Correlations between hemoglobin type and temperature preference of juvenile Atlantic cod Gadus morhua

Atlantic cod (Gadus morhua L.) exhibits polymorphic hemoglobin variants with the Hbl locus showing a strong North-South geographic cline in frequency distribution of three main types (1/1, 1/2 and 2/2). This may indicate selective advantages of the different Hbl types under various temperature regimes. Despite this only one study has directly examined the temperature preference of the two homozygous types, Hbl-1/1 and Hbl-2/2, whereas the preference of the heterozygote (Hbl-1/2) has never previously been addressed.

By exposing fish to a 4–19 °C temperature gradient in an annular preference chamber we recorded the preferred temperature of wild juvenile G. morhua of all three main Hbl types originating from an area where they co-exist. Hbl-2/2 G. morhua preferred significantly cooler water (8.9±0.2 °C) compared to the Hbl-1/1 group (11±0.6 °C), this difference, however, not being as distinct as previously reported. There was pronounced inter-individual variation in the temperature preference of the Hbl-1/2 G. morhua ranging between 6.7 and 13.8 °C, and their overall preference (10.5±0.9 °C) did not differ significantly from either of the homozygous Hbl types. Notably, the mean range of utilized temperature (temperature span between 1st and 3rd quartile) was very similar between all 3 Hbl types with 3.2–3.5 °C. Considering the complexity of a trait like temperature preference, there are clearly many other factors besides Hbl type that influence the thermal biology of cod, and therefore we also investigated possible associations between genotype and temperature preference for 12 variable candidate gene single nucleotide polymorphisms (SNPs) a priori expected to be related to growth and reproduction. There were, however, no significant correlations between temperature preference and any of the candidate gene SNPs indicating that none of these polymorphisms strongly associates with thermal behavior. Considering however the high-throughput genotyping methods becoming increasingly accessible there is great potential for association studies involving many more genetic markers to identify additional genetic polymorphisms that are important for temperature preference in G. morhua. In conclusion, we support the notion of a ‘warm’ (Hbl-2/2) and a ‘cold’ (Hbl-1/1) Hb type, although we suggest the difference to be more subtle than previously reported. Furthermore Hbl-1/2 G. morhua shows rather inconsistent thermoregulatory behavior. To obtain a more definitive picture of the extent to which thermal niches are realized under natural conditions field observations in areas where the 3 Hbl types co-exist should be performed.

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