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Bias, precision and validation of ageing 0+ European barbel *Barbus barbus* (L.) from their otoliths

Research Article

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Abstract: The European barbel *Barbus barbus* L. is considered a 'flag' species for river conservation and sport fishing, but it is increasingly threatened in its native range of distribution. To provide accurate age estimates during early life for appropriate management and conservation measures, the bias and precision of otolith (daily) micro-increment counts were evaluated and age determinations validated on laboratory-reared embryos and larvae. Out of the three pairs of otoliths, the lapillus and sagitta provided reliable age estimates for free embryos and larvae up to 17 days of (known) age post-fertilisation, with first micro-increment formation occurring five days post-fertilisation. On the other hand, micro-increments on asterisci formed only 16–17 days post-fertilisation. There was agreement in micro-increment counts based on lapilli and sagittae, but not between interpreters, indicating that despite consistency between the two pairs of otoliths extensive training and experience are required for reliable age interpretation. The ability to estimate the ages of 0+ *B. barbus from* their otoliths will contribute to a better understanding of growth rates from both hatchery-stocked and native/introduced cohorts.

Keywords: *Lapillus* • *Sagitta* • *Asteriscus* • *Conservation*

1. Introduction

Age and growth are key aspects of fish biology with which to inform fisheries managers on the general well-being and status of a stock, and this is particularly crucial in studies of growth in early life, which is a major determinant of over-winter survival [1,2]. Although classed in the IUCN Red List as being of 'Least Concern', the European barbel *Barbus barbus* (L.) is considered a 'flag' species for river conservation due to its sensitivity to pollution and its popularity, and thus socio-economic importance, as a sport fish [3]. Increasingly threatened in parts of its native range in Central Europe [4], *B. barbus* populations are endangered locally by water pollution and river regulation, including in the U.K., where the species is native to eastern rivers between Yorkshire and the Thames [5]. Apparent declines in population densities, such as in the River Lee, Hertfordshire [6,7], have emphasised the need for accuracy (hence, validation) and precision in the ageing of 0+ (young-of-year) *B. barbus* so as to improve understanding of growth rates during early life for appropriate management and conservation of *B. barbus* stocks [3,8].

As part of a broader investigation of the environmental biology of *B. barbus* early life stages in the River Lee [7,9-15], the aim of the present study was to evaluate bias and precision of otolith (daily) micro-increment counts (*sensu* Campana and Neilson [16]) in 0+ *B. barbus* and to validate the age determinations. The specific objectives were to: (i) determine which of

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