4.2.1 Branchiomycosis

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A. Etiological Agent

Branchiomycosis is caused by two oomycytes, *Branchiomyces sanguinis* and *B. demingrans*. The taxonomy of the oomyctes is in flux, but they are currently in the Kingdom Chromista, a diverse group that includes diatoms, brown algae, and other water molds including *Saprolegnia* spp.

Kingdom	Chromista
Phylum	Oomycota
Class	Oomycetes
Order	Saprolegniales
Family	(not assigned)
Genus	*Branchiomyces*

The species *B. sanguinis* and *B. demingrans* have been differentiated based on differences in hyphae and spore diameter and on the location of hyphae within fish gills. The *B. sanguinus* species has hyphae that are 8-30 µm in diameter, spores that are 5-9 µm in diameter, and it is found only in the blood vessels of the gills. The other species, *B. demingrans*, is found in gill tissues outside of blood vessels, and has spores larger in diameter (12-17 µm) than those of *B. sanguinis*. It is possible that there is actually just one species and that its morphology is different in blood vessels than it is in tissues. The relationship between species and location in gill tissues has been complicated in channel catfish, where hyphae (presumably *B. sanguinis*) have been seen exiting blood vessels into the gill parenchyma. There is a report of simultaneous infection by both *Branchiomyces* spp. occurring in tench that could also be interpreted as a single *Branchiomyces* sp. growing in two locations. There is no DNA sequence available for *Branchiomyces* spp. so the relationship between the two species remains ambiguous.

B. Known Geographical Range and Host Species of the Disease

1. Geographical Range

Branchiomycosis has been reported from Europe, Asia, the Middle East, Australia, and from North America including at least 10 states scattered across the eastern half of North America. Given that sensitive host species are globally distributed and frequently moved in commerce, it seems likely that *Branchiomyces* spp. are globally distributed in regions where summer water temperatures are in the range optimal for Branchiomycosis disease (above 20°C).

2. **Host Species**
   Branchiomycosis has been reported in a broad taxonomic range of fish species including anguillid eels (American eel *Anguilla rostrata*, European eel *A. anguilla*, Japanese eel *A. japonica*), cyprinids (common carp *Cyprinus carpio*, tench *Tinca tinca*, Indian carps), catfish (European catfish *Siluris glanis*, black bullhead *Ameriurus melas*), centrarchids (smallmouth bass *Micropterus dolomieu*, largemouth bass *M. salmoides*, pumpkinseed *Lepomis gibbosus* , bluegill *L. macrochirus*), salmonids (rainbow trout *Oncorhynchus mykiss* , brown trout *Salmo trutta*), cichlids (tilapia *Oreochromis niloticus, O.mossambicus, O. aureus*), Northern pike *Esox lucius*, European perch *Perca fluviatilis*, striped bass *Morone saxatilis*, burbot *Lota lota*, three-spined stickleback *Gasterosteus aculeatus*, and guppies *Poecuilia reticulate.* Given this broad host range, it is likely that many more species of freshwater fish are susceptible to *branchiomycosis*.

C. Epizootiology

Branchiomyces sanguinis and *B. demingrans* have been reported only within the gill tissue of freshwater fish. Both species produce spores that are shed from necrotic gill tissue and probably infect new hosts through a water-borne route. Mortality may be very high when conditions favor development of the disease. Branchiomycosis is most commonly associated with temperatures above 20°C. There is a strong association between outbreaks of the disease and poor water quality, especially high ammonia levels, high organic loads, and dense plankton blooms. In wild fish populations, eutrophication is thought to be a significant factor predisposing fish to the disease.

Prevention of branchiomycosis is facilitated by maintaining good water quality for susceptible farmed and wild fish, especially in systems with susceptible species at temperatures above 20°C. In farmed populations, dead fish should be removed to reduce the number of spores released into the water. There is no evidence that chemotherapeutant baths are effective in treating branchiomycosis. Given that the oomycete is systemic (not on the surface as in saprolegniosis) it is unlikely that baths of copper ions, formalin, peroxide, permanganate, or other surface acting compounds, could penetrate into the tissues where the hyphae are present without causing severe damage to the gills and skin.

D. Disease Signs

1. **Behavioral Changes Associated with the Disease**
   Fish with branchiomycosis may swim listlessly and exhibit signs consistent with oxygen deprivation or osmoregulatory distress**.**

2. **External Gross Signs**
   Fish with severe infections will have typical “gill rot” lesions (Figures 1 and 2). The lesions may be similar to those associated with columnaris disease or other gill infections.

Figure 1. Discoloration of gill filaments in a largemouth bass with branchiomycosis. Pale filaments are those in which the gill vasculature has been blocked or damaged by *Branchiomyces* sp. resulting in greatly reduced numbers of erythrocytes in gill lamellae. Photo by Andrew Goodwin.

Figure 2. A largemouth bass with branchiomycosis. In this fish, there is multifocal necrosis of gill filaments producing a notched appearance of the gill margin. Photo by Andrew Goodwin.

3. **Internal Gross Signs**
   None

4. **Histopathological Changes**
   Using special stains for fungi (periodic acid Schiff's (PAS) or silver stains), oomycete hyphae and spores can be easily seen in the gill vasculature and in extravascular gill tissues (Figures 3 and 4). There is little host response to hyphae within blood vessels, but extravascular hyphae provoke an inflammatory granulomatous response. Necrosis of filament tips occurs distal to regions where the gill vasculature has been damaged or blocked.

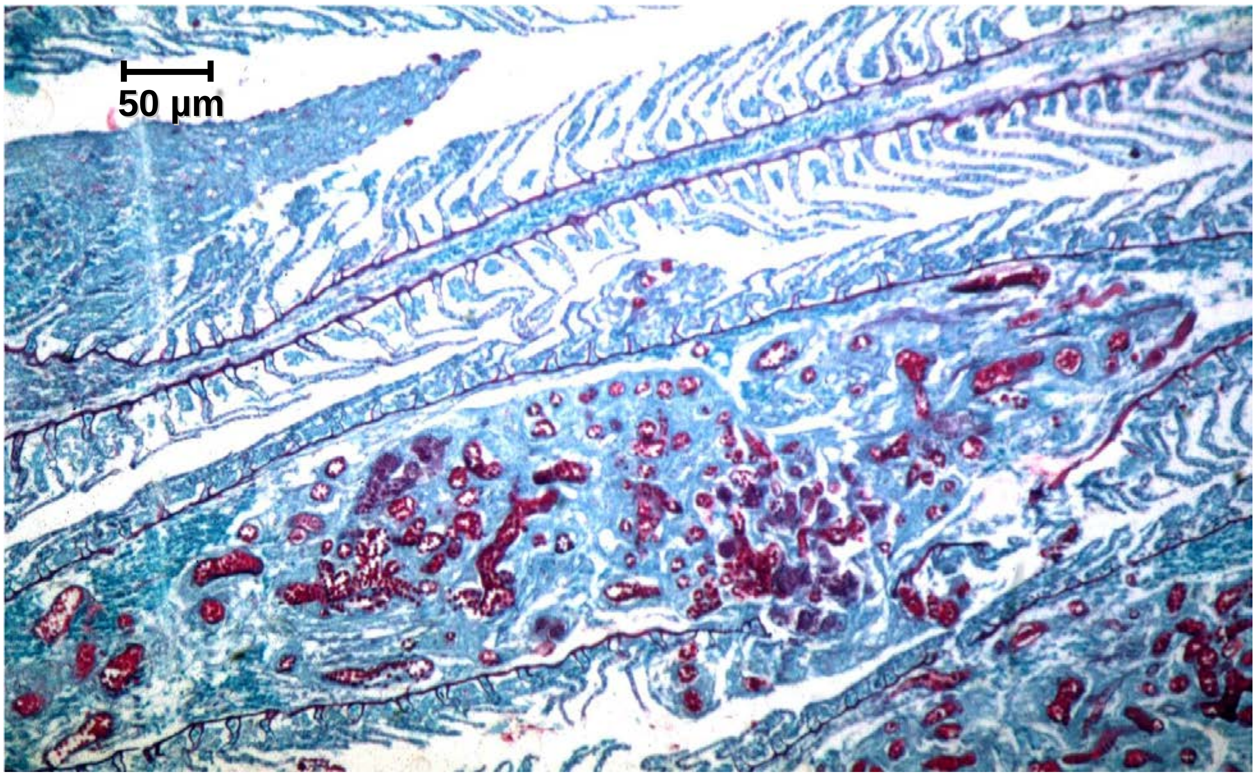

Figure 3. A histological section from the gill of a pumkinseed with branchiomycosis. In this PAS-stained paraffin section, hyphae and spores stain red. Photo by Fred Meyer.

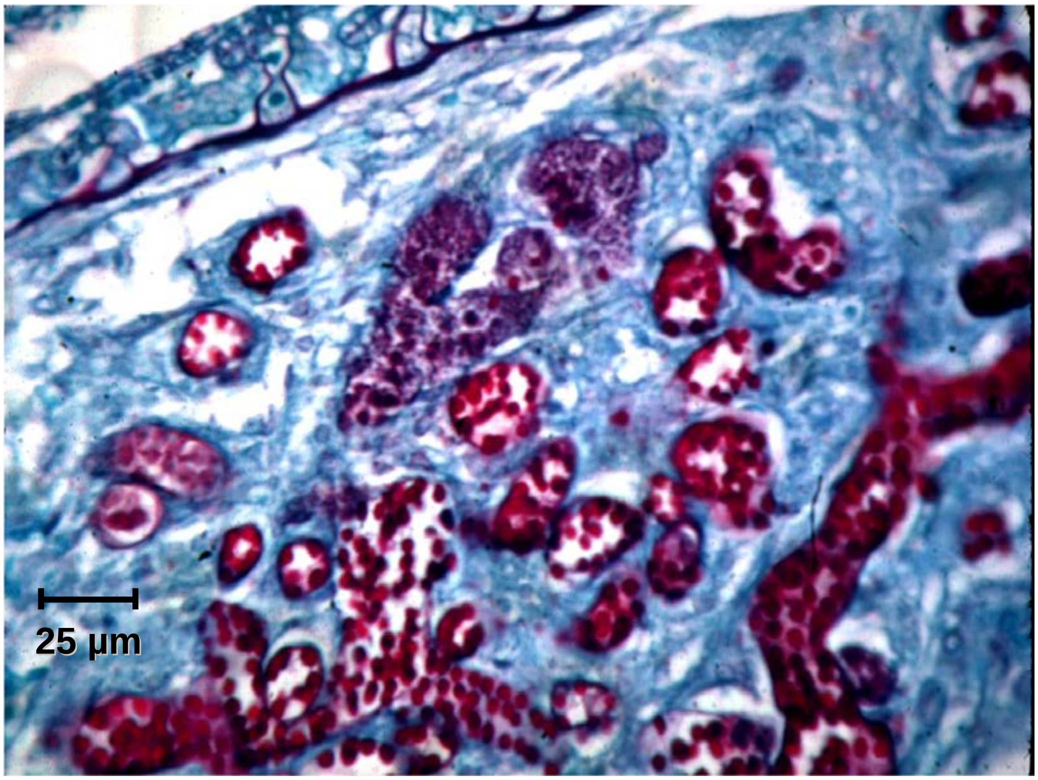

Figure 4. A higher-magnification view of the same section shown in Figure 3. Spores can clearly be seen within hyphae growing in the central sinus of the fish gill. Photo by Fred Meyer.

E. Disease Diagnostic Procedures

1. Presumptive Diagnosis

Presumptive diagnosis of branchiomycosis is based on gross clinical signs of typical "gill rot" lesions (Figures 1 and 2).

2. Confirmatory Diagnosis

Confirmatory diagnosis is based on the detection of non-septate branching oomycetes with spores within gill vasculature or within other gill tissues examined microscopically in wet mounts (Figures 5-8). In cases where the position or identity of the oomycetes are ambiguous in wet mounts, histological sections and special stains (PAS or silver) are needed. *Branchiomyces* spp. do grow well in culture, but there are no serological or molecular methods to confirm the identity of isolates. The presence of the oomycetes within the gill tissue is a critical part of the diagnosis of branchiomycosis so culture methods are not useful.

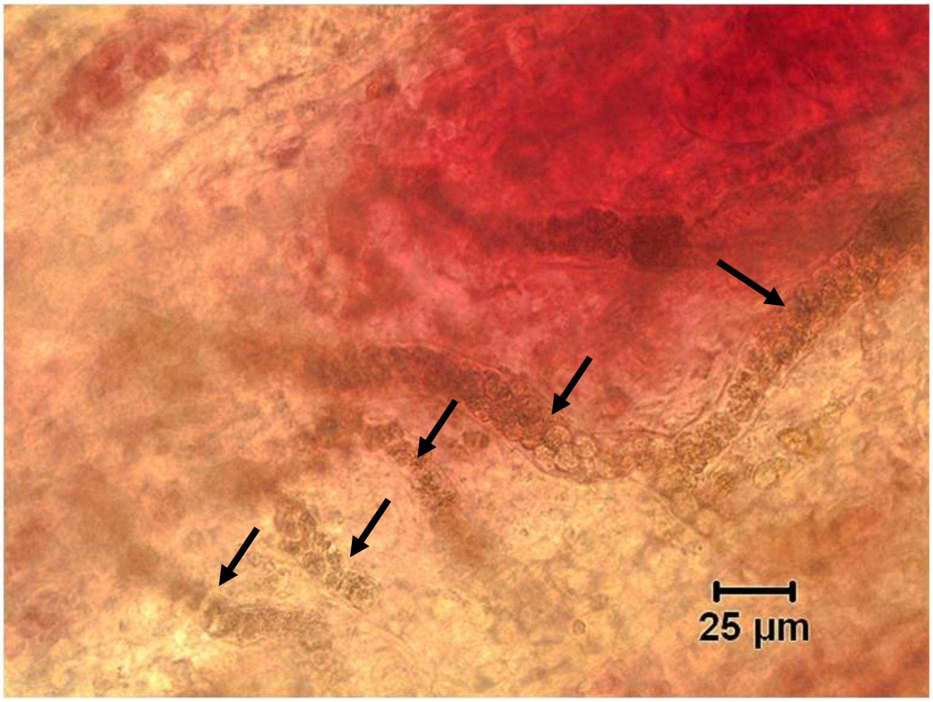

Figure 5. Branching hyphae of *Branchiomyces* sp. seen in wet mounts from a largemouth bass with branchiomycosis. Arrows point to hyphae. Photo by Andrew Goodwin.

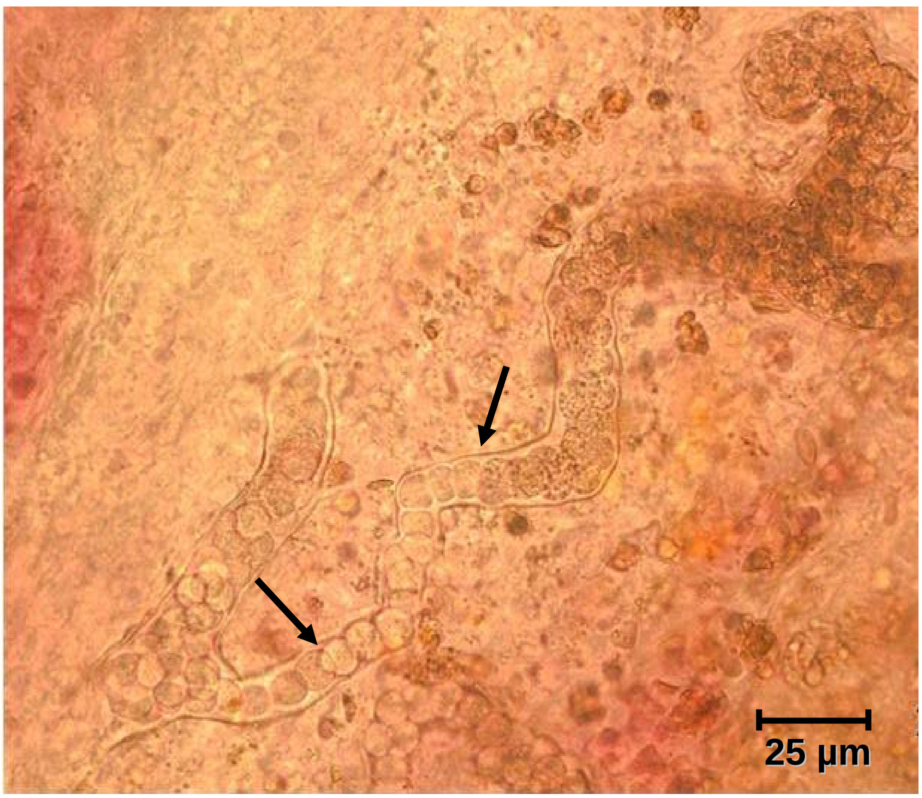

Figure 6. Branching hyphae of *Branchiomyces* sp. seen in wet mounts from a largemouth bass with branchiomycosis. The lighting in this picture more clearly reveals spores (arrows). Photo by Andrew Goodwin.

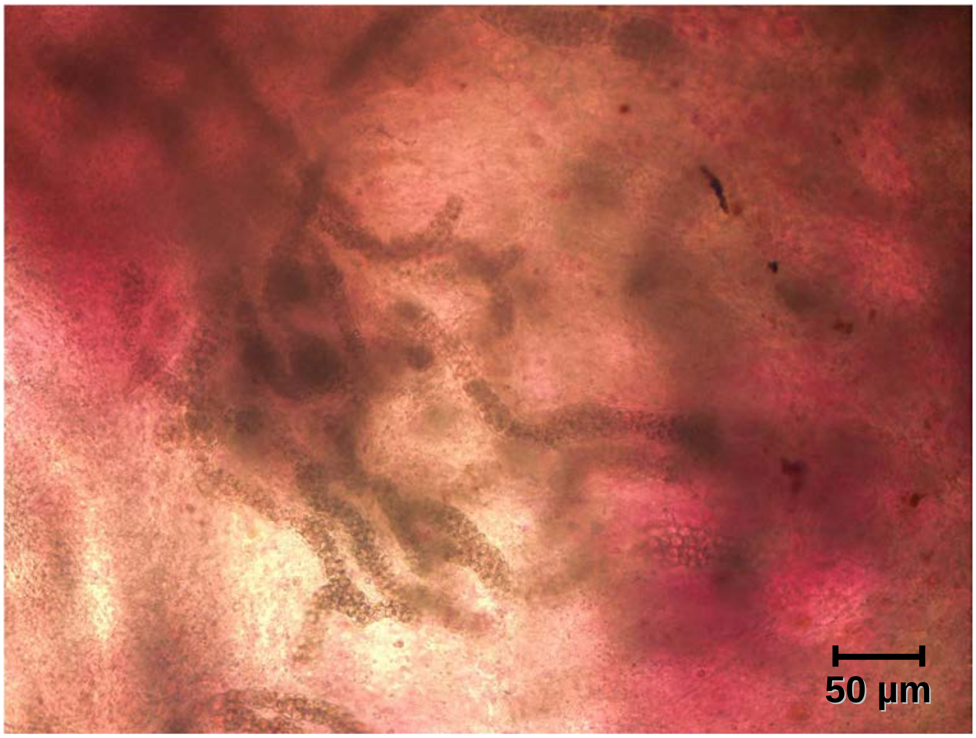

Figure 7. Branching hyphae of *Branchiomyces* sp. seen in wet mounts from a largemouth bass with branchiomycosis. Photo by Andrew Goodwin.

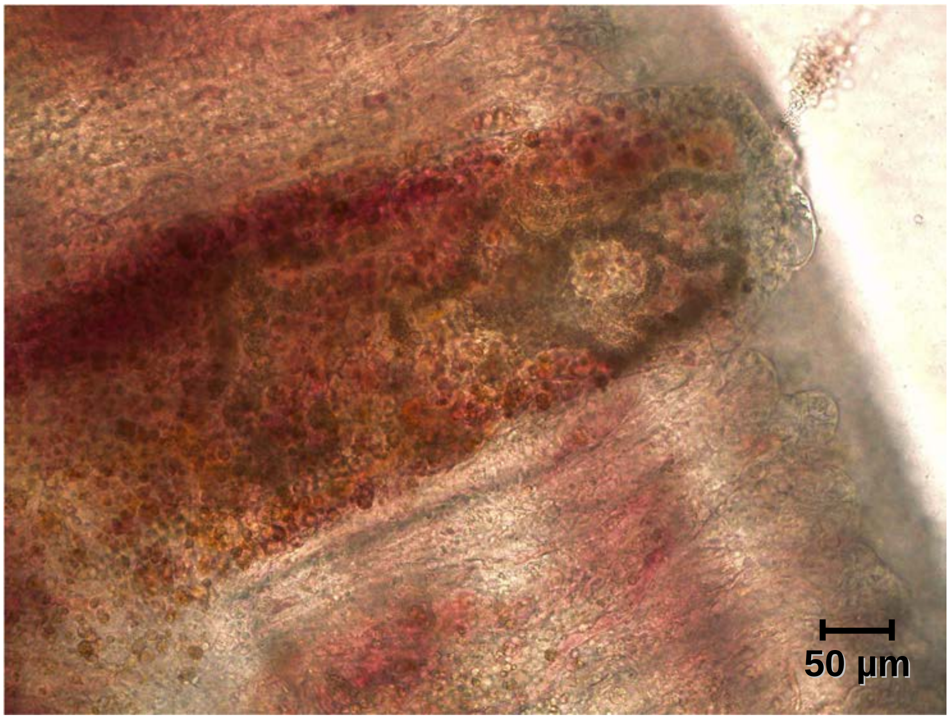

Figure 7. Branching hyphae of *Branchiomyces* sp. seen in wet mounts from a largemouth bass with branchiomycosis. In this photomicrograph, hyphae and inflammation appear to be associated with a single lamella. Photo by Andrew Goodwin.

F. Procedures for Detecting Subclinical Infections

Subclinical infections can be detected in wet mounts of gill tissue or in histological sections using special stains.

G. Procedures for Determining Prior Exposure to the Etiological Agent

No procedures for detecting prior exposure to the etiological agent are available.

H. Procedures for Transportation and Storage of Samples to Ensure Maximum Viability and Survival of the Etiological Agent

Live fish are preferable and are suitable for wet mounts and for histology. Fish shipped on ice are useful for wet mounts for at least 24 hours. The oomycete remains visible in post-mortem tissues until decomposition seriously compromises gill structure (several hours but depending on water temperature and fish species).

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