

Fishing in the deeper waters of Lake Malawi and the Precautionary Principle: A case study of Bombe, *Bathyclarias nyasensis* (Siluroidei)

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Abstract

The ecological role of *B. nyasensis* in Lake Malawi was identified from studies on life history traits, ecological and functional morphology in addition to diet and food habits of the species conducted between 1996-1998.

Dietary changes synchronised with changes in carbon isotope values and volume of the buccal cavity. These changes occurred when fish reached 50-60 cm TL, concomitant with habitat shifts. In in-shore areas, *B. nyasensis* was primarily piscivorous and was zooplanktivorous in offshore regions.

On the basis of trophic cascade theories and the planktivorous behaviour of *B. nyasensis* in the off-shore area, overfishing the stock could lead to unpredictable ecological changes in the pelagic ecosystem of Lake Malawi. It is recommended that the current interest in increasing fishing effort in off-shore deeper waters of Lake Malawi should proceed on the basis of the "Precautionary principle".

Key words: *Bathyclarias nyasensis*, dietary changes, carbon isotope, buccal cavity volume, Lake Malawi

Introduction

The lake Malawi genus *Bathyclarias* belongs to the family Clariidae that falls in the group of the specialised catfishes (Reagan 1907, Alexander 1975). Jackson (1959) created the genus *Bathyclarias*, endemic to Lake Malawi. However, Greenwood (1961) synonymised the Lake Tanganyika *Dinotopterus* and *Bathyclarias* where *Bathyclarias* became the junior synonym. Recently, using morphological, osteological and zoogeographical evidence, Anseaume & Teugels (1999) reinstated *Bathyclarias* as the valid generic name of the species found in Lake Malawi.

While the species of *Bathyclarias* and other catfishes are the target of artisanal fisheries in some localised areas and may contribute to about 20 per cent of the catch by weight, (Banda *et al.* 1995), biological and ecological studies on *Bathyclarias* have never been made to foster effective management options of the species. Scanty information and sporadic observations on the biology of *Bathyclarias* were made by Lowe (1952), Jackson (1961) and Thompson *et al.* (1996). This lack

of information led to omission of the *Bathyclarias* from the trophic model that was constructed for the Lake Malawi pelagic food web (Allison *et al.* 1995). In cognisance that life history traits such as age, growth and reproductive biology influence diet and food habits and/or vice versa (Wootton 1990), and that a full dietary analysis is necessary to elucidate ecological role of a species (Nagelkerke 1997), this study was conducted to investigate life history traits, diet and food habits of *B. nyasensis*. The information obtained would assist in determining the trophic role of *B. nyasensis*.

Materials and Methods

Samples of *B. nyasensis* (*Bathyclarias* species with a rugose head and a light crescent on the caudal fin) were collected month or bimonthly from the South-East Arm of Lake Malawi between December 1996 to November 1998 using a 17 m long research vessel Ndunduma, powered by a single caterpillar engine of 386 hp. The Gullopur bottom trawl net with a headrope of 23 m, a vertical opening of 4 m and a codend mesh size of 38 mm was used to obtain the material. The

trawling speed was 3-3.5 knots and the trawls were made at depths of 8 – 122 m.

Out of 776 fish that were dissected, 343 with identifiable stomach contents were analysed. Identification of prey items was made to the lowest taxon possible. Prey items were placed in a single petri dish and sorted into different taxonomic categories. The relative volume of each prey category was estimated visually. Prey items in each category were then counted. Where small prey items (e.g., zooplankton) were numerous, they were placed in a known volume of water and thoroughly mixed by swirling the water, of which 10 % was removed for sorting and enumerating. At most this dilution was done twice.

Stomach contents were analysed for the whole sample, fish size and in relation to water depth using numerical, percent of occurrence and volumetric methods according to Hynes (1950), Hyslop (1980), Tudorancea, Fernando, & Paggi (1988) and Cortés (1997). Index of Relative Importance (IRI) was computed according to Palomares, Garces, Sia III & Vega (1997):

$$IRI = \%V \times \%F$$

Where % V = percent volume

%F = percent frequency of occurrence

Isotopic composition of different size groups of fish were used to determine ontoge-

netic diet changes of *B. nyasensis*. Carbon isotope ratios ($\delta^{13}C$) of fish ranging from 37 to 73 cm total length (TL) and principal prey items (fish and zooplankton) were determined.

Parameters relating to filtering ability were determined by taking measurements on the first gill arch. The measurements included the length of the gill rakers, two on the lower arm and one on the upper arm of the first gill arch. The filtering area was estimated by calculating the two trapezoidal areas formed by the gill rakers where the lengths of the gill rakers were the heights of the trapezoids.

Results and Discussion

Distinct changes in relative importance (% IRI) of prey types were noted as fish grew (Fig. 1). The relative importance of zooplankton increased from about 10 % in small fish (20 - 29.9 cm TL), to 91.9 % in large fish (size F, 70 - 86.5 cm TL). "Fish remains" decreased in importance from 29.1 % in small fish (20 - 29.9 cm TL) to 2.6 % in large fish (70 - 86.5 cm, TL). The relative importance of insects decreased from 16.7 % (20-29.9 cm, TL) to less than 1 % in large fish (70-86.5 cm TL). The importance of all prey items in the small size category (20-29.9 cm TL) may have been masked by the high portion of "amorphous, digested food" (47.7 %). However, the amount of this amorphous material decreased

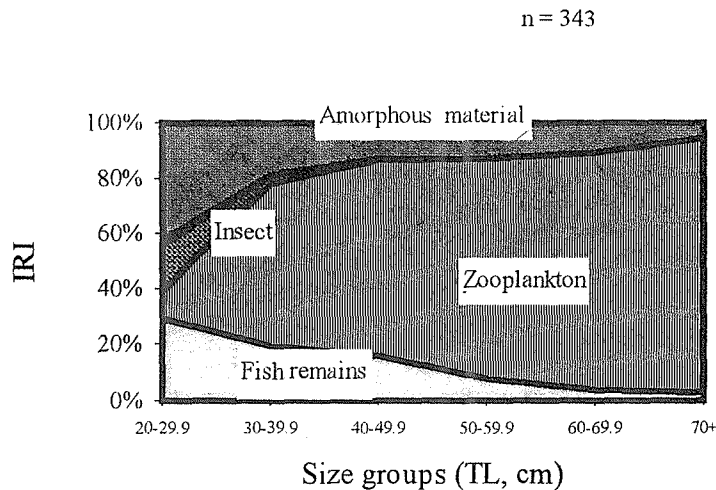


Fig. 1. Relative importance (%IRI) of principal prey items of *Bathyclarias nyasensis* of different sizes.

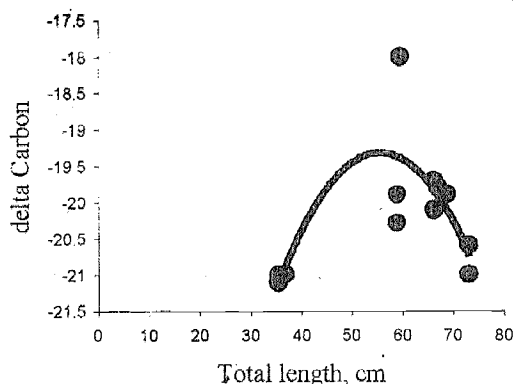


Fig. 2. $\delta^{13}\text{C}$ values in *Bathyclarias nyasensis* from Lake Malawi. The fitted 2nd order polynomial is provided in the text.

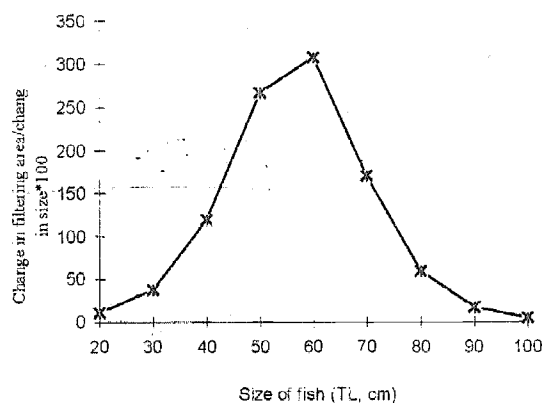


Fig. 3. Change in filtering area of *Bathyclarias nyasensis* at different sizes.

with fish size (5.5 % in size, 70-86.5 cm TL)

Results on $\delta^{13}\text{C}$ values also showed clear ontogenetic diet changes. A second order polynomial equation fitted the data (Fig. 2), and the equation was of the form:

$$\delta^{13}\text{C} = -33.188 + 0.4997L - 0.0045L^2 \quad (r^2 = 0.598, n = 12, p = 0.022)$$

where: L = total length of fish in cm.

From Fig. 2, it is apparent that the $\delta^{13}\text{C}$ values changed from "light" or "more negative" in small fish (approximately -21‰) to "heavy" or "less negative" in medium size fish (-19.5 ‰) and to "light" or more negative in large fish (-20.7 ‰) suggesting that fish changed diet with change in size. The $\delta^{13}\text{C}$ of approximately -21.0 ‰, is indicative of diet shift to zooplankton assuming a 1-2 ‰ enrichment factor from prey item ($\delta^{13}\text{C}$ value of zooplankton -23 ‰) to consumer (DeNiro

& Epstein 1978; Fry & Sherry 1984).

Results obtained on filtering area showed a distinct change as *B. nyasensis* reach 50 – 60 cm TL fish size (Fig. 3).

From the foregoing results on gut content and carbon isotope analyses, and filtering area, ontogenetic diet changes of *B. nyasensis* are clearly evident. In addition, an analysis of diet of *B. nyasensis* from different water depths suggests an ontogenetic, habitat diet change phenomenon. From Fig. 4, fish that were caught from the deeper waters (> 40 m, depths IN and DE), consumed higher proportion of zooplankton than fish from shallower waters (<40 m, depth SH). Conversely, fish from the shallower waters (<40m depth SH), had higher proportions of fish than fish from deeper waters (> 40 m, depths IN and DE).

By being zooplanktivorous in deeper waters,

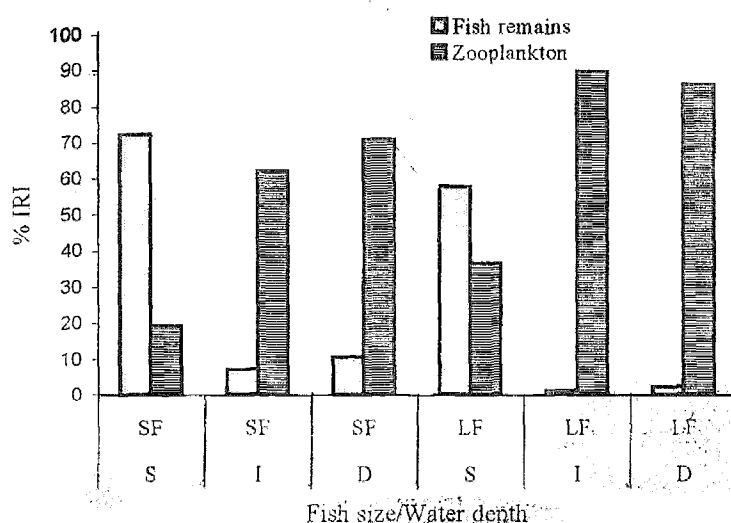


Fig. 4. % IRI of prey categories of small (SF, 20-40cm TL) and large (LF, 40 - 86 cm, TL) *Bathyclarias nyasensis* caught from different water depths. S = shallow (10- 40 m). I = intermediate (41- 60 m) and D = deep water (61- 86 m). Note that only prey items with high % IRI are shown.

and considering the zooplankton dynamics in Lake Malawi (Allison *et al.* 1995b), it is apparent that *B. nyasensis* feeds on the pelagic food web of the lake, although the species was omitted from the pelagic food web that was constructed by Allison *et al.* (1995a).

From an *in situ* 24-hr diel study (Kaunda 2001), food consumption per biomass (Q/B) ratio of 3.16 was estimated. This was similar to the estimate of 3.31 ± 0.61 δf (Ngatunga & Allison 1996) which was obtained using an empirical model of Jarre *et al.* (1991). Using the Q/B value of 3 it was estimated that *B. nyasensis* increases overall zooplankton consumption in the pelagic zone by 11 per cent (Kaunda 2001). Predation of zooplankton in the pelagic zone of Lake Malawi may therefore have been underestimated.

This new information raises questions to the implications of fishing in the pelagic zone of Lake Malawi with promotion of efficient fishing gears to deeper waters and where larger species are usually selectively overfished in a multispecies fishery (Welcomme 1999) and suffer from a "fishing down" syndrome (Pauly *et al.* 1998). The question that immediately comes up is, would overfishing of *B. nyasensis* lead to cascading effects to the lake

ecosystem? While cascading effects of plantivorous fish in natural systems are equivocal, their effects on the size distribution of zooplankton is unequivocal (Currie *et al.* 1999).

The presence of *B. nyasensis* in the offshore areas could affect the community structure of the lower trophic levels in two ways. Firstly, *B. nyasensis* may provide the right zooplankton size to other zooplanktivores such as the lakefly *C. edulis*, which has been identified as one of the most important zooplankton grazers in the lake (Turner 1982). The presence of planktivorous fish leads to dominance of small size zooplankton (Currie *et al.* 1999), and the gape of *C. edulis* limits the size of zooplankton that can be ingested (Irvine 1995). Hence, it can be expected that the absence or a reduced abundance of *B. nyasensis* would lead to dominance of large zooplankton which can not be ingested by *C. edulis*, resulting in starvation-induced mortality of the latter. In turn, a reduced biomass of *C. edulis* would affect *Diplotaxodon* "elongate", as this species relies almost entirely on *C. edulis* (Allison *et al.* 1995).

Secondly, *B. nyasensis* may reduce competition for dilute resource of the herbivorous zooplankton, *Tropodiptomus cunningtoni*. It is known that the carnivorous zooplankton *Mesocyclops aequatorialis aequatorialis*, larval *Engraulicypris*

sardella and *C. edulis* feed on *T. cunningtonii*. *B. niasensis* feeds on both *M. a. aequatorialis* and *T. cunningtonii*. While the circumstances under which *B. niasensis* take one type of zooplankton and not the other are not known, it can be assumed that by eliminating *M. a. aequatorialis*, *B. niasensis* reduces competition between *M. a. aequatorialis*, *E. sardella* larvae and *C. edulis* for *T. cunningtonii*. The absence of *B. niasensis* and therefore increase in abundance of *M. a. aequatorialis* may therefore, lead to stiff competition for *T. cunningtonii* which may culminate in low production of *C. edulis* and *E. sardella* larvae with possible effects to the upper level of the food web.

While these predictions remain speculative, it may be possible that in the past such ecological consequences have not been noticed because the offshore region has not been intensively fished and the pelagic ecosystem was hence considered to be stable (Allison *et al.* 1995). The current interest to expand demersal trawling in the offshore region (Allison *et al.* 1995) that may lead to elimination of *B. niasensis* may thus lead to undesirable ecological consequences to the "stable" pelagic ecosystem of Lake Malawi. These predictions should serve as a warning that exploitation of the offshore fisheries should proceed on the basis of the precautionary principle which is defined as "when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically" (Raffensperger & Tickner 2002).

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