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FOOD HABITS AND DIEL FEEDING RHYTHM OF INTRODUCED FISH, *T. ZILLII* GERVAIS, 1948 (PISCES: CICHLIDAE) IN LAKE ZWAI, ETHIOPIA

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ABSTRACT: Food habits of adult *Tilapia zillii* was studied in Lake Zwai from samples collected over 12 months during the year 2001 using gillnets of 60 and 100 mm stretched mesh. Younger fish caught in October, November and December using beach seine of 5 mm stretched mesh were also studied for food composition. Feeding rhythm of the fish was assessed based on samples collected in October 2001 over 24-hour period at 4-hour interval. Food items identified from stomach contents were analysed using the frequency of occurrence and the points methods. Macrophytes, detritus, blue greens, diatoms, green algae, *Ceratium*, *Euglena* and *Phacus* constituted food of plant origin whereas chironomid larvae, Copepoda, Cladocera, Rotifera, Nematoda, fish eggs and fish scales constituted food of animal origin. Furthermore, animal foods such as Ephemeroptera and molluscs were noted in the diet of adult fish. In adult *T. zillii*, macrophytes occurred in all of the stomachs examined and composed 86% of the diet whereas 11% was contributed by phytoplankton. However, in young fish phytoplankton constituted the bulk of the diet (63%) followed by plant detritus (17%) and chironomid larvae (12%). The feeding pattern of *T. zillii* showed both diel and nocturnal rhythm; however, feeding was more intense during daytime.

Key words/phrases: Ethiopia, feeding rhythm, food habits, Lake Zwai, *Tilapia zillii*

INTRODUCTION

As elsewhere, a number of attempts have been made to introduce exotic freshwater fish species into Ethiopia with different intentions. *Tilapia zillii* is one of such species, and have been particularly introduced into several water bodies including Lake Zwai (Shibru Tedla and Fisseha H. Meskel, 1981). The fish was imported from Uganda by the Ministry of Agriculture and introduced to Lake Zwai in 1975 where it has successfully established itself and become an important component of the commercial catch.

T. zillii, an ecologically tolerant species, is widely distributed extending from West Africa through Chad basin to the Nile, Lake Albert and Lake Turkana into Israel and to Jordan valley (Trewavas, 1982). Moreover, the fish is of a first choice for introduction around the world because of its herbivorous habit and consequent weed control capabilities in irrigation channels and dams. It is essentially a macrophyte-feeder in which the adults feed preferentially on aquatic macrophytes and vegetable matter of terrestrial origin (Buddington, 1979; Philippart and Ruwet, 1982). In addition, the fish is known to feed on green and blue green algae and diatoms (Abdel Malek, 1972; Spataru, 1978; Khallaf and Alne-na-ei, 1987). It also takes animal food comprising benthic invertebrates (Abdel Malek, 1972), and insect larvae and crustacea (Khallaf and Alne-na-ei, 1987). Nevertheless, information concerning the feeding rhythm of *T. zillii* is extremely scanty despite the general variation in the feeding behaviour of tilapias according to the time of the day. Nothing is known about the biology of the species in Lake Zwai and elsewhere in Ethiopia (Abebe Getahun and Stiassny, 1998). Information on biology of the species is certainly vital for proper exploitation of the species, to make management decisions and for future development of culture fisheries in the country. Thus, the objective of this investigation was to determine the food habits and feeding rhythm of *T. zillii* in Lake Zwai.

Lake Zwai is located 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 (Makin *et al*., 1975). The

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sampling sites (Fig. 1) were located in the littoral zone at the south-western 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. (Tudorancea *et al.*, 1999).

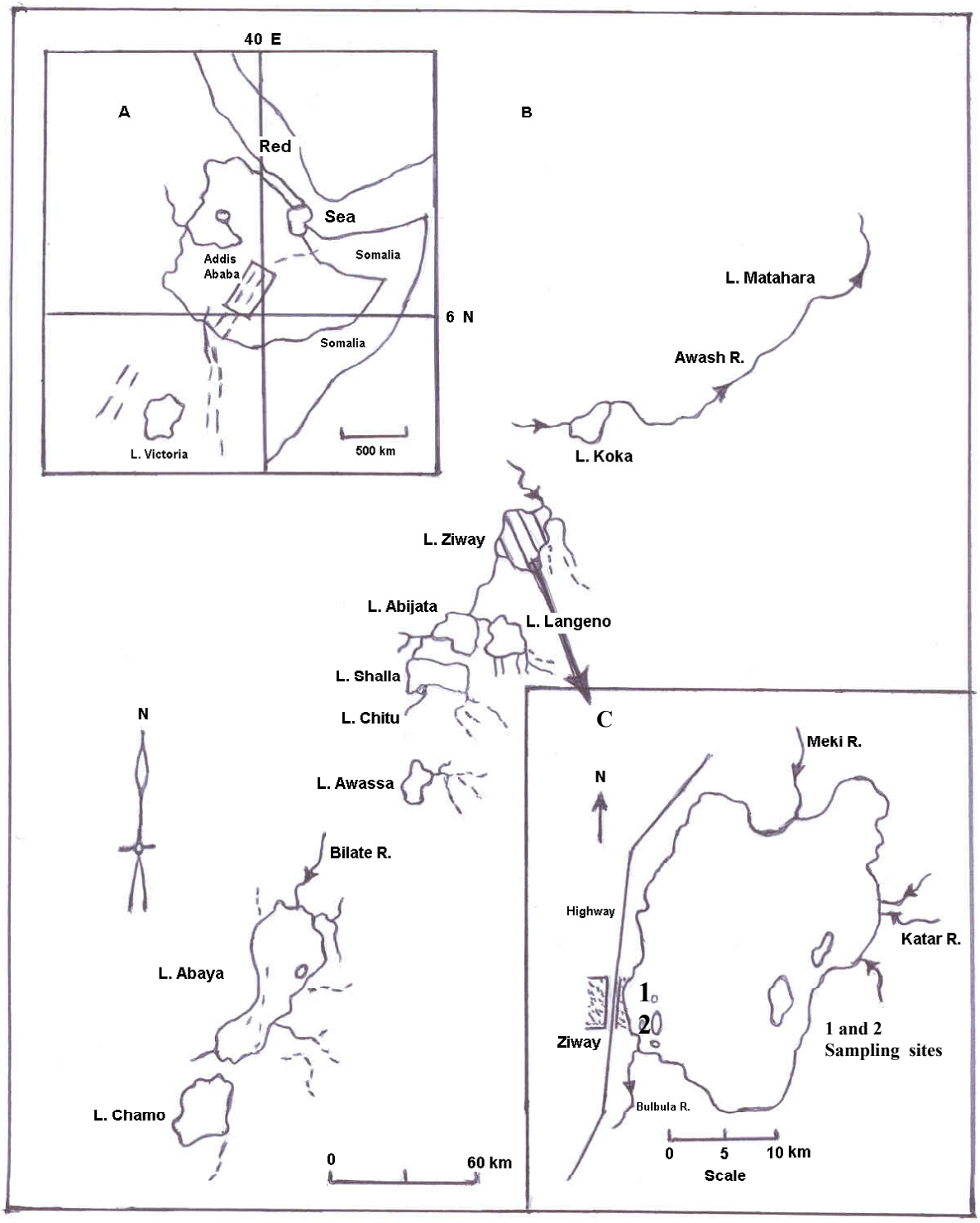

Fig. 1. Map of A) Ethiopia, B) Rift Valley lakes and C) Lake Zwai with the sampling sites.

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, *Staurastrum leptocladum* and *Pediastrum boryannum* are also important (Tsegaye Miheret-Ab, 1988).

Zooplankton community of the lake is composed of Cyclopoids *(Mesocyclops* spp., *Microcyclops* spp. and *Afrocyclops* spp.), Cladoceran (*Diaphanosoma excisum* and *Alona davidii* species) (Semeneh Belay, 1988), and Rotifers (*Keratella* species, *Brachionus* spp., *Filinia* spp., *Hexarthra* spp., *Lecane* spp., and *Trichocerca* spp.) (Green and Seyoum Mengistou, 1991). 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 in the range of 1000 to 6000 tones per year (LFDP, 1998).

MATERIALS AND METHODS

Food habits

Adult fish samples of *T. zillii* were collected over a twelve months period during the year 2001 using gill nets (60 and 100 mm stretched mesh) from the two sampling sites. In addition, younger fish were collected in October, November and December 2001, in shallow water less than 1m depth, using a 5 mm stretched mesh beach seine. The sampling time for younger fishes is restricted to the rainy season because of logistic problems. Fish caught were taken to the Zwai Fisheries Resources Development Research Center laboratory soon after capture. In the laboratory, total length (TL) of all specimens was measured to the nearest 0.1 cm using a measuring board. The stomach of each fish was then removed and preserved in a plastic bag containing 5% formalin for later examination in the laboratory. Stomach samples were then transported to Addis Ababa University for further laboratory studies.

A study on the natural food of *T. zillii* was made based on stomach of 703 adults (12.5–32 cm TL) and 150 younger fish (5.5–12 cm TL). The categorisation of fish into two-length groups is based on changes in the major component of the diet. The stomach contents preserved in 5% formalin were examined either with the naked eye or microscopically at several levels of magnifications. The food items were identified to the lowest taxonomic level possible using descriptions, illustrations and keys from various sources (Prescott, 1970; Whiteford and Schumacher, 1973; Harding and Smith, 1974; Pennak, 1978; Defaye, 1988). The frequency of occurrence and the points methods were used to describe the diet of the fish and to determine the relative importance of the different food items, respectively.

Frequency of occurrence method

The number of stomach samples in which one or more of a given food item was found was expressed as a proportion of all non-empty stomachs examined. This was considered as the proportion of the population that feeds on that particular food item and is referred to as frequency of occurrence (Hyslop, 1980).

Points method

The relative importance of the major food groups was estimated using points method which takes into account the abundance and volume of the food items (Windell and Bowen, 1978). The points method developed by Hynes (1950) was used as modified by Frost (1977). Accordingly, the stomach was opened and described based on the amount of food it contained, as full, ¾ full, ½ full, quarter full, or trace and according to the degree of fullness was allotted 100, 75, 50, 25, 12, or 6 points, respectively. Stomach contents were then put on petridish and food items were sorted into macrophytes, phytoplankton and animal components. Each category was given points equivalent to its estimated contribution to the stomach volume. The points were then divided by 100 and multiplied by fullness index. The method requires no special apparatus for measurement. Volumes of larger food items were estimated visually and that of smaller ones was estimated relating to simple geometric figures after counting.

Diurnal feeding rhythm

A total of 129 *T. zillii* individuals were caught in October 2001 over a 24-hour period using beach seine of 80 mm stretched mesh size. The number of fish caught at 6, 10, 14, 18, 22 and 2 hours at intervals of four hours were 22, 30, 25, 23, 17, and 12, respectively. After each capture, fish were immediately taken to the temporary laboratory near the shore, and total length and total weight

were measured to the nearest 0.1 cm and 0.1 g using a measuring board and a balance (EK-1200A), respectively. The stomach of each fish was then isolated and weighed to the nearest 0.1g. The pH of the stomach contents was measured using a pH meter with glass electrodes. The stomach was then washed of its contents and weighed. The difference in weight between the full and washed stomach gave the wet weight of stomach contents. Wet weight of stomach contents in percent of body weight was considered as stomach fullness. The number of empty stomachs was also recorded for each time interval.

RESULTS

Food habits

Of the total 703 adult fish examined for food composition study, 605 (86%) had food in their stomach. Analysis of the stomach contents showed that the diet of adult *T. zillii* in Lake Zwai was composed of diverse sources comprising both plants and animals (Table 1). The plant food was made up of macrophytes (unidentified) and phytoplankton including Cyanophyta (blue green algae), Bacillarophyta (diatoms), Chlorophyta (green algae), Dinophyta and Euglenophyta. Each of the first three families contributed several genera, many of which in turn contributed different species whereas Dinophyta was represented only by *Ceratium* sp. and Euglenophyta by *Phacus* sp. and *Euglena* sp. Chironomid larvae, Copepoda (*Mesocyclopes* sp.), Cladocera (*Alona* sp. and *Diaphanosoma* sp.), Rotifera (*Brachionus* sp., *Keratella* sp. and *Lecane* sp.), Ephemeroptera, molluscs, and eggs and scales of unidentified fish constituted food of animal origin. Moreover, plant detritus and unidentified broken animal body parts were other components of the diet.

However, these food items occurred in the diet of the fish with different average percentage frequency (Fig. 2). 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 greens, diatoms, green algae and plant detritus were found in 64%, 54%, 38% and 10% of the stomachs, respectively. Among blue greens *Microcsysts* spp. and *Lyngbya* spp. were frequent and noted in 59% and 33% of the stomachs, respectively, whereas *Navicula* (48%) and *Cymbella* (15%) were the diatoms with high frequency of occurrence. *Spirogyra* and *Staurastrum* (green algae) were relatively the most frequent and each occurred in 16% of the stomachs examined. Among foods of animal origin, chironomid larvae were the most frequent (10%) followed by fish scales (5%) and the remaining components were less frequent.

Further analysis in terms of percentage composition by points (Fig. 2) showed that macrophytes contributed the highest proportion (86%) of the total food ingested. The remaining plant food items together formed about 12% of the diet in which blue green algae and diatoms contributed about 7% and 3%, respectively. Animal food as a whole contributed not more than 2%, of which chironomid larvae were relatively more important.

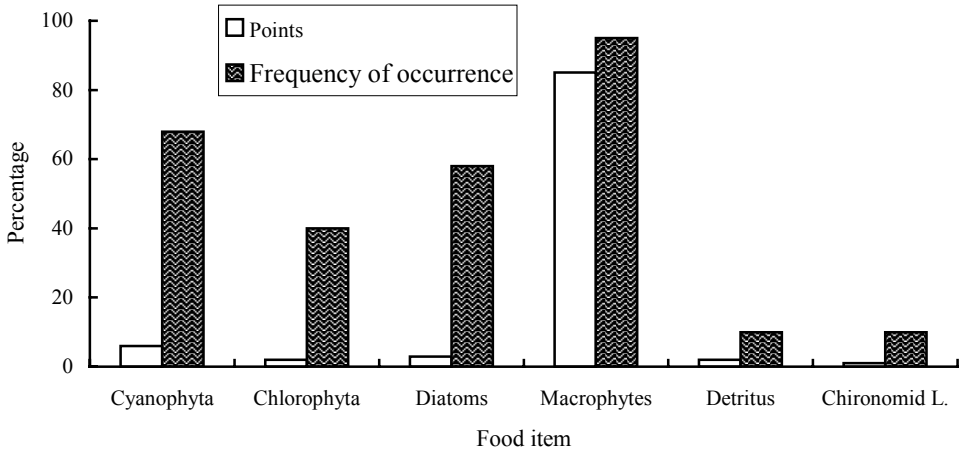

Fig. 2. Annual percentage frequency of occurrence (% occur.) and composition of food (% points) of adult *T. zillii* in Lake Zwai during the year 2001.

Table 1. Average percentage frequency of occurrence (% occur.) of different food items identified in the stomachs of adult and young *T. zillii* collected from Lake Zwai during the year 2001.

	(% occur.) (*T. zillii*)	
Food category	Adult	Young
A. Macrophytes	100	40
B. Phytoplankton		
i. Cyanophyta	64	86
Anabaena	18	32
Chroococcus	7	8
Gloeocapsa	0.4	4
Lyngbya	33	55
Merismopedia	11	28
Microcysts	59	91
Oscillatoria	33	54
Spirulina	1	3
ii. Bacillarophyta	54	96
Achnanthes	0.4	25
Cyclotella	11	30
Cymbella	15	59
Denticula	--	5
Frustulia	--	7
Gomphonema	0.2	--
Navicula	48	84
Nitzschia	2	18
Opephora	0.4	--
Rhoicosphenia	4	4
Rhopalodia	10	78
Surirella	--	9
Synedra	13	--
iii. Chlorophyta	38	59
Ankistrodesmus	2	--
Botryococcus	2	--
Coelastrum	6	5
Closterium	8	21
Cosmarium	3	3
Euastrum	2	1
Pediastrum	4	2
Scendesmus	6	32
Spirogyra	16	10
Staurastrum	16	10
Tetradron	0.2	--
C. Detritus	10	83
D. Chironomid larvae	10	58
E. Zooplankton		
Copepoda	1	3
Cladocera	0.6	--
Rotifera	0.9	--
F. Others		
Ceratium	8	4
Euglena	1	0.3
Phacus	0.2	0.2
Nematoda	0.4	--
Ephemeroptera	0.4	--
Molluscs	0.4	--
Fish egg	0.6	--
Fish scale	5	13
Unidentified species	0.8	--

All young *T. zillii* examined for diet had food in their stomachs, which was similar to that of the adults both in terms of composition and diversity (Table 1). In accordance, food of plant origin was composed of diatoms, blue green algae, green algae, plant detritus, macrophytes, *Ceratium*, *Phacus* and *Euglena* whereas chironomid larvae, Copepoda, Rotifera and fish scales formed food of animal origin.

These food items had different frequency of occurrence in the diet of the young fish (Fig. 3). As a group, diatoms, blue green algae and green algae occurred in 96%, 86% and 59% of the total stomach of young *T. zillii* examined, respectively. From diatoms, *Navicula* (84%), *Rhopalodia* (78%) and *Cymbella* (59%); and from blue green algae *Microcysts* (91%), *Lyngbya* (55%) and *Oscillatoria* (54%) were the most frequent food items. Among green algae, *Scenedesmus* (32%) and *Closterium* (21%) were relatively frequent. Plant detritus were found in 83% and macrophyte in 40% of the stomachs. Of animal food components, chironomid larvae occurred in 58% of the stomachs examined and the rest were less frequent.

When rated in terms of percentage composition by points (Fig. 3), plant components formed 86% of the food of young *T. zillii*, of which about 63% was contributed by phytoplankton belonging to diatoms (31%), blue green algae (21%) and green algae (11%). Plant detritus and macrophytes contributed 17% and 6%, respectively. Among foods of animal origin chironomid larvae constituted 12%, however, the contribution made by the rest (Copepoda and fish scales) was insignificant.

Diurnal feeding rhythm

The proportion of empty stomachs of *T. zillii* in Lake Zwai varied during the sampling periods of the day (Fig. 4). No empty stomach was recorded in samples taken between 6:00 and 14:00 h, but empty stomachs of lower proportion were observed between 14:00 h and 18:00 h, and the highest proportion was recorded between 18:00 h and 2:00 h. Nevertheless, the proportion dropped from 2:00 to 6:00 h. This variation in the proportion of empty stomach recorded during each time of capture indicated the feeding pattern of *T. zillii*. Accordingly, the fish was found to be both daytime and nocturnal feeder.

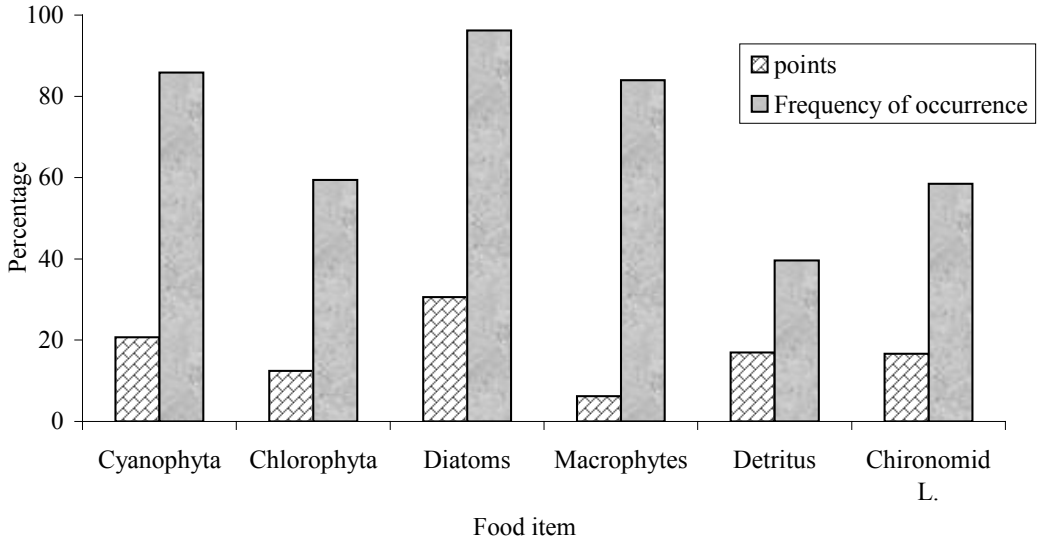

Fig. 3. Annual percentage frequency of occurrence (% occur.) and composition (% points) of young *T. zillii* in Lake Zwai during the year 2001.

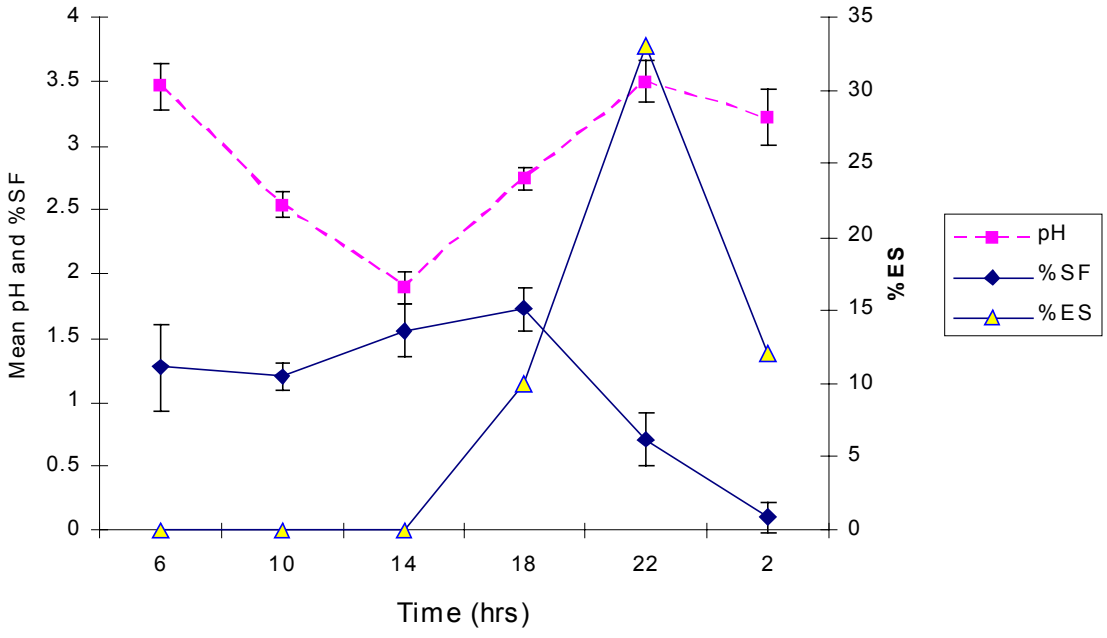

Fig.4. Diel changes in stomach pH (mean ± SE), percentage of stomach fullness (%SF) (mean ± SE) and percentage of empty stomachs (%ES) of *T.zillii* in Lake Zwai.

The average percent stomach fullness (Fig. 4) remained high between 6:00 and 10:00 h, and further increased to the highest point at 18:00 h. It then dropped to the lowest point at 2:00 h and increased between 2:00 and 6:00 h. Stomach pH (Fig. 4) of *T. zillii* in Lake Zwai decreased continuously starting from 6:00 h and reached a value as low as 1.89 at 14:00 h and then, increased progressively from 14:00 h to 2:00 h. There was also an instant where a pH of 1.24 was measured at 14:00 h.

DISCUSSION

The frequency of occurrence and the points methods were used to describe the diet of the fish and to determine the relative importance of the different food items, respectively. Though the former method may be employed in any diet study the method used in quantifying food items may vary with the nature of the diet. The diet of *T. zillii* is composed mainly of macrophytes, for which counting is not appropriate since the food items are fragmented and are not uniform size. Direct volumetric or gravimetric method could be applied if macrophytes are the sole food items. However, the fish also feeds on phytoplankton and animal components and this made the points method relatively more appropriate.

Stomach content analysis based on the occurrence method showed that in Lake Zwai both adult and young *T. zillii* had a broad natural food base comprising both plants and animals (Table 1). Nevertheless, food of plant origin was the major component of the diet. The same has been reported for adults from Lake Victoria by Welcomme (1967) and from Nile canal by Khallaf and Alne-na-ei (1987) and for fish belonging to both length groups from Lake Quarun by Abdel-Malek (1972).

Analysis using the frequency of occurrence and the points methods showed that the diet of *T. zillii* in Lake Zwai varied depending on the size of the fish (Figs. 3 and 4) as it chiefly feeds on macrophytes as adult and phytoplankton as young. In adults higher plant tissue including large portions of roots, leaves and stems of aquatic vegetation and seeds occurred in all of the stomachs examined and constituted 86% of the diet. Several authors (Welcomme, 1967; Abdel Malek, 1972; Balarin and Hatton, 1979; Buddington, 1979; Khallaf and Alne-na-ei, 1987) also reported that *T. zillii* feeds essentially on plant material and is consistent with the present observation. On the other hand, blue green algae, diatoms and green algae together composed about 11% of the diet. These items were also reported to be ingested by the fish from Lake Quarun (Abdel-Malek, 1972), Lake Kinnert (Spataru, 1978) and Nile canal (Khallaf and Alne-na-ei, 1987). However, in young fish phytoplankton (blue green algae, diatoms and green algae) constituted the bulk of the diet (63%) followed by plant detritus (17%) and chironomid larvae (12%) whereas macrophytes contributed not more than 6%.

This diet variation with size of the fish may be due to differences in the degree of development of structures used for feeding and the habitat occupied by the fish. It could be that adults have well developed teeth to utilize macrophytes more efficiently than younger ones. Philippart and Ruwet (1982) 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.

The occurrence of planktonic material in the guts of fishes with no filter feeding mechanism as is the case in *T. zillii* is a strange phenomenon. However, Welcomme (1967) suggested the source of planktonic material in the diet of *T. zillii* in Lake Victoria to be flocculent deposits off shore. On the other hand, the occurrence of larger animals like molluscs in the diet of adult *T. zillii* but not in that of young ones may be attributed to prey-predator size relationship. Abdel-Malek (1972) also associated the change in composition of the diet, as the fish grows in size to an increase in the minimum size of the organism eaten.

The feeding of *T. zillii* in Lake Zwai appeared to have both diel and nocturnal rhythm; however, feeding was more intense during daytime with the highest of activity in the afternoon. Khallaf and Alne-na-ei (1987) also reported that feeding in the fish was correlated to water temperature not to daily photoperiod. In addition, Cridland (1962) from his laboratory experiment noted that water temperature, and not photoperiod, affected growth of *T. zillii* in tanks. Nevertheless, some fish had empty stomach even during the day and this could be attributed to disease, which might have restrained feeding in these fish. Getachew Teferra (1989) has drawn similar conclusion for *O. niloticus* with empty stomachs observed during daytime when the fish is assumed to feed.

There was some association between the amount of food ingested and the pH of the stomach (Fig. 4). The pH of the stomach was lower during the afternoon when stomach fullness was relatively higher. As reported for other species including *O. niloticus* (Getachew Teferra, 1989) food in the stomach acts as stimulant towards the secretion of acid and consequently decreases pH and the same may hold true in *T. zillii* as well. However, pH started increasing when fullness was at its greatest value at 18:00 h to its maximum value at 2:00 h. The increase in pH value while fullness was at its highest point might be due to higher proportion of small sized stomachs, which could affect the reading, as the electrode was not fully immersed in the stomach contents. The difference in number of fish sampled in each time interval may also be important.

In conclusion, *T. zillii* grows to large size (up to 32 cm) in Lake Zwai and appears good in utilizing aquatic macrophytes especially as adult perhaps as intended when introduced. The preferred habitat of the fish was the shallow marginal waters of the lake and hence it can be better harvested from such areas when breeding is not at its climax with gillnets set especially during day time as it intensively feeds during day time.

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