Infection of yellow perch (*Perca flavescens*) by black-spot parasites in a public and private lake

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Abstract

The black-spot parasite is a common affliction among *Perca flavescens*, the yellow perch. How this parasite affects the health of its host is a source of contention, as some studies have reported weight loss, blood loss, and even death in fish infected with black-spot parasites, but others claim the parasites are harmless. This study takes aim at characterizing body condition and infection intensity among infected individuals. One hundred forty-six perch were collected from two lakes on the Michigan-Wisconsin border, one public lake with semi-developed shores and recreational traffic, and one private lake isolated from foreign boats. Parasite infection was more intense and body condition was worse in the public lake, but there was no significant correlation between the two variables. The results raise more questions in this parasite-host interaction, and hold implications for the spread of hitchhiking aquatic organisms in public lakes.

Introduction

Perca flavescens, the yellow perch, is one of the most important freshwater fish in the Great Lakes. Commercial fishing of yellow perch brought in 1.6 million pounds of fish worth $2.5 million in 2004, and they serve as a major sport fish, driving recreation and tourism in their native areas (USDA 2005). However, adult yellow perch have been in a sharp decline over the last 20 years, affecting population structures as well as commercial revenue (Burden 2013). Further stresses to perch populations or condition would represent a serious threat to not only to lake ecology, but also to a multi-million dollar fishing industry. Their age-driven shifting diet, ranging from zooplankton to benthic invertebrates and small fish, make perch an important agent of energy transfer in lake food webs, and so declining perch populations could have major implications in trophic cascade ecology.

The black-spot parasite, which includes two functionally similar species (C*rassiphiala bulboglossa* and *Uvulifer amboplitis*), utilizes yellow perch as an intermediate host. These parasitic trematodes exhibit a three-part lifecycle centered on aquatic systems. After leaving *Helisoma* snails during their cercariae life stage, they float in the water column until they contact a fish (Krause et al. 1999). They enter through the skin and form a cyst inside the muscle, but a pigmented immune response of the fish makes them visible on the outside around seven days after infection (Figure 1) (Hoffman 1956). The third and final life stage of the parasite begins when the perch is consumed by a bird, such as the kingfisher. The avian host is the site of parasite reproduction and therefore, the renewal of the parasitic lifecycle.

The general consensus among the angling and public education communities seems to be that black-spot parasites do not pose a threat to perch nor the humans who consume them (Michigan DNR 2013). However, the literature indicates a possible cause for concern. A 1956 study by US Fish and Wildlife Service reports many heavily infected fish in their experiment exhibited stress, blood loss, weight loss, and even death within 10-15 days of infection (Hoffman 1938, Hoffman 1956). A more recent publication by the Minnesota DNR also warns that the black-spot parasites can cause death when other environmental stressors like crowding or food limitations are present (Minnesota DNR 2006). Killifish are even known to select against shoaling in communities with infected conspecifics, indicating that the fish recognize the black-spot parasite as a threat for both novel and additional infections (Krause and Godin 1996).

Beyond acting as a disease to the host, a substantial parasite population in a water body can be an indicator of ecosystem health. One one hand, the parasite requires three hosts, whose presence in the ecosystem can be indicative of a functional food web (Kirse 2010). However, it potentially spells trouble for the organisms within that healthy food web through host-parasite interactions. For example, in addition to the stresses of harboring the parasite, infection has been shown to increase a fish's vulnerability to predation by birds, possibly caused by parasite-induced behavioral displays at the water's surface (Lafferty and Morris 1996). So while parasite presence may be an indication of unpolluted waters capable of sustaining a healthy ecosystem, they also negatively impact host species health.

Additionally, a lake's exposure to outside sources of contamination might increase the intensity of parasites in that lake. Snails and fish hitchhiking on boats from lake to lake could increase the volume of external parasite flow introduced to a water body. These stowaway-harboring boats could also provide supplements to the mollusk population of the exposed lake, an intermediate host that is often the limiting factor in the parasite's life cycle (Kirse 2010).

This study aims to look at influence of outside inputs as well as the effect of this parasite on yellow perch. I hypothesize that the public lake in this study, Tenderfoot Lake, should contain perch with higher parasite loads than in Morris

Lake, a private lake almost entirely isolated from outside boats. I also hypothesize that there will be a negative correlation between parasite load and body condition of the perch, resulting in better conditioned perch in Morris Lake.

Methods

Data Collection

Yellow perch were sampled from two lakes in the Upper Peninsula of Michigan, on the property of the University of Notre Dame Environmental Research Center. Seventy-two perch were collected from Morris Lake, a small, private body of water in Gogebic County, MI, isolated from boats used on other lakes. Seventy-four more were collected from Tenderfoot Lake, a larger, public-access lake in Gogebic County, MI, and Vilas County, WI. It has some residentially developed shores, connections to highly developed lakes, and high fishing and recreation traffic. Fish were collected via seining, fyke netting, and angling. Ninety-four of these fish were euthanized with MS-222 and frozen for up to 6 weeks before being thawed and processed. All fish were patted dry before they were measured for weight, total length, and number of parasites. Each black-spot cyst was counted as a single parasite infection.

Data Analysis

Body condition of each fish was calculated by finding the residual from the exponential regression of length to weight of all fish collected. Dividing the count of black-spot infections by length of the fish cubed determined the standardized parasite load. Data was transformed to achieve normal attributes (log(standardized parasite load) and sqrt(condition residual +70)). Independent t-tests were performed to determine differences in parasite load by lake as well as body condition by lake. A simple linear regression was performed to determine the relationship between parasite load and body condition. To dispel doubt that freezing and thawing fish might skew length and weight data, an independent t-test comparing body condition between fresh and frozen fish was also run. One fish was statistically proved to be an outlier in body condition and was therefore eliminated from the other statistics.

Results

Independent t-tests showed that perch in Lake Tenderfoot held significantly higher parasite load ($p = 0.000105$) and worse body condition ($p = 0.000156$) (Figures 2 and 3). However, a linear regression revealed no significant correlation between parasite load and body condition ($p = 0.678$, $R^2 = .00120$) (Figure 4). An independent t-test showed that fresh and frozen fish did not vary in body condition ($p = 0.403$).

Discussion

The fresh/frozen t-test validated the methods of using both kinds of perch, revealing no source of experimental error in freezing some of the fish. The results of the parasite load t-test are consistent with my hypothesis that Tenderfoot Lake perch would be more intensely infected. This may be due to the public access status of Tenderfoot Lake and the functional isolation of Morris Lake. Foreign boat traffic is surely exposing Tenderfoot Lake to more hitchhiking organisms that may carry the black-spot parasite, increasing inoculation pressure on Tenderfoot's perch.

While Tenderfoot Lake may harbor more mollusks than Morris Lake by sheer size comparison of the water bodies, *Helisoma* prefer eutrophic waters, and Morris Lake has over 8 times as much Chlorophyll A, providing a much better habitat for the snails, and therefore for the black-spot parasites (Kirse 2010, UNDERC unpublished). Even though Morris theoretically has better snail and parasite conditions, it does not exhibit higher levels of the parasite, likely due to its isolation. The lakes' other habitat differences should not be interfering with these results either, as black-spot infection rates among fish have been seen to be independent of habitat type (Krause et al. 1999). One area that is open for consideration, however, is the amount of piscivorous birds inhabiting the riparian zones of each lake, possibly providing a more suitable final host population for the parasites. Tenderfoot Lake appears to have a more dense population of birds of prey, but further study would have to be performed to account for this idea.

The body condition results also support my hypothesis that Morris Lake's perch would exhibit higher condition. While this difference's driver may lie within the varying food web structures of the two lakes, it does present an opportunity for black-spot parasite load and piscine host condition to correlate. Since the black-spot parasite leeches nutrients from its host and disrupts its fish host's endocrine system, the effects of a high parasite load could be the driver of the body condition results (Kirse 2010). That relationship, however, does not appear to be direct when examining the linear regression results.

Contrary to my hypothesis, parasite load and body condition of perch were not significantly related. Although the public Tenderfoot Lake has perch with higher parasite loads and lower conditions than Morris Lake, the parasites do not appear to be driving the condition. One possible explanation for Morris Lake's better-conditioned perch is the predator makeup of the systems. Morris Lake holds a high density of northern pike, a major predator of yellow perch (Mauck and Coble 1971). Compared to Tenderfoot Lake's wide diversity of species and habitat types, Morris Lake provides little refuge for perch from the intense predation by the large pike population. That pressure likely eliminates poorly conditioned, less fit perch, leading to our finding of Morris Lake's better-conditioned perch population (Jakob et al. 1996).

While this observational study did not reveal a direct link between the black-spot parasite and its host's health, more controlled, manipulative experiments might elucidate why others have seen adverse effects. Possible explorations of this relationship include observing body condition or endocrinological changes on the long term in infected and uninfected fish in controlled environments.

This study has further, broader implications beyond the black-spot parasite. The results of higher parasite load in the public versus the private lake present an opportunity to raise awareness of hitchhiking species. Not only might the displeasing aesthetics of parasite-peppered perch harm the fishing industry centered on this Great Lakes native, but human-spread invasive species are becoming an increasingly important problem in ecology. While the black-spot parasite may hitch a ride from lake to lake without devastating populations, there are other species that must be controlled before ecosystems are overrun with non-native invaders. From simple boat cleanings and equipment dryings to ballast water laws and global trade restrictions, steps must be made to curb this ever-growing issue. Although the black-spot parasite is not an invasive itself, it can provide a functional lesson in biological pollution.

Acknowledgements

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Figures

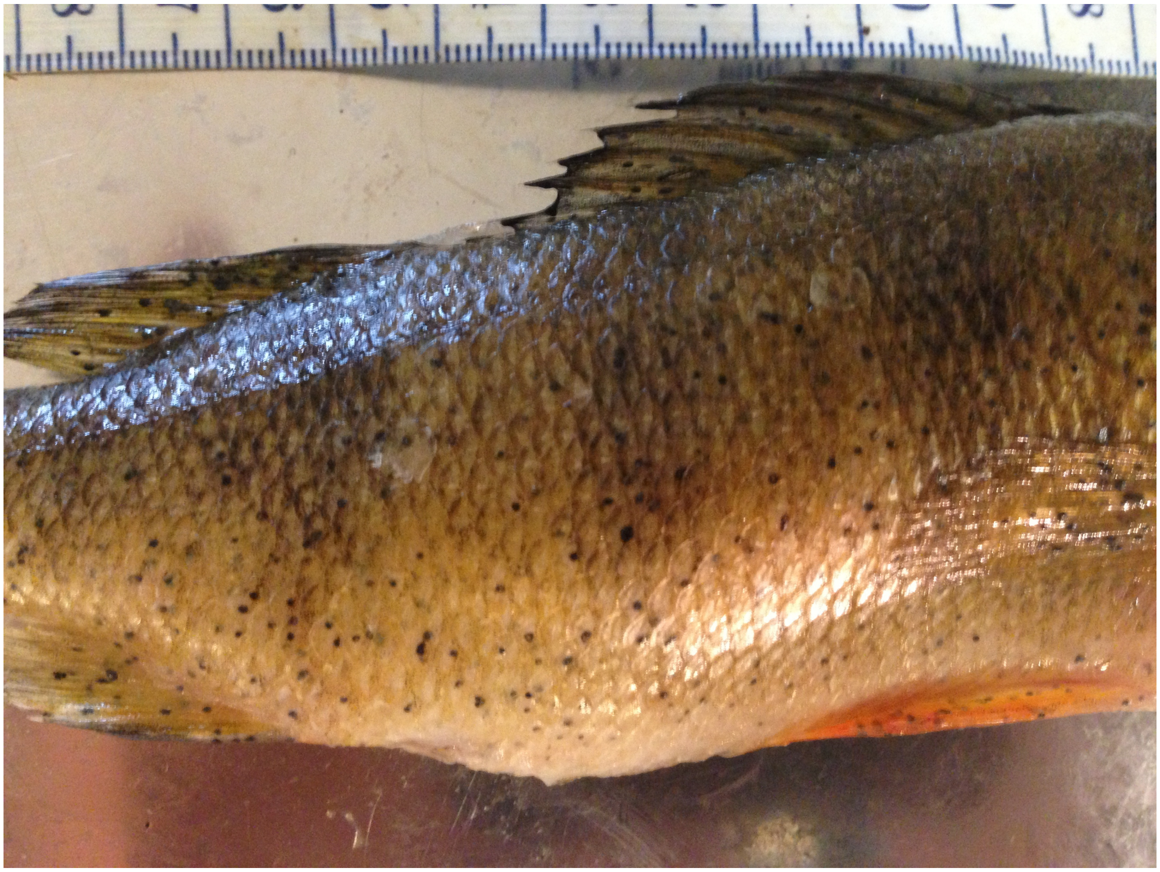

Fig. 1. The black-spot parasite is visible from the outside of the yellow perch as a dark cyst, the black color due to the perch's immune response. Centimeter tape included for scale.

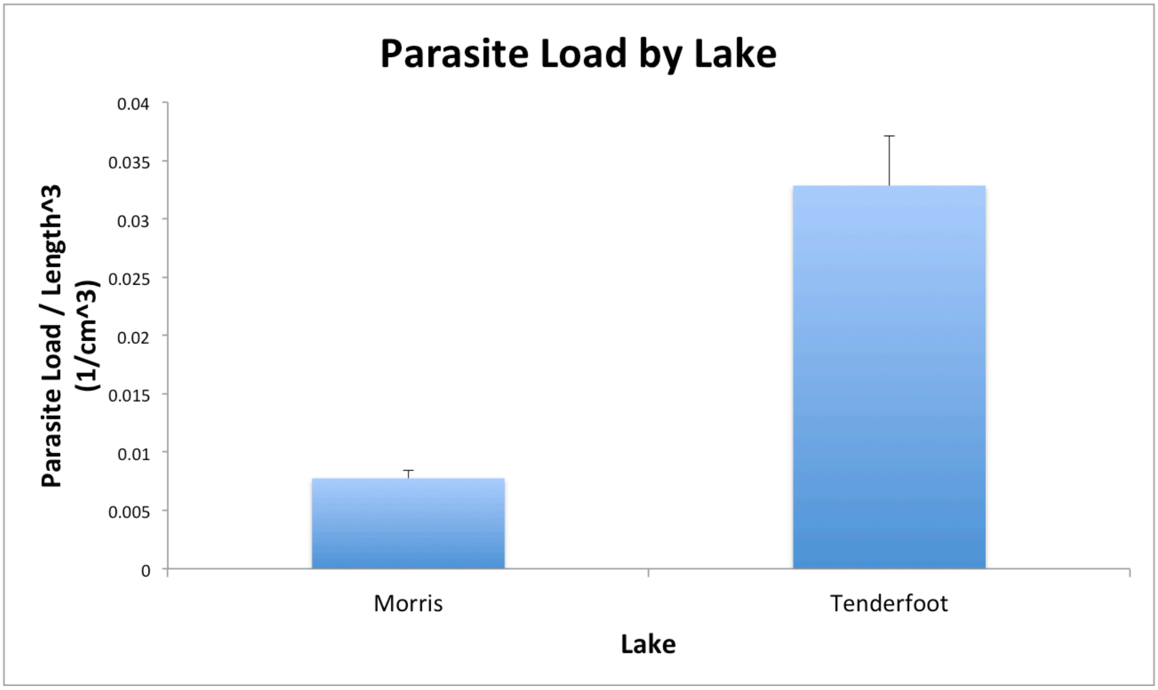

Fig. 2. Black-spot parasite load is significantly higher in Tenderfoot Lake perch than Morris Lake perch ($p = 0.000105$).

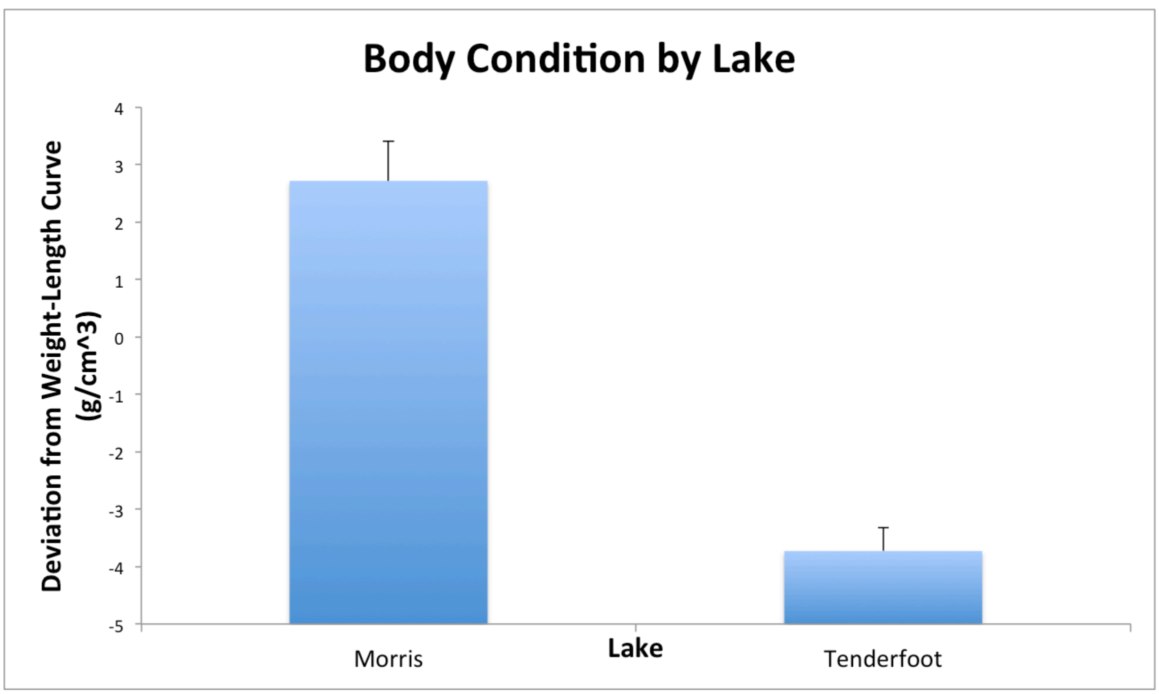

Fig. 3. Body condition in Morris Lake perch is significantly higher than Tenderfoot Lake perch ($p = 0.000156$).

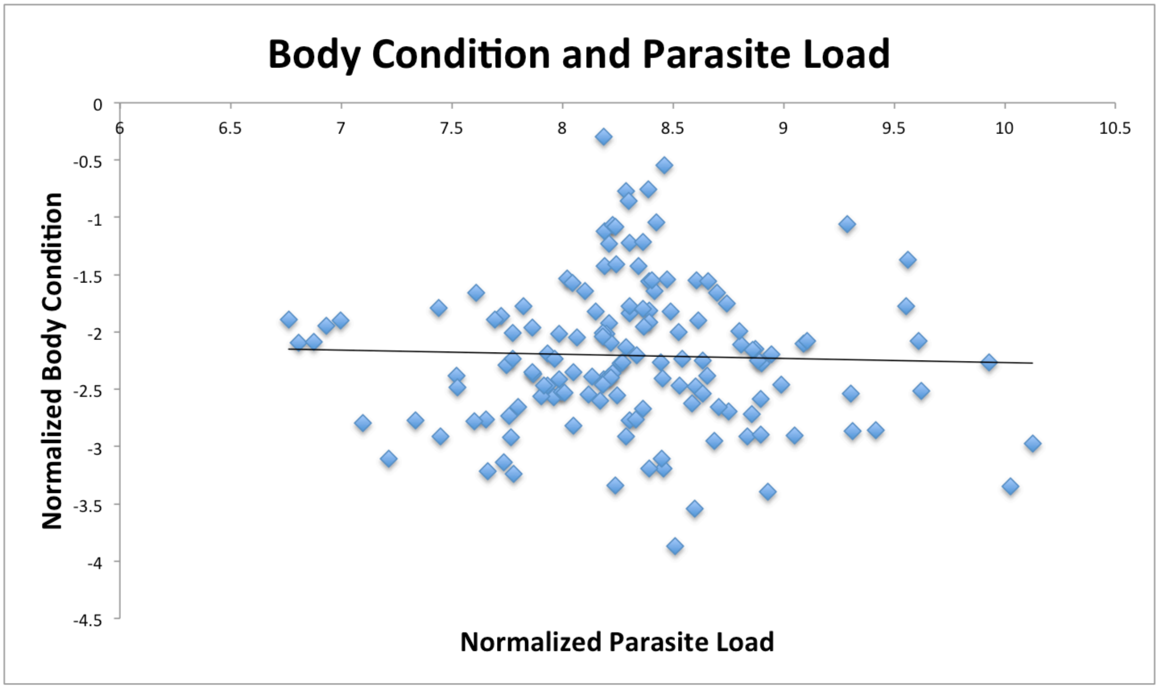

Fig. 4. There is no significant correlation between perch body condition and black-spot parasite load ($p = 0.678$, $R^2 = .00120$).