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Article *in* Lakes & Reservoirs Research & Management · July 2021

DOI: 10.1111/lre.12372

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Received: 9 April 2021 | Revised: 15 June 2021 | Accepted: 23 June 2021
DOI: 10.1111/lre.12372

ORIGINAL ARTICLE

Lakes & Reservoirs
Science, Policy and Management for Sustainable Use
WILEY

Age and growth rate estimations as a basis for assessing the population dynamics of *Hydrocynus vittatus* Castelnau 1861 in the Sanyati Basin of Lake Kariba, Zimbabwe

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Funding information
This study was funded by the University of Zimbabwe Lake Kariba Research Station

Abstract

In early fish life stages, information on their age structure can be used to clarify the effects of environmental changes on their growth and survival, thereby providing an improved understanding of factors affecting their recruitment success. There is currently inadequate understanding of the age structure of *Hydrocynus vittatus* in the Sanyati Basin of Lake Kariba in Zimbabwe. Accordingly, the present study investigated the age of tigerfish in the Sanyati Basin of Lake Kariba using whole otoliths and scales for comparison. The results indicated ages read on the basis of scales and otoliths of *H. vittatus* agreed to a larger extent for fish aged one to four years than for fish older than four years. There was a significant difference (χ^2 = 8.520, p = .024) in the ages obtained from analysis of scales and otoliths for fish older than four years. The average percentage error and coefficient of variation were found to be 6.03% and 8.1% for whole otoliths, respectively, for the present study. The APE and CV values for scales were 13.81% and 17.41%, respectively. Relatie age data for whole otoliths fit the von Bertalanffy growth model, while that for scales did not fit the von Bertalanffy model, resulting in many outliers and much scatter of the data. The whole otolith parameters for the von Bertalanffy growth curve were L-infinity = 682.5 mm, k = 0.530 and t_0 = 3.19. Based on the results of the present study, it can be concluded in this case that whole otoliths were the best method of ageing tigerfish from Lake Kariba. Accordingly, it is recommended that otoliths be used for ageing tigerfish in Lake Kariba and that scales be used for ageing tigerfish only up to four years in age.

KEYWORDS
growth rings, otoliths, precision, scales, tigerfish, von Bertalanffy

1 | INTRODUCTION

Hydrocynus vittatus (Castelnau 1861), also known as tigerfish, is one of the most important fish species being exploited in the freshwater bodies of Southern Africa (Marshall, 2011). According to Gerber et al. (2009), tigerfish in the Okavango Delta of Botswana are a sought-after sport fish and also an important component of a large commercial and recreational fishery in the region. It is also an important angling fish species in Zimbabwe (Dalu et al., 2012, 2013a, 2013b). Despite the importance of this fish species, little information is available regarding various aspects of the ecology of the species, specifically in regard to its age structure (Soekoe et al., 2013).

Accurate knowledge of age and growth is fundamental to fishery science (Filmalter et al., 2009). Information on age structure in early life stages can be used to clarify the effects of environmental changes on growth and survival and can result in an improved understanding of the factors affecting recruitment success (Soekoe et al., 2013). Knowledge of age and growth dynamics of adult fish can be used to determine the effects of fishing on the stocks and the efficacy of management policies in order to better understand life history events and maximize yields while also continuing to ensure the future of the resource (Winker et al., 2010).

Several studies have previously been conducted on fish ageing. The age and growth dynamics of fish can be determined by such methods as growing fish in confinement; raising fish from birth; examining the hard parts of fish that encode age information; and biochemical tests (Brouwer & Griffiths, 2004; Campana, 2001). The usefulness of these methods depends on the habitat and life history stage of the fish (Richardson et al., 2009). Scales and otoliths are the two most widely used hard parts for estimating age in fish, with growth rings in these parts having long been used to age fish. Scales were first used to age fish in 1888 (Carlander, 1987). Otoliths have been used to age fish since Reibisch first observed annular ring formation in *Pleuronectes platessa* in 1899 (Ricker, 1975). However, counting annuli is not always useful in estimating the age of juvenile fish that have not yet formed their first annulus, or for tropical or deep sea fish whose growth is more constant and annulus formation less certain (Campana, 2001).

Sectioned otoliths are considered the most appropriate structures for evaluating the age and growth dynamics of freshwater fishes. Gerber et al. (2009) and Soekoe et al. (2013) are the only studies using otoliths to estimate the age of *H. vittatus*. This is because otoliths show annual and daily patterns, therefore providing a permanent record of life history events. Moreover, experimental evidence indicates no resorption of otoliths under stress conditions (Taylor & Weyl, 2012). In contrast, fish scales have proven to be unreliable because deposition ceases at older ages, thereby often giving false age readings. A prime advantage of using scales is that their removal does not result in death of the fish, as well as the ease of scale extraction (Campana, 2001).

Chifamba and Videler (2014) previously reported that sectioned otoliths represented the best method for ageing *Oreochromis niloticus* and *Oreochromis mortimeri*, also recommending that future studies and monitoring programmes use sectioned otoliths. Taylor and Weyl (2012) reported that sectioned otoliths of *Micropterus salmoides* were more readable and provided more precise age readings than did scales. Further, another study concluded that sectioned otoliths of *Oreochromis andersonii* gave more reliable readings than scales (Bwanika et al., 2007).

Hydrocynus vittatus is an important fish in Lake Kariba since local communities along the lake shorelines depend on it for both income and food (Marufu et al., 2018). Accordingly, estimating fish age using otoliths (and scales for comparison) will facilitate accurate growth estimations of tigerfish in Lake Kariba. The age distribution of a stock is a good indicator of reproductive potential and reflects the survival chances of a given population. Accordingly, the primary objective of the present study was to estimate the age of tigerfish in the Sanyati basin of Lake Kariba using whole otoliths and scales for comparison. Whole otoliths instead of sectioned otoliths were used in the present study because of lack of appropriate equipment to section otoliths. The present study also aimed at determining tigerfish length distributions and growth rates, with the study results anticipated to inform conservation efforts for *H. vittatus* in the Sanyati Basin, Lake Kariba. The results of the present study will also provide baseline data for future studies of *H. vittatus* ageing in Lake Kariba.

2 | METHODS AND MATERIALS

2.1 | Study area

Lake Kariba is a manmade lake (reservoir) located on the Zambezi River (Figure 1) shared between Zambia and Zimbabwe (26°40′E–29°3′E and latitudes 16°28′S and 18°6′S). The lake is 276-km long, with a mean width and depth of 19-km and 29.5-m, respectively. The major tributary rivers draining into Lake Kariba are the Gwayi, Sengwa and Sanyati rivers. The main inflow sources into the Zambezi River are the Kafue, Luangwa and Shire sub-basin tributaries. A minor (10%) of the mean annual rainfall within the basin contributes to the flow of the Zambezi River. Surface water temperatures reach 32°C in October to December and drop to 18°C between June and August (Magadza, 2010). The mean monthly atmospheric temperature around Lake Kariba usually exceeds 20°C, with distinct seasonal variations. Three seasons are distinct for Lake Kariba, namely (i) cool to warm dry season from April to September; (ii) hot dry season from September until onset of the October rains; and (iii) hot–wet season from late-October to late-March (Magadza, 2010).

The lake is divided into five hydrological basins, namely the Sengwa, Binga, Ume, Mlibizi and Sanyati basins. The five basins are separated by narrower lake zones and/or a series of islands. The first and second basins are shallower and smaller in terms of surface area and volume, compared to the other three basins. The third and fourth sub-basins are deeper, containing 90% of the total reservoir capacity. The main land use in the lake catchment area is subsistence farming and pastoralism. The Sanyati Basin, in which most studies have been conducted, is the one most accessible to the University Lake Kariba Research Station (ULKRS). The basin is fed by the Sanyati, Gache Gache, Nyaodza and Charara rivers. The most influential river in the basin is the Sanyati River which exerts a significant influence on the Sanyati Basin in terms of productivity (Sanyanga et al., 1995). The Sanyati River brings highly mineralized water to the lake from farms, sewage and mining drainage effluents from Kwekwe through Sebakwe River.

2.2 | Sampling procedure

A total of 892 fish of different sizes were captured between June 2017 and June 2018. Gillnetting and seine netting were used to capture the fish at the Gache Gache, Nyaodza, Forthegill and Tsuwa fishing grounds (Figure 1). A total of 324 and 306 samples