Age and growth of wild-caught grass carp in the Waikato River catchment

Cindy Baker and Joshua Smith

DOC RESEARCH & DEVELOPMENT SERIES 238

Published by
Science & Technical Publishing
Department of Conservation
PO Box 10–420
Wellington, New Zealand

DOC Research & Development Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff or external contractors funded by DOC. It comprises reports and short communications that are peer-reviewed.
Individual contributions to the series are first released on the departmental website in pdf form. Hardcopy is printed, bound, and distributed at regular intervals. Titles are also listed in our catalogue on the website, refer www.doc.govt.nz under *Publications*, then *Science and Research*.

ISSN 1176-8886
ISBN 0-478-14077-0

This is a client report commissioned by Waikato Conservancy and funded from the Science Advice Fund. It was prepared for publication by Science & Technical Publishing; editing and layout by Ian Mackenzie. Publication was approved by the Chief Scientist (Research, Development & Improvement Division), Department of Conservation, Wellington, New Zealand.

In the interest of forest conservation, we support paperless electronic publishing. When printing, recycled paper is used wherever possible.

CONTENTS

Age and growth of wild-caught grass carp in the Waikato River catchment

Cindy Baker and Joshua Smith

National Institute of Water & Atmospheric Research Ltd,
PO Box 11-115, Hamilton, New Zealand

ABSTRACT

Two relatively small grass carp (*Ctenopharyngodon idellus*) were captured in the lower Waikato River basin, New Zealand: one from Lake Whangape (1.65 kg, 435 mm fork length (F_L)), and one from Pungarehu Canal, below the floodgates to Lake Waikare (3.1 kg, 570 mm F_L). There was concern that they may be the progeny of a naturally reproducing population, however, they could also be escapees from stocked populations. Otolith growth patterns between these two wild-caught grass carp were compared with hatchery-reared stock to determine whether the origin of the two fish could be deduced. Growth patterns inferred from annuli in otoliths indicated that the two wild-caught grass carp could be escapees from the 1999 stocking of Churchill East Drain. However, such otolith analyses are not conclusive because large differences in growth rates can occur between hatchery-reared fish. Batch marking future releases of grass carp should be considered to enable easy identification of escaped hatchery-reared fish.

Keywords: fish, otolith, grass carp, *Ctenopharyngodon idellus*, age, growth, Waikato River, New Zealand

Baker, C.; Smith, J. 2006: Age and growth of wild-caught grass carp in the Waikato River catchment. *DOC Research & Development Series 238*. Department of Conservation, Wellington. 11 p.

1. Introduction

Two grass carp (*Ctenopharyngodon idellus*) were captured in the lower Waikato River basin: one from Lake Whangape and one in Pungarehu Canal, below the floodgates to Lake Waikare. Both fish were too small to be escapees from the original releases undertaken in 1984, but may have escaped from more recent releases of grass carp in the lower Waikato River catchment such as the June 1999 stocking of Churchill East Drain (K. Hutchinson, Department of Conservation (DOC), pers. comm.).

Initially only triploid fish were used for grass carp releases, more recently (and including the 1999 releases relevant here) all grass carp stocked into waterways are now diploid. Therefore, genetic analyses cannot be used to identify whether the two wild-caught grass carp are escapees, or the result of natural reproduction in the Waikato River. An estimate of age and analysis of growth patterns may shed light on the origin of these fish.

Determination of age and growth in fish is commonly assessed from calcified structures. Otoliths are considered the most accurate bony structures for estimating ages of fish because they are less susceptible to resorption compared to more metabolically active parts (Beamish & McFarlane 1983). This report compares otolith growth patterns for the two wild-caught grass carp with that of the hatchery-reared fish to determine whether the wild-caught fish could be escapees from stocked populations, or progeny of a naturally reproducing population.

2. Methods

Three grass carp were supplied by DOC for analysis:

- A fish captured in February 2004 from Lake Whangape (1.65 kg, 435 mm F_L)
- A fish captured not later than spring of 2001 from Pungarehu Canal, below the floodgates to Lake Waikare (3.1 kg, 570 mm F_L)
- A fish supplied by Gray Jamieson Holdings Ltd, which originated from his fish farm in Warkworth (1.14 kg, 437 mm F_L)

Both sagittal otoliths were removed from each carp, mounted on microscope slides, and embedded in Crystalbond 509, a heat-labile thermoplastic polymer. The otoliths were ground with carborundum paper (wet/dry paper 1200 grade) in a transverse plane to the approximate level of the core and then polished with Emery polishing paper (crocus grade) (Chisnall & Kalish 1993). The slides were heated until the Crystalbond liquefied, and the otoliths were repositioned with the ground and polished side face down on the slide. The grinding procedure was then repeated on the other side of the otolith.

The mounted otoliths were viewed using a Leica Wild MZ8 microscope. Annual hyaline rings were counted across the largest otolith axis (Todd 1980). The width of hyaline rings was assessed to gauge the amount of growth for a given year. Otoliths were photographed using a Nikon Coolpix 995.

Scales can also be used to age fish and identify growth patterns, but otoliths offer several benefits over scales in aging studies, especially in long-lived fish such as grass carp, where over 10 annuli can be present. Scale annuli are affected by resorption at the scale edge, plus scales often display irregular growth (Carlos 1990; Casselman 1990). In addition, replacement scales often form a large proportion of the scales in older fish and show no structure for the period before their formation. These factors cause problems in the interpretation of scale annuli. Otoliths are considered the most accurate bony structures for estimating ages of fish because they are less susceptible to resorption (Beamish & McFarlane 1983) and do not suffer from replacement effects.

In interpreting growth patterns, it is imperative that the age-determination techniques used be validated. Validation of scale annuli has not been conducted for grass carp, but Song et al. (2003) have used otolith annuli to identify differences in growth patterns between hatchery-reared and wild juvenile grass carp. It appears that grass carp deposit annuli at yearly intervals. For these reasons our analyses focused on otoliths.

3. Results

The grass carp caught in Lake Whangape revealed at least 7 clear annuli indicative of growth in the wild (Fig. 1A). This indicates the fish was at least 6+ years old. The width of the translucent zones between each annulus was relatively narrow, which suggests the fish was slow-growing. However, the zones are relatively uniform, which suggests the fish had consistent growth each year.

The carp captured from Pungarehu Canal appeared to be in its fourth year (Fig. 1B). Four distinct annuli represented growth checks from age 0+ to 3+. Each translucent zone was wide, which indicates growth in this fish was rapid each year. The rapid growth is verified by the size of the fish, which was 570 mm at 3+ years. In comparison, the 6+-year-old fish from Lake Whangape was only 435 mm.

The hatchery-reared fish supplied by Gray Jamieson Holdings Ltd was 437 mm long and appeared to be in its sixth year of growth because six distinct annuli were visible (Fig. 1C). The width of the translucent zones between annuli indicate that growth was rapid in the first two years, followed by slower growth in the last three years. Even with faster growth in the first two years, the growth rate of this fish, measuring 437 mm at 5 years, is similar to that of the fish captured from Lake Whangapae. Both fish display markedly slower growth compared to the carp captured from Pungarehu Canal.

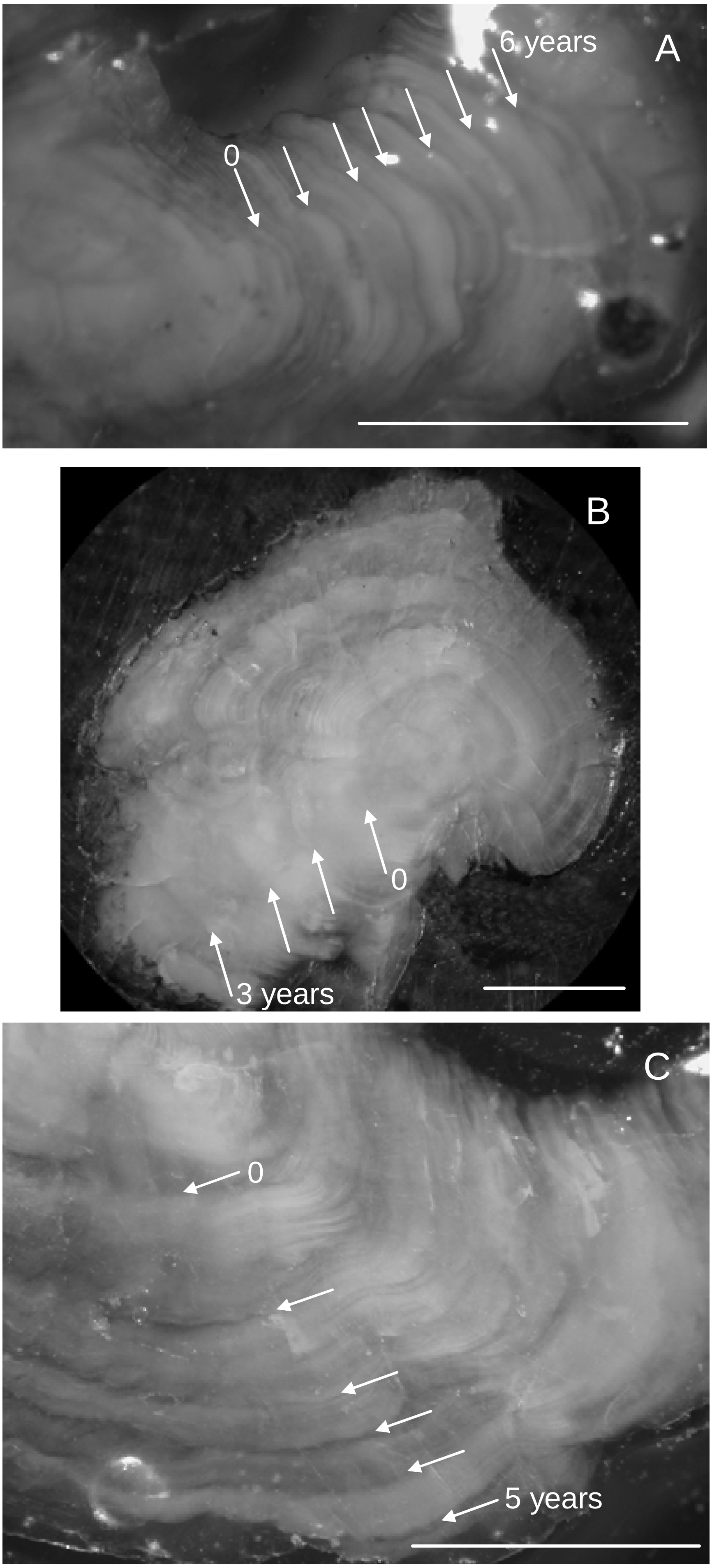

Figure 1. Otoliths of grass carp from the lower Waikato River catchment. **A**. The wild-caught fish from Lake Whangape. **B**. The wild-caught fish from Pungarehu Canal. **C**. The hatchery-reared fish. Scale bars represent 1 mm. Arrows highlight annuli used to age the fish.

4. Discussion

The two wild-captured fish differed markedly in their growth patterns. The fish captured from Pungarehu Canal had a much faster growth rate for all years, compared to that from Lake Whangape. This resulted in a larger fish at half the age. The fish supplied from Gray Jamieson was of similar length and age to the fish from Lake Whangape, indicating similar overall growth. The hatchery-reared fish displayed rapid early growth, with a reduction in growth over time, whereas the fish from Lake Whangape showed consistent slow growth over time.

Environmental conditions play a large role in determining growth patterns in fish. Analysis of longfinned eel (*Anguilla dieffenbachii*) otoliths revealed annual bands whose widths corresponded to habitat-specific growth (Chisnall & Hicks 1993). Song et al. (2003) successfully discriminated hatchery-reared grass carp from wild fish on the basis of zone width. In the present study, the Pungarehu Canal fish displayed fast growth at an early age and differed markedly from the other two carp. In this respect it could be a wild fish, but natural variation in growth rates does exist for fish of the same age class, reared in the same environment (Casselman 1987). Therefore, this carp could also be an escaped hatchery-reared fish that was stocked as a fast-growing (and hence large) 0+ yearling. With only one fish from each location, interpreting growth patterns to discern whether the wild-caught fish have been hatchery-reared was difficult. The life history of the hatchery-reared fish was also unknown. The fish supplied by Gray Jamieson was released into the natural environment at an unknown age and had spent the last two years in Lake Omapere in Northland before being returned to the holding ponds at Warkworth (M. Lake, DOC, pers. comm.). This meant the annuli which correspond to hatchery growth could not be identified.

The age of the fish will give the best idea as to whether the two wild-caught carp could be escapees from grass carp stockings. The last release of grass carp into the lower Waikato River catchment occurred in Churchill East Drain 6 years ago in 1999. It was noted at the time that some undersized fish were released that were expected to pass through the drain screens (K. Hutchinson, DOC, pers. comm.). The fish from Lake Whangape was captured at an age of 6 years, in February 2004; 5 years after the stocking. The overall growth rate was similar to the fish (supplied from Gray Jamieson) which is known to originate from hatchery-reared stock. It is likely that the fish from Lake Whangape is also a hatchery-reared fish which has escaped from the Churchill East Drain.

The precise capture date of the fish from Pungarehu Canal is unknown, but is thought to be no later than spring of 2001 (K. Hutchinson, DOC, pers. comm.). At 3+ years old, it is, therefore, conceivable that this fish is also an escapee of the 1999 stocking. However, the fast growth rate of this fish is markedly higher than the fish supplied by Gray Jamieson with known farmed origins, and the rapid growth is consistent over all three years. As hatchery-reared fish are kept at relatively high densities and feeding is not undertaken in a manner to enhance growth, it is likely that in the natural environment with abundant food supplies, growth rates of grass carp may be enhanced over hatchery-reared stock. Therefore, the grass carp caught from Pungarehu Canal may have come from a naturally reproducing population within the lower Waikato River, however, its age indicates it could have been a fast-growing escapee from a stocked population. Given the low sample sizes in the present study, the origin of this fish cannot be identified.

Although aging techniques can be validated to identify absolute age, growth patterns between fish of the same age class raised in the same environment are still variable. Therefore, age and growth analyses may not be precise enough to determine the origin of fish when the life history is unknown. Previous otolith and scale analyses have also been inconclusive in determining the origin of wild-caught grass carp in the lower Waikato River (Chisnall 1997).

To determine whether wild-caught grass carp from waterways which have not been stocked are escapees from nearby stockings or are the progeny of a naturally reproducing population, batch marking of the hatchery-reared fish may be the best technique for later identification. Fish could be fin clipped or tagged for future identification as hatchery-reared stock, or the otoliths could be labelled by immersing fish in a solution of oxytetracycline, which creates a fluorescent mark visible under ultraviolet light. Presently, all techniques have a limited lifespan. Fin clipping is useful for several years, but fins often regenerate. Tagging can be expensive, and tags can be shed or lost from the fish over time. Labelling of otoliths has been shown to last for over two years (Brown et al. 2004), but the long-term retention of the fluorescent marker is unknown.

5. Conclusions

The origin of the two wild-caught grass carp cannot be conclusively determined. Based on growth patterns, the Pungarehu Canal fish could be a wild-reared fish, but based on age, it is conceivable that both the Pungarehu Canal and Lake Whangape fish are escapees from the 1999 stocking of grass carp into Churchill East Drain. Batch marking future releases of grass carp should be considered, to enable easy identification of escaped hatchery-reared fish. However, it should be remembered that the retention time of current marking methods does not extend beyond several years.

6. Acknowledgements

We wish to thank Gray Jamieson for providing a known hatchery-reared carp. We also thank Kevin Hutchinson and Michael Lake from the Department of Conservation for background information. This research was funded from the DOC Science Advice Fund.

7. References

Beamish, R.J.; McFarlane, G.A. 1983: The forgotten requirement for age validation in fisheries biology. *Transactions of the American Fisheries Society 112*: 735–743.

Brown, P.; Green, C.; Sivakumaran, K.P.; Stoessel, D.; Giles, A. 2004: Validating Otolith annuli for annual age determination of common carp. *Transactions of the American Fisheries Society 133*: 190–196.

Carlos, F.D. 1990: Life history patterns of the common carp, *Cyprinus carpio*, in the estuary of the Guadalquivir River in southwest Spain. *Hydrobiologica 206*: 19–28.

Casselman, J.M. 1987: Determination of age and growth. Pp. 209–242 in Weatherley, A.H.; Gill, H.S. (Eds): The biology of fish growth. Academic Press, Orlando, Florida.

Casselman, J.M. 1990: Growth and relative size of calcified structures of fish. *Transactions of the American Fisheries Society 119*: 673–688.

Chisnall, B.L. 1997: Juvenile grass carp in the Waikato River—May 1997. *NIWA Client Report: DOC70214*. National Institute of Water & Atmospheric Research, Hamilton, New Zealand. 10 p.

Chisnall, B.L.; Hicks, B.J. 1993: Age and growth of longfinned eels (*Anguilla dieffenbachii*) in pastoral and forested streams in the Waikato River basin and in two hydro-electric lakes in the North Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 27*: 317–332.

Chisnall, B.L.; Kalish, J.M. 1993: Age validation and movement of freshwater eels (*Anguilla dieffenbachii* and *A. australis*) in a New Zealand pastoral stream. *New Zealand Journal of Marine and Freshwater Research 27*: 333–338.

Song, Z; Chang, J.; Cao, W.; Xia, L. 2003: Otolith microstructure of hatchery-reared and wild juveniles of grass carp, *Ctenopharyngodon idellus*. *Acta hydrobiologica sinica 27*: 7–12.

Todd, P.R.1980: Size and age of migrating New Zealand freshwater eels (*Anguilla* spp.). *New Zealand Journal of Marine and Freshwater Research 14*: 283–293.