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THE FRESHWATER BIODIVERSITY CRISIS: THE CASE OF THE ETHIOPIAN FISH FAUNA

Abebe Getahun[1,2] and Melanie L. J. Stiassny[2]

[1] Department of Biology, Faculty of Science, Addis Ababa University
PO Box 1176, Addis Ababa, Ethiopia

[2] Department of Ichthyology, American Museum of Natural History Central Park West at 79th Street, New York, NY 10024-5192, City College of the City University of New York, New York, USA

ABSTRACT: As the fragile freshwater ecosystems of the planet become increasingly patchy and isolated the threat of extinction to their biota rises. Underscoring the enormity of the potential loss is the fact that about one quarter of all vertebrate biodiversity is concentrated in these vulnerable biotopes. The problem is particularly acute in countries like Ethiopia, where the diversity of the freshwater biota is poorly known and the rate of degradation of the environment is very high. Accordingly, field data and revisional studies are urgently needed if the full extent of the country's ichthyofauna is to be documented before it is too late. Literature review and preliminary survey efforts indicate that only one group of native fishes, the cyprinids, still persist in many of the country's freshwaters. This paper combines review of relevant literature, field data and personal experiences to present an overview of the current status of the country's freshwater fish fauna.

Key words/phrases: Deforestation, Ethiopia, fish diversity, freshwater ecosystems, introduced species

INTRODUCTION

While our planet is largely made up of water, only about 2.5% of that water is fresh - all the rest is marine. Of the World's freshwater as little as 0.3% is actually available as freshwater habitat (see Fig. 1). The planet's natural freshwaters consist of rivers, marshes, flood plains, lakes, and coastal wetlands,

while the man-made ones include irrigation channels, hydroelectric dams and reservoirs. These natural and artificial aquatic habitats provide us with harvestable plants and animals, travel and transportation routes, renewable energy supplies, and a wide range of so-called "ecological services" in particular waste removal and water purification. The discrete and often patchy nature of freshwater habitats results in a higher degree of isolation than is encountered in open water marine environments and this has apparently resulted in greater genetic divergence and speciation. Surprisingly enough, it is in this tiny 0.01% of the planet's total water, that about one-quarter of all vertebrate biodiversity (i.e., freshwater fishes) is concentrated (Stiassny and Raminosoa, 1994; Stiassny, 1996).

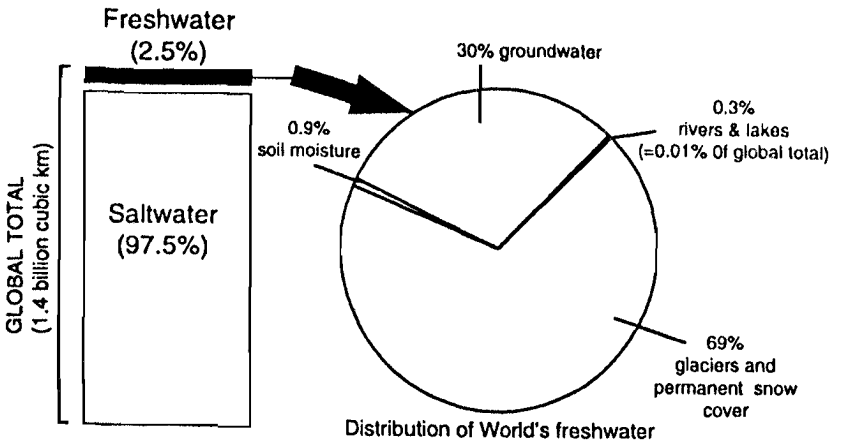


Fig. 1. World water resources, with apportionment of freshwater indicated in pie chart.

In many ways freshwater ecosystems are the functional analogues of terrestrial islands and like other insular systems these aquatic refuges are among the most fragile of habitats. Yet despite their insular nature and the high concentrations of biological diversity that they contain, freshwater systems have received little attention from conservationists, and rivers and streams perhaps least of all. One concrete evidence is the IUCN (1994; 1996) Red Data Book listings in which conservation of biodiversity is highly biased towards terrestrial life (Ryman *et*

al., 1994). This problem is particularly acute in species-rich yet poorly-studied countries such as Ethiopia.

Ethiopian freshwater systems

Ethiopia contains some 7000 km^2 of inland water bodies (Wood and Talling, 1988) and the drainage pattern is the result of the uplifting during the tertiary period, which created the Rift Valley and consequently the two separate highlands (Mohr, 1966; Westphal, 1975).

The northern and central highlands of the country are drained by westward flowing rivers (e.g., the Abay, Angereb, and Tekezze, which form part of the Nile drainage basin) and the eastward flowing rivers draining into the Rift Valley (*e.g.*, the Katar, Meki, and Mojo). The south-western part of the highlands is drained by left bank tributaries of the Abay, the Baro-Akobo and the Ghibe-Omo river systems.

The south-western part of the eastern highlands is drained mainly by the Ghenale and Dawa rivers while the south-eastern part of the eastern highlands is drained by the head waters of the Shebelle and the Fafan.

The Ethiopian Rift Valley and Afar lowlands are drained largely by the Awash river and its tributaries. The Ethiopian Rift Valley also contains a number of small endoreic lakes from which the greater part of the country's fish harvest is drawn. The Ethiopian rift lakes include the southern lakes (Chamo and Abaya), the northern lakes (Awassa, Shala, Abiata, Langano, and Ziway) and the saline northern lakes (Afambo, Gamari, Afdera, Asale and part of Abbe). There are also crater lakes such as the high plateau Bishoftu group (Lakes Hora, Bishoftu, and Arenguade), and Lake Chitu in the Rift Valley. The Ethiopian highland lakes include Lakes Tana, Hayq, Ardebo and Ashengie. Lakes Garba Guratch and Orgona are high mountain lakes found in the Bale region (see Fig. 2 for an overview of the major drainage basins).

Many of the small and medium sized rivers of Ethiopia are seasonal and strongly influenced by rainfall fluctuations. Sadly, the first author has witnessed a number of rivers which had earlier been perennial now flow only during the rainy season: a deplorable state of affairs associated with the spread of desertification which in turn is accelerated by deforestation and other human

activities. It is easy to imagine that much of the biota native to these heavily impacted habitats may have already vanished from the country's freshwaters.

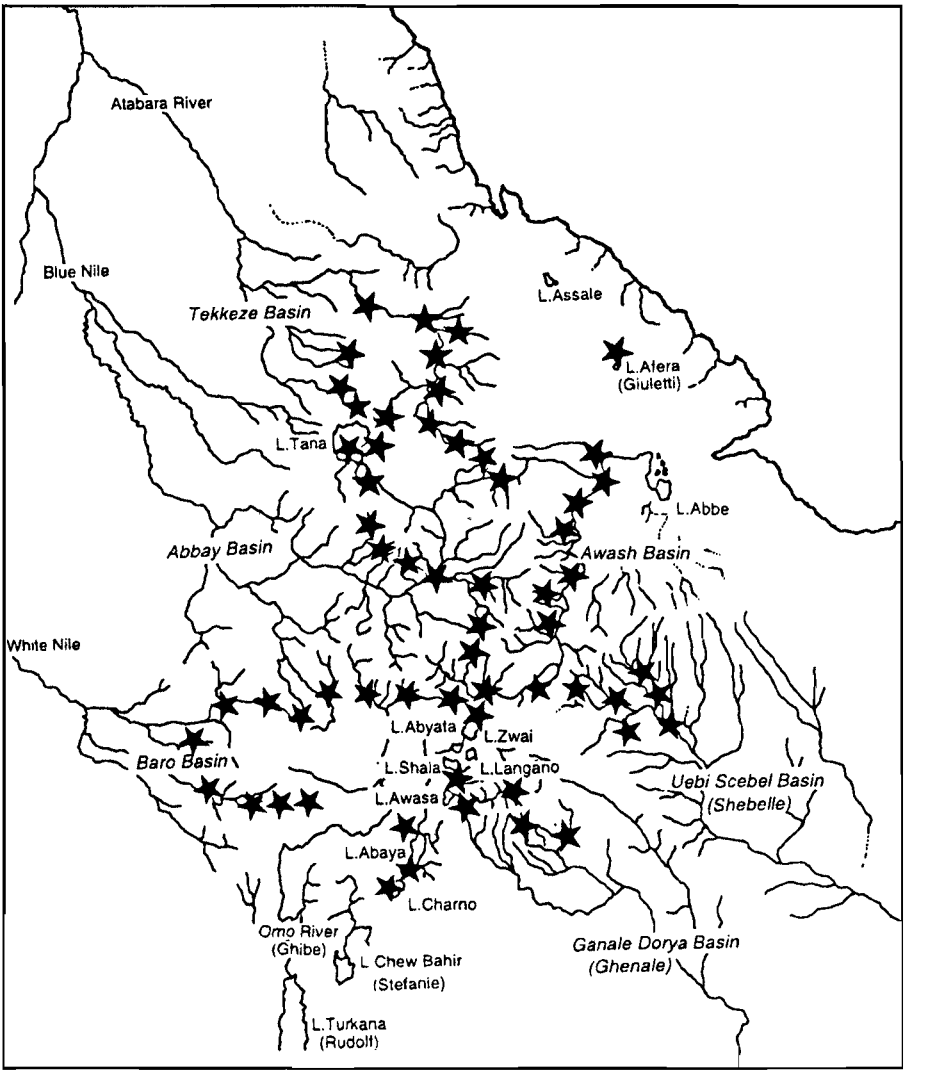


Fig. 2. Main river drainages of Ethiopia and surrounding regions. Stars indicate sites sampled in present study.

The fish fauna of Ethiopia

The freshwater fish fauna of Ethiopia is of particular interest since it contains a mixture of Nilo-Sudanic, East African, and endemic forms (Boulenger, 1905; Nichols and Griscom, 1917; Roberts, 1975; Bănărescu, 1995).The Nilo-Sudanic forms are represented by a large number of species found in the Baro-Akobo, Omo-Ghibe and Abay drainage basins (*e.g.*, the genera *Alestes, Bagrus, Barilius, Citharinus, Hydrocynus, Hyperopisus, Labeo, Malapterurus, Mormyrus, Polypterus,* and *Protopterus*; see also Fig. 3). The southern Rift Valley lakes (Lakes Chamo and Abaya), and the Shebelle-Ghenale basins also have elements of these forms and it is believed that these lakes and river basins had former connections with the upper White Nile (through Lake Rudolf in the former case) as recently as 7500 years ago (Roberts, 1975; McClanahan and Young, 1996). These Nilo-Sudanic forms are related to West African forms and this too is believed to be due to past connection of the Nile to Central and West African river systems (Boulenger, 1905; Nichols and Griscom, 1917; Nichols, 1928).

The highland East African forms are found in the northern Rift Valley lakes (*e.g.*, Awassa, Ziway, Langano), the highland lakes (*e.g.*, Tana and Hayq), and associated river systems, and the Awash drainage basin. These include the genera *Barbus, Clarias, Garra, Oreochromis,* and *Varicorhinus*. They are related to fishes of Eastern and Southern Africa. Nilotic fishes are almost entirely absent from the Awash and northern Rift Valley lakes.

Ethiopian endemics are so far represented by a few species such as *Danakilia franchettii, Nemacheilus abyssinicus, Garra makiensis, G. ignesti* and a large number of *Barbus* species.

Unfortunately, the true extent of the fish faunal diversity, particularly that of the fluviatile habitats, is poorly studied. Some information is included in the early ichthyological literature of Africa (*e.g.*, Ruppell, 1836; Pellegrin, 1905; Bini, 1940; see also Fig. 3). A major literature study was undertaken by Shibru Tedla (1973) that listed 93 species as occurring in Ethiopian waters. Boulenger's Catalogue of the Freshwater Fishes of Africa in the British Museum (Boulenger, 1909–1916) is a fundamental starting point for all subsequent studies.

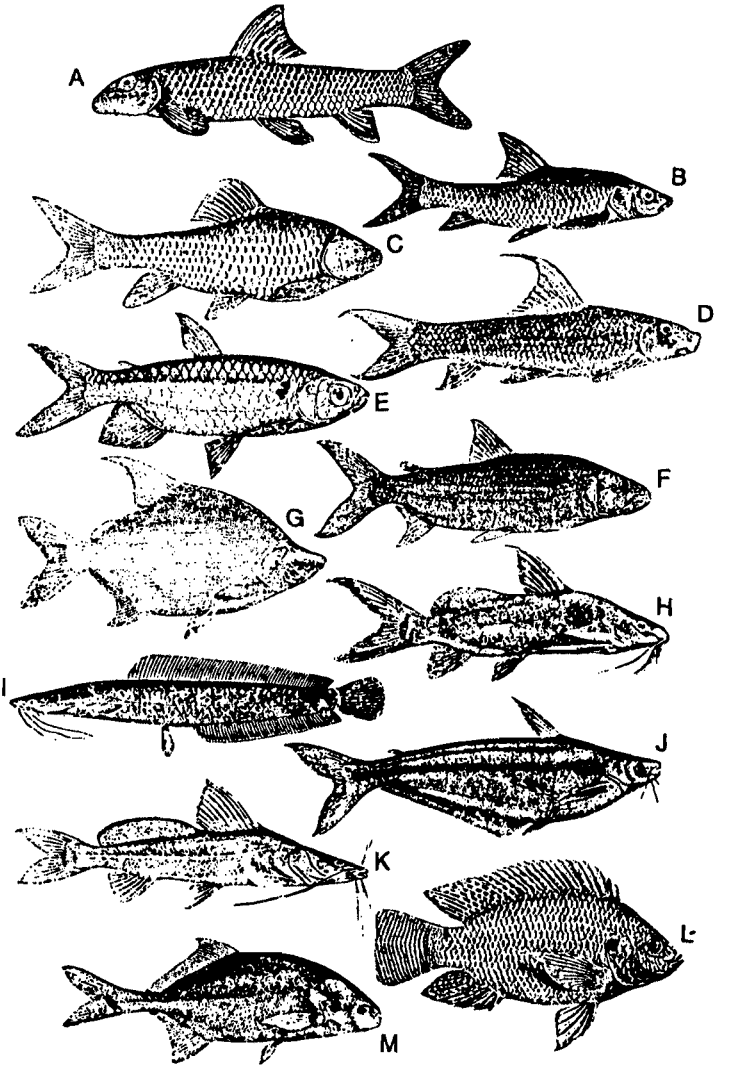


Fig. 3. Typical Nilo-Sudanic fishes of Ethiopian freshwaters. A, *Garra*; B, *Barbus*; C, *Varicorhinus*; D, *Labeo*; E, *Alestes*; F, *Hydrocyon*; G, *Citharinus*; H, *Synodontis*; I, *Clarias;* J, *Eutropius*; K, *Bagrus*; L, *Oreochromis*; M, *Marcusenius.*

Additionally, the recently completed Checklist of the Freshwater Fishes of Africa (CLOFFA I–IV, 1984–1991) is also a valuable resource for basic information on the Ethiopian ichthyofauna. However, CLOFFA is based almost entirely on literature review. More recently, a substantial field investigation especially investigating the diversity of fishes from certain major water bodies of the country has been undertaken by the Fresh Water Biology Team of the Joint Ethio-Russian Biological Expedition (JERBE previously JESBE). For example, the artificial key prepared for fishes of the Gambella region (Golubtsov *et al.*, 1995), is a useful aid in identifying the Nilo-Sudanic fishes within the territories of Ethiopia. This work appears to be a result of an extensive survey of the rivers of the Gambella region. Other results of the JERBE team are mentioned elsewhere in this paper.

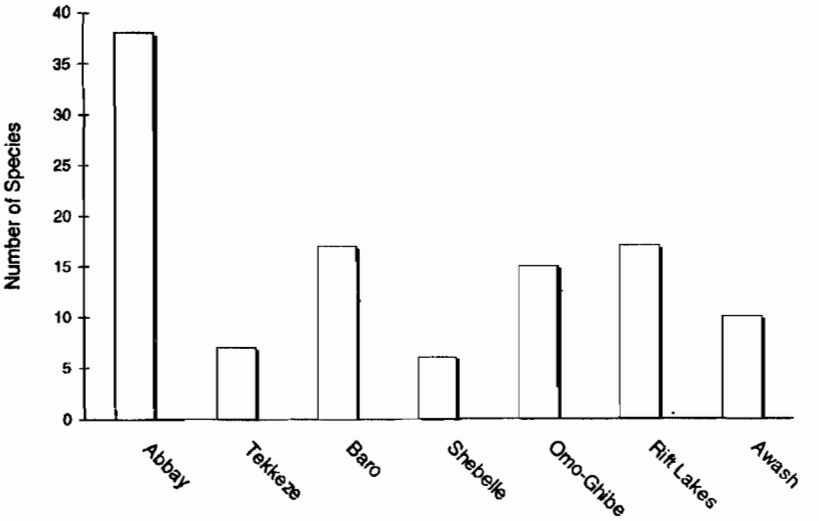
Most previous collecting effort has been concentrated on lakes and large rivers, and biological studies have placed particular emphasis to *Oreochromis niloticus* (*e.g.*, Tudorancea *et al.*, 1988; Getachew Teferra, 1987; 1989; Getachew Teferra and Fernando, 1989; Seifu Seyoum, 1989; Eyualem Abebe and Getachew Teferra, 1992; Seifu Seyoum and Kornfield, 1992; Demeke Admassu, 1994; Zenebe Tadesse, 1997). Limnological studies have also focused on lakes (*e.g.*, Baxter and Wood, 1965; Prosser *et al.*, 1968; Baxter and Golobitsh, 1970; Wood *et al.*, 1978; Amha Belay, 1982; Green, 1986; Brook Lemma, 1995). The medium and small sized waterways of the country, however, remain virtually unexplored. Two reasons could be the driving forces behind this biased sampling: ease of accessibility and relative economic importance.

In an effort to ameliorate this lack of comprehensive and systematic information we have begun a program of survey and collection as well as revisional studies of certain taxa. Accordingly, 109 localities have been surveyed in the different drainage basins of the country using seine net, trawl net, and hook and line during 1995–97 (see Fig. 2). More than 6000 specimens have been collected and deposited in the Department of Ichthyology, American Museum of Natural History (AMNH) and the Department of Biology, Addis Ababa University. So far, 65 species referable to 19 genera and 9 families have been identified and although our results are preliminary and selective (based on limited gears and coverage), already a number of pertinent observations can be made.

The Abay drainage basin contained the largest proportion of the species identified from our collections (Fig. 4a). This finding is consistent with review of literature of collections made by previous workers (*e.g.*, Boulenger, 1902;

1907; 1909–16; Menon, 1964; Banister, 1973; Trewavas, 1983; Daget *et al.*, 1981; 1986a; 1986b; 1991; Golubtsov *et al.*, 1995; Nagelkerke and Sibbing, in press) in which the highest number of nominal species identified are from this drainage basin (Fig. 4b). The *Barbus* species of Lake Tana contribute to this high proportion from the Abay drainage basin, and more than 30 nominal species of *Barbus* have so far been recorded from the Lake Tana region alone (Nagelkerke and Sibbing, in press).

While the abundance of the native cichlid, *Oreochromis niloticus,* in some large lakes is notable and this species constitutes the largest component of the commercial inland fish catch in the country, species of the family Cyprinidae are the most diverse group countrywide constituting 81.5% of the total number of species in our collections (see Fig. 5). The predominance of this group in east African waters is never in dispute (McClanahan and Young, 1996) and might have been favoured by the generally high altitude habitats of the region (Lowe-McConnell, 1987; Skelton, 1994). It seems probable that widespread deforestation, degradation of the pristine environment, and other human induced factors might have left many Ethiopian streams, especially the northern ones, devoid of all fish but the apparently highly resilient cyprinids. At present, we have no evidence of species extinctions from Ethiopian freshwaters (Harrison and Stiassny, in press) resulting from the degradation of the environment, nor are we able to conclude that these habitats are naturally depauperate. But, in light of the extent of degradation of many of the sampled habitats by human influence or by the drying up or decreased water level of many of the water bodies in the northern and central part of Ethiopia, and based on the lessons learned from other water bodies of other countries, it seems highly probable that some species of fishes might have been extirpated from these habitats. Other studies elsewhere (*e.g.*, Whitter *et al.*, 1997) show that increased human activity along shorelines and in the watershed is related to decreased species richness. The same authors have also mentioned that cyprinids are among the fishes most sensitive to chemical, biological and habitat perturbations which make them susceptible to local, watershed and regional extirpation. Some North African countries in the Maghreb Ichthyofaunal region have similar rivers with a depauperate fish fauna dominated by cyprinids (Doadrio, 1994) but this phenomenon could also be a result of massive deforestation and other human activities experienced in the past century in these countries (Zaimeche, 1994). McNeely (1992) also highlights the role of deforestation in the acceleration of desertification.



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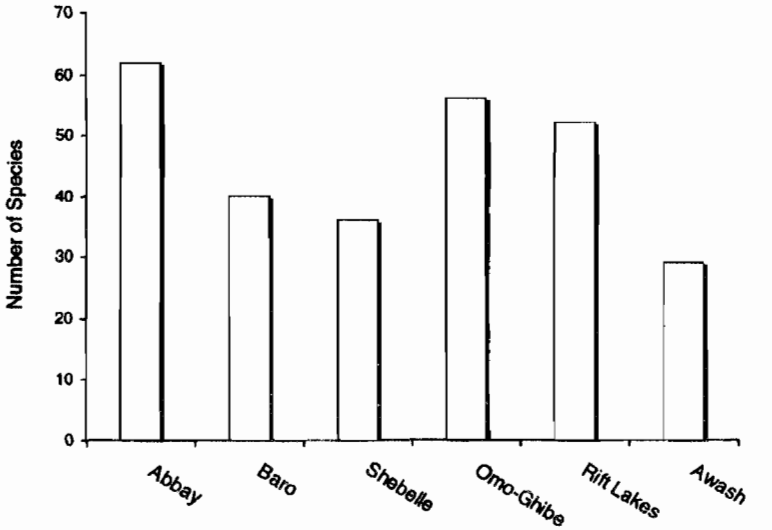

B

Fig. 4. Number of fish species collected from the different drainage basins of Ethiopia. A, Material collected in present study; B, From literature review.

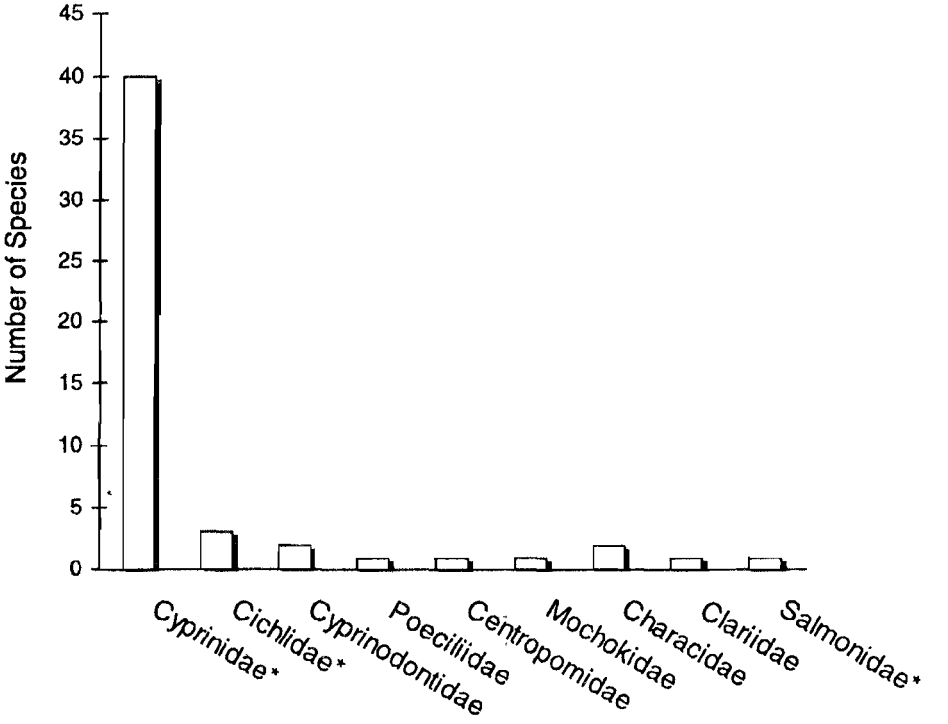

Fig. 5. Number of fish species of different families (collected in present study). *, includes introduced species: Cyprinidae (*Cyprinus carpio* and *Carassius auratus*), Cichlidae (*Tilapia zillii*) and Salmonidae (*Salmo trutta*).

To try and resolve some of these questions in relation to the Ethiopian fish fauna we have sought to obtain an historical baseline by collating data from all museums known to have collections of Ethiopian fishes. The aim of this exercise was to enable us to compare inferred past distributions and ecological associations with present day diversity and distributional patterns. Unfortunately, much of the historical data have proven insufficient since previous collections have not been exhaustive, are frequently poorly documented, and probably cannot be interpreted as representative of the country's former fish distributions and diversity. Given the paucity of historical data it may prove impossible to provide a definitive answer as to whether or not some Ethiopian species have gone extinct. This lack of data highlights the importance of current

faunal studies and underlines the necessity for these studies to be well-documented by publications that are available and widely disseminated, and for voucher collections to be properly archived and made readily accessible to the international community.

Of the cyprinid genera, *Barbus* species are by far the most diverse group found in many of the water bodies investigated. The group stands second, next to *Oreochromis niloticus*, in total commercial catches from the country's water bodies. However, with the exception of the Lake Tana "species flock", the diversity, distribution, biology, and ecology of the Ethiopian *Barbus* is poorly studied. Some additional information is included in Demeke Admasu and Elias Dadebo (1997).

As noted above, the diversity of *Barbus* is apparently highest in Lake Tana where there are about 14 morphotypes in the interior of the lake alone (Nagelkerke *et al.* 1994, 1995a) and 7 of these have recently been recognized as new species (Nagelkerke and Sibbing, in press). However, we collected a number of morphotypes from affluent rivers around Lake Tana and elsewhere which cannot be assigned to, and are distinctly different from, the Lake Tana taxa. It is evident that a comprehensive study of the riverine, as well as the lacustrine, small and large *Barbus* species of Ethiopia is going to be necessary if the evolutionary dynamics of the extraordinary "species flock" of Lake Tana is to be fully understood. The Lake Tana flock is the sole surviving cyprinid flock in the world (Kornfield and Carpenter, 1984). The one in Lake Lanao, Philippines have recently been exterminated following the introduction of a range of exotic species combined with over-harvesting and localized habitat degradation (Harrison and Stiassny, in press).

On the other hand, there is an encouraging international participation in the study of this interesting group of Lake Tana *Barbus*. Notable contributions have been made by the Netherlands Wageningen Agricultural University team and the Freshwater Biology team of the Joint Ethio-Russian Biological Expedition (JERBE). Several studies have been undertaken since the existence of a possible species flock in Lake Tana was suggested by Golubtsov (1993). Nagelkerke *et al.* (1994) soon announced the presence of 13 distinct morphotypes and later (Nagelkerke *et al.*, 1995a) added another "short head" form bringing the

number of morphotypes to 14. Mina *et al.* (1993; 1996) studied the ontogenetic divergence of these morphotypes and stated that clear distinction between forms is only possible when individuals exceed 30 cm standard length, while Nagelkerke *et al.* (1995a) demonstrated that 11 of the morphotypes can be distinguished by external features at fork lengths of less than 12 cm. Nagelkerke and Sibbing (1996) also reported spatial and temporal reproductive segregation among the different morphotypes. Clearly an extraordinary radiation of *Barbus* species exists in Lake Tana (whether these species constitute a real "species flock" *sensu* Greenwood (1984) or not remains to be demonstrated). Now that the biological reality of the distinct species is recognized, appropriate management measures are needed to sustainably manage the fishery there (Nagelkerke *et al.*, 1995b) .

Probably as important from a biodiversity standpoint as *Barbus*, at least in the small and medium sized streams of the country, are members of the cyprinid genus *Garra* (our collections, McClanahan and Young, 1996). *Garra* is distributed throughout Asia and Africa but about 60% of the African species are found in Ethiopia (Menon, 1964; Boulenger, 1902, 1907, 1909–1916; Krysanov and Golubtsov, 1992), with many of them endemic to the region. *Garra* are apparently highly resilient fishes found in large numbers even in streams that hardly flow and where there is light pollution (*e.g.*, the Kebena, Mekanisa and Akaki rivers in and around Addis Ababa). *Garra* were found in almost all streams despite widely varying temperatures and pH values. Interesting exceptions were the high altitude rivers (greater than 3000 m above sea level) where no *Garra* were present. From preliminary revisional study it appears that the species diversity of *Garra* is considerably higher than has been previously estimated and currently a number of new species are under description (Abebe Getahun, in preparation).

A new species of the cyprinodontid, *Lebias*, has recently been discovered from Lake Afdera, in the Afar region of northern Ethiopia (Abebe Getahun and Lazara, in preparation). This lake also contains two other species: an endemic cichlid *Danakilia franchetti* and *Lebias dispar*. Lake Afdera is an isolated saline lake and worthy of further limnological and biodiversity studies in light of the fact that two of the three fish species so far identified from a small segment (about 100 m^2) of the shore are endemic.

The range of the only known loach species in Africa, *Nemacheilus abyssinicus*, is now extended to the Baro drainage basin as a result of the discovery of a specimen from the Sore river near Metu town. This species was first reported from Lake Tana (Boulenger, 1902) but later was found in the Ghibe basin (Dgebuadze *et al.*, 1994). Degbuadze *et al.* (1994) also reported the presence of three other species not previously known from the Omo-Ghibe basin (*Pollimyrus isidori, Barbus paludinosus* and *Labeo forskalii*). In addition, the prevalence of other poorly studied groups such as *Varicorhinus* and numerous small *Barbus* species in the small streams of the country (our collections; Golubtsov and Krysanov, 1993) is further indication that the true diversity of the Ethiopian fish fauna has yet to be fully and accurately documented.

Clearly, much remains in the study of the diversity of fishes of Ethiopia and an ongoing program of field collection and taxonomic revisional study is necessary if we are ever going to be able to provide a comprehensive picture of the true fish diversity of the country. In light of the increasing degradation of the environment, the high potential threat from introduced species, increasing localized exploitation of fish resources, and other human induced impacts, it is critical that the fish fauna be documented before the historical record is obliterated entirely.

THREATS TO THE FISH DIVERSITY

Throughout Africa fishes are major sources of food accounting for some 25% to 30% of the total animal protein consumed (René and Kinadijan, 1994). However, this is not the case in Ethiopia where people do not include fish in their daily diet (pers obs.). Although no precise data are available, it appears that most Ethiopians prefer beef to fish even though it is much more expensive and hence not easily obtained. Even those who would eat fish were it readily available cannot since market supply is poor. The development of aquaculture is also limited (Kutty, 1986), and some previous attempts have been doomed to failure. For example we have seen two aquaculture stations built around Akaki and Dukem (near Addis Ababa) some 20 years ago which are today bean and cattle pasture fields, respectively. According to an FAO report (FAO, 1973), only about 3% of the potential Ethiopian fishery is being exploited, and despite a

chronic food shortage in the country this trend appears to have changed little since the early 1970's. Therefore, while there is a growing but localized trend in some Lakes (e.g., Lake Awassa, Lake Chamo and the southern part of Lake Tana) over-exploitation of fish resources is not at present a significant problem in most of Ethiopia (Lake Fisheries Development Project Reports and personal communication with Fisheries Department personnel). Needless to say proper management studies and measures should be taken now, before this becomes a real threat. Similarly, chemical pollution, which is a critical problem in developed nations, is only threatening to the fish fauna of Ethiopia in highly localized regions at this point in time.

Alterations of rivers and stream courses for various human benefits (*e.g.*, hydroelectric projects and channelling for irrigation) have deleterious effects on the biota of freshwater systems (Roberts, 1993). This is brought about through reduction of water levels thereby altering temperature, pH, nutrient regimes and sediment levels. In addition to the negative aspects they have in spreading diseases and aquatic weeds (Fernando, 1981) dams, unless carefully designed, affect most migratory fishes thereby hindering reproduction. In Ethiopia, there are past, present and future plans to divert freshwater bodies for various human uses. There are major projects currently under implementation or due to take place in the future in the Omo-Gibe, Baro-Akobo and the Blue Nile (Mengistu Wube, 1994; 1997; Swain, 1997). These, and the widespread medium irrigation projects like the ones seen in the Wollo region, should be closely examined to determine the ecological imbalances that may be caused by such undertakings, in addition to their political, economic, and social ramifications.

Nevertheless most important in Ethiopia, as elsewhere, could be the combined effects of deforestation and the introduction of alien species. Many workers including Myers (1984) confirm that these two factors have disastrous consequences on aquatic systems throughout the globe.

a. Deforestation

Forest destruction in Ethiopia is known to be one of the highest, probably comparable to the currently identified "hot spots" of forest destruction in Tropical Africa and Asia (Goldammer, 1990). The Ethiopian highlands, especially the northern ones, inhabited by a traditional agriculture populace,

have already been striped off much of their natural vegetation. For much of the region very small patches of forest around churches are all that remains of the once densely forested highlands. The impact is aggravated by the high human population which now exceeds 60 million with a growth rate of about 3% per annum. More than 90% of the population depend on agriculture and the search for more arable land has resulted in the clearance of a vast area of forest. As a result of this high impact upon the cover, about 1.5 billion tons of soil is lost every year from the highlands of Ethiopia (Sileshi Teferra, 1994).

As has been well-documented in many other countries, the negative impacts of deforestation on aquatic systems are manifold and result in major perturbations of nutrient availability, water temperature, turbidity, pH and water levels of associated water bodies (*e.g.*, Groombridge, 1992; Sussman *et al.*, 1994; Leveque, 1995). Sediment accumulation as a result of erosion covers benthic organisms, depresses oxygen levels, and reduces light penetration and photosynthesis (McClanahan and Young, 1996). Damage to forest cover is exacerbated by poor regeneration due to overgrazing by high densities of cattle, sheep, and goats (Amour *et al.*, 1994; Sussman *et al.*, 1994), and this can be an important factor in countries like Ethiopia where the cattle population is particularly high (FAO, 1991).

The worsened conditions of watershed loss and the resultant erosion is well-evidenced in rivers and streams of central and northern Ethiopia while rivers of the south-western regions are relatively protected. The people in the south--western regions are not traditional agriculturists and are benefiting from the presence of the forest cover (*e.g.*, shed for coffee plantations, hanging bee hives, shed and grazing ground for domestic animals). One can easily see the negative effect of agricultural traditions and way of life on the forest cover where resettlement programs have taken place.

Reforestation programs in the country are focused mainly on hillsides and mountainous areas. We believe that reclaiming drainage basins and riparian zones should be given the necessary attention by concerned Government and Non-Government bodies. At this juncture, we would like to raise the notion of recognizing protected zones on sides of rivers as a potential conservation tool.

b. Introduction of alien species

Alien fish species have been introduced into a new environment for a wide variety of reasons, among which are the following: fisheries enhancement, bait and ornamental fish escapees, and biological control. According to the International Register of the Food and Agriculture Organization (Welcomme, 1981) about 160 exotic species are recorded from some 120 countries worldwide.

In Ethiopia, it has been reported that silver carp and grass carp were introduced into Fincha Dam in 1975 (Shibru Tedla and Fisseha H/Meskel, 1981); common carp is known to exist in Koka Dam (Melaku Mesfin *et al.*, 1985). Seifu Seyoum (1990) presented evidence of the introduction of *Tilapia rendalli* (often confused with *T. zillii)*, into Lake Langano. We have collected *Cyprinus carpio* from river Meribu, in the Bale region and *Carassius auratus* from Lake Ziway the ultimate origin of which is believed to be the Far East (Skelton, 1993). It has been indicated (Shibru Tedla and Fisseha H/Meskel, 1981) that 250,000 *Esox* and 1000 *Gambusia* specimens have been stocked in Lake Tana and that these had acclimatized. However, recent sampling in the lake by ourselves and other workers has failed to record their presence there. Lake Hayq was stocked with *Tilapia sp.* (probably from Lake Hora) in 1978 and Lake Ardibo (located ~ 5 km south east of Lake Hayq) was also stocked with fishes that came from Lake Hayq (Elizabeth Kebede *et al.*, 1992). Various sources indicate that *T. zillii* has been introduced to Lake Ziway and river Neri; Rainbow Trout into the Weyb river; Brown Trout into the Danka river; *Oreochromis niloticus* into Melka Wakena dam. The list is by no means complete.

Although introduction of alien species have often been made with "good intentions", the negative effects of their presence on the native fauna is rarely in dispute (Carlton, 1989; Soule, 1990; Allan and Flecker, 1993; Lodge *et al.*, 1998). This fact is underlined by Ross (1991) who made 31 case studies of fish introductions to stream communities and found that in 77% of cases there was a subsequent decline in the native fishes. While the precise manner in which exotics act to displace native species has yet to be fully established, it is evident that competition for food resources and nursery grounds, as well as direct predation, habitat alteration, hybridization and the introduction of parasites and diseases are all obvious mechanisms of displacement. Of all examples of the

catastrophic impact of alien species on native communities the example of Lake Victoria where the introduction of the Nile Perch, *Lates niloticus*, in the 1950's resulted in a 10,000 fold decrease in the abundance of native cichlids is outstanding (*e.g.*, Ogutu-Ohwayo, 1990; Witte *et al.*, 1992; Riedmiller, 1994). As Stiassny (1996) has stressed, it is imperative that the lessons drawn from the Lake Victoria biodiversity disaster be carried to other freshwater systems throughout the globe.

In Ethiopia, not all is known about the history of introductions of alien fish species, and nothing is known about how they are performing now or what their effects on native species in the natural water bodies has been. It is clear that a full understanding of the complex interaction and impact of introduced species on native systems is imperative for future management, and research in this area is much needed. The Sebeta Aquaculture Center is the main source of fish rearing for transplantation in the country. Translocation of indigenous and introduction of exotic species to various water bodies is one of its objectives (Anon, 1977). We strongly concur with the Fisheries division that appropriate precautions and research should be undertaken before any additional translocations or introductions are made in Ethiopian freshwaters.

CONCLUDING REMARKS

The total area of Ethiopia is more than a million square kilometers and the 7000 km^2 freshwater body represent just a small island in that sea of terrestrial habitat. Preliminary studies indicate that these vulnerable freshwater ecosystems are not well protected, the diversity of the fish fauna has been underestimated, and that the fish fauna is faced with considerable threats, some serious and widespread. As elsewhere, these threats are generally associated with a combination of factors summarized in the acronym H.I.P.P.O. (Habitat destruction, Introduced species, Pollution and Population growth). Clearly much remains in the study of Ethiopian freshwater fishes, and there is an urgent need for baseline studies to provide accurate faunal lists, distribution maps, and identification keys. Central to this goal must be continued survey efforts as well as revisional taxonomic study of all groups. However, to be of any lasting value, the results of these studies and surveys must be made available in the

form of publications that are accessible and widely disseminated. For proper implementation of this task, international cooperation is much needed while the core responsibility falls on trained Ethiopian nationals.

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