SMOLTIFICATION PHYSIOLOGY IN THE CULTURE OF SALMONIDS

Jeremy S. Langdon

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1. Introduction

The delicate silvery fish, the smolts, which migrate seawards each spring were thought by early naturalists to be a distinct species from the drab, brownish parr in the freshwater reaches of rivers, until it was demonstrated that both were juvenile forms of the anadromous salmon and trout (Shaw, 1836, 1838). The remarkable transformation of the parr to the smolt stage, known as smoltification, is evident as silverying of the body, darkening of the fins in some species, a streamlining of the body, and seaward migration. Multiple changes in growth, metabolism, osmoregulation and behaviour also occur during the transformation, and affect the subsequent survival and growth of the fish in the marine environment. Knowledge of the smolting process is thus basic to the efficient culture and propagation of anadromous salmon and trout in the genera *Oncorhynchus* and *Salmo*. This review aims to describe the current understanding of the physiology of smoltification, and to indicate how this information can be used in salmonid culture and management.

2. Growth, Morphology and Metabolism

2.1 Growth

Rapid growth and the attainment of a critical body size are associated features of smoltification. The growth rate of smolting fish exceeds that of non-smolting fish (Saunders and Henderson, 1970; Thorpe *et al.*, 1980, 1982) and there also appears to be a critical body weight or length below which smoltification will not occur (Clarke, 1982; Conte and Wagner, 1965; Mahnken *et al.*, 1982; Wedermeyer *et al.*, 1980). Individuals within a population may grow and smoltify at different rates. A variable proportion of juvenile Atlantic salmon (*Salmo salar*) within sibling groups in Scottish and North American hatcheries showed accelerated growth rates in their first year of life, giving the sibling groups a bimodal length frequency distribution (Bailey *et al.*, 1980; Thorpe, 1977; Thorpe *et al.*, 1980, 1982). In Scotland this divergence in growth rate was detectable as early as the first summer of life, and the fast growing upper mode fish represented the potential 1+ smolts of the following spring, whereas the lower mode fish represented the potential 2+ smolts (Thorpe *et al.*, 1980, 1982). Since, however, smoltification is growth-related, and growth is related to temperature, the rate of smoltification in wild and hatchery stocks decreases with increasing latitude (Mills, 1971; Power, 1959).

Early sexual maturation and rapid growth are also associated and inheritable traits in fish (Alm, 1959; Bilton, 1980; Thorpe and Morgan, 1978a, 1980; Thorpe *et al.*, 1983), but maturation among male parr (so-