------------AAAATTATTGAATTTCA-----
Myxiditruttae     --------------------------------TTTGACTGCT--------
Myxidium          --------------------------------TTTGTGATTT--------
Ethclone1AM       ----------------------------------TATGTATT--------
Ethclone3AM       ----------------------------------TATGTATT--------
Ethclone2AM       ----------------------------------TATGTATT--------
Mdiaphanus        ----------------------------------TG-AAATT--------
M.lieberkuehni    AGGACGTATGGCAATAACAGGTCTGTGATGCCCTTAGATGTTCGGGGCCG
Myxosp.           ----------------------------------TGGTAGTT--------
Hennzschokkei     -------------------------CAACTCGTTAAAAGGTTG-------
Hennsalminicola   -------------------------CAATTGGTTTACTAGTTG-------
Ethclone2MA       --------------------------------------------------
```

```
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     --------------------------------------------------
Mprocerus         --------------------------------------------------
Henneguya         ---------------------------CAAG----GTTACCTTTCGGG--
Hsp.              ---------------------------GAGA---TGTTTGATGGGAAG--
Hdoori            ---------------------------GAGA---TGTTTGATGGGAAG--
Hennictaluri      ---------------------------AAGGGTGTATTGGTTGAGGTG--
Hennexilis        ---------------------------CAGGGGGCATTGGCTGAGATC--
Mspinacurvatura   --------------------------------------------------
Michkeulensis     --------------------------------------------------
Mosburni          ---------------------------AAGAGTGTATCT-CTGTTTCG--
Muvuliferus       ---------------------------GAAAATGTGAC--CTGGCTCG--
Ceratomyxa        --------------------------------------------------
Malgonquinensis   ---------------------------GGAATTTGGTGCAGTGGGGTA--
Perchclone1AM     --------------------------------------------------
Perchclone2AM     --------------------------------------------------
Perchclone3AM     --------------------------------------------------

Melipsoides       ---------TGAAATATAAAGAGTTGCGAGAACGGA-CTTAACCCCAT--
Mdjragini         ---------TGAAATATAAAGAGTTGCGAGAACGGN-CTTAACCCCAT--
Mbramae           ---------TGAAATATAAAGAGTTGCGAGAACGGNTCTTAACCCCAT--
Mneurobius        ---------TGAAATATAAAGAGTTGCGAGAACGGT-CTTAACCCCAT--
Marcticus         ---------TGAAATATAAAGAGTTGCGAGAACGGA-CTTAACCCCAT--
Msandrae          ---------TGAAATATAAAGAGTNGCGAGAACGTT-CTAAACCCCAT--
Minsidiosus       ---------TGAAATATAAAGAGTTGCGAGAACGGT-CTTACCCCCATA-
Mcerebralis       ---------GAAAATACAGTTTGTTGCGAGGACGGG-ATAAAACTCTT--
Mlentisuturalis   ---------------CTTGAGAGGCAGAAACGTACC-TCTGCTGTGA---
Mxiaoi            --------------------------------------------------
Myxo.             ---------------CTTGAGAAGCAGAAAAGCGGC-TTGG--GTCG---
Mportucalensis    ---------------GCTAGAGATTTGGTTTGCANA-CTTGTTTTTGAG-
Mmusculi          ---------------GCAGTGAT----CAGGGTGAT-C-GGGCAAC-CG-
Mcyprini          ---------------TCAGAAAG----CTGGGCAAA-C-GGGCAAC-CG-
Mpseudodispar     ---------------TCAATTGG----TTGGGTTTT-C-AGGCAAC-TG-
Mbibullatus       AGTGGCTATAACAGGTCAGTGATGCCCTTCGATGTT-CAGGGCTGCACG-
Melegans          ---------------TCAGTAGG---CTGTTGCAGG-AGGGGTAACCCG-
Mpendula          ----------------CAGGGAA----AAGTATGAA-T-GGGCAACCAA-
Mpellicides       ----------------CAGGGAA----AAGTATGAA-T-GGGCAACCAA-
Mhungaricus       ----------------T-GGGTG----CGATGCGGT-G-GGGCAACTCG-
Myxiditruttae     ---------------ATACTT------GCGG--------TAGTTGCACC-
Myxidium          ---------------ACAATG------GTGGATGC----CATTTGCTCT-
Ethclone1AM       --------------TGCATTG-------TTGGTAA----AATGTG-----
Ethclone3AM       --------------TGCATTG-------TTGGTAA----AATGTG-----
Ethclone2AM       --------------TACATTG-------TTGGTAA----AATGTG-----
Mdiaphanus        --------------TACGTTG-------TGGGTAA----AGTGTG-----
M.lieberkuehni    CACG-----CGCGCTACAATGGTAACAACAGATAG----AGTCTGGTTC-
Myxosp.           -----------------ACTG-----AATAACTGG----ATTTTT-----
Hennzschokkei     ---------------ATATTGCTTAAGGTGGCTGTT--TAGCTTGCACTC
Hennsalminicola   ---------------GTGTGGCTTAAAGTGGCTGCT--TAGCTTGCACTC
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     --------------------------------------------------
Mprocerus         --------------------------------------------------
Henneguya         ----------GTGCCTTCAGTCGTAAGGATGGCGTCGCATGCTGCT----
Hsp.              ----------GCAAC-----GACTT----GCGGACTACAAGGTAATGAC-
Hdoori            ----------GCAAC-----GACTT----GCGGACTACAAGGTAATGAC-
```

```
Hennictaluri       ----------GCAACATCAAGGCTG----ATGCATT-TGAGGTAAT----
Hennexilis         ----------GCAA-GTCAAGGCTG----GTGCACT-TTGAGTTAT----
Mspinacurvatura    -----------------------TT----G-AAATC----GGTAAA----
Michkeulensis      -----------------------TT----GCGGATC----GGTAAA----
Mosburni           ----------GCAGAGTGTATATTTGAGAGCGCATC--AAGATTGG----
Muvuliferus        ----------CCAG--TTAGCATCGTAGAACGCATC--AAGGCTGG----
Ceratomyxa         -----------------------------GAATAGA--------------
Malgonquinensis    -----------ACTTGCTGTGCCTTTTTTTGACACG--CGGCTCTCCCT-
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        ----------------TCTGGTAGCAAT------------------TTGT
Mdjragini          ----------------TCTGGTAGCAAT------------------TTGT
Mbramae            ----------------TCTGGTAGCAAT------------------TTGT
Mneurobius         ----------------TCTGGTAGCAAT------------------TTGT
Marcticus          ----------------TCTGGTAGCAAT------------------TTGT
Msandrae           ----------------TCCGGNAGCAAT------------------TGGT
Minsidiosus        ----------------TCTGGTAGCAAT------------------TGGT
Mcerebralis        ----------------ACTTGTTGCAAA------------------TTGT
Mlentisuturalis    -----------------TTGCTTCACGG------------------TGGT
Mxiaoi             --------------------------------------------------
Myxo.              -----------------TGAGTGGCAAC------------------ATTT
Mportucalensis     ----------------CTGAATTGAAGG------------------TGAT
Mmusculi           ----------------T-GAACT-CTGTGAT---------------CTGA
Mcyprini           ----------------G-GAGCT-CAGTGAT---------------TTGA
Mpseudodispar      ----------------G-CGACT-CAATCCG---------------TTG-
Mbibullatus        ----------------C-GCGCTACAATGATGACGACAGCAAGTATCTGG
Melegans           ----------------A-ATGTGGCTGT------------------CTGC
Mpendula           ----------------ACCTACT-TTAT------------------CTCT
Mpellicides        ----------------ACCTACT-TTAT------------------CTCT
Mhungaricus        ----------------CTGTGTT-GTAT------------------CT--
Myxiditruttae      -----TATGG-----TGTG-CGTACAG----------------------C
Myxidium           -----TTTGG-----TGTG-CGTACAG----------------------A
Ethclone1AM        ------AAAGA----TATA-ATCATAA----------------------T
Ethclone3AM        ------AAAGA----TATA-ATCATAA----------------------T
Ethclone2AM        ------AAAGA----TATA-ATCATAA----------------------T
Mdiaphanus         ------GAGGA----GACA-AGGA-AA----------------------G
M.lieberkuehni     -----GAAAGAATCAGGTA-ATCATAAATTG------------TTACCGT
Myxosp.            -------------TCTTTT-ATTGTGA----------------------C
Hennzschokkei      CCTTGTACCAAACAGTATACAGTGTAA-----------------------
Hennsalminicola    CCTTGTACCAAACAGTATACAGTGTAA-----------------------
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          --------------GGCAAGCCTTCAGCCA-----------------GAC
Hsp.               ----------TTGCGAGTTCCCTACGGTCG-----------------AAC
Hdoori             ----------TTGCGAGTTCCCTACGGTCG-----------------AAC
Hennictaluri       ----------CTGTGCGCTCCCTCCGGCTT-----------------AGC
Hennexilis         ----------CTCCACAATCCCTCCGGTTT-----------------AAC
Mspinacurvatura    -----------------------ACGGTT------------------A-C
Michkeulensis      -----------------------ACGGTA------------------AGC
Mosburni           ---------------CATTCCCTTTGACGT-----------------TAC
Muvuliferus        ---------------CATTCCCTCTGACGT-----------------TAC
Ceratomyxa         --------------------GAGACAAC---------------------T
```

```
Malgonquinensis     ---------------TTCATCACACAGAGACTG-----------GCCTCG
Perchclone1AM       --------------------------------------------------
Perchclone2AM       --------------------------------------------------
Perchclone3AM       --------------------------------------------------

Melipsoides         ACTAAATGTA----AATTTGTTGGCATAC---CCTTC-------------
Mdjragini           ACTAAATGTA----AATTTGTTGGCATTC---CCTTC-------------
Mbramae             ACTAAATGTA----AATTTGTTGGCATTC---CCTTC-------------
Mneurobius          ACTAAATGTA----AATTTGTTGGCATTC---CCTTC-------------
Marcticus           ACTAAATGTA----AATTTGTTGGCATNC---CCTTC-------------
Msandrae            ACTAAANGNA----AATTGGTGGGCATTC---CCTTC-------------
Minsidiosus         ACTAAATGTA----AATTTGNNGGCATTC---CCTTC-------------
Mcerebralis         ACTACACCTG----AGTTTGTTGGCATTC---CCTTC-------------
Mlentisuturalis     TGCAATA-------GAGGGCACCGATCTC---CATG--------------
Mxiaoi              --------------------------------------------------
Myxo.               CATGGCC-------CANGCTGCTGATCTC---TATG--------------
Mportucalensis      TGTGCTT-------AGC----TTGTTCTC---CCTT--------------
Mmusculi            --TGGAA-------GAA--GTGTATTTTC---TCTT--------------
Mcyprini            --TGGAG-------GA---GTGTATTTTC---TCTT--------------
Mpseudodispar       --TGGAA-------TGC--GGGTATTTTC---TCTT--------------
Mbibullatus         GTTGAAA-------AACTTGGGTAATCTCGAATCGTCATC------GTGA
Melegans            --TGGGT-------CA---GCCAATTCTC---CCTT--------------
Mpendula            TGTTGAA-------GGA--GATTGTTTTC---CCTA--------------
Mpellicides         TGTTGAA-------GGA--GATTGTTTTC---CCTA--------------
Mhungaricus         -GTGAAA-------GGA--TATGGTTTTC---CCTA--------------
Myxiditruttae       AATGTGCGTC--CCTATGGAGAGACAGCCGGATTGTAAG-----------
Myxidium            AATGTATGTC--CCTATGGAGAGACAGCCGGATTGTAAG-----------
Ethclone1AM         GATGAA-ATA--TAGG----GTAAAAACTATATTGAAT------------
Ethclone3AM         GATGAA-ATA--TAGG----GTAAAAACTATATTGAAT------------
Ethclone2AM         GATGAA-ATA--TAGG----GTA---------------------------
Mdiaphanus          GAGAGG-GAG--TGTG----GCAACATGCAACTTCGAA------------
M.lieberkuehni      AATGGG-GAC--TGTGCTTTGTAATTATCGCACACGAAAG------AGGA
Myxosp.             GTTGGA-G------------GCAACTTTGAC---CGAT------------
Hennzschokkei       ACTGTATGCTGTCTCATGGAGAGACGGGTGGATATAATCA------AA--
Hennsalminicola     ACTGTATGCTGTCTCATGGAGAGACGGGTGGATATAATCA------AA--
Ethclone2MA         --------------------------------------------------
Ethclone3MA         --------------------------------------------------
Ethclone1MA         --------------------------------------------------
Myxobprocerus       --------------------------------------------------
Mprocerus           --------------------------------------------------
Henneguya           AGTGCTTCGTTTGGAGTG---------CTGTATCATGGAG-AGACAACGG
Hsp.                AGT-CGTGAATCCGTGAGAGTTCCGTGCTGTATCATGGAGGAGACAACGG
Hdoori              AGT-CGTGAATCCGTGAGAGTTCCGTGCTGTATCATGGAGGAGACA-CGG
Hennictaluri        AGTGCATGT-CTTGCAAGAGTCGTGTATTGTATCATGGAG-AGACAACGG
Hennexilis          AGTGCGTG--CTCGCAAGAGTGG-GTATTGTATCATGGAG-AGACAACGG
Mspinacurvatura     AGTGCGTACGTGTGCAGG---------CAGTAT-ATG-------------
Michkeulensis       AAGTTGTGCGTTTGCAGG---------CAGTAT-ACG-------------
Mosburni            AGAGTAT-TGTTCGCAAGAGCGATGCTTTGTTTCATGGAG-AGACGTCGG
Muvuliferus         AGAGTAT-TGTTCGTAAGAGTGGTGCTTTGT-------------------
Ceratomyxa          AGTTCAAG------------------------------------------
Malgonquinensis     GTTGGTCGCTGTCTCATGGGGAGACAACGAGGTATAANCA----------
Perchclone1AM       --------------------------------------------------
Perchclone2AM       --------------------------------------------------
Perchclone3AM       --------------------------------------------------

Melipsoides         -------------C-GTTATACGCTGTTCTACTTACCAAAGT------GG
Mdjragini           -------------C-GTTATACGCTGTTCTACTTACCAAAGT------GG
```

```
Mbramae            -------------CCGTTATACGCTGTTCTACTTACCAAAGT------GG
Mneurobius         -------------C-GTTATACGCTGTTCTACTTACCAAAGT------GG
Marcticus          -------------C-GTTATACGCTGTNCTACTTACCAAAGT------GG
Msandrae           -------------C-GTAAAACGCTGTTTAACTACCCAAAGT------GG
Minsidiosus        -------------C--TTAATAACTGTTCTACTTRCCAAAGT------GG
Mcerebralis        -------------C-GTTATACGCTGTTCAACTACCCA--GT------TG
Mlentisuturalis    -------------CTGCCA--AGCAGTGCAAGGCTGAGAAGT------TG
Mxiaoi             --------------------------------------------------
Myxo.              -------------TTGCCG--AGCAGTGGGAGACCGAAAGGT------TG
Mportucalensis     -------------TTGTGA--AGTAGTGTGTAATCTCGTTAT------TG
Mmusculi           -------------TTGTCA--AGCAGTCTTG---GGGTAACC------TT
Mcyprini           -------------TTGTCA--AGCAGTCATG---GGGCAACC------TA
Mpseudodispar      -------------TTGTCA--AGCAGTCATT---GGGCAACC------TT
Mbibullatus        TGGGGATTGACCGTTGTAATTATCGGTCATGAAAGAGGAATC------CC
Melegans           -------------TCGTTG--AGCAGTATTT-----GGATTC------TC
Mpendula           -------------CTGTTA--AGCAGATTAG----GGTCTAC------CT
Mpellicides        -------------CTGTTA--AGCAGATTAG----GGTCTAC------CT
Mhungaricus        -------------CCGTTG--TGCAGTGGTG----GGCAAAA------CC
Myxiditruttae      ----------------CCGGAGGAAGCGTGGCAATAACAGG-------TC
Myxidium           ----------------CCGGAGGAAGCGTGGCAATAACAGG-------TC
Ethclone1AM        -----------------TAGAATGAGTATGGAAGT-------------TA
Ethclone3AM        -----------------TAGAATGAGTATGGAAGT-------------TA
Ethclone2AM        --------------------------------------------------
Mdiaphanus         -----------------TGGAAAGGTT---GAATC-------------TA
M.lieberkuehni     A------------TTCCTAGTAAGTGCTCGGAATCAACGAGTGCTGATTG
Myxosp.            -----------------CAGTAGGAGATTAAATTTGG------------A
Hennzschokkei      ----------------CCACAGGACGGCTGGCAAAAACAGG-------TC
Hennsalminicola    ----------------CCACAGGACGGCTGGCAAAAACAGG-------TC
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          AACATATTACAAAATCCGAGG--AAGTGTGGCTATAACAGGT-------C
Hsp.               AAAAATATAAGAAAATCCGAGGAAAGTGTGGCTATAACAGGT-------C
Hdoori             AAAA---TAACCAAATCNA---GAAGTGTG-CTATAACAGGT-------C
Hennictaluri       AAAATATTTTAAAAATCCGAG-GAAGTGTGGCTATAACAGGT-------C
Hennexilis         AATATACTAAAAAAATCCGAG-GAAGTGTGGCTATAACAGGT-------C
Mspinacurvatura    ----------------TTG----AACTGCT--------------------
Michkeulensis      ----------------CTG----AGTTGTT--------------------
Mosburni           AATATA--TNCAAAATCCGAG-AAAGTGGCGCCATAACAGGT-------C
Muvuliferus        --------------------------------------------------
Ceratomyxa         ----------------CTAGGGGAAGCGTGGCAATAACAGGT-------C
Malgonquinensis    --------------AGCTCGAGGAAGAGTGGCTATAACAGGT-------C
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        AGC----------------------------------AGTGTGTCATGGA
Mdjragini          AGC----------------------------------AGTGTGTCATGGA
Mbramae            AGC----------------------------------AGTGTGTCATGGA
Mneurobius         AGC----------------------------------AGTGTGTCATGGA
Marcticus          AGC----------------------------------AGTGTGTCATGGA
Msandrae           ACC----------------------------------AGTGTGTCATGGA
Minsidiosus        AGC----------------------------------AGTGTGTCATGGA
Mcerebralis        AGC----------------------------------AGTGTGTCATGGA
Mlentisuturalis    AAC----------------------------------ACTGTATCATGAA
```

```
Mxiaoi           --------------------------------------------------
Myxo.            AAC----------------------------------ACTGTATCATGAA
Mportucalensis   CAC----------------------------------AGTACACCATGGA
Mmusculi         TGG-----------------------------------CTGACTTATGGA
Mcyprini         TGG-----------------------------------CTGACTTATGGA
Mpseudodispar    TGG-----------------------------------CTGACTTATGGA
Mbibullatus      TAGTATATGTATTTTATTAGAATACATAGACTTAGTCCCTGCCCTTTGTA
Melegans         CGAG--------------------------------TGCTGTCTTATGGG
Mpendula         TA---------------------------------ACGCTGCCTTATGGA
Mpellicides      TA---------------------------------ACGCTGCCTTATGGA
Mhungaricus      TAC--------------------------------ACGCTGCCCTATGGA
Myxiditruttae    TGT----------------------------------GATGCCCTTCGAT
Myxidium         TGT----------------------------------GATGCCCTNCGAT
Ethclone1AM      TAT----------------------------------TTTAC-CTCCAGT
Ethclone3AM      TAT----------------------------------TTTAC-CTCCAGT
Ethclone2AM      --------------------------------------------------
Mdiaphanus       CAT----------------------------------TTTGC-CTCCAGT
M.lieberkuehni   CGT----------------------------------CCCGC-CCTTTGT
Myxosp.          GAT----------------------------------GCTGTACTCCTTT
Hennzschokkei    TGT----------------------------------TATGCCCTTAGAT
Hennsalminicola  TGT----------------------------------TATGCCCTTAGAT
Ethclone2MA      --------------------------------------------------
Ethclone3MA      --------------------------------------------------
Ethclone1MA      --------------------------------------------------
Myxobprocerus    --------------------------------------------------
Mprocerus        --------------------------------------------------
Henneguya        TGT----------------------------------GATGCCCTTAGAT
Hsp.             TGT----------------------------------GATGCCCTTAGAT
Hdoori           TGT----------------------------------GAT-CCCTTAGAT
Hennictaluri     TGT----------------------------------GATGCCCTTAGAT
Hennexilis       TGT----------------------------------GATGCCCTTAGAT
Mspinacurvatura  --T----------------------------------GGTGTC------T
Michkeulensis    --T----------------------------------GGTGTC------T
Mosburni         TGT----------------------------------GATGCCCTTAGAT
Muvuliferus      --------------------------------------------------
Ceratomyxa       TGT----------------------------------GATGCCCTTCGAT
Malgonquinensis  AGT----------------------------------GATGCCCTTCGAT
Perchclone1AM    --------------------------------------------------
Perchclone2AM    --------------------------------------------------
Perchclone3AM    --------------------------------------------------

Melipsoides      GAGACTGT--------------------GAGG------------------
Mdjragini        GAGACTGT--------------------GAGG------------------
Mbramae          GAGACTGT--------------------GAGG------------------
Mneurobius       GAGACTGT--------------------GAGG------------------
Marcticus        GAGACTGT--------------------GAGG------------------
Msandrae         GAGACTGT--------------------GAGG------------------
Minsidiosus      GAGACTGT--------------------GAGGAATATATCCAAGC---TC
Mcerebralis      GAGACTGT--------------------GAGGTATATATCCAAGC---TC
Mlentisuturalis  GAGACAACT------------------GTGTATATT-CAAAGAC----AG
Mxiaoi           --------------------------------------------------
Myxo.            GAGACAACT------------------GTGGATATAACAAAGAC----AG
Mportucalensis   GAGACTGTT------------------GGGTATATC-CAAAGCC----AA
Mmusculi         GGGACTGC---------------------TGGTGTTACAAAACC---AGA
Mcyprini         GGGACTGC---------------------TGGTGTTACAAAACC---AGA
Mpseudodispar    GGGACTGC---------------------TGGTGTTACAAAACC---AGA
Mbibullatus      CACACCGCCCGTCGCTACTACCGAGTGAATGGTGTCATGATGCCTTGGGA
```

```
Melegans           GAGACAAC--------------------GAGGTATATTTAAGCTC---GC
Mpendula           GAGACAAC---------------------AGGTATATAAAAACCT---GA
Mpellicides        GAGACAAC---------------------AGGTATATAAAAACCT---GA
Mhungaricus        GAGACAAC---------------------AGGTATATAAAAGCCT-----
Myxiditruttae      GTTCAGG----------------------CCGCACG--------------
Myxidium           GTCAGGGT---------------------CCGCACGCGCGCTACA-ATGA
Ethclone1AM        -TAAAC----------------------AGTGTATAGT--------TAAC
Ethclone3AM        -TAAAC----------------------AGTGTATAGT--------TAAC
Ethclone2AM        --------------------------------------------------
Mdiaphanus         -CAAAC----------------------ATTGTGTAGT--------TAGC
M.lieberkuehni     ACACACCGCC----CGTCGCTACTACCGAGTGAATGGTGTCATGA-TGCC
Myxosp.            GCAA--------------------------TAAACGGT---------GGC
Hennzschokkei      ATCCGAG---------------------GCGGCACGCGCGCTACA-ATGA
Hennsalminicola    ATCCGAG---------------------GCGGCACGCGCGCTACA-ATGA
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          GTTC-AGG----------------------GCTGCACGCGCGCTACAATG
Hsp.               GNC--AGG----------------------GCTGCACGCGCGCTACAATG
Hdoori             GTTCGAGG----------------------GCTGCACGCGCGCTACAATG
Hennictaluri       GTTC-AGG----------------------GCTGCACGCGCGCTACAATG
Hennexilis         GTTC-AGG----------------------GCTGCACGCGCGCTACAATG
Mspinacurvatura    GTTC-AGG----------------------GCAACCTG---GCTGAAGGA
Michkeulensis      GTTC-AGG----------------------GCAACCTG---GCGGAAGGA
Mosburni           GTTC-AGG----------------------GCTGCACGCGCGCTACAATG
Muvuliferus        --------------------------------------------------
Ceratomyxa         GTTCTGG-----------------------GCTGCACGCGCGCTACAATG
Malgonquinensis    GTTCAGG-----------------------GCTGCACGCGCGCTACAATG
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        --------------------------------------------------
Mdjragini          --------------------------------------------------
Mbramae            --------------------------------------------------
Mneurobius         --------------------------------------------------
Marcticus          --------------------------------------------------
Msandrae           --------------------------------------------------
Minsidiosus        AATGAAGCTAGGCCATAA---CAGGTCTGTGATGCCCTAAGATGTCCTGG
Mcerebralis        AATGAAGCAAGGCCATAA---CAGGTCTGTGATGCCCTAAGATGTCCTGG
Mlentisuturalis    AGGAAG-TG-----------------------------------------
Mxiaoi             --------------------------------------------------
Myxo.              AGGAAG-TG-----------------------------------------
Mportucalensis     ACGAAGCTG-----------------------------------------
Mmusculi           --GGAAGTG-----------------------------------------
Mcyprini           --GGAAGTG-----------------------------------------
Mpseudodispar      --GGAAGTG-----------------------------------------
Mbibullatus        CTGGACGTGGGATGGATT---CTCGGATCTGTTCTACGCTGGGATCAATG
Melegans           --GGAAGAG-----------------------------------------
Mpendula           --GGAAGTGTGGCTATAA---CAGGTCAGTGATGCCCTTCGATGTTCGAG
Mpellicides        --GGAAGTGTGGCTATAA---CAGGTCAGTGATGCCCTTCGATGTTCGAG
Mhungaricus        --------------------------------------------------
Myxiditruttae      --------------------------------------------------
Myxidium           TAACGACAGCGAGAGTCT---GGACTGAAAGGTTCTGGGTAATCTTATGA
Ethclone1AM        TTTTAACTGTGTGCTGTA--------------TCATGGAGAGA-------
```

```
Ethclone3AM       TTTTAACTGTGTGCTGTA--------------TCATGGAGAGA-------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        TTTTAGCTGCATGGTGTA--------------TCATGGAGAGA-------
M.lieberkuehni    TTGTGACCGGACGTCGTA---GAGGATGAAAGTCTTCGAACGATGCTGGA
Myxosp.           GGGAAACTGTCCACTGTC--------------TTATGGAGAGA-------
Hennzschokkei     TAACGACAGC-GAGTTTC---TAGGTTGAAAGACCTGGGTAATCTT-TGA
Hennsalminicola   TAACGACAGCAGAGTTTC---TAGGTTGAAAGACCTGGGTAATCTT-TGA
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     --------------------------------------------------
Mprocerus         --------------------------------------------------
Henneguya         GCAGCGACAGCGAGTGTT---TGAATCGAAAGATTCGGGTAATCTTGTAA
Hsp.              GCGGCGACAGCGAGTGTC---TGGATCGAAAGATTTGGGTAACCTTGTAA
Hdoori            G---CGACAGCGAGTTTT---TGGATCGAAAGATTCGAGTAATCTTGTAA
Hennictaluri      ACTACGACAGCGAGTCTC---TGGATCGAAAGATTCGGGTAATCTTGTAA
Hennexilis        ACTACGACAGCGAGTCTC---TGGATCGAAAGATTCGGGTAATCTTGTAA
Mspinacurvatura   A----GGCAGTGAGAC-------GAT------ACTC------CCTT-TGG
Michkeulensis     A----GACGATAAGGC-------GAT------ACTC------CCTT-TGG
Mosburni          GCAACGACAGCGAGTATC---TGCATCGAAAGATGTGGGTAATCTTGTAA
Muvuliferus       --------------------------------------------------
Ceratomyxa        GCAGCGACAAAAAGCATCACCTGCTCTGAGAAGAGTGGGAAATCTTTAAA
Malgonquinensis   ATAACGTCAGCGAGTGTC---TGCGTCGAAAGACGTGGGTAATCTTT--A
Perchclone1AM     --------------------------------------------------
Perchclone2AM     --------------------------------------------------
Perchclone3AM     --------------------------------------------------

Melipsoides       --------------------------------------------------
Mdjragini         --------------------------------------------------
Mbramae           --------------------------------------------------
Mneurobius        --------------------------------------------------
Marcticus         --------------------------------------------------
Msandrae          --------------------------------------------------
Minsidiosus       GCTGCACGCGCGCTACAATGATGGTGACAGCAAGTTTCTAGGTCGAGAGA
Mcerebralis       GCTGCACGCGCGCTACAATGATGGTGACAGCGAGTTTCTAGGTCGAGAGA
Mlentisuturalis   -----TGGCA--ATAACAGGTCTGTGATGCCCTTAGATGTTCGGGGCTGC
Mxiaoi            --------------------------------------------------
Myxo.             -----TGGCA--ATAACAG-------------------------------
Mportucalensis    -----CGGCA--ATAACAGG------------------------------
Mmusculi          -----TGGCG--ATAACAAG------------------------------
Mcyprini          -----TGGCG--ATAACAGG------------------------------
Mpseudodispar     -----TGGCG--ATAAC---------------------------------
Mbibullatus       TAAAATGGCGCAATTTCGAGGAAGTAAAA---------------------
Melegans          -----TGGCT--ATAAAC--------------------------------
Mpendula          GCAGCACGCGCGCTACAATGATAACAACAACAAGTTTCTGGGTCGAGAGA
Mpellicides       GCAGCACGCGCGCTACAATGATAACAACAACAAGTTTCTGGGTCGAGAGA
Mhungaricus       --------------------------------------------------
Myxiditruttae     --------------------------------------------------
Myxidium          ATCGTTATCGTGATGGGGATTGAGCATTGTAATTGTTGCTCATGAAATAG
Ethclone1AM       -----CAACGGAA-ATA-ATAAAAATC-GAGGAA----------------
Ethclone3AM       -----CAACGGAA-ATA-ATAAAAATC-GAGGAA----------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        -----CAACGGAACATA-ATCAAAATCCGAGGAAGTGTG-GCTATAACAG
M.lieberkuehni    AT---CAATGTAAAATG-GCGCAATTTCGAGGAAGTAAAAGTCGTAACAA
Myxosp.           -----CAACGGTGAATACGTCAAAGACCGAGGACGTGTG-GCGATAACAG
Hennzschokkei     ATCGTTATCGTGATGAGGATTGACGGTTGTAATTTTCCGTCATGAAATAG
Hennsalminicola   ATCGTTATCGTGATGAGGATTGACGGTTGTAATTTTCCGTCATGAAATAG
```

```
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          TCG-TTGCCGTGATGGGGATTGACGTTTGTA---ACTCCTCATGAAAGAG
Hsp.               TCG-CCGCCGTGATGGGGATCGACGTTTGTA--AATACGTCGTGAAAGAG
Hdoori             TCGGCCGCCGTGATGGGGATCGACGTTTGTA--AATACGTCGTGAAAGAG
Hennictaluri       TCG-TAGTCGTGATGGGGATCGACGTTTGTA--ATTACGTCGTGAAAGAG
Hennexilis         TCG-TAGTCGTGATGGGGATCGACGTTTGTA--ATTACGTCGTGAAAGAG
Mspinacurvatura    CTA-----CACAACG--------TATTTATAC-GTTGCATCATGGA-GAG
Michkeulensis      TTA-----CACAACG--------TATTTATAC-GTTGCATCATGGA-GAG
Mosburni           TCG-TTGCCGTGAAGGGGATTGATGTTTGTA--AATACGTCATGAAAGAG
Muvuliferus        --------------------------------------------------
Ceratomyxa         ATCGCTGTCGTGATTGGGATTGAGCCTTGTAATAATTGCTCATGAAATAG
Malgonquinensis    ATCGTTATCGTGATGGGGATTGACCGTTGTAATTGTCGGTCATGAAAGAG
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        --------------------------------------------------
Mdjragini          --------------------------------------------------
Mbramae            --------------------------------------------------
Mneurobius         --------------------------------------------------
Marcticus          --------------------------------------------------
Msandrae           --------------------------------------------------
Minsidiosus        CCCGGGCAATCTTGTAATCACCATCGTGATGGGGATTGACCATTGTAATT
Mcerebralis        CCTGGGCAATCTTGTAATCACCATCGTGATGGGGATTGACCATTGTAATT
Mlentisuturalis    ACGCGCGCTACAATGATGACTACAACAAGCTTCTGGGTCGAGAGACTCGG
Mxiaoi             --------------------------------------------------
Myxo.              --------------------------------------------------
Mportucalensis     --------------------------------------------------
Mmusculi           --------------------------------------------------
Mcyprini           --------------------------------------------------
Mpseudodispar      --------------------------------------------------
Mbibullatus        --------------------------------------------------
Melegans           --------------------------------------------------
Mpendula           CTTGGGTAATCGCTAATTGTTATCGTGATGGGGATTGACGATTGTAATTT
Mpellicides        CTTGGGTAATCGCTAATTGTTATCGTGATGGGGATTGACGATTGTAATTT
Mhungaricus        --------------------------------------------------
Myxiditruttae      --------------------------------------------------
Myxidium           GAATCCCTTGTATACGTGT-CTCACTTAGGACACGTAGAATGCGTCTCTG
Ethclone1AM        --------------------------------------------------
Ethclone3AM        --------------------------------------------------
Ethclone2AM        --------------------------------------------------
Mdiaphanus         GTCTGTGATGCCTAAGATG-TCCTGGAAGGG-------------------
M.lieberkuehni     GGTT----TCCGTAGGTGA-ACCTGCAGAAGGATCAAGCTT---------
Myxosp.            G-------------------------------------------------
Hennzschokkei      GAATTCCTCGTATGTGTACCGTCATTAGCCGTGTACAGAATAAGTCCCTG
Hennsalminicola    GAATTCCTCGTATGTGTAC-GTCATTAGC-GTGTACAGAATAAGTCCCTG
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          GAATCCCTAGTATGTGCGATTCA--TGAGATCCCCAAATTACGTCCCTGC
Hsp.               GAATNCCTANTACGTGCGATTCA-TGAAATCGCGCGGATTTAGTCCCTGC
```

```
Hdoori              GAATCCCTAGTACGTGCGATTCAATGAAATCGCGCGGATTTAGTCCCTGC
Hennictaluri        GAATCCCTAGTACGTGCGATTCA-TGAAATCGCGCGGATTTAGTCCCTGC
Hennexilis          GAATCCCTAGTACGTGCGATTCA-TTAAATCGCGCGGATTTAGTCCCTGC
Mspinacurvatura     ACAGC---GGTATAT---ATTCA---AAAAC-CGAGGA---AGT------
Michkeulensis       ACGGC---GGTATAT---ATTCA---AAAAC-CGAGGA---AGT------
Mosburni            GAATCCCTAGTAGATGCGATTCA-TGAGATTGCATCGATTAAGTCCCTGC
Muvuliferus         --------------------------------------------------
Ceratomyxa          GAATTCCTCGTAAGCGTGAGTCA-CCAACTCATGTTGAATACGTCTCTGC
Malgonquinensis     GAATCCCTAGTATGCACATTTTA-TTAGAATGTGCAGATTGAGTCCCTGC
Perchclone1AM       --------------------------------------------------
Perchclone2AM       --------------------------------------------------
Perchclone3AM       --------------------------------------------------

Melipsoides         --------------------------------------------------
Mdjragini           --------------------------------------------------
Mbramae             --------------------------------------------------
Mneurobius          --------------------------------------------------
Marcticus           --------------------------------------------------
Msandrae            --------------------------------------------------
Minsidiosus         TGGTCATGAAATAGGAATTCCCTTGTAGGCACACTTTATTAGAGTGTGCC
Mcerebralis         TGGTCATGAAATAGGAATTCC-TTGTAGGCACACTTTATTAGAGTGTGCC
Mlentisuturalis     GTAATCAGTAATAGTCATCGTGATGGGGATTGACCGTTGTAATTATCGGC
Mxiaoi              --------------------------------------------------
Myxo.               --------------------------------------------------
Mportucalensis      --------------------------------------------------
Mmusculi            --------------------------------------------------
Mcyprini            --------------------------------------------------
Mpseudodispar       --------------------------------------------------
Mbibullatus         --------------------------------------------------
Melegans            --------------------------------------------------
Mpendula            CGTCATGAAATAGGAATCCCTAGTATGTGTAATTTATTAAATTGCACAGA
Mpellicides         CGTCATGAAATAGGAATCCCTAGTATGTGTAATTTATTAAATTGCACAGA
Mhungaricus         --------------------------------------------------
Myxiditruttae       --------------------------------------------------
Myxidium            CCCTTTGTA-----------------------------------------
Ethclone1AM         --------------------------------------------------
Ethclone3AM         --------------------------------------------------
Ethclone2AM         --------------------------------------------------
Mdiaphanus          --------------------------------------------------
M.lieberkuehni      --------------------------------------------------
Myxosp.             --------------------------------------------------
Hennzschokkei       CCCTTTGTA-----------------------------------------
Hennsalminicola     CCCTTTGTA-----------------------------------------
Ethclone2MA         --------------------------------------------------
Ethclone3MA         --------------------------------------------------
Ethclone1MA         --------------------------------------------------
Myxobprocerus       --------------------------------------------------
Mprocerus           --------------------------------------------------
Henneguya           CCTTTGACACACCCCCGT--------------------------------
Hsp.                CCTTTGTA------------------------------------------
Hdoori              CCTTTGTACACACCGCCCGTCGCTACTACCGAGTGAATGGTGTCATAATG
Hennictaluri        CCTTTGTACACACCGCCCGTCGCTACTACCGAGCGAATGGTGTCATAATA
Hennexilis          CCTTTGTACACACCGCCCGTCGCTACTACCGAGCGAATGGTGTCATAATA
Mspinacurvatura     -----GTA-------------GCTATAACAGG------------------
Michkeulensis       -----GTA-------------GCTATAACAGG------------------
Mosburni            CCTTTGTACACACCGCCCGTCGCTACTACCGAGTGAATAGTGTCATAATG
Muvuliferus         --------------------------------------------------
```

```
Ceratomyxa        CCTTTGTACACACCGCCCGTCGCTAGTACCG-------------------
Malgonquinensis   CCTTTGTACACACCGCCCGTCGCTACTACCGAGTGAATGGTGTCATGATG
Perchclone1AM     --------------------------------------------------
Perchclone2AM     --------------------------------------------------
Perchclone3AM     --------------------------------------------------

Melipsoides       --------------------------------------------------
Mdjragini         --------------------------------------------------
Mbramae           --------------------------------------------------
Mneurobius        --------------------------------------------------
Marcticus         --------------------------------------------------
Msandrae          --------------------------------------------------
Minsidiosus       GAACGAGTCCCTGCCCTCTGTA----------------------------
Mcerebralis       GAACGAGTCCCTGCCCTTTGTA----------------------------
Mlentisuturalis   CATGAAAGAGGAATCCCTAGTATGTGCACGTCATAAGCGTGCGCGGACTG
Mxiaoi            --------------------------------------------------
Myxo.             --------------------------------------------------
Mportucalensis    --------------------------------------------------
Mmusculi          --------------------------------------------------
Mcyprini          --------------------------------------------------
Mpseudodispar     --------------------------------------------------
Mbibullatus       --------------------------------------------------
Melegans          --------------------------------------------------
Mpendula          TTTAGTCCCTGCCCTTTGTACACACCGCCCGTCGCTACTACCGAGTGAAT
Mpellicides       TTTAGTCCCTGCCCTTTGTACACACCGCCCGTCGCTACTACCGAGTGAAT
Mhungaricus       --------------------------------------------------
Myxiditruttae     --------------------------------------------------
Myxidium          --------------------------------------------------
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    --------------------------------------------------
Myxosp.           --------------------------------------------------
Hennzschokkei     --------------------------------------------------
Hennsalminicola   --------------------------------------------------
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     --------------------------------------------------
Mprocerus         --------------------------------------------------
Henneguya         --------------------------------------------------
Hsp.              --------------------------------------------------
Hdoori            CCTTGGGAACGGACGTTG-GCTGGGTCTTGTATCCGGA-CAATGCTGCAA
Hennictaluri      CCTTGGGAGCGGACGTCGCGCTGGG-CCTGTGCTCGGAGCGATGCTGCGA
Hennexilis        CCTTGGGAGCGGACGTCGCGCTGGG-CTTATGCTCGGAGCGATGCTGCGA
Mspinacurvatura   --------------------------------------------------
Michkeulensis     --------------------------------------------------
Mosburni          CCTTGAGAGTGGACGTTTTTCCAG--CGTTCTGTTGGGAAAACGCTACAA
Muvuliferus       --------------------------------------------------
Ceratomyxa        --------------------------------------------------
Malgonquinensis   CGCTGGGACTGGACGTTA-GATGGGTGTAACAGCTCGTCCGACGCTGGGA
Perchclone1AM     --------------------------------------------------
Perchclone2AM     --------------------------------------------------
Perchclone3AM     --------------------------------------------------

Melipsoides       --------------------------------------------------
```

```
Mdjragini          --------------------------------------------------
Mbramae            --------------------------------------------------
Mneurobius         --------------------------------------------------
Marcticus          --------------------------------------------------
Msandrae           --------------------------------------------------
Minsidiosus        --------------------------------------------------
Mcerebralis        --------------------------------------------------
Mlentisuturalis    AGTCCCTGCCCTTTGTACACACCGCCCGTCGCTACTACCGAGTGAATGGT
Mxiaoi             --------------------------------------------------
Myxo.              --------------------------------------------------
Mportucalensis     --------------------------------------------------
Mmusculi           --------------------------------------------------
Mcyprini           --------------------------------------------------
Mpseudodispar      --------------------------------------------------
Mbibullatus        --------------------------------------------------
Melegans           --------------------------------------------------
Mpendula           TATGTCATGATGCTCTGGGACTGGACTTTGAAGGGGCTTAACCGTTTTTT
Mpellicides        TATGTCATGATGCTCTGGGACTGGACTTTGAAGGGGCTTAACCGTTTTTT
Mhungaricus        --------------------------------------------------
Myxiditruttae      --------------------------------------------------
Myxidium           --------------------------------------------------
Ethclone1AM        --------------------------------------------------
Ethclone3AM        --------------------------------------------------
Ethclone2AM        --------------------------------------------------
Mdiaphanus         --------------------------------------------------
M.lieberkuehni     --------------------------------------------------
Myxosp.            --------------------------------------------------
Hennzschokkei      --------------------------------------------------
Hennsalminicola    --------------------------------------------------
Ethclone2MA        --------------------------------------------------
Ethclone3MA        --------------------------------------------------
Ethclone1MA        --------------------------------------------------
Myxobprocerus      --------------------------------------------------
Mprocerus          --------------------------------------------------
Henneguya          --------------------------------------------------
Hsp.               --------------------------------------------------
Hdoori             TCAGCGTAGAATGGCGCAATTTCGAGGAAGTAAAAGTCGTAACAAGGTTT
Hennictaluri       TCAGCGTAGAATGGCGCAATTTCGAGGAAGTAAAAGTCGTAACAAGGTTT
Hennexilis         TCAGCGTAAAATGGCGCAATTTCGAGGAAGTAAAAGTCGTAACAAGGTTT
Mspinacurvatura    --------------------------------------------------
Michkeulensis      --------------------------------------------------
Mosburni           CCAGCGTAGAATGGCGCAATTTCGAGGAAGTAAAAGTCGTAACAAGGTTT
Muvuliferus        --------------------------------------------------
Ceratomyxa         --------------------------------------------------
Malgonquinensis    TCAGCGTAAAATGGCGACATTTCGAGGAAGTAAAAGTCGTAACAAGGTTT
Perchclone1AM      --------------------------------------------------
Perchclone2AM      --------------------------------------------------
Perchclone3AM      --------------------------------------------------

Melipsoides        --------------------------------------------------
Mdjragini          --------------------------------------------------
Mbramae            --------------------------------------------------
Mneurobius         --------------------------------------------------
Marcticus          --------------------------------------------------
Msandrae           --------------------------------------------------
Minsidiosus        --------------------------------------------------
Mcerebralis        --------------------------------------------------
```

```
Mlentisuturalis  ATCGTGATGCCTTGGGACTGGACGCCGTGCGAGCTTCGGTTCGCAATGGC
Mxiaoi           --------------------------------------------------
Myxo.            --------------------------------------------------
Mportucalensis   --------------------------------------------------
Mmusculi         --------------------------------------------------
Mcyprini         --------------------------------------------------
Mpseudodispar    --------------------------------------------------
Mbibullatus      --------------------------------------------------
Melegans         --------------------------------------------------
Mpendula         CGAAGCTAGAATCAGCGTAAAATGGCGCAATTTCGAGGAAGTAAAAGTCG
Mpellicides      CGAAGCTAGAATCAGCGTAAAATGGCGCAATTTCGAGGAAGTAAAAGTCG
Mhungaricus      --------------------------------------------------
Myxiditruttae    --------------------------------------------------
Myxidium         --------------------------------------------------
Ethclone1AM      --------------------------------------------------
Ethclone3AM      --------------------------------------------------
Ethclone2AM      --------------------------------------------------
Mdiaphanus       --------------------------------------------------
M.lieberkuehni   --------------------------------------------------
Myxosp.          --------------------------------------------------
Hennzschokkei    --------------------------------------------------
Hennsalminicola  --------------------------------------------------
Ethclone2MA      --------------------------------------------------
Ethclone3MA      --------------------------------------------------
Ethclone1MA      --------------------------------------------------
Myxobprocerus    --------------------------------------------------
Mprocerus        --------------------------------------------------
Henneguya        --------------------------------------------------
Hsp.             --------------------------------------------------
Hdoori           CCGTAGGTGAACCTGCGAAG------------------------------
Hennictaluri     CCGTAGGTGAACCTGCGGAAGGATC-------------------------
Hennexilis       CCGTAGGTGAACCTGCGGAAGGATC-------------------------
Mspinacurvatura  --------------------------------------------------
Michkeulensis    --------------------------------------------------
Mosburni         CCGT----------------------------------------------
Muvuliferus      --------------------------------------------------
Ceratomyxa       --------------------------------------------------
Malgonquinensis  CCGT----------------------------------------------
Perchclone1AM    --------------------------------------------------
Perchclone2AM    --------------------------------------------------
Perchclone3AM    --------------------------------------------------

Melipsoides      --------------------------------------------------
Mdjragini        --------------------------------------------------
Mbramae          --------------------------------------------------
Mneurobius       --------------------------------------------------
Marcticus        --------------------------------------------------
Msandrae         --------------------------------------------------
Minsidiosus      --------------------------------------------------
Mcerebralis      --------------------------------------------------
Mlentisuturalis  GCCGGGATCAATGTAAAACGGTGCAATTTCGAGGAAGTAAAAGTCGTAAC
Mxiaoi           --------------------------------------------------
Myxo.            --------------------------------------------------
Mportucalensis   --------------------------------------------------
Mmusculi         --------------------------------------------------
Mcyprini         --------------------------------------------------
Mpseudodispar    --------------------------------------------------
```

```
Mbibullatus       --------------------------------------------------
Melegans          --------------------------------------------------
Mpendula          TAACAAGGTTTCCG------------------------------------
Mpellicides       TAACAAGGTTTCCGT-----------------------------------
Mhungaricus       --------------------------------------------------
Myxiditruttae     --------------------------------------------------
Myxidium          --------------------------------------------------
Ethclone1AM       --------------------------------------------------
Ethclone3AM       --------------------------------------------------
Ethclone2AM       --------------------------------------------------
Mdiaphanus        --------------------------------------------------
M.lieberkuehni    --------------------------------------------------
Myxosp.           --------------------------------------------------
Hennzschokkei     --------------------------------------------------
Hennsalminicola   --------------------------------------------------
Ethclone2MA       --------------------------------------------------
Ethclone3MA       --------------------------------------------------
Ethclone1MA       --------------------------------------------------
Myxobprocerus     --------------------------------------------------
Mprocerus         --------------------------------------------------
Henneguya         --------------------------------------------------
Hsp.              --------------------------------------------------
Hdoori            --------------------------------------------------
Hennictaluri      --------------------------------------------------
Hennexilis        --------------------------------------------------
Mspinacurvatura   --------------------------------------------------
Michkeulensis     --------------------------------------------------
Mosburni          --------------------------------------------------
Muvuliferus       --------------------------------------------------
Ceratomyxa        --------------------------------------------------
Malgonquinensis   --------------------------------------------------
Perchclone1AM     --------------------------------------------------
Perchclone2AM     --------------------------------------------------
Perchclone3AM     --------------------------------------------------

Melipsoides       ----------------------------
Mdjragini         ----------------------------
Mbramae           ----------------------------
Mneurobius        ----------------------------
Marcticus         ----------------------------
Msandrae          ----------------------------
Minsidiosus       ----------------------------
Mcerebralis       ----------------------------
Mlentisuturalis   AAGGTTTCCGTAGGTGAACCAGCGGAAG
Mxiaoi            ----------------------------
Myxo.             ----------------------------
Mportucalensis    ----------------------------
Mmusculi          ----------------------------
Mcyprini          ----------------------------
Mpseudodispar     ----------------------------
Mbibullatus       ----------------------------
Melegans          ----------------------------
Mpendula          ----------------------------
Mpellicides       ----------------------------
Mhungaricus       ----------------------------
Myxiditruttae     ----------------------------
Myxidium          ----------------------------
```

```
Ethclone1AM       ----------------------------
Ethclone3AM       ----------------------------
Ethclone2AM       ----------------------------
Mdiaphanus        ----------------------------
M.lieberkuehni    ----------------------------
Myxosp.           ----------------------------
Hennzschokkei     ----------------------------
Hennsalminicola   ----------------------------
Ethclone2MA       ----------------------------
Ethclone3MA       ----------------------------
Ethclone1MA       ----------------------------
Myxobprocerus     ----------------------------
Mprocerus         ----------------------------
Henneguya         ----------------------------
Hsp.              ----------------------------
Hdoori            ----------------------------
Hennictaluri      ----------------------------
Hennexilis        ----------------------------
Mspinacurvatura   ----------------------------
Michkeulensis     ----------------------------
Mosburni          ----------------------------
Muvuliferus       ----------------------------
Ceratomyxa        ----------------------------
Malgonquinensis   ----------------------------
Perchclone1AM     ----------------------------
Perchclone2AM     ----------------------------
Perchclone3AM     ----------------------------
;
end;
```

Letters of Permission for Articles

15 January 2004

Our ref: HW/ MR/ JAN 04 J165

Dr Russell H Easy
National Research Council
St. Mary's University

Dear Dr Easy,

CLADISTICS, Vol 15, 1999, pp 9-24, Siddall et al: "Long-branch abstractions...", 1 figure only

As per your letter dated 11 January 2004, we hereby grant you permission to reprint the aforementioned material at no charge **in your thesis** subject to the following conditions:

1. If any part of the material to be used (for example, figures) has appeared in our publication with credit or acknowledgement to another source, permission must also be sought from that source. If such permission is not obtained then that material may not be included in your publication/copies.

2. Suitable acknowledgment to the source must be made, either as a footnote or in a reference list at the end of your publication, as follows:

   "Reprinted from Publication title, Vol number, Author(s), Title of article, Pages No., Copyright (Year), with permission from Elsevier".

3. Reproduction of this material is confined to the purpose for which permission is hereby given.

4. This permission is granted for non-exclusive world **English** rights only. For other languages please reapply separately for each one required. Permission excludes use in an electronic form. Should you have a specific electronic project in mind please reapply for permission.

5. This includes permission for the National Library of Canada to supply single copies, on demand, of the complete thesis. Should your thesis be published commercially, please reapply for permission.

Yours sincerely

Helen Wilson
Rights Manager

Gerald W. Esch, Editor

Journal of Parasitology

Dear Mr. Esch. I am writing for permission to reproduce an illustration from a research paper published in the Journal of Parasitology. The illustration is entitled "A summary of life cycles of myxozoans" and is from the following paper;

Kent M.L., J. Khattra, R.P. Hedrick, and R. H. Devlin. 2000. *Tetracapsula renicola* N. sp. (Myxozoa:saccosporidae); The PKX Myxozoan-The cause of proliferative kidney disease of salmonid fishes. Journal of Parasitology pp. 103-111.
(Kent et al., 2000).

I would like to reproduce the figure for my Masters Thesis. The title of my thesis is

TAXONOMY OF SELECTED SPECIES OF *MYXOBOLUS* (MYXOZOA) FROM FRESHWATER FISHES IN CANADA; APPLICATIONS OF LIGHT MICROSCOPY AND MOLECULAR METHODS

My graduate work is being completed at St. Mary's University, Halifax, Nova Scotia, Canada.

Thank you for your attention to this matter.

Sincerely,

Russell H. Easy

Hi Russell,
Permission is of course granted. Please include reference to JP as the source.
GWE

You may reproduce FWS images and printed material as long as you credit it.

Thanks.

Anne

Anne Post Roy
U.S. Fish and Wildlife Service
National Conservation Training Center

on 03/12/2004 07:49 AM ----

To: Anne

cc:
Subject: New message

Regards,

Customer Service Center - Tier II
U.S. Fish and Wildlife Service

If you have any further questions, you may prefer to contact us by telephone,
we encourage you to call our Customer Service Center at 1-800-344-WILD, Monday through Friday from 8:00 am to 8:00 pm eastern time.

Let us know how we are doing. Please send us a message by visiting...
http://www.fws.gov/duspit/letusknow.htm

Email submitted from Contact Us form received: 3/11/2004 11:39:51 MT
Message ID: FACB58B6-5FF8-43DA-AD47B1BEE379D047

From:
First Name: Russell
Last Name: Easy'
State:
Country: CA

Greetings. I am looking for the individual from whom I can obtain permission to reprint a figure from a scientific article. I was informed
that the article is the copyright permission of the US Fish and Wildlfie
Service. The illustration is entitled "Biphasic life cycle of a myxozoan"
and is from the following;

Wolf K. and M.E. Markiw. 1984. Biology contravenes taxonomy in the Myxozoa:
New discoveries show alternation of invertebrate and vertebrate hosts. Science 225:1449-1452.

I would like to reproduce the figure for my Masters Thesis.

Thank you for your attention to this matter.

Sincerely,

Russell H. Easy Biochemistry/Molecular Biology National Research Council