PHOTOPERIOD EFFECTS ON ENDOCRINE PATHWAYS CONTROLLING JUVENILE DEVELOPMENT (SMOLTIFICATION) IN CHINOOK SALMON (*Oncorhynchus tshawytscha*): TSH, THYROID HORMONES AND IGF-I.

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Salmonid smoltification is the metamorphic-like process whereby a freshwater adapted parr goes through a series of physiological, morphological and behavioral changes to become a seawater adapted smolt. This phenomenon is entrained by changes in photoperiod during spring and/or autumn and regulated by endocrine pathways associated with growth and development. These pathways include, the thyroid axis, growth hormone--insulin-like growth factor-I axis, and the adrenal axis. The thyroid hormones, growth hormone and cortisol have all been shown to increase in plasma during smoltification. Each of these pathways is further regulated by negative feedback loops from downstream products, allowing for temporal coordination of endocrine events. Other non-endocrine measures of smoltification are frequently examined. These include subjective measurement of appearance (skin silvering, pectoral fin clearing, caudal fin darkening), gill Na+/K+-ATPase activity, condition factor (a relative ratio of weight to length which normally decreases during smoltification) and (less frequently examined) instantaneous growth rate.

Our laboratory has recently developed two new endocrine tools for use in smoltification research. The first is an ribonuclease protection assay designed to measure thyroid stimulating hormone messenger RNA (TSH mRNA). TSH is the pituitary hormone which is responsible for stimulation of thyroid hormone secretion. Thus, quantification of the mRNA which codes for this protein has allowed us to better understand regulation of the pituitary - thyroid axis. The second tool is a homologous radioimmunoassay (RIA) for salmon plasma insulin-like growth factor-I (IGF-I). Pituitary growth hormone stimulates the liver to produce IGF-I which, in turn, stimulates somatic growth, and cell division and differentiation. The objective of this investigation was to examine the effect of photoperiod change on pituitary TSH mRNA as well as plasma triiodothyronine (T_3), thyroxine (T_4) and IGF-I. Other non-endocrine parameters measured included appearance, gill Na+/ K+-ATPase activity, condition factor and instantaneous growth rate.

Juvenile spring chinook salmon were reared under ambient temperature (6 - 15° C) and photoperiod from hatch to the parr stage. On December 29 of their second winter, one half of the fish were subjected to a 3 hour photoperiod advancement while the other half were allowed to undergo smoltification under natural photoperiod. Fish from both the normal and photoperiod advanced treatments were sampled every two weeks from January to mid-May for each of the above mentioned parameters.

In general, photoperiod advancement caused an acceleration in the non-endocrine smolt associated parameters. The photoperiod treated fish showed an advancement (of approximately 1 month) in their smolt appearance, peak levels of gill Na+/K+-ATPase and characteristic decline in condition factor. Furthermore, photoperiod advancement caused marked differences in the instantaneous growth rate when compared to normal fish. The photoperiod advanced fish showed an immediate increase in instantaneous growth rate from January to March and a decline thereafter, while the normal fish had low instantaneous growth rates during January and February and high rates thereafter.

The fish reared under normal photoperiod had characteristic smoltification associated increases in plasma T_3 and T_4, from low levels in January and February to peak levels in April and May. Pituitary TSH mRNA and plasma IGF-I also showed a similar pattern of increase to that of the thyroid hormones. However, photoperiod advancement did not result in a concomitant advancement in the peak in plasma T_3, T_4 and IGF-I. In contrast, levels of these hormones were generally lower than those of the normal photoperiod fish. Pituitary TSH mRNA levels showed an initial response to photoperiod advancement, with significantly higher levels in mid-February, however, from March through May, there was no significant difference between the treatments.

In conclusion, we observed that photoperiod treatment caused an advancement in smolt appearance, the decline in condition factor, increased instantaneous growth rate and increased gill Na+/K+-ATPase. However, these events were coupled with muted endocrine responses. These events are dependent on endocrine mediation, that may have been initiated in the thyroid and GH--IGF-I pathways during the initial 2-3 weeks following photoperiod advancement (prior to our first sampling date). Such short term endocrine changes may initiate the smoltification phenomenon, giving rise to the physical changes observed. Furthermore, we speculate that the muted endocrine changes seen in photoperiod advanced fish compared with normally smolting animals may be due to alterations in the relationship between hormone synthesis, secretion, receptor coupling, degradation and negative feedback, resulting in weak elevations in plasma levels of these hormones. Nevertheless, the advancement of the physiological aspects of smoltification, which are dependent on endocrine factors, suggests that advanced photoperiod stimulated the endocrine pathways directing smoltification irrespective of the plasma titers we observed.

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