

Anadromy, potamodromy and residency in brown trout *Salmo trutta*: the role of genes and the environment

General summary

Should I stay or should I go? That is the decision facing a young brown trout in the tributary stream where it hatched. In other words, remain in the stream or migrate elsewhere. Brown trout show three main optional migratory life histories (downstream–upstream within a river system, to and from a lake, to and from the estuary /sea). Migration to the sea is referred to as anadromy while that within freshwater is potamodromy, with the latter being the more common type in many areas, e.g. Scotland and Ireland where there are numerous lakes. Both types of migration share many features and indeed individuals can switch between sea and freshwater migrations during their lifetime. Previous recognition of sea trout as different from freshwater brown trout migrants is no longer tenable. Non-migrant trout remain within the stream, perhaps moving only a few hundred metres within their life (river-resident trout). Trout can also spend their entire life cycle within a lake with spawning occurring in the lake gravels (lake-resident trout). Lake-residency is undoubtedly much more common than previously recognised and often occurs in small upland lakes, as well in some large lowland ones.

Migration results in improved feeding allowing greater growth. More sea trout and freshwater trout migrants are female since larger size is of greater importance in producing more eggs, compared to males where sufficient sperm can be produced at small size. There are, however, disadvantages to migration. Considerable energy is expended in making the journey to the feeding destination and back again to the original tributary stream for spawning. There is also an increased risk of predation and mortality from other causes. At the end of the day, whether to migrate or remain as a resident is a balance between the benefits and costs. An individual has no way of assessing these directly but its decision is informed by its genes, which have been shaped by the experiences of its ancestors through natural selection, together with current environmental conditions. Overall genes and environmental factors contribute about equally to the variability in migration versus residency in trout. The principal environmental factor involved is feeding quantity and quality. If an individual's nutritional status, especially the amount of energy stored as fat, is below a genetically determined threshold level the individual migrates to find better feeding. If above the energy status threshold it remains in the stream. Thus, the higher the threshold level the more likely it is than an individual will migrate as it will be more difficult to reach the condition required for residency. Female trout have higher mean thresholds than males and separate populations can have different mean thresholds resulting in varying propensities for migration. Since larger smolts are more successful at migration this can occur at different ages depending on when an individual reaches its optimal size.

The next decision is where to migrate to. In some catchments feeding may be better in the sea than in a lake but in others the opposite is the case. River-lake migration reduces the likelihood of being predated or parasitised compared to at sea and involves less energy expenditure. Indeed the largest rod-caught records in Britain, Ireland and Scandinavia are all of lake-feeding trout rather than sea trout. Thus, where a lake with good feeding is present in a river catchment, sea trout are often absent even though there may be no barriers to

movement to and from the sea. Where there are no lakes, then feeding downstream in the main part of the river may be a better cost-benefit strategy than going to sea. Migration destination is largely determined by an individual's genes based on the past experience of its ancestors as influenced by natural selection. Genes also play a considerable part in determining the timing of return migration and sexual maturation.

In many cases, the advantages and disadvantages of migration are likely on a 'knife-edge' and it takes very little to tip the balance in favour of not-migrating, or migrating to a different habitat. Many human impacts can result in such changes. These include: partial barriers within rivers, which increase energy expenditure and predation; predation by birds and mammals both in freshwater and at sea; greater human exploitation of (larger) migrants compared to (smaller) residents; sea lice infestation; climate change resulting in changes in food availability and river flows.

We now have a greater understanding of the genetic and environmental influences that determine migration although there are still many gaps on the genetic side. We also know various human impacts that adversely affect migrants. Only with full knowledge of all factors involved can we hope to protect and restore sea and freshwater brown trout migrant runs, especially in the face of rapidly changing environmental conditions.

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