

Age and growth of the Nile perch, *Lates niloticus* L. in Lake Victoria, Uganda

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Abstract

This research determined age and growth of Nile perch (*Lates niloticus*) from Lake Victoria commercial catches using transverse-sectioned sagittal otoliths. Marginal increment analysis of the otoliths indicated bimodal deposition of annuli over a 12-month period, with the highest opaque zone deposition corresponding to the two seasonal peaks of rain (i.e. March to May and September to November) characteristic of this equatorial region. A difference in growth rate between male and female Nile perch was observed with the females having faster growth rates and reaching a large size at older ages than their male counterparts.

Key words: Age determination, annuli, growth, Lake Victoria, Nile perch, otoliths

Résumé

Cette recherche a déterminé l'âge et la croissance du poisson qu'on appelle la perche du Nil (*Lates niloticus*) se trouvant dans le lac Victoria. Ils sont capturés pour de raisons commerciales en utilisant une section d'otolithes sagittaux transversaux. L'analyse de croissance marginale des otolithes a montré de dépôt bimodal des anneaux sur une période d'au-delà de 12 mois, avec une zone plus opaque de déposition correspondant aux deux pics saisonniers de pluie (c'est-à-dire de mars à mai et septembre à novembre), caractéristique de cette région équatoriale. Une différence de taux de croissance entre la perche du Nil mâle et femelle a été observée avec les femmes ayant des taux de croissance plus rapides et peuvent atteindre une grande taille chez les personnes âgées que leurs homologues masculins.

Mots clés: détermination de l'âge, anneaux, la croissance, le lac Victoria, la perche du Nil, les otolithes

Background

The overdependence on the Nile perch for export has fuelled intense fishing pressure raising concerns and uncertainty about the stability and sustainability of the Nile perch stocks (Matsuishi *et al.*, 2006), and associated investments, local employment and

livelihoods of the people in the Lake Victoria basin. Any heavily-exploited fisheries resource such as the Nile perch requires accurate knowledge of its annual age composition and growth (Godinho *et al.*, 2001; Dwyer *et al.*, 2003) to be managed successfully; however age and growth studies on Nile perch are limited. This hinders the ability to predict annual and long-term variation in recruitment to the fishery as well as to develop a predictive sustainable management of the Nile perch fishery. The aim of this study was to determine the age and growth of Nile perch in Ugandan waters of Lake Victoria in relation to its recruitment into the commercial fishery.

Literature Summary

In temperate regions where there are well marked hot and cold seasons and where fish generally have definite breeding seasons, several calcified structures including otoliths (earstones) encode periodic growth increments useful for age determination in fish (Campana, 2001). In the equatorial tropics where there are weak temperature fluctuations and some fish breed several times of the year, ageing of fish has been traditionally assumed difficult because of the absence of clear annular rings in their otoliths (Campana and Nielson, 1985). However, some recent studies on tropical fish species have demonstrated possible deposition of one annulus (Egger *et al.*, 2004) or biannuli (Bwanika *et al.*, 2007) in sagittal otoliths per year including studies of tilapia species in Uganda.

Study Description

This study was conducted in three fish processing factories where Nile perch captured in the commercial fishery from Lake Victoria were randomly sampled between March 2006 and February 2007. Each selected fish was weighed (in grams) and measured to the nearest centimetre. Maturity stages were determined from gonads after dissection of the fish, and sagittal otoliths were removed and used for age determination.

Transverse sections of 0.8 mm thickness through the nucleus of each left otolith were made using an Isomet digital saw. The best transverse sections were read under a stereomicroscope by two different readers. Age validation was done using edge and marginal-increment analyses to determine the periodicity of annuli formation in the otoliths. Non linear (3 parameter von Bertalanffy growth (VBG) equation; the VBG equation with $t_0 = "0"$, the 4 parameter Schute growth model) and linear regression models were used to model Nile perch growth separately for males and females, and for combined sexes. Differences in the non-linear and linear growth curves were

compared between males and females using Likelihood ratio tests (Cerrato, 1990) and Analysis of Covariance (ANCOVA) respectively. The goodness of fit of the different growth models was compared by using Akaike's (1973) Information Criterion (AIC) (Akaike, 1973) and the model with the smallest AIC value (AIC_{min}) was selected as the "best" among the models tested.

Research Application

Annuli deposition in Nile perch otoliths was bimodal corresponding to the two seasonal peaks of rainfall characteristic of this equatorial region. Akaike's Information Criterion (AIC) used to compare the goodness of fit for all growth models, was greatest for the Schnute model for males, females and combined sexes (Table 1). Likelihood ratio tests for coincident curves indicated significant differences ($P < 0.001$) in growth between male and female Nile perch using all four growth models. Female Nile perch grew faster than males reaching a larger size at older ages (Fig.1).

Table 1. Akaike model selection criteria for 4 growth models of male and female Nile perch and both sexes combined. (lower AIC values indicate a statistically better fit; RRS = residual sums of squares; AIC – Akaike Information Criterion; ΔAIC – measure of each model relative to the best model; w_i – Akaike weight representing the probability of choosing the correct model from the set of candidate models).

Model	RRS	AIC	ΔAIC	w_i	r^2
Females (n=563)					
Schnute 4 parameter	10456834	5544.11	0.00	0.998593	0.628
von Bertalanffy 3 parameter	10745624	5557.41	13.30	0.001291	0.618
von Bertalanffy with $t_0=0$	10877107	5562.23	18.12	0.000116	0.613
Linear 2 parameter	11134355	5577.42	33.31	5.84E-08	0.620
Males (n=703)					
Schnute 4 parameter	8871573.7	6648.52	0.00	0.999996	0.568
von Bertalanffy 3 parameter	9218156.9	6673.43	24.91	3.89E-06	0.551
Linear 2 parameter	9528968.6	6696.74	48.22	3.37E-11	0.536
von Bertalanffy with $t_0=0$	9728052.8	6709.26	60.74	6.47E-14	0.526
Males and Females (n=1266)					
Schnute 4 parameter	20591457	12286.2	0.00	1	0.585
von Bertalanffy 3 parameter	21373491	12331.3	45.17	1.55E-10	0.57
von Bertalanffy with $t_0=0$	21924835	12361.6	75.40	4.23E-17	0.558
Linear 2 parameter	22179447	12378.2	92.03	1.03E-20	0.554

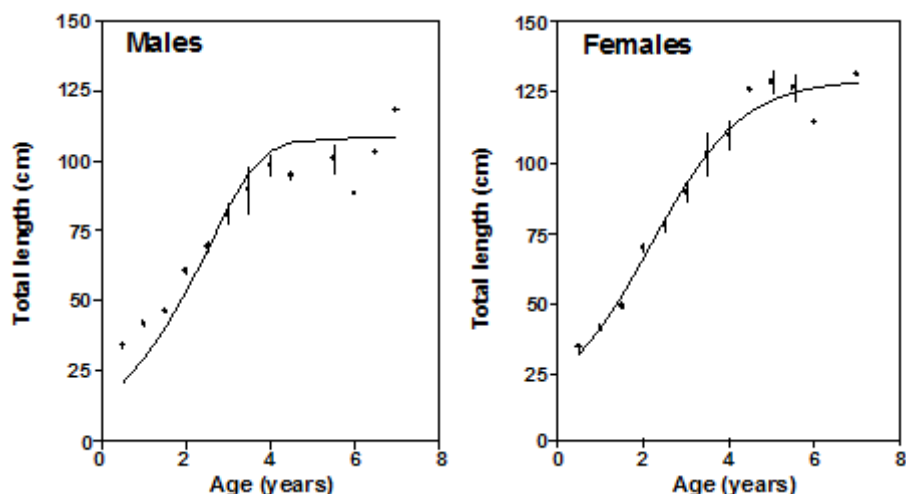


Figure 1. Mean ($\pm$ SE) of back-calculated length (L_t) as function of age for male ($n=703$) and female ($n=563$) Nile perch (Schnute growth curves).

References

- Akaike, H. 1973. Information theory as an extension of the maximum likelihood principle. In Petrov, B.N. and Csaki, F. (Eds.). Proceedings of the Second International Symposium on Information Theory. *Akademiai Kiado, Budapest* 267-281.
- Bwanika, G.N., Murie, D.J. and Chapman, L.J. 2007. Comparative age and growth of Nile tilapia (*Oreochromis niloticus* L.) in lakes Nabugabo and Wamala, Uganda. *Hydrobiologia* 589:287-301.
- Campana, S.E. 2001. Accuracy, precision and quality control in age determination including a review of the use and abuse of age validation methods. *Journal of Fish Biology* 59: 197 – 242.
- Campana, S.E. and Nielson, J.D. 1985. Microstructure of fish otoliths. *Canadian Journal of Fisheries and Aquatic Sciences* 42: 1014 – 1032.
- Cerrato, R.M., 1990. Interpretable statistical tests for growth comparisons using parameters in the von Bertalanffy equation. *Canadian Journal of Fisheries and Aquatic Sciences* 47: 1416-1426.
- Dwyer, K.S., Walsh, S.J. and Campana, S.E. 2003. Age determination, validation and growth of Grand Bank yellowtail flounder (*Limanda ferruginea*). *ICES Journal of Marine Science* 60:1123 -1138.

- Egger, B., Meekan, M., Salzburger, W., Mwape, L., Makasa, L., Shapola, R. and Sturmbauer, C. 2004. Validation of the periodicity of increment formation in the otoliths of a cichlid fish from Lake Tanganyika, East Africa. *Journal of Fish Biology* 64: 1272-1284.
- Godinho, M., Afonso, H. and Morgado, C. 2001. Age and growth of hake *Merluccius merluccius* Linnaeus 1758 from the Northeast Atlantic (ICES division IXa). *Boletín Instituto Español de Oceanografía* 17:255-262.
- Matsuishi, T., Muhoozi, L., Mkumbo, O., Budeba, Y., Njiru, M., Asila, A., Othina, A. and Cowx, I. 2006. Are the exploitation pressures on the Nile perch fisheries resources of Lake Victoria a cause for concern? *Fisheries Management and Ecology* 13: 53-71.