RELATIONSHIP BETWEEN WATER TRANSPARENCY AND SPECIES RICHNESS OF SURVIVING HAPLOCHROMINES IN SELECTED HABITATS IN MWANZA GULF - LAKE VICTORIA

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ABSTRACT

Several of the surviving haplochromine species have been recorded in habitats of different water transparencies within the Mwanza Gulf. Sampling for the haplochromines was carried out in muddy, rocky, sandy and vegetated habitats. All of the recorded species had been reported previously. Fewer species were encountered than previously reported in the same sampling stations. There was evidence for positive correlation between species richness and water transparency that was reinforced with data on ecological differentiation. Further exploration and conservation measures of diversity have been suggested for Lake Victoria haplochromines.

INTRODUCTION

Lake Victoria is the largest tropical lake in the world with an area of 68,800 km2 lying between 00 21'N-310 20' E and 30 0'S-340 30'E (Fig. 1), sharing a catchment of about 195,000 km2. The lake is among the world's popular examples of fish species rich lacustrine ecosystems. The haplochromine cichlids used to constitute more than 80% of the fish biomass (Kudhongania & Cordone 1974) and 90% of the total number of fish species (Seehausen 1996, Snoeks 2000) in the lake. It is of particular interest to note that with the exception of *Astatotilapia nubila*, *Astatoreochromis alluaudi*, and *Pseudocrenilabrus multicolor*, all the other haplochromines are endemic to the main lake and its satellite lakes belonging to either a monophyletic group (Meyer *et al.* 1990) or derived from just a few ancestral species (Nagl *et al.* 2000). Some members of the widely spread riverine *Astatotilapia* species represent the body plan of the ancestors of the Lake Victoria haplochromines (Meyer 1993).

The haplochromine cichlids and about 10 other genera belonging to different families contributed to the Lake Victoria fisheries in the past. From the beginning of the last century the two indigenous tilapiine cichlids *Oreochromis esculentus* and *O. variabilis* were the target species (Fryer and Iles 1972). Consequently these species had declined drastically. To boost the fisheries *O. niloticus*, *O. leucostictus*, *Tilapia zillii*, *T. rendalli* and later a large predator, the Nile perch (*Lates niloticus*) were introduced into the lake. After these introductions, there was an explosive increase of Nile perch in the early 1980s. Simultaneously, stocks of many other fish species declined in several areas of the lake (e.g Hughes 1983, Barel *et al.* 1985, Witte *et al.* 1992). Strikingly there was a decline of the haplochromines which were the dominant prey of the Nile perch (Barel *et al* 1985, Kaufman and Ochumba 1993, Witte *et al.* 1992). Some haplochromine species were thought to be extinct in the sub littoral (6-20m deep) and offshore (>20m) waters. This "greatest extinction of vertebrate species in our life time" has aroused international concern (Lowe-McConnell 1997).
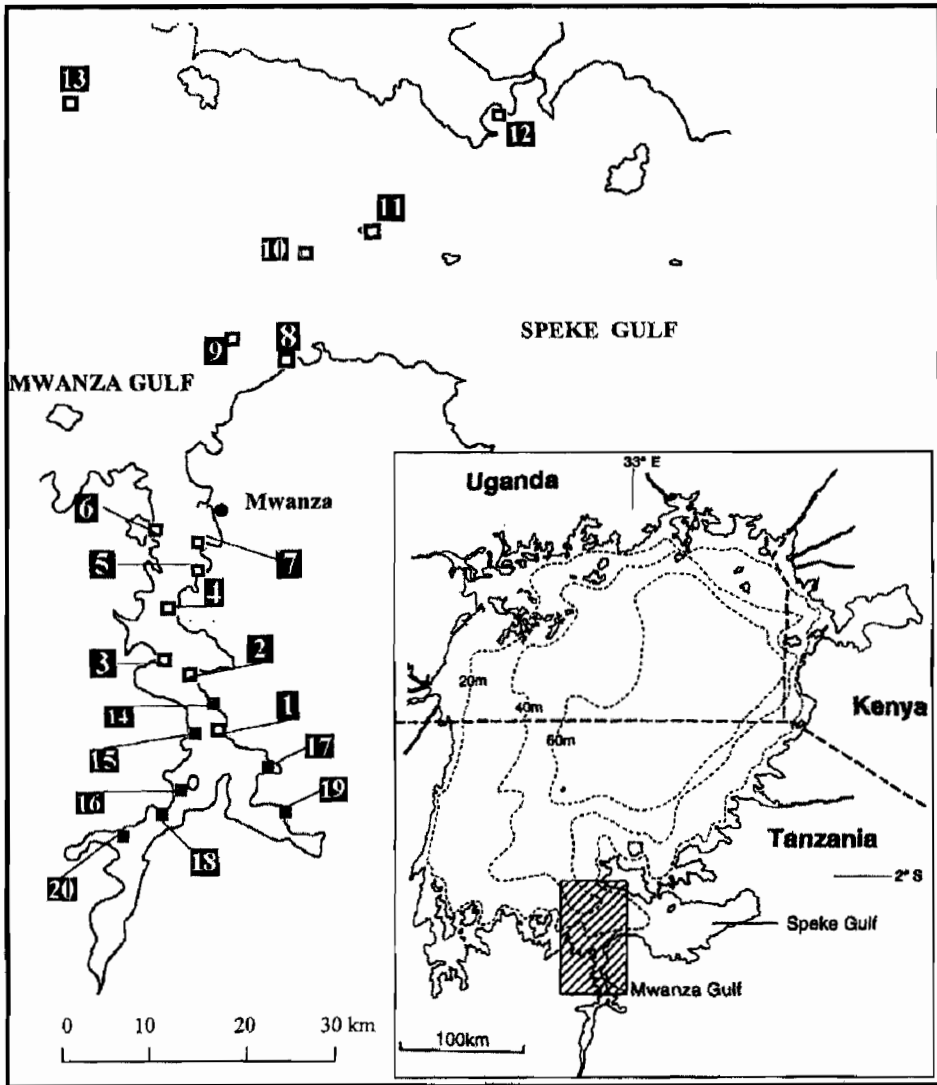
Open squares mark rocky sites while solid squares represent mixed habitats (rocky and non-rocky sites). 1 = Marumbi Island, 2 = Luanso Island, 3 = Matumbi Island, 4 = Python Islands, 5 = Nyegezi rocks and island, 6 = Kissenda Island, 7 = Anchor Island, 8 = Igombe Island, 9 = Makobe Island, 10 = Ruti Island, 11 = Mabibi Island, 12 = Nansio Island, 13 = Kunene Islands, 14 = Kigongo Ferry, 15 = Busisi, 16 = Nyabusura, 17 = Chole, 18 = Nyamasare, 19 = Bulima, 20 = Nyambogo

Figure 1:   Study area.

In the second half of 1980s, the Nile perch constituted more than 90% of the total catch weight in the demersal trawl catches (Ligtvoet and Mkumbo 1990). Other great changes in the ecosystem were observed such as in algal composition and

eutrophication (Hecky 1993 and Mugidde 1993).

The decline of fish species diversity was first noticed in the 1980's when new species were still being discovered (Witte, pers. comm.). It might be possible that the actual species richness was much greater than what has been so far documented. This suggests that the magnitude of species loss could be higher than observed. Witte *et al.* (1992) and Seehausen *et al.* (1997) reported the first quantitative details of the extinction process for the southern part of Lake Victoria. Similar alerting reports were given by Kaufman (1992) and Kaufman and Ochumba (1993) on the Ugandan and Kenyan parts of the lake, respectively. From 1991 onwards some zooplanktivorous haplochromines e.g. *Haplochromis laparogramma* and *H. pyrrhocephalus* (Witte *et al.* 2000) have been recorded particularly in the light assisted fishery for *Rastrineobola argentea* (dagaa).

With the disappearance of such a large number of haplochromine species in Lake Victoria, there has been a tendency to focus more on the need for understanding mechanisms by which biodiversity is regulated in relation to human influences on those mechanisms. Studies show that fish need good visibility for mate choice especially where closely related species coexist. (Seehausen *et al.* 1998a, 1998b). In turbid waters haplochromines of different species interbreed and produce viable offspring of intermediate phenotype hence a lower level of interspecies variation due to mixing of gene pools (Seehausen *et al.* 1997). This may be worsened where high turbidity impairs resource partitioning among coexisting species whereby interspecific competition is intensified leading to survival of only the fittest and thus reducing the number of coexisting species.

Water transparency has been decreasing over the years (Worthington 1930, Talling 1966,

Melack 1979, Ochumba & Kibaara 1989, Ochumba 1990). The increasing turbidity in Lake Victoria is mainly a consequence of the human induced eutrophication (Hecky 1993). In attempt to elucidate possible causes for the recent mass extinction, we explored relationship between water transparency and the haplochromine species diversity.

MATERIALS AND METHODS
This study was conducted in Mwanza Gulf of Lake Victoria (Fig. 1). A survey was conducted only around selected rocky islands in the gulf for the period of December 2000 to October 2001. A later survey was conducted between February and September 2002 in some of the non-trawlable areas.

Multifilament and monofilament nets of 25 mm to 101 mm with an increment of 12.5 mm mesh sizes were used. For non-rocky sites electric fishing and beach seining with 25 mm cod end mesh net were conducted complementarily. Angling was applied for species that inhabit narrow crevices in rocky shores where other gear types could not be used. Where water transparency was good enough (> 1.5 m Secchi depth reading), underwater counting of fish and habitat description was carried out through SCUBA diving. Notes on the date, time, depths and water transparency by Secchi disk reading were also taken on each sampling occasion. Live fish specimens were photographed in a Perspex cuvette soon after being caught to avoid discoloration. The specimens were killed on ice, fixed in 5% formalin and later preserved in 70% ethanol for identity confirmation and morphometric measurements. Initial identification was made possible with the help of Seehausen (1996) taxonomic identification guide for rock restricted species and that of Witte and van Oijen (1990) for other haplochromines. In order to back up the species richness data some data on ecological and genetic differentiation were collected. Closely related species are ideal for fine details of

differentiation. For that purpose, in this study two species of the genus *Pundamilia* namely *P. nyererei* and *P. pundamilia* were selected to represent closely related species occurring at each sampling station on the study transect. These species are generally red and blue respectively, thus are herein referred to as red and blue except for turbid water populations where they hybridize so extensively that individuals are assigned to a 6-point colour score scale. For the purpose of this paper we leave out the details of colour scores, instead, we identify as blue individuals of colour score 1 - 3 and as red those of 4 - 6.

For closely related species pair morphometric measurements were taken that included standard length (SL), body depth (BD), head length (HL), snout length (SnL), preorbital depth (POD), eye length (EyL), cheek depth (ChD), lower jaw length (LJL), lower jaw width (LJW), and interorbital width (IOW) as per Barel *et al*. (1977). The choice of these measurements was based on the fact that they are directly or indirectly associated with the feeding apparatus hence

trophic interactions among the fish species (Bouton *et al*. 1999). On the basis of these measurements, discriminant scores were calculated for each measured fish specimen using an SPSS statistical classification tool. Ecological differentiation between these species was further followed up by determining their spatial microdistribution across the depth profile; and their stable isotope signatures (15N/14N and 13C/12C ratios).

RESULTS
Secchi readings showed that water transparency increases along the transect from South to North (Fig. 2). The stations for which transparency was measured constitute the rocky habitats sampled in this study. However, species richness presented in Fig. 2 is of randomly selected locations only along the transect. Species richness, simply defined as the number of species occurring at a particular place in time, was significantly correlated with water transparency (Coefficient of determination: $r_ = 0.3997$, $t = 2.3080$, $P = 0.0498$, $n = 10$, Y-int = 4.3954, Slope = 5.6090).
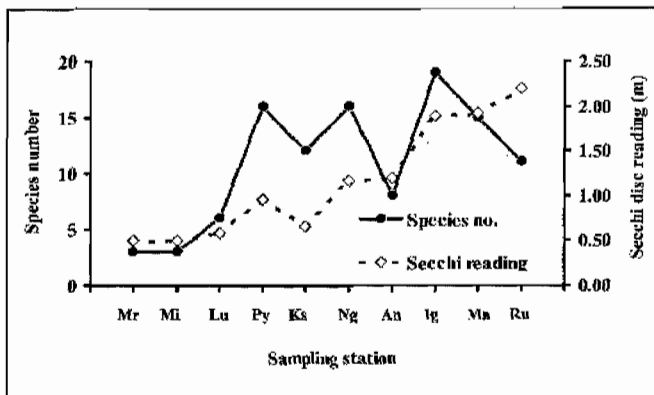

Figure 2: Effect of water transparency on haplochromine species number along the research transect. From the South to North locations are Mr = Marumbi, Mi = Matumbi, Lu = Luanso, Py = Python, Ks = Kissenda, Ng = Nyegezi, An = Anchor, Ig = Igombe, Ma = Makobe, Ru = Ruti

Fig. 3 shows that there is a stronger habitat overlap between closely related species in turbid than in clear water stations for pairs

of similar species. On the same species pair it was noted that morphological differentiation was more distinct in clear

water than in turbid water (Fig. 4). Individuals belonging to either of the two test species could be discriminated into their own species groups more distinctly when

they originate from clear waters (Makobe Island) than from murky waters (Python Islands and Luanso Island in that order of increasing turbidity - see also Fig. 2)
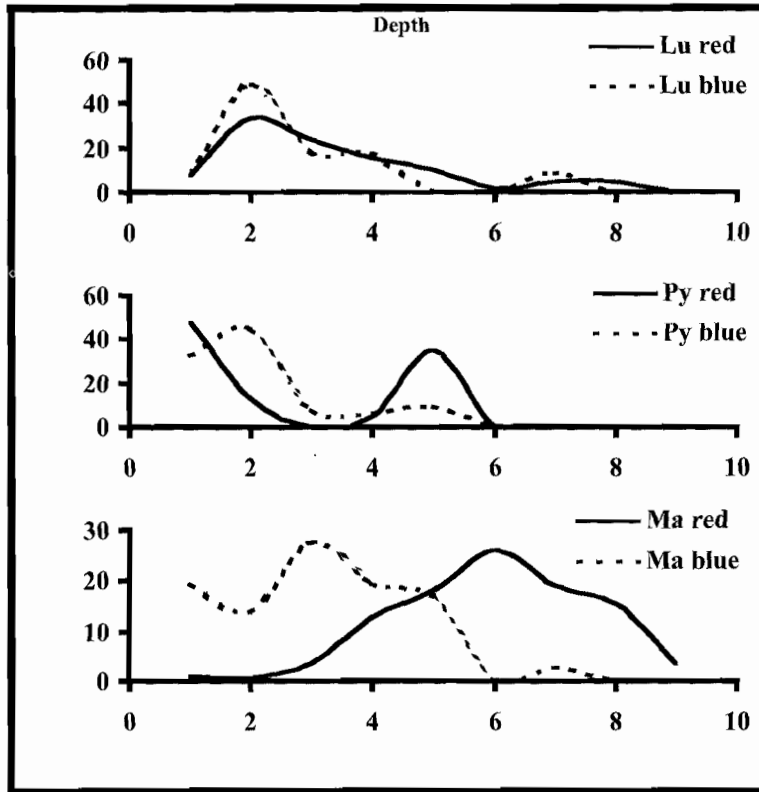
Figure 3:   Spatial niche segregation by depth for *Pundamilia nyererei* and *P. pundamilia* designated red and blue respectively where Lu = Luanso Island, Py = Python Islands and Ma = Makobe Island of increasing water transparency in that order.

DISCUSSION
The number of surviving haplochromine species observed in this study is far below the actual species richness. This comes from the fact that about 200 haplochromine species have gone extinct (Lowe-McConnell 1997), in the lake. The number encountered is even lower than that reported recently (Seehausen 1996) for rock restricted species only. This can be attributed to decreasing water transparency over the years (Worthington 1930, Talling 1966, Melack

1979, Ochumba & Kibaara 1989, Ochumba 1990).

In line with previous findings (Seehausen *et al.* 1997), the relationship between species richness and water transparency revealed in this study (Fig. 2) provides an evidence for the importance of light to fish, particularly for foraging, mate recognition, and predator avoidance. These aspects are strongly affected by the light transmission properties of the aquatic environment. Thus, the low

species richness in turbid water stations can be associated with niche shrinkage (Fig. 3) that results into competitive exclusion where resources are limited. It can also be attributed to poor mate recognition hence excessive gene flow between species which could otherwise be reproductively isolated.

The high species numbers in the more transparent waters could be explained by ecological and genetic differentiation. The observed deviations from the expected trend (Fig. 2) may be attributed to variation in sampling intensity among the stations.
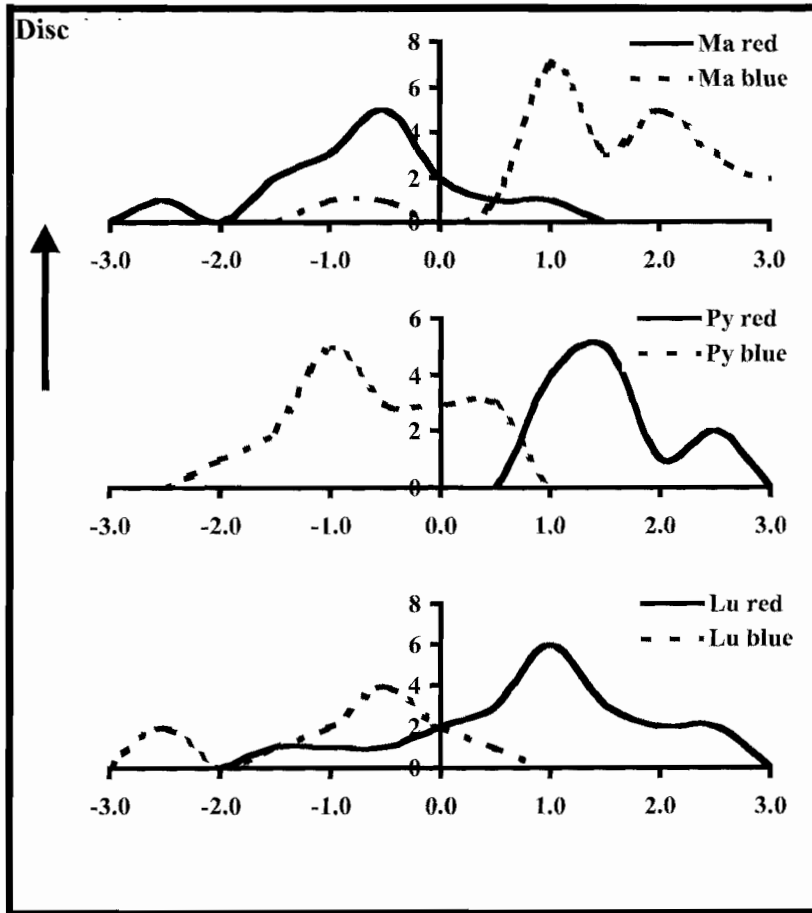
Figure 4: Discriminant scores as a measure of morphological overlap between *Pundamilia nyererei* and *P. pundamilia* (for abbreviations see caption for Figure 3).

The trends of morphological differentiation (Fig. 4) and spatial niche utilization (microdistribution) (Fig. 3) signify a shrinking ecological diversity from clear to turbid waters. Likewise, turbid water inhabitants have strongly overlapping trophic positions compared to those of clear

water stations. The latter is derived from stable isotope signatures of closely related species. Further evidence for increasing diversity along the turbid-to-clear water transect comes from analysis of molecular markers whereby genetic differentiation follows similar patterns as for

microdistribution and morphology. From the above it can be noted that turbidity has a negative effect on morphological, ecological and genetic diversity and hence the diversity of haplochromines in general.

Most of the information presented in this article is based on the rock dwelling haplochromines which constitute a group of species that needs to be conserved. However, conserving the rock cichlids is far from remedy for the species loss that has been incurred lakewide so far. Yet it is worth taking deliberate measures since it is evident that rocky habitats harbour relatively less disturbed diversity. As human activities increase on the islands, there is a corresponding increase in fishing pressure and environmental degradation on the islands as well as the surrounding waters. This enhances the problem of loss of species as a consequence of deteriorating light transmission properties of the water.

To meet the requirements for the conservation of haplochromine diversity there is a need to explore other areas of the lake, to monitor the spatial and temporal changes of the species richness and diversity. This should be part of the mainstream activities of the research institutions working on Lake Victoria to generate current information on the status of the flock. The work presented herein may contribute to the baseline information on this part of the lake.

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