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FOOD AND FEEDING HABITS OF *TILAPIA ZILLII* (GERVAIS) (CICHLIDAE) IN LAKE KINNERET (ISRAEL)

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ABSTRACT

Spataru, P., 1978. Food and feeding habits of *Tilapia zillii* (Gervais) (Cichlidae) in Lake Kinneret (Israel). *Aquaculture*, 14: 327—338.

Analysis of the gut content of 329 specimens of *T. zillii* (Cichlidae) collected from Lake Kinneret, has shown great variation in the sorts of food.

A study of seasonal dynamics has proved the prevalence in the food of Chironomida pupae (Diptera) in winter and spring and of zooplankton forms in summer and autumn. The additional food consisted of the various groups of algae, the most frequently found being Cyanophyta (100%) and Pyrrophyta (64.16%). An extremely voraceous species, it consumes — while searching for its preferred food — anything that comes its way in the water: algae, scraps of macrophytes, autochthonous and allochthonous insects, and forms of benthic origin, such as Nematoda, Ostracoda, Porifera and Chironomida (larvae).

The satiation index is high (between 4.08 and 5.63), in contradiction to the low values of the coefficient of condition (between 3.05 and 3.51), and with the slow rate of growth in Lake Kinneret. The main food of *Tilapia zillii*, consists of arthropod species with a chitin content (which is eliminated unchanged) of more than 50% of the total weight, and this may account for the poor exploitation of the trophic base.

This species of fish may be considered as being detrimental to others (i.e. commercially important species) because of its successful competition for food, and not, as is often incorrectly assumed, because it is an aggressive consumer of their spawn and fry.

INTRODUCTION

Tilapia zillii (Gervais), the third species of Cichlidae of Lake Kinneret that we have studied (Spataru, 1976; Spataru and Zorn, 1978), is wide spread in Israel, in both running and stagnant waters (Steinitz, 1953; Ben-Tuvia, 1960; Goren, 1974). As a eurihalinous secondary freshwater species, it is tolerant of considerable variations in salinity.

In Lake Kinneret it is caught both near the shore and in deep water, in quantities that vary from one season to the next. Out of a total of more than 2,000 tonnes of fish of different species, only 0.1 tonne of *T. zillii* is caught each year (Sarid, 1977). This figure, however, does not accurately reflect the relation in quantities between *T. zillii* and the other species in the lake, because this is a species which, in the given ecosystem, never reaches a larger size; it therefore slips through the meshes of the net, or is sold 'in bulk' together with small specimens of other species, or is simply thrown back into the water by the fishermen. Fishermen do not appreciate this species, not only because of its non-commercial size but also because of the ill-conceived notion that it destroys the spawn and fry of valuable species of fish.

In Africa, where *T. zillii* reaches a larger size and is grown in ponds for purposes of production and vegetation control, it has been studied more extensively (Fish, 1952; Chimits, 1955; El Zarka, 1956; Greenwood, 1957; Mathieu, 1960; Cridland, 1962; Kiener, 1963; Welcomme, 1966; Petr, 1967; Bayonmi, 1969; Hickling, 1971; Payne, 1971; Fryer and Iles, 1972; Ibrahim et al., 1975).

In America and in the Far East some attempts are already being made to introduce this species for the purpose of vegetation control, especially in reservoirs and ponds (Bardach et al., 1972; Hauser, 1975).

In Israel, the comparatively few studies already made deal mainly with the systematics of *T. zillii* (Steinitz, 1953; Yashouv and Hefetz, 1959; Goren, 1974), with its ability to adapt itself to high salinity (Chervinski, 1967; Chervinski and Hering, 1973), and with other aspects of its biology in ponds and in Lake Kinneret (Yashouv, 1958; Fishelson, 1966; Kugler and Chen, 1968; Chervinski, 1971; Nun, 1974).

This study is an attempt to understand the various contradictory aspects of the feeding habits of *T. zillii* in Lake Kinneret, as compared with the feeding habits of the same species in Africa and other parts of the world. The main food consumed by this species in Africa, both in the natural water systems and in ponds, consists of leaves and stems of macrophytes. Alkholy and Abdel Malek (1972) have pointed out, however, that in Lake Quarum it consumes the live elements of plankton and benthos, detritus and spawn.

MATERIALS AND METHODS

Specimens for examination were taken from commercial catches, using pure seines, with and without light, in various regions and at various depths of the lake. In order to examine the feeding habits of the fish living near the shore, collections were made using a trammel net (active fishing) system.

Fish were collected monthly, 329 altogether, and classified by age. The size ranges (standard length, in cm) for each group are given in Table I.

The fish collected between September 1973 and July 1975 were used for qualitative examination; quantitative calculations of the food components were performed on fish collected between November 1973 and October 1974. The fish were weighed and measured immediately after being caught and, in addition, the scales were kept and the sex was determined. The intestines were removed and immediately placed in 6% formalin.

TABLE I

Age, standard length and number of *Tilapia zillii* examined in the years 1973—1975 in Lake Kinneret

Age	Standard length (cm)	Number of fish examined
0+	3.5—6.5	18
1+	6.5—11.5	9
2+	11.0—15.0	17
3+	11.5—16.5	59
4+	12.0—17.5	121
5+	12.5—18.0	69
6+	13.5—18.5	31
7+	14.5—18.0	5

For the purpose of specifying feeding places, food components were determined down to species and stages of metamorphosis.

Numerical counts of small organisms were carried out with the Sedwick Rafter counting cell and with Utermohl's eyepiece (Utermohl, 1958). Volumetric determination and gravimetric data of food components were based on the knowledge of the volume of every cell of the various species of algae (Berman and Pollingher, 1974), of every species in the zooplankton (Gophen, 1973), and on weighing the moist zoobenthos forms and the stages of insects.

To estimate the degree of satiation (index of fullness), the following formula was used:

$$\text{Index of fullness} = w \times 100/W,$$

where w is the weight of the gut contents and W is the weight of the fish.

The quantitative utilization of the trophic basis by the fish is reflected by the condition of the fish and was therefore estimated by calculating the coefficient of condition (Beckman, 1948), using the formula:

$$\text{Coefficient of condition} = W \times 10^5/L^3,$$

where L is the length of the fish.

RESULTS AND DISCUSSION

Food components and their stage of digestion

Qualitative analysis of the intestinal contents has established the great variation of the sorts of food: algae and animals from plankton and benthos, insects from the body of water and from its surface, autochthonous and allochthonous forms, vegetable detritus and Macrophyta. Analysis of the forms of food has also shown that, while in search of its 'preferred' food and in intervals between finds, this species consumes everything that comes its way in the water. It was possible to verify this by an analysis performed on successive portions of the intestine, from the oesophagus to the anus. Comparatively small quantities of vegetable material in the intestine of this species have demonstrated the difference between its feeding habits in Lake Kinneret, on the one hand, and in other habitats, on the other hand.

In African lakes, where vegetation is abundant and specialization is imperative because of the existence of a great number of species of Cichlidae, with highly varied trophic niches, *T. zillii* has preserved the phytophagous character of its feeding and, consequently, also the initial adaptations of its food-collecting apparatus.

In Lake Kinneret, the frequency of gales with huge waves, changes in the water level, chemical condition (pH around 8), the turbulence of the water and, consequently, the poor penetration of light to the depths, have all been restrictive factors in the development of submerged, and even emergent, plants. There is only a narrow strip of emergent plants along the western, southwestern and southeastern shore and very few places with submerged vegetation (Waisel, 1967).

The absence of a rich aquatic vegetation has led to a change in the feeding habits of *T. zillii*. Apart from this, the number of fish species in Lake Kinneret is rather small (25 species); the dominant species among Cichlidae are *T. galilaea* (Artedi), *T. zillii* (Gervais) and *T. aurea* (Steindachner) the latter having been reintroduced into the lake comparatively recently. Consequently, competition is less keen in Lake Kinneret than in some African lakes.

The above has resulted in a modification of certain morphological and behavioral features. Certain changes have appeared in the food-collecting apparatus. Some features, which are specific for feeding on Macrophyta, have disappeared; others have developed that are suited to the seizure and filtration of small forms of zooplankton and phytoplankton.

A detailed description of these modifications will form the subject of a separate study, but it should be noted that there is a tendency towards a reduction in the rows of internal teeth on the jaws (2—3 rows, instead of the 4—5 rows which played a part in the trituration of aquatic plant leaves) and toward a change in the shape of external teeth to more elongate and more closely serried.

Table II gives a list of the principal species found in the intestinal contents, the frequency of their occurrence, their maximum number, and their size.

Among our observations on the stage of digestion of forms of food, a point is worth mentioning which had not previously been observed in the fish species studied by us. This is the capacity of *T. zillii* to disintegrate the gelatinous matrix of colonies of Cyanophyta, especially of *Microcystis* sp., and consequently to feed on these algae as well (Fig.1). We consider this phenomenon to be very important, because it opens the way to the utilization of this fish species in big ponds, where mass multiplication of Cyanophyta occurs periodically. In the absence of a cyanophyte feeder, the algae may

TABLE II

List of the main species found in the gut content *of Tilapia zillii* and their frequency of occurrence, maximum number and volume

Species		Frequency of occurrence (%)	Maximum number in gut content	Volume per individual (μ^3)*
Microcystis aeruginosa		100.00	5,232,175,000	20—100
Peridinium cinctum f. *westii*		64.16	38,750,000	70,000—125,000
Melosira granulata		49.84	11,525,000	320—1,100—1,500
Cosmarium sp.		80.24	4,211,000	500
Bosmina longirostris		76.89	394,000	18.3×10^6
Mesocyclops leuckarti		52.88	151,000	18.0×10^6
Keratella cochlearis		27.05	43,125	0.1×10^6
Synchaeta oblonga		36.77	235,000	0.2×10^6
Procladius choreus	pupa	74.46	1,523	357×10^7
	larva	29.48	2,351	173×10^7

*Volume of algae cells according to Berman and Pollingher (1974); volume of zooplankton forms according to Gophen (1973); volume of Chironomida stages from weighing these forms.

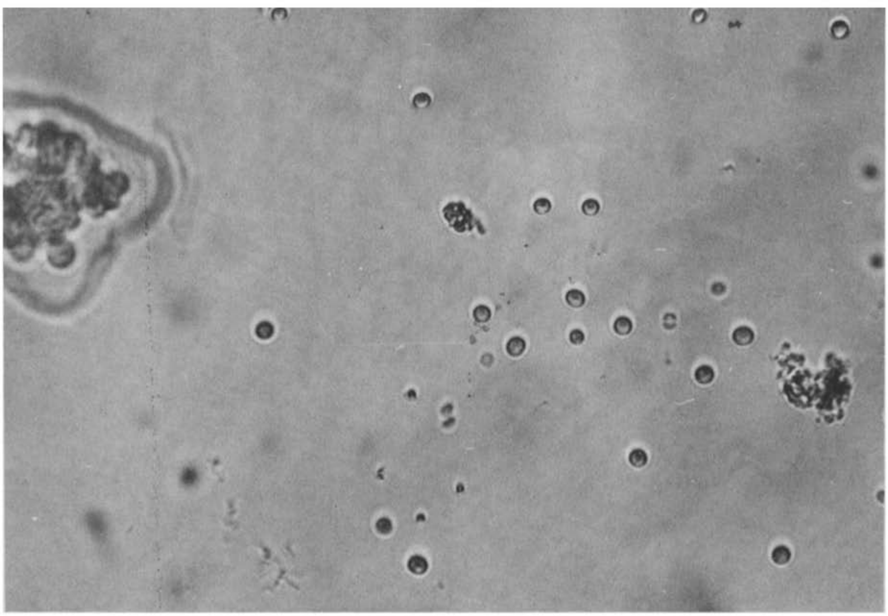

Fig.1. A colony and isolated cells of *Microcystis* sp. in the intestine of *T. zillii.*

bloom at an explosive rate causing oxygen depletion at night and during the early morning, which in turn results in mass mortalities of fish.

An important part in the food is played by a few species living in the zooplankton, such as *Bosmina longirostris* (Cladocera), *Mesocyclops leuckarti*

(Copepoda), *Keratella cochlearis* and *Synchaeta oblonga* (Rotatoria). Also very frequently found were larvae and pupae of *Procladius choreus* and, to a lesser extent, larvae of *Polypedilum tiberialis* (Chironomida).

The fact that the same fish species can consume elements of plankton on

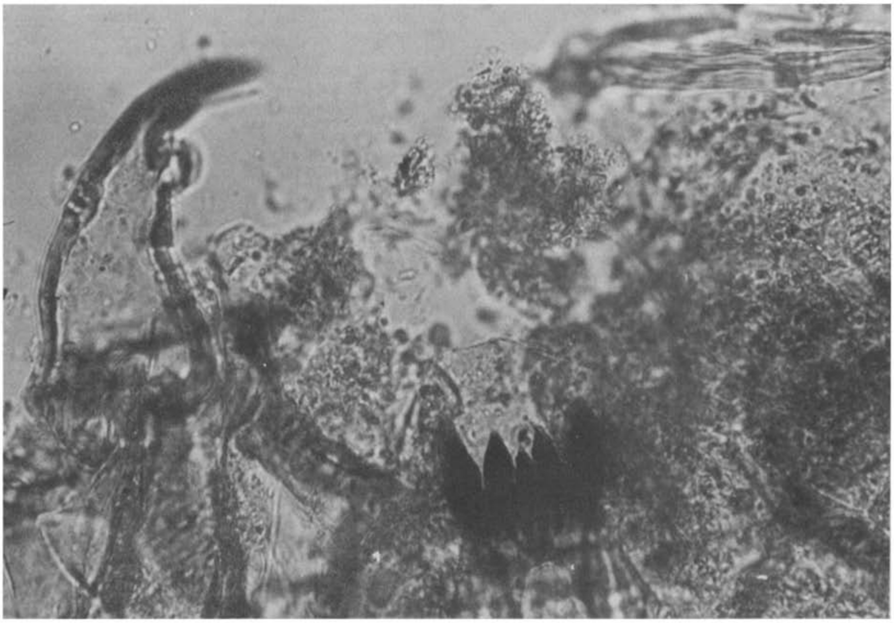

Fig.2. Part of head of *Procladius choreus* in the gut content of *T. zillii*. In the foreground mandible and glossa of larva.

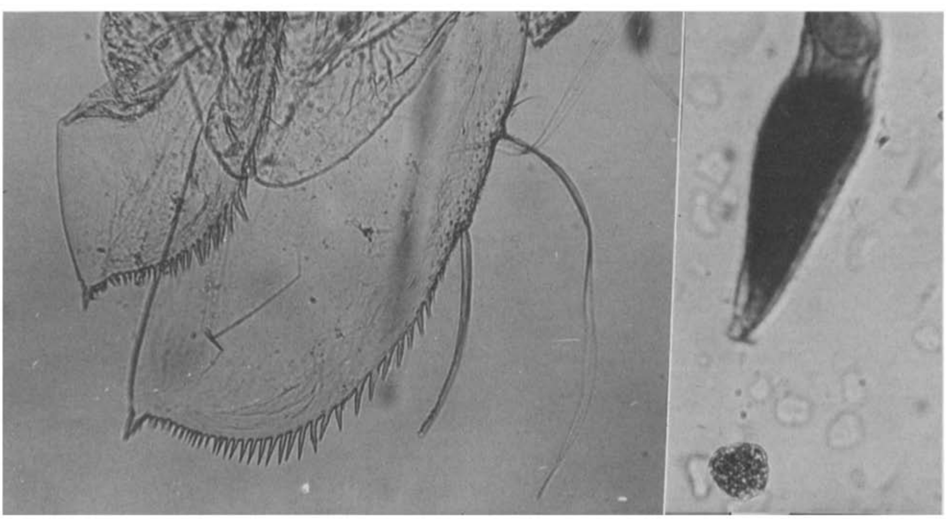

Fig.3. Hind end and respiratory organ of pupa of *Procladius choreus* in the gut content of *T. zillii*.

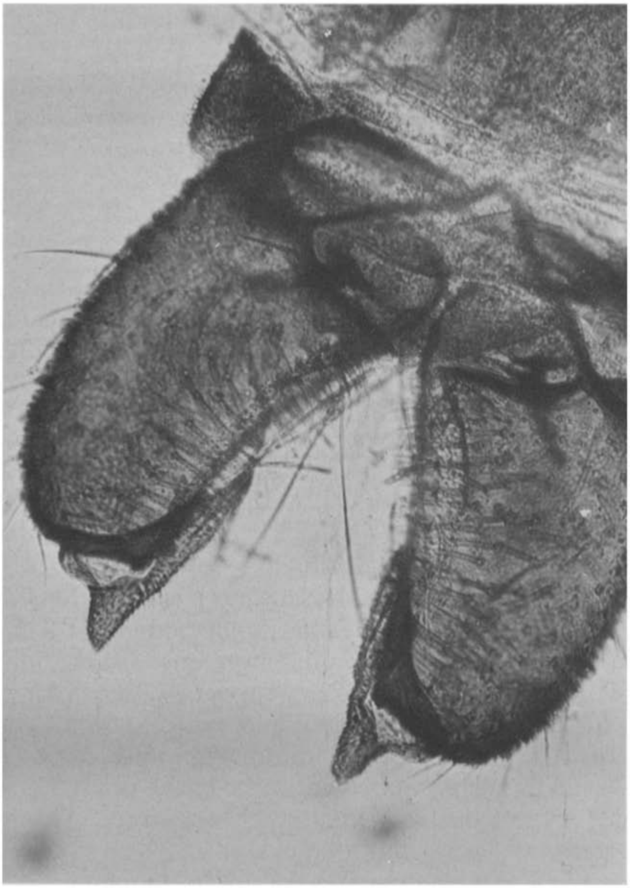

Fig. 4. Hind end with male genitalia of *Procladius choreus*, in the gut content of *T. zillii*.

the one hand, and of benthos on the other hand, may at first appear to be contradictory. Actually Chironomida are consumed in the plankton phase, namely, at their first larva stage, and also at their pupa stage, when they rise to the surface, before the adults (imago) come out. Indeed, in all the transparent pupae found in the intestine of *T. zillii*, the adult could be discerned, with all its characteristic features. In this way it has been possible to find most metamorphosis stages (larva, pupa, and imago) in the fish intestine. The main morphological features that made it possible to determine the *Procladius choreus* species are shown in Figs. 2, 3 and 4.

Comparatively frequently found, but always as additional food, were larvae and adults of aquatic Coleoptera, appreciable quantities of Lepidoptera wing scales, and fragments of *Agyroneta aquatica* (Arachnidae).

The dynamics of feeding

Monthly observations over a year (November 1973 — October 1974), on the way in which the elements of food are utilized, have led us to conclude that *T. zillii* collects its food at and below the surface, but very seldom at the benthos level.

In Fig.5, where the numeric and volumetric monthly variations of the principal groups of food are shown in percentages, the prevalence of zooplankton forms and of Chironomida can be seen clearly. *Microcystis aeruginosus* and *Peridinium cinctum* f. *westii* reach very high percentages numerically, but owing to their size they never exceed 28% in volume of the total quantity ingested; this peak is reached in May only, at the height of Pyrrophyta bloom. On the other hand, the zooplankton, represented mainly by *Bosmina longirostris* and *Mesocyclops leuckarti*, exceeds 90% of the total volume of intestinal contents during the summer and autumn months. In winter and spring its place is taken by pupae of Chironomidae and other aquatic insects.

An interesting phenomenon has been noted during the study, which should be studied experimentally. In April and May and, to a lesser extent, June, the males of *T. zillii* feed on Chironomida larvae, collected inside the benthos or at its surface. In the intestines of these fish, were also found Ostracoda, Nematoda, small quantities of sand, vegetable detritus and sponge gemmules, all of which are benthos forms. This phenomenon is no doubt connected with the behavior of the fish during the period in which they protect their young, which are sheltered in nests dug by the adults in the ooze. We have no explanation, as yet, for the fact that females continue to feed within the water mass or at the surface.

No qualitative differences were observed concerning the feeding habits of fish at the various ages studied by us (0+, up to 7+).

Results of the satiation index determination, as shown in Fig.6, indicate the fast feeding pace and voracity of this fish and its propensity to consume huge quantities of food; its intestine is almost always filled to maximum capacity. In spite of this, the pace of growth is much slower than in other parts of the world (Kiener, 1963; Fryer and Iles, 1972).

Fig.6 also shows the seasonal variation of the coefficient of condition, which reflects the growth of the fish in relation to the feeding conditions in its environment. Its low values, varying between 3.05 in the autumn and 3.50 in winter and spring, considered in connection with the pace of growth data, are contradictory to the high values of the satiation index.

The principal food — consisting mainly of Arthropoda, namely, Crustacea in the summer and autumn and Chironomida (pupae) and Coleoptera in winter and spring — is insufficiently utilized. More than 50% of it consists of chitin, which is eliminated unchanged. This is also confirmed by the lack of fat reserves on the viscera, the presence of which might indicate a high rate of utilization of the trophic base.

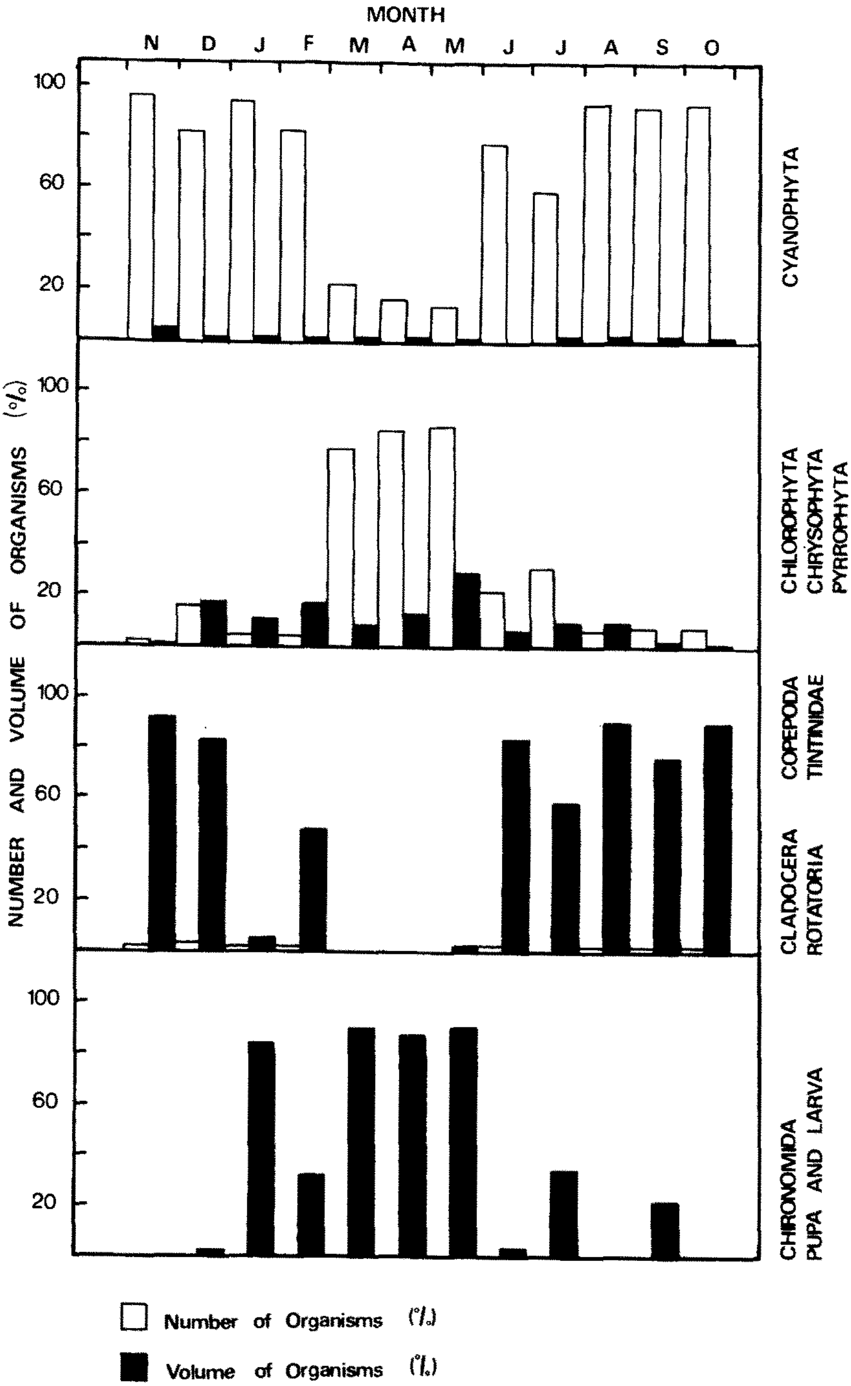

Fig.5. Relative number and volume (percentages) of algae and animals found in the gut content of *T. zillii* in the course of a year (November 1973—October 1974).

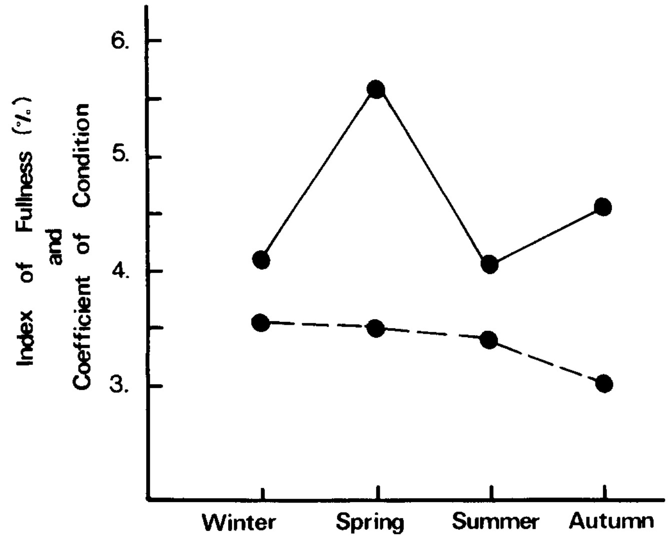

Fig.6. Seasonal changes in the values of the fullness index of the gut (% of the total weight of the fish) and in the coefficient of condition in the course of a year. •——• index of fulness; •------• coefficient of condition.

Another problem tackled and which has been solved by our observations, concerns the harmful character of the species in question in Lake Kinneret. It is our opinion that at times when food is scarce or difficult to obtain (due to violent storms, interspecies competition, a higher density during periods of reproduction and protection of the fry, etc.) *T. zillii* — like any other species — consumes indiscriminately whatever comes its way including spawn and fry, if obtainable.

We have observed this phenomenon in several species of Cyprinidae, the characteristic diet of which was one of benthophagy, of zooplanktonophagy, or of phytophagy, and which turned to ichthyophagy under certain conditions (Spataru, 1967; Spataru and Hepher, 1977). This has been observed by other research workers as well (Payne, 1971).

The low frequency of spawn and fry (less than 1%) in the *T. zillii* intestine on the one hand, and their presence in fish that were caught during violent storms, on the other hand, confirm our assumptions.

In our opinion, the harmful character of this species is inherent in its voracity. As this fish consumes quantities of food that are enormous in relation to its size, it is a competitor of commercially-valuable fish. In Lake Kinneret the zooplankton, composed of comparatively few species, is consumed by many species of fish, some of which are of economic value.

Apart from this, *Tilapia zillii* consumes Chironomid pupae a very short time before the emergence of the adult and the process of mass reproduction of these Diptera. This interruption of their metamorphosis leads to a diminution of the mass of Chironomids and is thereby detrimental to commercially-valuable benthophagous fish species, for which Chironomids are the basic food. This applies in particular to the carp, a species that has not yielded satisfactory results in Lake Kinneret.

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