AQUACULTURE GENETICS RESEARCH IN MALAWI

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ABSTRACT

Aquaculture genetics research is carried out at the National Aquaculture Centre at Domasi, Malawi, by staff of the University of Malawi (UM) and the Department of Fisheries. The main species cultured are from genera *Tilapia* and *Oreochromis*. The genus *Oreochromis* was domesticated without proper identification of the various species especially in the subgenus *Nyasalapia* where three species (*O. karongae, O. squamipinnis,* and *O. lidole*) are difficult to identify before they reach breeding size. It is, however, observed that local fishers can identify these species using morphological characters. There have been no attempts to carry out deliberate domestication selection in the small-scale farms with the prevailing practices probably leading to deterioration of stock performance and decline in genetic diversity. Studies showed that wild populations grow faster than domesticated populations, and results of mass selection on collimated individuals suggest that selected individuals grow faster than unselected individuals. Studies of population genetics of domesticated and wild tilapias are underway at UM.

Introduction

The aquaculture industry in Malawi is characterized by small-scale farmers, and tilapia is the major fish species cultured. The Government has put a ban on importation of exotic species, which have been domesticated and selected, to fairly greater extent than the indigenous species. The ban is intended to protect the genetic integrity of fish populations in the natural water bodies.

Although aquaculture has developed to considerable extent in Malawi, compared to other African countries, it is still faced with the problem of culturing species with low growth rate. This, among other factors, is due to poor domestication protocols in the government and private farms. There is little regard for quality of germplasm being cultured. Small-scale farmers and government stations do not practice deliberate and effective genetic selection. They reserve a portion of fingerlings from grow-out ponds at the time of harvest for the next grow-out cycle. Although no criteria are known to be used in selecting the fingerlings, strong indirect or domestication selection can nevertheless occur, e.g., if the fingerlings come from very few parents or from particularly early or late maturing parental stock. Not much is known at present if such a system depletes genetic variation or

not, but DNA analysis of farm populations indicates that depletion is actually rather rapid.

The species cultured have not been properly identified or characterized. As a result, information has not been reproducible, consistent or easily transferable among programs. The domestication efforts of the *Nyasalapia* species have been carried out without sorting out the confusion surrounding the identity of the various species of *Oreochromis* (*Nyasalapia*) sp. Lack of documentation of the available genetic material is due not merely to lack of facilities and trained personnel to identify the species, but also to lack of knowledge of the structure of the gene pool of species relevant to aquaculture.

The increasing pressure from human population growth and activities associated with the lakes on aquatic biodiversity in Malawi is of particular concern. Cyprinids, like *Opsaridium microleps* and *Labeo mesops*, have disappeared from their traditional natural habitats where they used to occur in abundance. *O.* (*Nyasalapia*) sp. catches have declined considerably in the wild. The country is currently faced with the challenge of conserving the aquatic biodiversity in the lakes. *Ex situ* conservation is not economically feasible in such a country where financial resources are limited; the economic feasibility of *in situ* conservation offers achievable promise as an alternative means of preserving the otherwise threatened biodiversity. Several reservoirs exist in the country, but most of them are underutilized for fishery production.

Tilapia Genetic Resources in Malawi

In Malawi, the genus *Tilapia* is represented by *T. rendalli* while the genus *Oreochromis* is divided into two subgenera: *O. Oreochromis* and *O. Nyasalapia*. *Oreochromis* is composed of *O. shiranus* sp. (subdivided into *O. shiranus shiranus* and *O. shiranus chilwae*), *O. mossambicus* and *O. placidus*. The *O.* (*Nyasalapia*) species flock is composed of *O. Ny. karongae*, *O. Ny. lidole*, *O. Ny. squamipinnis* and *O. Ny. saka*. The taxonomy of *O. Nyasalapia* sp. is based almost entirely on morphometric data, some of which are extremely preliminary. Contrary to the species division listed above, multivariate morphometric analysis carried out recently suggests that there are only three species of *O. (Nyasalapia)*, i.e., *O. karongae*, *O. lidole* and *O. squamipinnis*. *O. saka* is classified as a junior synonym of *O. karongae* (Turner and Robinson 1990). Difficulties in identifying the *O. Nyasalapia* species have deterred proper broodstock handling procedures and development of improved strains for aquaculture.

Affinities

The *O. Nyasalapia* species flock appears morphologically to be the derivatives of *S. galilaeus* group (Fryer and Iles 1972) and they have affinities with *O. machrochir* and *O. rukwaensis*. Thys van Audernaerde (1968, cited in Sodsuk et al. 1995) proposed a separate subgenus *Nyasalapia* as part of the genus *Tilapia* which would be only restricted to the Lake Malawi species and subgenus *Lowuwiala* to include all other tasseled male species, for instance *O. (Ny.) machrochir*.

O. shiranus sp. is divided into two subspecies based on morphological and meristic characteristics (Trewavas 1983), *O. sh. chilwae* and *O. sh. shiranus*. The subspecies are from a common ancestor *O. shiranus* which existed in Rovuma River into which the ancient Lakes Chilwa-Chiuta drained to the Indian Ocean via Lujenda River. The most nearly related species is *O. rovumae*, and together with *O. mossambicus* and *O. placidus*, they belong to the *mossambicus* group of tilapias (Fryer and Iles 1972).

Zoogeographical distribution

The *O. Nyasalapia* sp. is endemic to Lakes Malawi and Malombe only. The fishes are distributed throughout Lake Malawi from north to south. Their population in the lake is reported to be declining. *O. shiranus* and *T. rendalli* are the most widely distributed tilapias in the country. They are found in Lake Malawi and Malombe, lagoons and rivers. *O. mossambicus* and *O. placidus* are only found in the Lower Shire (Table 1).

In aquaculture, the species have been moved without regard to their natural geographical distribution. The *O. Nyasalapia* subgenus has been stocked in reservoirs and fishponds outside their natural regions of distribution.

Indigenous knowledge on characterization of tilapias

It has been observed that fishers at the lakes and along the Shire River have their own methods of distinguishing among fish species based on morphometric characters and fish behavior. This knowledge has been passed on from several

Table 1. Distribution of tilapia in the water bodies of Malawi.

Water bodies	Species
Lake Malawi, Lake Malombe and Upper Shire	*O. shiranus shiranus* *O. Nyasalapia* species flock *T. rendalli*
Middle Shire	*O. shiranus shiranus* *T. rendalli*
Lower Shire	*O. mossambicus* *O. placidus* *T. rendalli*
Reservoirs	*O. shiranus hybrids* and pure strains *O. Nyasalapia* sp. *O. mossambicus/O. placidus* hybrids
Rivers and lagoons	*O. shiranus* sp. *T. rendalli*
Aquaculture	*O. Nyasalapia* sp.(distributed in all regions of the country but only recently domesticated)
	O. shiranus shiranus (common in all regions) *O. shiranus chilwae* (common in southern and central regions) *O. mossambicus* (common at Kasinthula Fish Farm, the species has hybridized with *O. shiranus* in Zomba district)
	O. placidus (rare, mainly hybridized with *O. mossambicus)* *T. rendalli* (common in all regions)

generations but has not been well documented. A nationwide survey of indigenous knowledge of the fishing communities on the taxonomy and behavior of tilapias has been completed and data are being analyzed.

Also, a survey of local names of tilapia species was carried out throughout the country. The main interest was in determining the local classification system for species in the *O. Nyasalapia* subgenus which are difficult to identify before breeding stages. These species are as follows:

- *O. squamipinnis* - deep body and sharp bend on the forehead; breeding males have characteristic vertical blue band on the forehead;
- *O. karongae* - deep body with depression on the forehead; males do not have vertical bands on the forehead as in *O. squamipinnis*; and
- *O. lidole* - big head and small body; generally slender in appearance.

Quantitative Genetics

Comparison of growth between wild and domesticated populations

Wild broodstock populations of *O. shiranus chilwa* were collected from Lakes Chilwa and Chiuta for domestication. F_1 progenies were compared to populations that have been at the National Aquaculture Centre (NAC) for several years. The experiment was carried out between August 1997 and April 1998. The results obtained in 1998 indicated that wild population grew faster than domesticated one, 16.6 g and 13.3 g, respectively (Table 2).

Mass selection on collimated populations

Broodstock of *O. shiranus* were collected from domesticated populations at the NAC. These were stocked in three ponds where they bred naturally. Fingerlings were collected and stocked randomly into 16 200 m^2 ponds at stocking rate of 5 fish m^{-2}. After one month, standard length (SL) measurements

Table 2. Growth comparison between wild and domesticated populations of *O. shiranus*.

Month	Mean weight (g)	
	Wild fish	Domesticated fish
Aug	05.3 ± 0.00	03.8 ± 0.00
Oct	06.2 ± 0.00	04.9 ± 0.01
Nov	10.0 ± 0.06	06.9 ± 0.03
Jan	12.2 ± 0.03	09.7 ± 0.06
Mar	16.5 ± 0.03	12.3 ± 0.03
Apr	21.9 ± 0.03	17.4 ± 0.05

were taken from fish in eight of the 16 ponds. All length measurements were converted to weight (W) using the formula, $W = 2.46x10^{-2}SL^{2.79}$. Individuals of the weight range 7.3-14.1 g were selected and restocked at stocking rate of 800 fish per pond. The fish were grown for another 3 months before SL measurements were taken. The average length was 17.2 g and range was 11.4-30.4 g. Fish of the range 20.7-30.4 g were selected for grow-out for 6 months, August 1998-January 1999. The mean size of selected population was 24.7 g and selection differential was 7.2 g. Stocking rate was 300 fish per pond. The rest of the fish were discarded. Length measurements were taken monthly.

The second group formed a control population which was stocked in eight ponds at 5 fish m^2 and then randomly trimmed to 800 fish per pond after a month. Two months later, the stocking density was reduced to 300 fish per pond and grown for 6 months, from August 1998 to January 1999, to compare the growth between selected and unselected populations. The stocking size range in this control population was 4.9-37.1 g and mean was 23.1 g.

In both populations, fish were fed 10% body weight with maize bran; chicken manure purchased from nearby chicken farms was applied to the ponds to promote primary productivity.

Selected populations grew faster than unselected ones (Table 3). Overall, the population had very low growth rate, probably supporting the fact that domesticated tilapias in Malawi have poor growth rate than their wild counterparts.

Population genetics

Studies of genetic characterization and population structure of *O. shiranus* sp. have been carried out at UM in collaboration with Dalhousie University of Canada with funding from the International Development Research Centre. In these studies, microsatellite DNA markers were used to determine the level of genetic diversity in wild and domesticated populations. Considerable decline in genetic diversity was reported in populations which were domesticated for longer period (Ambali 1996; Ambali et al. 1999).

A DNA analysis laboratory has been established at Chancellor College, UM, with funding from the Japanese International Cooperation Agency. Activities in the laboratory include characterization of indigenous tilapias and cichlid species with potential for aquaculture.

Table 3. Growth comparison between selected and unselected populations of *O. shiranus*.

Month	Mean weight (g)	
	Unselected fish	Selected fish
Aug	23.12 ± 0.04	24.69 ± 0.02
Nov	23.46 ± 0.00	34.06 ± 0.03
Dec	25.77 ± 0.00	37.68 ± 0.04
Jan	29.00 ± 0.01	39.02 ± 0.04
Feb	29.40 ± 0.01	39.02 ± 0.03
Mar	31.02 ± 0.00	42.04 ± 0.00

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