

Walleye *Sander vitreus* Visceral Fat Accumulation

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Fish Research

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For ectothermic species, proper lipid retention is critical to surviving in regions with limited growing seasons. Visceral fat is the dominant form of this energy storage in fish. Build up and depletion of these lipids occur seasonally as activity levels change throughout winter and spring. Due to this annual pattern, the purpose of this study is to determine a trend in the amount of visceral fat Walleye *Sander vitreus* accumulate in a time of year when metabolic rates are low and transition into the spawning process has yet to occur. Angling was the method of capture conducted during the months of January and February between two northern Minnesota lakes. Percent visceral wet mass was significantly different among listed fish sex categories with mature females having the highest levels ($P < 0.01$). Total visceral wet weight compared to percent visceral dry mass also had a significant positive relationship ($P = 0.04$). No evidence suggests correlation between relative weight (Wr) and percent visceral dry mass ($P = 0.08$).

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Introduction

Body composition in freshwater fish is an important indicator of fish condition and is influential during spawning periods. Fish condition can be determined using multiple indices including Fulton's condition factor (K), relative weight (Wr), and relative condition (Kn). Since lipids are the most influential energy storage material in fish, a surplus of these is imperative to ensure proper body maintenance and growth (Casselman et al. 2007). In general, body fat, protein, and water are all influential factors in the health and condition of most freshwater fish (Bursell and Caulton 1977).

Any shortage of these energy resources, specifically in Walleyes, can result in a possible decrease in reproduction rates. Sufficient amounts of visceral fat present in female Walleyes dictate whether gonadal tissue can be produced (Henderson et al. 1996). Walleyes that suffer from poor condition may lead to the lack of natural reproduction. This may determine whether stocking efforts need to be implemented.

The purpose of the study will be to identify possible biological trends related to reproduction in Walleyes prior to the spawning period using the following variables: total fish weight, organ/gonad weight, length, sex, and maturity. The main objective is to assess the amount of visceral fat within each fish to distinguish the accumulation in Walleye fat storage before the spawn. Relative weight (Wr) will be established by analyzing weights and lengths in both mature and immature

fish before the spawning period. This condition estimate will be compared to the total visceral dry mass. Ratios between the mass of visceral components and total wet weight between different sex categories will be determined, as well as a comparison between visceral wet weight and percent visceral dry mass.

Methods

Walleyes sampled in this study were taken from two northern Minnesota Lakes. The two lakes chosen were Lake Bemidji and Lake Plantagenet because of their morphological and biological similarities. The specimens were captured by angling beginning in the month of January and ending in the last week of February.

After samples were collected, fish ID's were assigned. Sex, maturity, and important morphometric measurements were taken immediately. To determine the amount of visceral fat in each fish, all innards were removed, including the fish's gonads, and separately weighed. Intestines and stomachs were scraped clean to prevent a possible weight bias during the drying process.

Lantry and O'Gorman (2007) determined that drying temperatures as high as 100 °C yielded shorter drying times but can lead to loss of volatile materials. Therefore, gonads and organs were dried in groups at 80 °C until dry mass remained stable. Samples were dried in tin pans which varied in

weight but were subtracted from the dry mass after the drying process was complete.

Relative weight (Wr) was found by using the following equation: $Wr = (W/W_s) \times 100$, where W is total fish weight and W_s is the standard weight for a fish that length. A standard weight equation developed by Brown et al. (1990): $\log_{10}(W_s) = -5.453 + 3.180 \log_{10}TL$ was used to calculate condition. Condition was then compared to the percent visceral dry mass of the body cavity components. To test for a relationship between total visceral wet weight (g) and percent visceral dry mass a linear regression model was used. The final statistical test used was an ANOVA to determine if percent visceral wet mass differed by sex categories. Percent visceral wet mass is a ratio between total visceral wet weight and total fish wet weight.

Results

Relative weight (Wr) of sampled fish ranged from 70.8 to 96.7 and percent visceral dry mass varied from 20.6 to 37.7% (Figure 1). Total visceral wet weight (g) ranged from 22.0 to 127.7 (Figure 2). Percent visceral wet mass fluctuated from 7 to 18.6% (Figure 3).

Relative weight (Wr) and percent visceral dry mass did not display a significant relationship ($P = 0.08$). Total visceral wet weight (g) and total percent visceral dry mass did reveal enough evidence to suggest there was a significant correlation ($P = 0.04$). A significant difference in percent visceral wet mass among sex categories was also established ($P < 0.01$). The average percent visceral wet mass between all sexes and maturity was 9.4%.

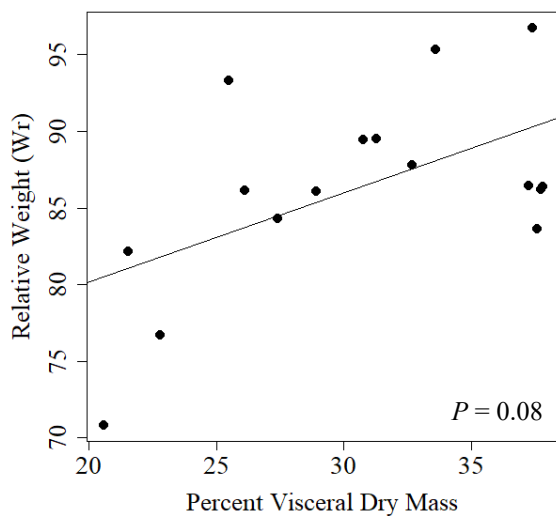


Figure 1: Relative weight (Wr) compared to percent visceral dry mass. There was no significance between the two variables.

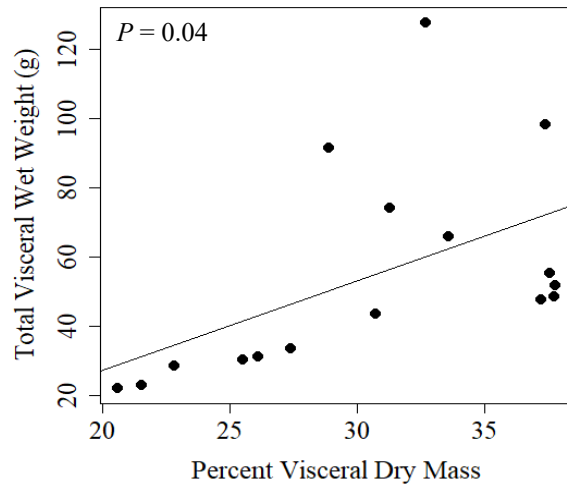


Figure 2: Total visceral wet weight (g) in relation to percent visceral dry mass. There was significance between the two factors.

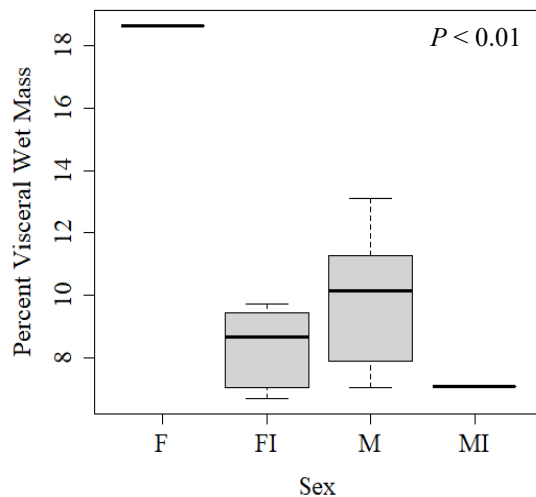


Figure 3: Median percent visceral wet mass by immature and mature male and female Walleyes. Sex groups are characterized by F = mature female, FI = immature female, M = mature male, and MI = immature male. The shaded boxes represent the interquartile range. There was a significant difference in percent visceral wet mass among sex categories.

Discussion

There are multiple influences linked to the reproductive potential of Walleyes, such as fish condition, visceral and gonadal health (Feiner et al. 2019). Condition of collected fish fell within the expected values for similar lakes in Minnesota. Mean relative weight (Wr) of Walleyes from the two sample locations was 86, which corresponds to

results found by Brown et al. (1990), ranging Walleye condition from 86 to 98 throughout Minnesota.

Since Walleyes are capital breeders, visceral and gonadal health is essential. Based on this statement it was hypothesized the total visceral wet weight (g) would have a correlation with the percent dry mass of gonadal and organ tissue. This conjecture assumed larger fish would have larger visceral components; therefore, mature fish will experience a higher visceral dry mass on average.

It is important to note one major outlier occurred when organ and gonad dry masses were combined and compared to total visceral wet weight (g). This fish was the only sampled mature female and exhibited the largest visceral wet weight as well as the largest gonadal weight. After the drying process, 40.1% of the female's gonad mass remained. Lipids comprised the majority of the gonad dry mass, although a small portion was likely made up of other visceral tissue. Johnston et al. (2012) found the gonad dry mass values of Walleyes in lake Winnipeg were 35.5% adjacent to active spawn. The variance in this comparison is likely due to the time of year fish were sampled. Walleyes begin replenishing lipid storage during the early fall to augment gonadal development throughout the winter (Cook et al. 2009).

Maturity in Walleyes collected for this study was highly inconsistent. Only one of the ten females captured were sexually mature, while only one of the six males were immature. However, there was a significant relationship between maturity and percent visceral wet mass. This provides evidence that lipids may have an influence on reproductive components in sexually mature Walleyes.

Casselman et al. (2008) found that gonad lipid concentrations in mature female Walleyes were closely related to a liver-lipid concentration indices called hepatosomatic index (HSI), while lipid concentrations in male gonads were more closely related to total body lipid concentrations. Similar results were found by Bernard et al. (2011) which supported that lipid concentration in mature female Walleye livers were highly correlated with gonadal lipid content. Walleye organs in this study were dried separately from gonads, although organs were not segregated any further.

The results of this study concluded sex and maturity was significantly related to percent visceral wet mass. Visceral dry masses were highly associated with visceral wet weights displaying different levels of lipid accumulation in the body cavity. Proper lipid storage is critical to gonadal development and successful reproduction. Lake Bemidji and Lake Plantagenet have a resilient,

naturally sustaining population of Walleyes, and relative weights are within the expected values; therefore, it is inferable the populations examined in this study possess healthy visceral condition.

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