BODY SIZE, BODY CONDITION, AND REPRODUCTIVE POTENTIAL IN SEA LAMPREY: NATURE OR NURTURE?

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ABSTRACT:

Damage and reproductive potential of sea lamprey is strongly influenced by body size, but it is not known to what extent other phenotypic factors (e.g., body composition), environmental and ecological factors (e.g., temperature, prey abundance and nutritional status), and genetic factors alter this relationship. To address these gaps in our knowledge, this pilot project collected detailed phenotypic data from five male and five female upstream-migrating sea lamprey collected from 10 Great Lakes tributaries (two from each of the Great Lakes basins). Whole genome resequencing has already been conducted on these sea lamprey (and the next step will be to test for phenotype-genotype correlations), but in this project, we tested for differences among sites and for correlations with environmental factors. We measured 14 phenotypic traits in all individuals: body size (total length, total mass, gonad-free mass); gonadosomatic and hepatosomatic indices (GSI, HSI), and proximate composition (water, protein, and lipid content) of the gonad, liver, and muscle; and an additional five phenotypic traits were measured in females: fecundity (number of eggs per gram, total number of eggs) and mean egg size (diameter, wet mass, and dry mass). Given sex-specific differences in many traits (e.g., GSI, gonad protein content, and gonad lipid content were higher in females; and gonad-free mass, gonad water content, and liver lipid content were higher in males), comparisons among sites were made in females and males separately. In females, significant differences were observed between sites for length, mass, gonad-free mass, GSI, HSI, and protein content of all three tissues. In males, there were significant differences between sites in length, HSI, water content of the liver, protein content of the gonad, and the lipid content of the muscle. Mean fecundity at each site ranged from 58,131 in the Au Gres River (Lake Huron) to 96,140 in the Grand River (Lake Erie), but fecundity was only moderately correlated with female length. Liver lipid content was also positively correlated with egg number, and a generalized mixed model using both female length and lipid liver content explained 51% of the variance in fecundity while length alone explained only 28% of the variance. Thus, both anatomical and

physiological constraints likely determine the number of eggs that a female sea lamprey is ultimately able to elaborate and mature. GSI and egg size (diameter and wet and dry egg mass) were positively correlated, and egg diameter was positively correlated with gonad protein content. Six lake-level environmental factors (lake surface area and drainage area, maximum ice cover for 2018 and 2019, and annual 2018 surface lake temperature and summer/fall 2018 surface lake temperature) and three stream-level characteristics (latitude and longitude at the stream mouth and maximum lake depth within 10 km of the mouth) were collated and tested for correlations with the phenotypic traits. As predicted, temperature appeared to be the most significant factor affecting biological parameters in sea lamprey; it was positively correlated with length, mass, fecundity, egg diameter, and liver lipid content, and negatively correlated with HSI. The results of this pilot project showed that individual- and population-level differences in reproductive potential can be influenced by traits that have not typically been measured in sea lamprey. This does not necessarily mean that liver lipid levels should be measured in upstream-migrating sea lamprey to better predict the reproductive potential of an individual or population. Rather, it can help us understand what other factors may be influencing an individual or population's reproductive fitness. Females that show more eggs than expected from length alone may be in superior body condition, which is presumably influenced by environmental and ecological factors that may vary spatially and temporally in the Great Lakes basin. Future work should also test for spatial patterns in sea lamprey body composition and fecundity resulting from differences in the species composition, abundance, or body condition of host fishes.