Mycobacterial disease in striped bass: questions remain unsolved

SOOJIN JEON

Although lots of studies have been done to understand the mycobacterial dise ase, some questions are still in mystery.
Thus, I will give you background information on mycobacterial disease in stripe d bass and introduce unsolved questions that are necessary to study.

Striped bass

- An economically and ecologically significant finfish species on the US Atlantic coast
  - Recreational fishing
  - Top predator in food web
- The Chesapeake Bay, Massachusetts Bay, Hudson River and Delaware River
- Endemic mycobacteriosis

Mycobacteria can cause disease in both human and fish. However, today, I am focusing on striped bass disease because SB is an economically and ecologically significant finfish species on the US Atlantic coast. SB are used for recreational fishing and are one of the top predators in the Chesapeake Bay food web .The Chesapeake Bay, Massachusetts Bay, Hudson River and Delaware River are the primary spawning and breeding areas for striped bass. It has been reported that SB has been impacted by endemic mycobacteriosis for decades

Mycobacterium spp.♪

- *Mycobacterium* spp. isolated from Striped Bass
  - *M. marinum*
  - *M. shotsii* (Host specific)
  - *M. pseudoshotsii*
  - *M. chesapeaki*

Mycabacteriosis is caused by several mycobacterium spp. They are ubiquitous and are found everywhere.

Among them, *Mycobacterium* spp. related to striped bass disease are *M. marinum, M. shotsii, M. pseudoshotsii and M. chesapeaki. M. marinum* are closely related to *M. tuberculosis,* resulting in human tubercuosis. *M. shotsii and M. pseudoshotsii* are newly identified from diseased striped bass and they mainly attack striped bass. Also, multiple mycobacterial infection can occur.

Distribution

- *M. shotsii & M. pseudoshotsii*
  - **Chesapeake Bay**
  - Albemarle Sound, North Carolina
  - Rhode River, Maryland
  - New York Bight, New York

M. Shottsii and M. pseudoshotsii are host specific and mostly isolated from Chesapeake Bay striped bass(Stine et al., 2011). So, distribution of mycabacteria may be related to distribution of SB. Mycobacteria are also found in Albemarle Sound, North Carolina, Rhode River, Maryland and New York Bight off Long Island, New York. Transmission of mycobacteria from Chesapeake bay to other states is unclear but may be due to migration of striped bass.

Clinical signs

- A chronic and systemic
- Similar to TB
- Nonspecific external signs

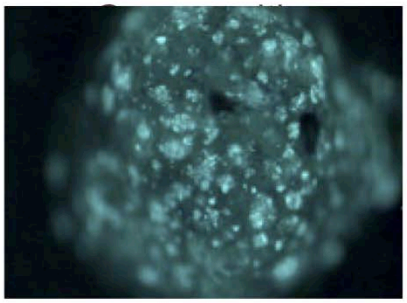
- Enlargement and grey or w
  ite nodules in internal orga
  s

- Spleen, kidney and liver

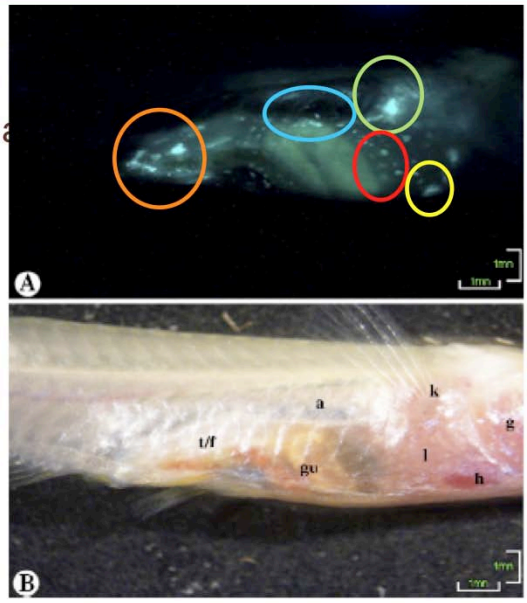
Disease is a chronic and systemic. It is similar to human TB. Nonspecific exter nal signs are found in infected striped bass. External clinical signs include scal e loss, skin ulceration, emaciation and exophthalmia. In most cases, disease l eads to enlargement and nodules in the primary target organs such as spleen, kidney and liver.

Histopathology

- *Mycobacterium* spp.
  - Intracellular bacteria



GFP in kidney



Disease leads to granulomatous inflammation. Once fish get infected, macrophages receive signal and move toward the site of infection. They phagocytose mycobacteria but cannot kill them. Mycobacteria are capable of surviving in vesicle of macrophage by escaping protease and bactericidal products. Macrophages are surrounded by lyphocytes, neutrophil, eosinophils, fibroblast and collagen, resulting in onion-like granuloma formation. Granuloma formation is found in chronic infection and it is beneficial to prevent spread of bacteria.
We can detect mycobacterial infection using molecular biology as well as histopathology.
Medaka were infected by fluorescence labled *M. marinum. M. marinum* are detected by green fluorescence under fluorescent microscopy. The pictures show whole infected organs and even swim bladder not found in histological section.
Mycobateria are found in kidney, liver, swim bladder and heart. Along the peritoneal lining, mycobacteria is found in testes. However, there is no detection of bacteria in gill.

Environmental stressors.

- Environmental stressors that affect the ability of animals to fight off infection
  - Diet
  - Hypoxia
  - Temperature
  - Salinity
  - Organic matter

Environmental stressors can affect the ability of animals to fight off infection. Environmental factors include diet, hypoxia, temperature, salinity and organic matter.

Stressor - Diet

- A poor diet affects the progression and sever ity of mycobacteriosis in SB
- A severe, systemic infection is characterized by a high bacterial load and poor granuloma formation (Jacobs et al. 2009)

According to study by Jacobs in 2009, a poor diet affects the progression and severity of mycobacteriosis in SB.
SB with poor diets showed a high bacterial load and poor granuloma formation . It suggests that disease development may be associated by nutrient (diet).

Stressor - Water quality

Mycobacterium species abundance (MAC)

- in brown water swamps in the southeastern United States

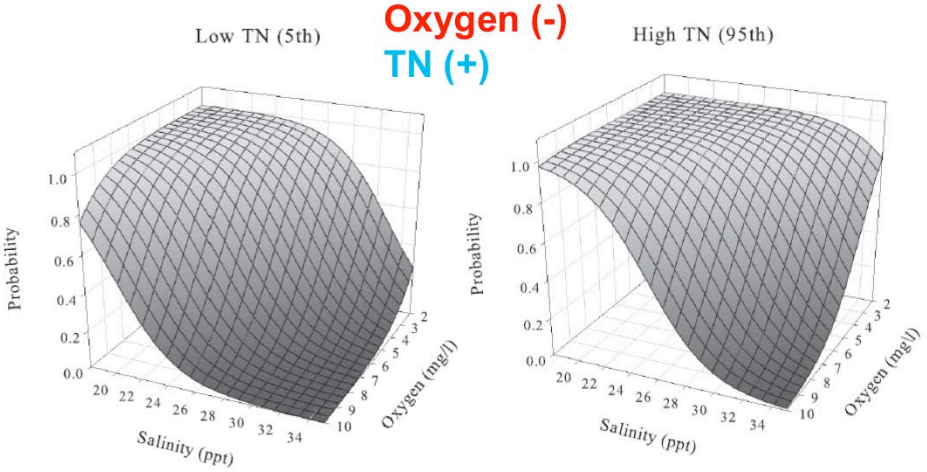
- Dissolved oxygen (negative)
- pH (negative)
- Nitrogen components and turbidity (positive)
- Temperature (positive)
- Several metals (positive)
- Presence of *Escherichia coli* (positive)

Kirschner et al. (1992)

This shows association of water quality and abundance of MAC in brown wate r swamps in the southeastern United States.
Water quality can affect bacterial density in water as well as fish immune respo nse.
DO and pH have a negative effects on abundance of MAC, while nitrogen, tem perature, several metals and presence of E. coli have a positive effects on bac terial density in water.

Stressor - Water quality

Salinity (-)
Oxygen (-)
TN (+)

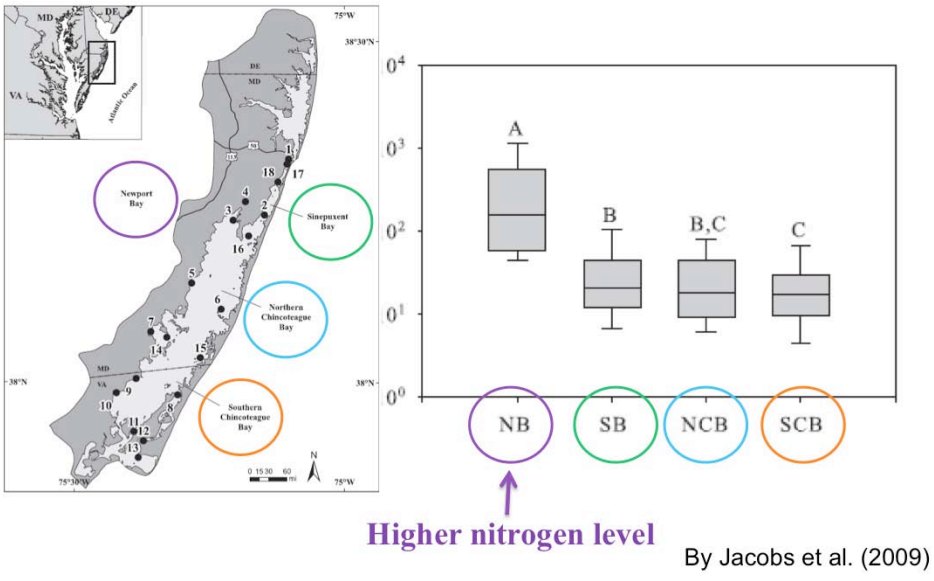


Probability of *Mycobacterium* spp. concentrations in estuarine/marine
By Jacobs et al. (2009)

It shows association of environmental factors with *Mycobacterium* concentrations. Probability of occurrence of *Mycobacterium* spp concentrations may be expressed as a function of salinity and oxygen at the total nitrogen (TN) levels. Salinity and oxygen have negative effect on Mycobacterial concentration, while nitrogen has positive effect. Under the same condition of salinity and oxygen, probability is lower in low TN. Environment is so complicated and thus it is necessary to consider multiple factors. Oxygen or salinity wouldn't be working alone.

Spatial distribution

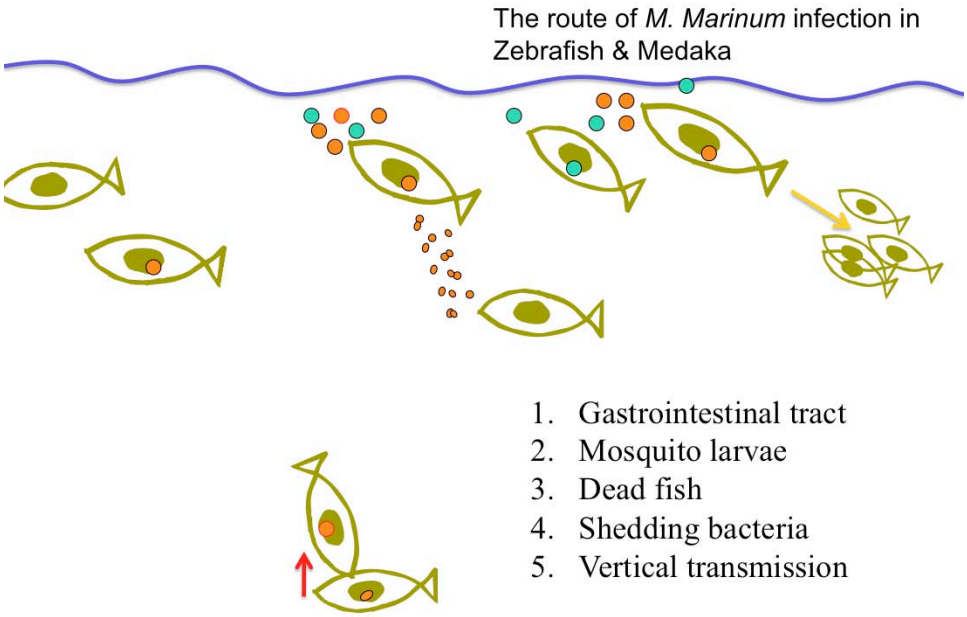
estuarine/marine waters



By Jacobs et al. (2009)

These data show spatial distribution of *Mycobacterium spp.* concentration. Me an estimated abundance slightly increases with latitude, the lowest in southern Chincoteague Bay. However, it is not significantly different. In Newport Bay, t he highest concentration of *Mycobacterium spp.* may be explained by the high est nitrogen concentration. It is hard to say that there is a relationship of abund ance of bacteria with latitude. However, it is clear that the abundance of bacter ia differs depending on locations.

Transmissions



M. marinum is ubiquitous and thus it is possible that a fish is naturally exposed to bacteria, which could invade through gastrointestinal tract. Disease occurs only when fish immunity is suppressed by environmental stressors.

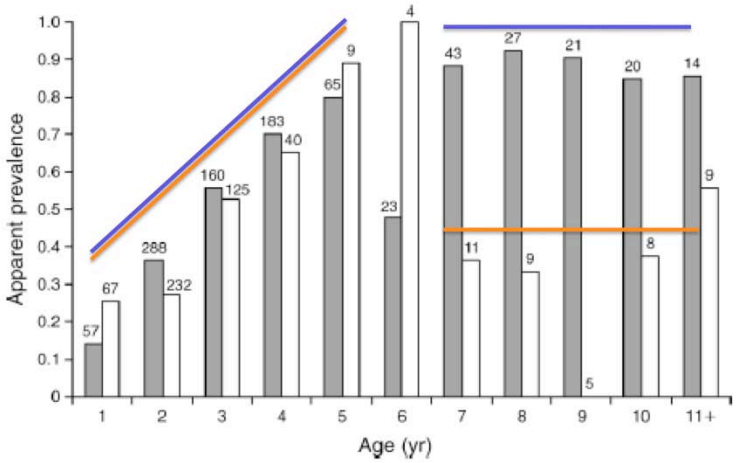
Mosquito larvae may be a vector to transport bacteria. Mycobacteria is consumed by mosquito larvae, which in turn are eaten by SB. So, finally, SB is infected by pathogenic mycobacteria.

Another hypothesis is that healthy SB eats carcass which is dead by mycobacterial infection.

Fourthly, infected SB may shed bacteria through wound or feces, which can make bacteria more pathogenic and invasive. Healthy SB may be more susceptible by shedding bacteria.

Finally, based on the detection of bacteria in testes and ovary, vertical transmission is also suspicious.

Ecological effects - Population



Male (gray bars) and Female (open bars)

By Gauthier et al. (2008)

High mortality caused by mycobacterial infection are found in aquaculture. Ho wever, it is hard to estimate disease associated mortality in wild fish because t he disease is chronic. According to epidemiological model by Gauthier et al. (2 008), it suggests that a chronic disease has negative impacts on striped bass population. This graph shows mycobacteriosis prevalence for male and female striped bass in Chesapeake Bay. Prevalence of mycobacteriosis increases wit h age through age 5 in both male and female. Interestingly, prevalence in fema le is highly diseased in older striped bass (> 5 years old). It is likely that reducti on in prevalence is due to disease associated mortality because the result is b ased on the assumption that once fish gets disease, it will remain diseased. Th ere is no non-diseased state in SB. So, disappearance in prevalence is only ex plained by mortality.

Ecological effects - Population

- Prevalence of mycobacteriosis increases with age th rough age 5 in both male and female
- More energetic demands from spawning and migrati on in older female
- Reduction in prevalence in older female is explained by disease-associated mortality
- Mycobacteriosis is likely to have negative effects on SB population

In summary, prevalence of mycobacteriosis increases with age through age 5 i n both male and female. Due to more energetic demands and stress from spa wning and migration, immune response in older female is less protective for ch ronic disease. Reduction in prevalence in older female is explained by disease -associated mortality. Thus, Mycobacteriosis is likely to have negative effects o n SB population. However, this result is base on a hypothesis and sample size is too small to be true. So the reality could be different.

Human infection

- ***M. marinum, M. fortuitum and M. chelonae* are capable of infecting human through**
  - direct injury from the fish fins or bite
  - handling of the aquarium
  - swimming pools (rare)

- **The organism shows poor growth at 37 ◦C**
  - the superficial, cooler body tissues, most often the extremities (skin lesions)
- Dissemination is apparently rare

Mycobacterium spp. are capable of affecting man as well as fish. Especially fish handlers and aquarium hobbyists are infected. Infection may be caused by direct injury from the fish fins or bites, handling of the aquarium. Infection can occur in swimming pools but is rare. Although infection is less common in human but immunocompromised patients are susceptible to infection of *M. marinum, M. fortuitum and M. chelonae.* Due to the organism's poor growth at 37 ◦C, infection is observed in cooler body tissues, most often the extremities.

Summary

- An economically and ecologically significant finfish
- Striped bass are more susceptible to mycobacterial infection than other fish
- Environmental stressors can affect the ability of ani mals to fight off infection
- Environmental factors can affect bacterial growth
- Ecological effects and transmission are still unclear (ongoing study)

In summary, SB is an an economically and ecologically significant finfish along the East coast of America. However, SB have been impacted by endemic myc obacteriosis because SB is more susceptible to mycobacterial infection than ot her fish. Environmental stressors can affect not only the immune response of SB but also bacterial growth. In spite of its importance, ecological effects and t ransmission are still unclear Ongoing study is necessary for better undestandi ng.

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