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Full Paper

Abundance, food habits, and breeding season of exotic *Tilapia zillii* and native *Oreochromis niloticus* L. fish species in Lake Zwai, Ethiopia

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Abstract: Relative abundance, diet and breeding season overlap in the reproduction of exotic *Tilapia zillii* and native *Oreochromis niloticus* in Lake Zwai were studied from samples collected over 12 months. Younger fish of both species collected were also evaluated for food composition. Food items from stomachs of both species were collected and analysed using the frequency of occurrence method. In terms of number, *T. zillii* dominated *O. niloticus* at the sampling sites. In both species, macrophytes, detritus, blue green algae, diatoms, green algae, *Ceratium*, *Euglena*, and *Phacus* constituted foods of plant origin, whereas chironomid larvae, Copepoda, Cladocera, Rotifera, Nematoda, fish eggs, and fish scales constituted foods of animal origin. Foods of the latter type such as Ephemeroptera and mollusks were also noted in the diet of adult *T. zillii.* Despite the extensive overlap in food habits of the two species, however, the food items were found in the diet of the species with different average percentage frequencies of occurrence. The level of gonad maturation and gonadosomatic index (GSI) values showed that in Lake Zwai breeding was year-round for both *T. zillii* and *O. niloticus*, with a peak during April-September and February-August respectively, indicating extended breeding season overlap in reproduction. The two species were always found together in the catches from the sampling sites, which indicated some niche overlap between them.

Keywords: breeding season, *Oreochromis niloticus*, *Tilapia zillii*, Lake Zwai, Ethiopia

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Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

Introduction

Though fishes are the most diverse among the major vertebrate groups [1], they are faced with considerable threats which are generally associated with a combination of factors summarised in the acronym HIPO (habitat destruction, introduced species, pollution, and over-exploitation) [2]. As elsewhere, a number of attempts have been made to introduce exotic freshwater fish species into Ethiopia. *Tilapia zillii* is one of such species and has been particularly released into several water bodies including Lake Zwai [3]. *T. zillii* and *Oleochromis niloticus* are widely distributed and have a very wide common range. However, in East Africa while *O. niloticus* is widely distributed and supports important commercial fisheries, *T. zillii* is indigenous only to Lake Albert and Lake Rudolf.

T. zillii is essentially a macrophyte-feeder. The adult feeds preferentially on aquatic macrophytes and vegetable matter of terrestrial origin [4], whereas *O. niloticus* is among the many phytoplanktivorous species. and is also known to include animals in its diet consisting of zooplankton and benthic organisms like insect larvae, crustaceans, and mollusks [5]. *T. zillii* is a monogamous biparental guarder as opposed to *O. niloticus* which is a polygamous maternal mouth brooding species. It is both economically and ecologically important in the country as a whole, but its population in Lake Zwai is currently declining.

It is clear that the knowledge on the complex interaction between the fish species and the impact of introduced species on native ones is imperative for management of the ecosystem and the fisheries. Yet limited information is known about how these different species are performing in all of the water bodies in general and in Lake Zwai in particular. Accordingly, the present study was conducted to determine the status of *T. zillii* and assess its relations in feeding and breeding with the native *O. niloticus* species in Lake Zwai.

Materials and Methods

Study area: Lake Zwai

Lake Zwai (Figure 1) is located in the most northerly part of the upper rift lakes in the country of Ethiopia. The lake is situated at 7^0 52’ to 8^0 8’N latitude and 38^0 40’ to 38^0 56’E longitude and lies at an altitude of 1636 m, with a surface area of 434 km^2 and mean depth of 2.5 m [6]. The lake is fed by a number of rivers, the major two being Meki and Katar, and outflows south from its southwest corner via the Bulbula River. The lake lies in a region with an almost constant semi-arid climate characterised by the rainy season period (mid-June to mid- September), the dry season period (October to February), and a "small" rainy season with occasional

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

precipitation in March. Significant rainfall was also noted in May during the study period (Figure 2).

The sampling sites, Edo Kontella (Site 1) and Kontella (Site 2), were located in the littoral zone at the southwestern end of the lake and characterised by extensive macrophyte vegetation and sandy substratum. The littoral zone of the lake is fringed by emergent and submergent vegetation. The most common emergent plants are *Scripus* spp., *Cyperus* spp., *Typha angustifolia*, *Paspalidium geminatum,* and *Phragmites* sp., whereas the floating and submerged vegetation is represented by *Nymphea coerulea* and *Potamogeton* spp.

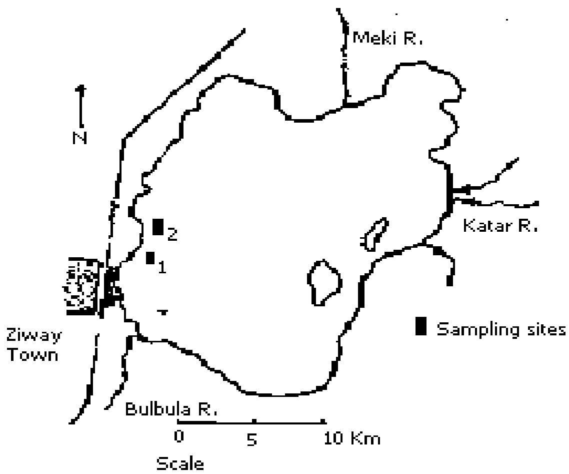

Figure 1. Map of Lake Zwai showing the sampling sites

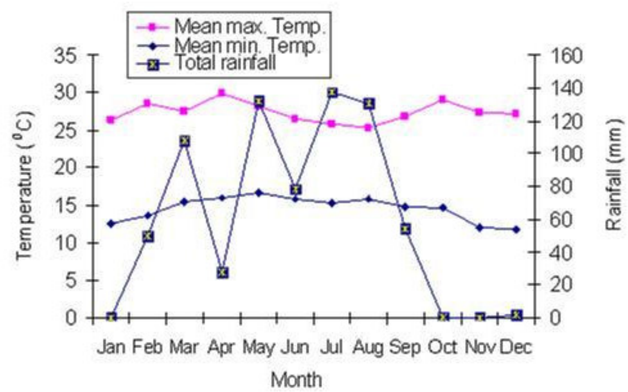

Figure 2. Meteorological data of Lake Zwai during 2001

The phytoplankton community is dominated by blue-green algae, of which *Lyngbia limnetica, Microsystis aeruginosa* and *Synechococcus elongatus* are the major species in terms of biomass. The diatoms, *Melosira granulata, Navicula* spp. and *Surirella* spp., and the green algae, *Straurastrum leptocladum* and *Pediastrum boryannum* are also important. The zooplankton community of the lake is composed of cyclopoids (*Mesocyclops* spp., *Microcyclops* spp., and *Afrocyclops* spp.), cladocerans (*Diaphanosoma excisum* and *Alona davidii*), and rotifers (*Keratella* sp., *Brachionus* spp., *Filinia* spp., *Hexarthra* spp., *Lecane* spp., and *Trichocerca* spp). The bottom fauna comprises gastropod and chironomid larvae. The fish community is composed of both native and introduced species. The native species comprise *O. niloticus* and some *Barbus* species, whereas the introduced ones are *T. zillii*, *Clarias gariepinus* and *Carassius auratus*. The potential yield of all species combined is estimated to be in the range of 1,000 to 6,000 tons per year [7].

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

Collection of samples

Adult fish samples of *T. zillii* and *O. niloticus* were collected from the two sampling sites over a twelve-month period during the year 2001 using gill nets (60 x 100 mm stretched mesh). Younger fish of both species were collected in October, November, and December 2001, in shallow waters less than 1m in depth using a 5-mm stretched mesh beach seine. Fish caught were sorted according to species and counted. The fish samples were then taken to the Zwai Fisheries Resources Development Research Center laboratory soon after capture for stomach content analysis. The stomach of each fish was removed and preserved in a plastic bag containing 5% formalin. Sex determination of each adult specimen was done through examination of the gonad, and the maturity level of the gonad was determined through visual examination following maturity keys for *T. zillii* [8] and *O. niloticus* [9]. Accordingly, five-point and six-point maturity scales were used for *T. zilii* and *O. niloticus* respectively. Each gonad was weighed to the nearest 0.1 g, and stomach samples were then transported to Addis Ababa University for further laboratory studies.

Relative abundance

The relative abundance of *T. zillii* and *O. niloticus* was estimated from catch per unit effort (CPUE) records. Catch per unit effort was recorded as the number of fish in each species caught per trap per set during the sampling occasions.

Food habits

A study on the natural food of *T. zillii* was made based on stomach contents of 703 adults (394 M and 309 F, 12.5-32 cm total length), and 150 young fish (5.5-12 cm total length). Similarly, assessment on the food of *O. niloticus* was made from stomach contents of 591 adults (291 M and 300 F, 13.5-40 cm total length), and 120 young fish (6-13 cm total length). The basis for categorising *T. zillii* into two-length groups in diet study was the change in the major component of the diet, whereas in *O. niloticus* it was the association of the fish with *T. zillii* belonging to either of the length groups in the catches. The stomach contents preserved in 5% formalin were examined either macroscopically or microscopically at several levels of magnification. The food items, excluding macrophytes and detritus, were then identified to the lowest taxonomic level possible using descriptions, illustrations, and keys from various sources [10-12]. The results were then analysed using the frequency of occurrence method in which the number of stomach samples containing one or more of a given food item was expressed as a percentage of non-empty stomachs examined.

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

Breeding season

Breeding seasons of *T. zillii* and *O. niloticus* were determined based on the frequency of the various gonad stages identified and the gonadosomatic index (GSI) values. GSI was calculated as gonad weight as percentage of total body weight (including the gonad):

$$GSI = \frac{\text{Gonad wt}}{\text{Body wt}} X\ 100$$

The percentage frequency of breeding fish and GSI were then plotted monthly, and the time of the year when the frequency and GSI were high was considered as the peak-breeding season for the fish.

Results

Relative abundance

Throughout the sampling periods, *T. zillii* was always more abundant than *O. niloticus* in the catches from both sampling sites in Lake Zwai (Figure 3). The former species constituted 74% and 82.8% of the total collections of 709 and 1038 fish made from Edo Kontella and Kontella respectively.

Food habits

Adult and young T. zilli. Of the total 703 adult fish examined for food composition, 605 or 86% had food in their stomachs which contained diverse items of both plant and animal origins (Table 1). Foods of plant origin were made of macrophytes (unidentified) and phytoplankton belonging to blue-green algae, diatoms, and green algae. Foods of animal origin comprised chironomid larvae, copepoda (*Mesocyclopes* sp.), cladocera (*Alona* sp. and *Diaphanosoma* sp), Rotifera (*Brachionus* sp., *Keratella* sp. and *Lecane* sp.), Ephemeroptera, mollusks, and eggs and scales of unidentified fish. Other components of the diet were plant detritus and unidentified broken parts of animal body. However, these food items occurred in the diet of the fish with different average percentage frequency (Table 1).

Of all elements of the diet of adult *T. zillii*, macrophytes were the most frequent and occurred in all of the stomachs examined. As a group, blue green algae, diatoms, green algae, and plant detritus were found in 64%, 54%, 38%, and 10% of the stomachs respectively. Among blue green algae, *Microcsysts* spp. and *Lyngbya* spp. were found to be frequent (59% and 33% of the stomachs respectively), whereas *Navicula* (48%) and *Cymbella* (15%) were the diatoms noted with high frequency of occurrence. *Spirogyra* and *Staurastrum* were the most frequently occurring green algae, each with 16% occurrence of the stomachs examined. Among foods of

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

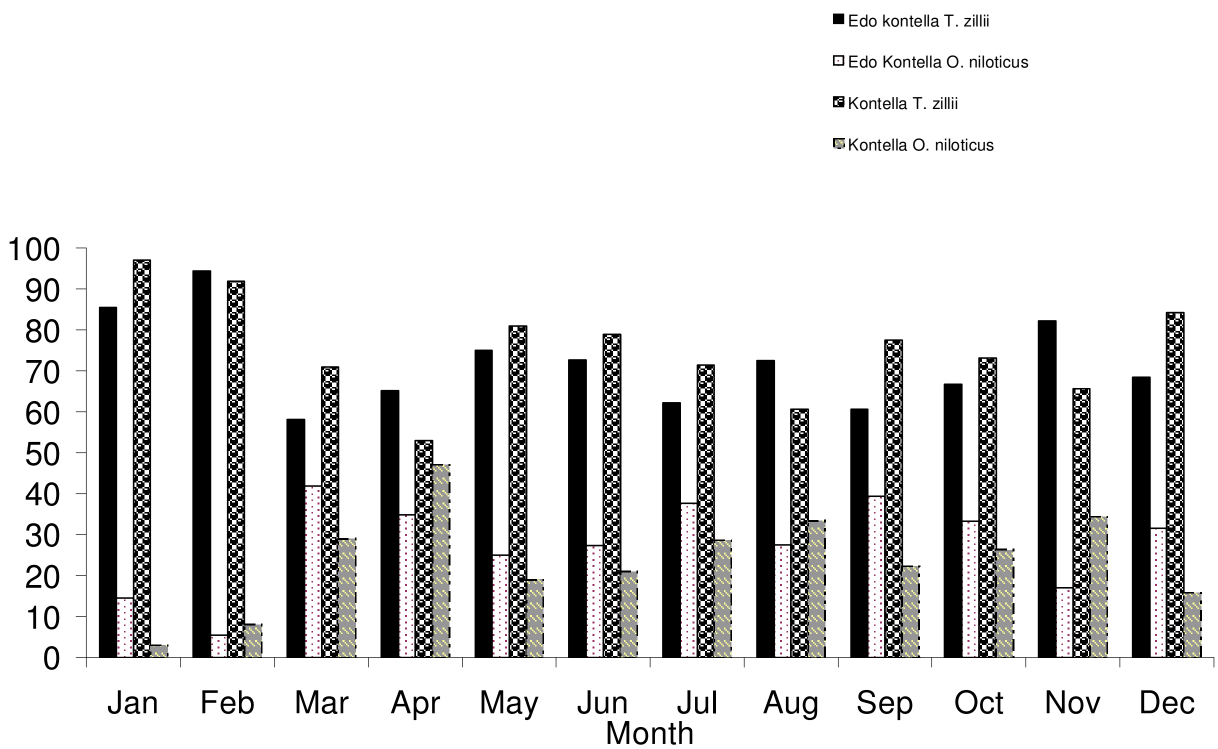

Figure 3. Relative abundance of the two species at the two sites

animal origin, chironomid larvae were most frequently found (at 10% occurrence), followed by fish scales (at 5% occurrence). The other remaining components were noted to be less frequent in occurrence.

All young *T. zillii* examined for diet composition had food in their stomachs. Analysis based on these food contents showed that the foods of this group of fish in the lake were diverse, consisting of both plants and animals (Table 1). Foods of plant origin were composed of diatoms, blue-green algae, green algae, plant detritus, macrophytes, *Ceratium*, *Phacus*, and *Euglena,* whereas chironomid larvae, copepoda, rotifera, and fish scales formed the foods of animal origin. These food items had different frequencies of occurrence in the diet of the young fish (Table 1). As a group, diatoms, blue-green algae and green algae occurred in 96%, 86%, and 59% respectively of the total stomachs. For diatoms, *Navicula* (84%), *Rhopalodia* (78%) and *Cymbella* (59%), and for blue-green algae, *Microcsysts* (91%), *Lyngbya* (55%) and *Oscilatoria* (54%) were the most frequent food items. Among green algae, *Scenedesmus* (32%) and *Closterium* (21%) were relatively frequent. Plant detritus were found at 83% and macrophytes at 40% of the stomachs. Of animal-originated food components, chironomid larvae occurred at 58% of the stomachs examined and the rest were less frequent.

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

Table 1. List of food items identified in the stomachs of adult and young *T. zillii* and *O. niloticus* collected from Lake Zwai during the year 2001 with their percentage frequency range of occurrence (% occurrence). Number in parenthesis indicates average value.

	% Occurrence (*T. zillii*)		% Occurrence (*O. niloticus*)	
Food category	Adult	Young	Adult	Young
A. Macrophytes	100	35-65(40)	11-100(84)	2-42(11)
B. Phytoplankton				
i. Cyanophyta	12-100(64)	78-92(86)	100	100
Anabaena	0-51(18)	16-47(32)	5-95(58)	45-50(48)
Anabaenopsis	--	--	0-11(6)	--
Chrococcus	0-9(7)	0-12(8)	10-71(46)	45-55(50)
Gloeocapsa	0-2 (0.4)	0-8 (4)	0-7 (1)	--
Lyngbya	2-52(33)	47-63(55)	48-100(89)	55-68(62)
Merismopedia	0-27(11)	21-34(28)	0-80(33)	33-75(74)
Microcsysts	12-100(59)	84-92(91)	97-100(100)	100
Oscillatoria	0-40(33)	39-89(54)	33-100(89)	20-64(62)
Spirulina	0-5(1)	0-8(3)	0-16(4)	0-5(1)
ii. Bacillarophyta	2-82(54)	84-100(96)	100	95-100(98)
Achnanthes	0-5(0.4)	0-61(25)	0-84(30)	32-45(38)
Amphora	--	--	--	0-5(2)
Cyclotella	8-28(11)	5-39(30)	5-43(22)	0-5(2)
Cymbella	5-36(15)	5-71(59)	19-91(66)	73-75(74)
Denticula	--	0-9(5)	0-21(9)	5-23(14)
Frustulia	--	0-13(7)	0-33(11)	14-20(17)
Gomphonema	0-4(0.2)	--	0-89(44)	36-45(40)
Navicula	4-84(48)	63-97(84)	40-100(75)	60-91(76)
Nitzschia	2-8(2)	8-32(18)	0-33(12)	18-60(24)
Opephora	0-3(0.4)	--	0-89(16)	0-6(2)
Pinullaria	--	--	0-89(33)	28-85(36)
Rhoicosphenia	2-9(4)	0-8(4)	0-20(5)	--
Rhopalodia	8-41(10)	47-87(78)	0-80(29)	86-90(88)
Surirella	--	8-11(9)	0-16(10)	10-18(14)
Synedra	6-18(13)	--	0-98(61)	0-50(16)
iii. Chlorophyta	13-83(38)	58-61(59)	87-100(96)	100
Ankistrodesmus	2-6(2)	--	0-53(18)	9-35(21)
Botryococcus	2-8(2)	--	0-41(14)	0-9(5)
Coelastrum	2-12(6)	0-8(5)	0-29(4)	0-14(7)
Closterium	2-24(8)	16-26(21)	0-67(23)	9-50(28)
Cosmarium	2-6(3)	2-5(3)	0-58(20)	10-18(14)
Euastrum	0-8(2)	0-3(1)	0-32(9)	0-14(7)
Pediastrum	2-19(4)	0-3(2)	0-84(46)	27-30(28)
Scendesmus	2-23(6)	24-39(32)	10-87(71)	60-82(71)
Selenastrum	--	--	0-16(2)	--
Spirogyra	4-26(16)	5-12(10)	5-95(41)	5-41(24)
Staurastrum	2-71(16)	0-13(10)	0-84(36)	75-77(76)
Tetradron	0-3(0.2)	--	--	--

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

C. Detritus	2-37(10)	20-88(83)	0-38(9)	0-15(11)
D. Chironomid larvae	2-48(10)	39-68(58)	0-14(3)	0-9(5)
E. Zooplankton				
Copepoda	0-3(1)	0-4(3)	0-50(8)	0-5(2)
Cladocera	0-4(0.6)	--	0-20(4)	--
Rotifera	0-2(0.9)	--	0-43(13)	0-13(2)
F. Others				
Ceratium	0-29(8)	0-12(4)	0-27(7)	0-8(3)
Euglena	0-5(1)	0-2(0.3)	0-47(14)	27-35(31)
Phacus	0-2(0.2)	(0-0.2)	0-63(17)	23-25(24)
Nematoda	0-3(0.4)	--	--	0-5(1)
Ephemeroptera	0-4(0.4)	--	--	--
Molluscs	0-8(0.4)	--	--	--
Fish egg	0-5(0.6)	--	0-10(0.8)	--
Fish scale	0-9(5)	10-16(13)	0-8(2)	4-5(5)
Unidentified species	0-6(0.8)	--	--	--

Adult and young O. niloticus. Adult *O. niloticus* in Lake Zwai was found to utilise quite a wide range of food material particularly phytoplankton which were distributed among three major groups consisting of blue-green algae, diatoms and green algae (Table 1). The blue green algae consisted mainly of *Microcsysts* (100% ocurrence), *Lyngbya* (89%) and *Oscillatoria* (49%). Occurrence of the green algae was noted to be 41% for *Spirogyra* and 36% for *Staurastrum*, while *Navicula* (75%), C*ymbella* (66%) and *Synedra* (61%) were among those of the diatoms that were frequent. Macrophytes, plant detritus, *Ceratium*, *Phacus*, and *Euglena* were also noted to be among the components of the diet. Foods of animal origin included chironomid larvae, crustacea (Copepoda and Cladocera), Rotifera, and fish scales.

The diet of young *O. niloticus* in the lake was very similar to the food items of the adults both in terms of food composition and diversity and included blue-green algae, diatoms, green algae, plant detritus, *Ceratium*, *Euglena,* and *Phacus* (Table 1). Foods of animal origin were encountered and consisted of chironomid larvae, Copepoda, Cladocera, Rotifera, Nematoda, and fish scales. The blue-green algae (100% *Microcsysts*, 62% *Lyngbya* and 50% *Chrocoocus*), the green algae (76% *Staurastrum* and 71% *Scenedesmus*), and the diatoms (88% *Rhopalodia,* 76% *Navicula* and 74% *Cymbella*) were items with high frequency of occurrence. These food items were numerically more important in the diet.

Breeding season of T. zillii and O. niloticus

Monthly variation of GSI of both sexes was evident for *T. zillii* (Figure 4) as well as for *O. niloticus* (Figure 6). The mean monthly GSI ± SE of female *T. zillii* ranged from 0.32 ± 0.02 (in

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

January) to 3.58 ± 0.31 (in August), while that of the males ranged from 0.15 ± 0.02 to 0.34 ± 0.04. *T. zillii* had its highest GSI values from February to September, while lower values were recorded between October and January. The percentage of mature females and males ranged from 5-68% and 6-76% respectively, with high values between April and September (Figure 5).

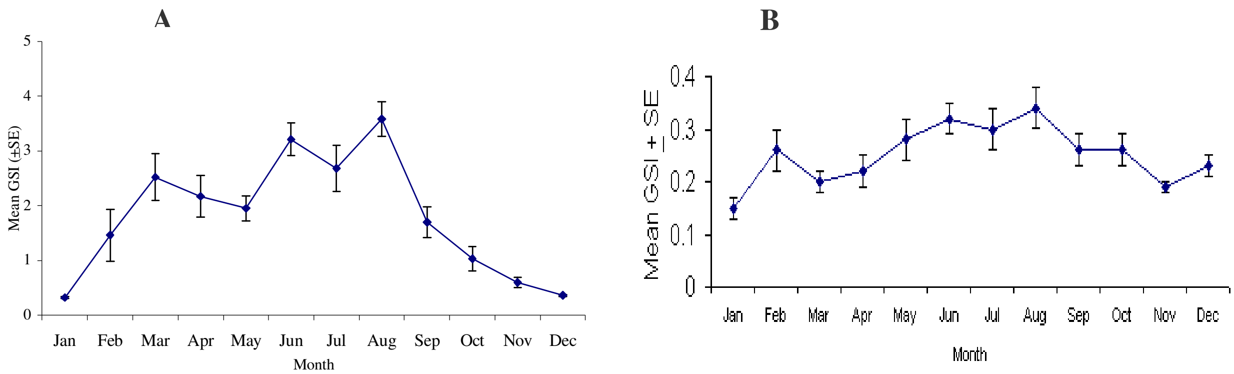

Figure 4. Gonadosomatic index (mean ± SE) of *T. zillii* (A: female, B: male) in Lake Zwai during 2001

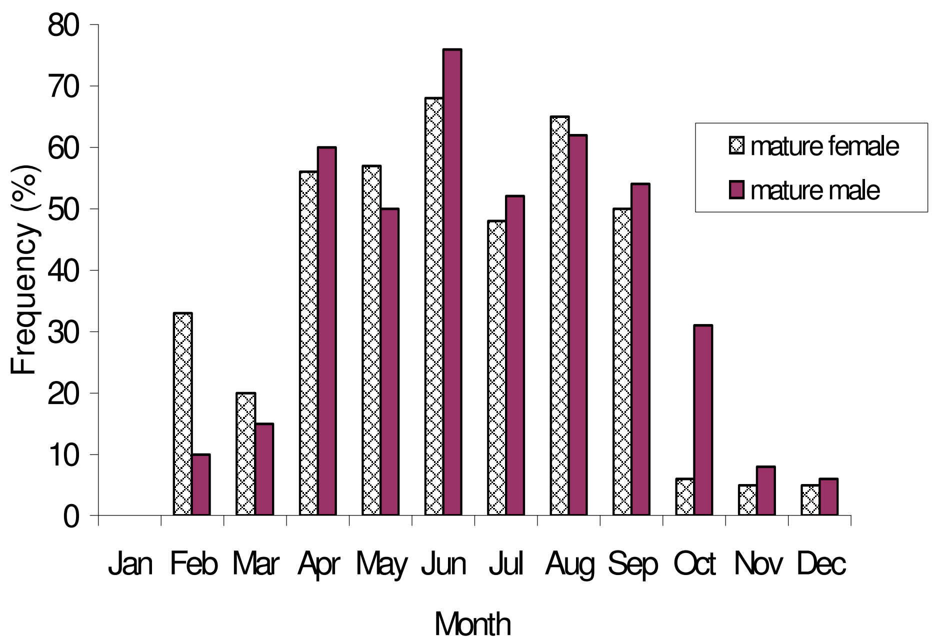

Figure 5. Percentage of mature female and male *T. zillii* in Lake Zwai during the year 2001

In *O. niloticus* the mean monthly GSI ± SE of females ranged from 0.30 ± 0.03 (in October-November) to 2.02 ± 0.46 (in August), whereas that of males ranged from 0.09 ± 0.01 (in September-December) to 0.50 ± 0.10 (in May and August). High GSI values extended from February to August, whereas low GSI values were recorded between September and January

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

(Figure 6). The percentage of mature females and males ranged from 3-42% and 3-45% respectively, with higher values between February and August (Figure 7).

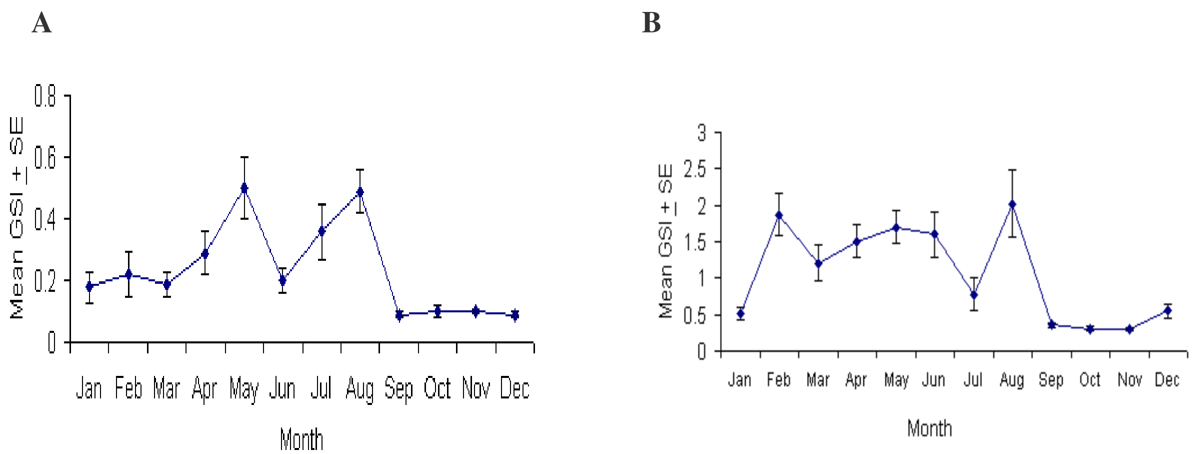

Figure 6. Gonadosomatic index (mean + SE) of *O. niloticus* (A: female, B: male) in Lake Zwai during 2001

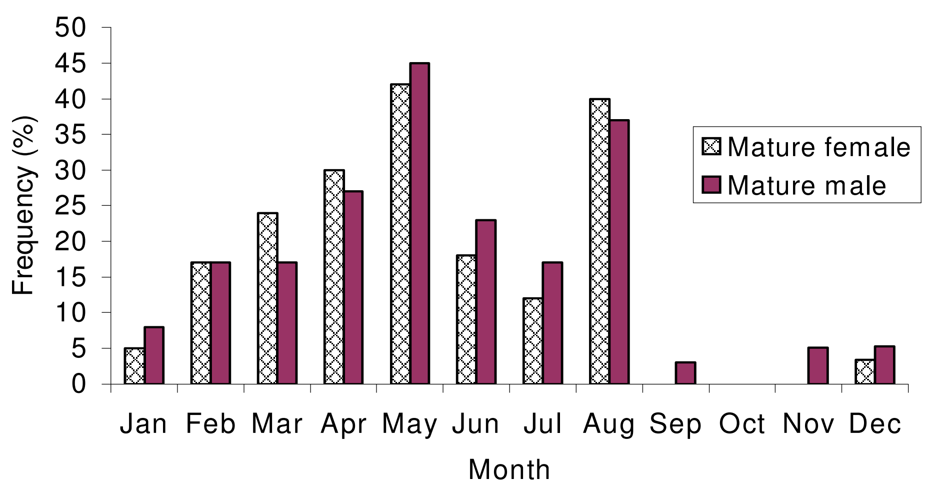

Figure 7. Percentage of mature female and male *O. niloticus* in Lake Zwai during 2001

From the above observations it was evident that the reproduction of *T. zillii* and *O. niloticus* in Lake Zwai was continuous throughout the year and was most active between April-September and February-August respectively.

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

Discussion

At the sampling sites in Lake Zwai, *T. zillii* regularly appeared in the catches during the sampling periods. The fish were also noted to be present in many places around the shallow marginal water of the lake, which indicated that this particular species has successfully established itself in the lake. *O. niloticus*, however, was always associated with *T. zillii* in the catches, including the ones with mature gonads from both species, which indicated a niche overlap. Young fish of the two species were also found together in collections employing beach seine net. Results from catch per unit effort records indicated that *T. zillii* was more abundant than *O. niloticus* (Figure 3). On the contrary, *T. zillii* was rarely encountered in the catches far from the lakeshore. Thus, the catch records from the sampling sites alone may not reflect the exact abundance of the species in the whole lake.

T. zillii was observed to be more dependent on shoreline habitat compared to *O. niloticus,* and differences in the distribution of the species in the lake might be due to their habitat preferences. This is in agreement with the findings conducted in Lake Victoria [13]. McConnell [14] also pointed out that substrate-spawners with macrophyte feeding habit (e.g. *T. zillii*) are more dependent on shoreline habitat than are the mouth brooders with their microphagous feeding and more pelagic habitat, (e.g. *O. niloticus*), especially in waters rich in plankton. Thus, *T. zillii* may be an important component of the Zwai ecosystem because of its abundance in shallow waters as required by spawning fish including *O. niloticus*.

Stomach content analysis based on the occurrence method showed that both *T. zillii* and *O. niloticus* exploited diverse food sources of both plant and animal origins (Table 1). Similar findings have been reported for the two species in Lake Victoria [13] and Nile canal [15]. Nevertheless, foods of plant origin were the major components of the diet in both species and comprised macrophytes, plant detritus, and phytoplankton consisting of blue-green algae, green algae, diatoms, C*eratium*, *Phacus,* and *Euglena.* On the other hand, chironomid larvae, Ephemeroptera, mollusks, Copepoda, Cladocera, Rotifera, and eggs and scales of unidentified fish were foods of animal origin. Of these, Ephemeroptera, mollusks and unidentified animal pieces of larger size were noted exclusively in the diet of adult *T. zillii*.

Though not quantified, the diet of *T. zillii* in Lake Zwai varied depending on the size of the fish as the adult chiefly fed on macrophytes and the young on phytoplankton. This may be due to difference in the degree of development of the feeding organs and the habitat occupied by the fish. Philipart and Ruwet [4] also reported the variation in the feeding regime of fish species depending on size, age and the microhabitat occupied by the fish in a given water body.

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

In adults, higher plant tissues including large portions of roots, leaves and stems of aquatic vegetation and seeds occurred in all of the stomachs examined. Several authors [5,13,15] also reported that *T. zillii* feeds essentially on plant materials, which is consistent with the present observation, in which blue-green algae, diatoms, and green algae were found in 64%, 54%, and 38% respectively of the stomachs examined. These items were also reported to be ingested by the fish from Lake Quarun [16], Lake Kinnert [17], and Nile canal [15]. The occurrence of planktonic material in the guts of fish with no filter feeding mechanism, as is the case in *T. zillii*, is a strange phenomenon. However, Welcomme [13] suggested that the source of planktonic material in the diet of *T. zillii* in Lake Victoria was a flocculent deposit offshore.

Adult *T. zillii* were also known to ingest benthic invertebrates [16], insect larvae and crustacea [15] in other water bodies, and the observation from Lake Zwai also supports this findings. The occurrence larger animals like mollusk in the diet of adult *T. zillii*, but not *O. niloticus*, may be due to the relatively greater tendency of the former species to exploit animal foods, whereas their exclusion from the diet of young ones may be attributed to prey-predator size relationship. Abdel-Malek [16] also associated to the change in composition of the diet as the fish grows with an increase in the minimum size of the organism eaten. Diet composition of young *T. zillii* in Lake Zwai was similar to what has been reported [8] for Lake Quarun for fish whose total length ranged from 4.5-9 cm.

From analysis using the frequency of occurrence and personal observations on the abundance of the food items, it was clear that phytoplankton (blue greens, diatoms and greens) were the principal foods of both adult and young *O. niloticus* in the length range considered. Previous reports of some Ethiopian rift valley lakes including Zwai also showed that adult *O. niloticus* mainly feeds on phytoplankton [17-18]. On the other hand, juvenile *O. niloticus* was known to be an omnivore feeding on algae, zooplankton and insect larvae [19]. These reports further stated that young *O. niloticus* in the length range considered in the present study feeds primarily on phytoplankton. Thus, the food composition of young *O. niloticus* in the present observation (mainly phytoplankton) could have resulted from a possible ontogenetic diet shift.

Analysis of the food habits of *T. zillii* and *O. niloticus* in Lake Zwai revealed extensive diet overlap (Table 1). However, the food items utilised by both species varied in their contribution to the diet. There was a clear tendency for adult *T. zillii* to feed mainly on macrophytes while phytoplankton was found to be the principal food of young *T. zillii* and *O. niloticus* (adult and young). This observation is contrary to the conclusion by Bowen [20] who stated that tilapias in general feed on any food particle small enough to pass through the esophagus. Consequently, the

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

diet overlap between adult *T. zillii* and the remaining groups (young *T. zillii* and *O. niloticus* in both length groups) might be moderated by their food preferences.

On the other hand, differences in feeding site and habitat could be important for resource partitioning between adult *O. niloticus* and the young of both species. The preferred habitat of adult *O. niloticus* is the pelagic zone and that of the young is the lakeshore. Ribbink et al. [21] emphasised the importance of feeding site to resource partitioning rather than the foods they take in coexisting related species of cichlids in the African Great Lakes. Nevertheless, the young of both *T. zillii* and *O. niloticus* having a similarity in diet preference were found to share similar habitat as they were collected together from the same fishing ground. Thus, spatial relation and overlap in the major diet of the young of *T. zillii* and *O. niloticus* indicate possible competition for food resources.

The seasonal variation in GSI and percentage of mature fish of both sexes of *T. zillii* (Figures 4-5) and *O. niloticus* (Figures 6-7) was quite apparent. The seasonal pattern of gonad development and variation in percentage of mature fish of both sexes were more or less similar for *T. zillii* and *O. niloticus*. Indeed, fish with well-developed gonads and mature eggs in both species were noted almost throughout the year. GSI values and percentages of mature fish indicated that breeding in both species was year-round with its peak during April-September for *T. zillii* and February-August for *O. niloticus.*

The presence of breeding fish in Lake Zwai throughout the year may be attributed to the low seasonal fluctuation in temperature and photoperiod (Figure 2). It is a well-established fact that in the tropics seasonal fluctuation in temperature and photoperiod is generally very low and this might be favourable for fish species to spawn any time of the year. The annual peaks of reproductive activity in both species are coincident with the rainy season (Figure 2). With the advent of the rainy season the lake level rises and due to the flooding of landl nutrients are flushed into the lake. As a result, habitat and food resource for fish expand greatly and this may trigger reproduction. McConnell [14] also concluded that breeding among tilapias often occurs sporadically year-round but has a distinct peak just before or at the onset of the rainy season, which is in accordance with the present findings. Rainfall increases production [22] and water level, which in turn provides suitable spawning grounds for adults, and feeding and nursery grounds for the young [23].

Mj. Int. J. Sci. Tech. **2008** *02* (02), 345-359

Conclusions

The level of gonad maturation and mean gonadosomatic index (GSI) values indicated extended breeding season overlap in reproduction between *T. zillii* and *O. niloticus.* The reproduction of young fish that share similar habitat by the two species during similar seasons might have had some effect on the population of *O. niloticus* due to possible competition on nursery grounds. Such phenomenon, in which the young of *T. zillii* were introduced into Lake Victoria, has displaced the young of a native tilapia species from crucial nursery areas, causing a severe decline in the native species. The competitive interaction in feeding and on nursery grounds between young *T. zillii* and young *O. niloticus* may therefore have been one of the factors that contributes to the decline in the population of *O. niloticus* in Lake Zwai and should be further studied in detail.

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