EKOLOGIA POLSKA (Ekol. pol.)	24	2	211–235	1976

Janusz GUZIUR

Institute of Ichthyobiology and Fisheries
Academy of Agriculture and Technology, Olsztyn

THE FEEDING OF TWO YEAR OLD CARP (*CYPRINUS CARPIO* L.) IN A VENDACE LAKE KLAWÓJ

ABSTRACT: Animal food (mainly *Mollusca, Chironomidae Trichoptera, Sialis* sp), which is on average 94% of the reconstructed food weight, is the most important in the food of two year old carp. The remaining 6% is plant food (mainly macrophytes). In particular years of the study the quality of consumed food did not vary much. The weight percentage of particular components and their frequency of occurrence (feeding) changed slightly in consecutive seasons of the year. The feeding by the carp is most intense between June and August. A thermocline is a thermal barrier significantly limiting the vertical feeding range of the carp in this type of water body. The littoral zone is the main feeding ground for two year old carp almost entire the whole vegetation season. The carp feeds sporadically in other zones.

Contents

I. INTRODUCTION

The carp (*Cyprinus carpio* L.) is commonly considered as a omnivorous fish (phytozoophag) (Boruckij 1960). It eats both specimens of bottom fauna and of fauna living on plants, insects falling into water, zooplankton and also parts of macrophytes, detritus, algae and seeds (Marsilius 1726, Bean, Dill, Cole, Forbes, Richards, Hunt and Mottley after McCrimmon 1968, Alikhuni 1952, Dyk 1956, Sigler 1958, Lapinskaite 1959, Vass and Vass van Oven 1959 after Prejs 1973, Pekař and Krupauer 1966, Balon 1967, Niculescu-Duvaz 1970, Prejs 1973). There are also some cases of cannibalism among the carp (Hrabě and Kostomarov 1943 after Dyk 1956, Harlan and Speaker 1956, Sigler 1958). As the species grows it changes from feeding on small to bigger food forms (Merla 1959, Ciborowska 1970). According to Gurzęda and Wolny (1962) the most important food components of carp fry in ponds are the larvae of *Chironomidae* and *Ephemeroptera* and zooplankton. Other components are the incidental food (as understood by Schiemenz 1924). But Wunder (1949) says that plankton is of secondary significance, and especially in the cases of older fish. According to Špet (1961) and others, the *Mollusca* are a main food component for the carp. Wunder (1949) and Popovska-Stanković (1971, 1972) say that the molluscs prevail only in the diet of carps from large water bodies and among older individuals.

In the years 1968– 1961–1971 Prejs (1973) has made an attempt to determine the feeding character of stocks of carp (C_2, C_3, C_4)[1] and other species and their effect on animal and plant communities in the eutrophic Lake Warniak. He has observed that of the 31 animal food components the most significant (weight) are the *Chironomidae* (*l*)[2], *Trichoptera* (*l*), *Mollusca*, *Ephemeroptera* (*l*), *Odonata* (*l*) and *Cladocera* which are 90% of the total reconstructed food. Nümann (1962) who has studied the carp in 8 lakes of Anatolia (Turkey) claims that there is no point in discussing the "favourite" or "compulsory" (Verlegenheitsnahrung) food of the carp as this species eats all available components of plant, animal and even mineral (gravel, sand) origin.

2. THE AIM OF RESEARCH AND A CHARACTERISTIC OF THE LAKE

The aim of this work was to learn about: (1) the qualitative and quantitative composition of natural food of carp in various stocks, (2) the seasonal changes in the composition of consumed food, (3) the feeding intensity in particular seasons, (4) the distribution of feeding grounds of the carp in the lake.

Lake Klawój is in the Masurian Lake District and is one of the 6 lakes under the joint name of Legińskie Lakes (Braun 1905, Fig. 1). The surface area of Lake Klawój is 29.3 ha and the maximum depth 17.3 m (Olszewski and Tadajewski 1965) (Fig. 2). A lack of forestration of areas surrounding this lake is its characteristic feature, due to which the water is easily mixed (eumictic type). As regards the thermal stratification there are considerable differences in different years. The epilimnion was 5 m deep in 1968 (Guziur, Lossow and Widuto 1975), 8 m in 1969, and slightly over 9 m in 1970 (Guziur and Wielgosz 1975; Fig. 3).

[1] C_2, C_3, C_4 – two, three and four years old carps.
[2] *l* – larvae.

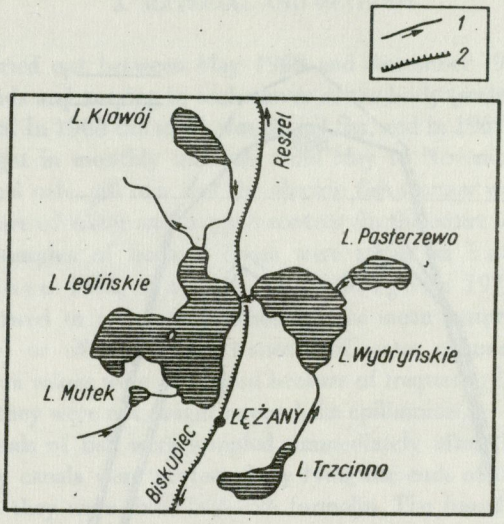

Fig. 1. Group of Legińskie Lakes of the Agricultural Experimental Institute at Łężany (Biskupiec district)
1 – streams and the direction of water outflow, *2* – roads

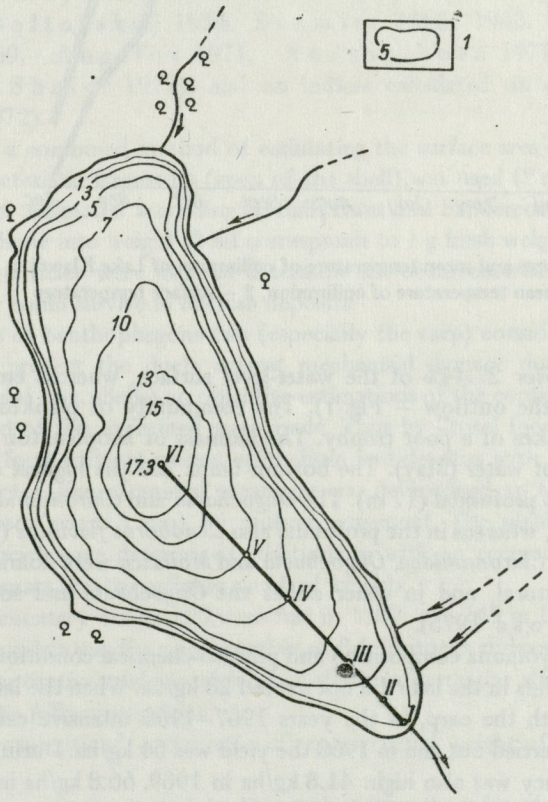

Fig. 2. Batimetric map of Lake Klawój and sites for sampling bottom fauna
I-IV – numbers of sites: *I-III* – littoral, *IV* – sublittoral, *V*, *VI* – profundal; *1* – depth in metres

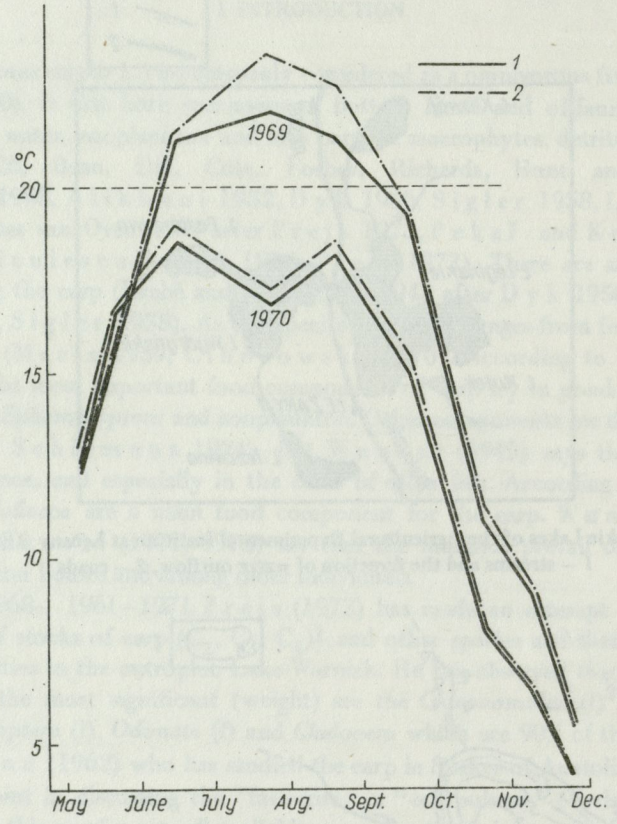

Fig. 3. Surface temperatures and mean temperature of epilimnion of Lake Klawój in 1969 and 1970
1 – mean temperature of epilimnion, *2* – surface temperature

Submerged plants cover 27.44% of the water-level surface, whereas emergent vegetation only 3.83% (mainly at the outflow – Fig. 1). The community of planktonic crustaceans is regarded as typical for lakes of a poor trophy. The biomass of zooplankton in 1968 was from 0.5 (April) to 1.6 g/m^3 of water (May). The bottom fauna had the highest density in shallow littoral (2 m) and in deep profundal (17 m). The *Oligochaeta* and *Chironomidae* were dominant groups in these biotopes, whereas in the profundal also *Chaoborus flavicans* (Meig.) dominated. In 1969 and in 1970 the *Chironomidae*, *Oligochaeta* and *Mollusca* were dominant groups of the bottom fauna in the littoral, and in other zones the *Oligochaeta* and some *Chironomidae* (Guziur and Wielgosz 1975).

Considering the ichthyofauna composition and physico-chemical conditions this is a vendace lake. Up to 1965 the yields in the lake did not exceed 28 kg/ha. When the lake was being made ready to be stocked with the carp, in the years 1967–1968 intensive catches of predators (mainly the pike) were carried out and in 1968 the yield was 64 kg/ha. During the period under study the fishing efficiency was also high: 41.8 kg/ha in 1969, 66.8 kg/ha in 1970 (Guziur, Lossow and Widuto 1975).

3. MATERIAL AND METHODS

The study was carried out between May 1968 and November 1970. Two years old carps (C_2) reared in the ponds and varying in scale cover of the body (scaled and mirror carps) were used in the experiments. In 1968 the stock was 33 ind./ha, and in 1969 – 128 ind./ha.

The carp was caught in monthly intervals from May to November (in 1969 and 1970). Summer seines, trammel nets, gill nets and the electric fish stunner were used. Before catching the carp the temperature of water and oxygen content (in the entire water column, every 1 m) were measured and samples of bottom fauna were taken on 6 sites (Fig. 2) (Guziur, Lossow and Widuto 1975, Guziur and Wielgosz 1975). The measurements of water temperature allowed to calculate additionally the mean temperature of the epilimnion layer (May-September) or of the whole transect of water column in the lake (October--November). These mean values were calculated because of frequent gill net catches of the carp at various depths, but they were not caught beyond the epilimnion.

The alimentary canals of fish were sampled immediately after the fish were caught. The contents of alimentary canals were protected by tying the ends of these canals with a nylon thread and afterwards they were fixed in 4–5% formalin. The found specimens of fauna and flora, or their remains, were counted, measured, weighed (whole), identified and their weight was reconstructed. The weight reconstruction was based on indices between the body length and weight as given by several authors (Boruckij 1939, 1958, Jablonskaja 1953, Morduchaj-Boltovskoj 1954, Szumiec 1962, 1963, Leszczyński 1963, Čislenko 1969, Angelov 1971, Andronikova 1971, Baudonin and Ravera 1972, Shafer 1972), and on indices calculated on own material from Lake Klawój (1968–1972).

For molluscs, a combined method of estimating the surface area occupied by their remains and finding characteristic fragments (apex of the shell) was used (Prejs 1973). Detritus and plant material was estimated according to Ball, Hunt and Sandercock after Prejs 1973 by calculating the volume into weight (1 ml corresponds to 1 g fresh weight).

Fragments of cuticles were used to determine the occurrence of *Oligochaeta* as it is very unlikely that they could survive in bottom deposits.

As in the guts of benthophagous fish (especially the carp) considerable amounts of mucus are produced to protect the ducts against mechanical damage due to some hard parts of organisms consumed (e.g. shells) no objective estimations of the contribution of epithelium and mucus to the food of fish examined were made. Thus by "total food" one should understand plant and animal food without mucus, epithelium and detritus with admixtures (sand, gravel).

The reconstructed size of animal organisms was determined up to 1 mm and then divided into classes of size (every 3 mm) by mutual agreement. The planktonic forms (*Copepoda Cladocera, Rotatoria*) were determined additionally with an accuracy to 0.1 mm in order to calculate their biomass acc. to available standard weights.

Of the 338 alimentary canals 120 were full in 1969, and 149 in 1970 (Table I). The reason for such a small number was the small number of fish in stocks and some difficulties in catching the carp. The quantitative analysis of food contents in particular alimentary canals was made with the help of the following indices:

a. Index of consumption[3] – the ratio of reconstructed weight of food components to the

[3]The index of consumption is used to distinguish it from the index of filling the alimentary canals (Blegvaad 1917) which expresses the ratio of the weight of the entire gut contents to the weight of fish. This distinction is also made by Fortunatova (1964) and Prejs (1973).

Table I. The number of filled and empty alimentary canals of the carp in Lake Klawój, in particular months in 1969 and 1970

Year	The filling of alimentary canal	May	June	July*	Aug.	Sept.	Oct.	Nov.	Sum total
1969	full	13	20	–	27	12	29	19	120
	empty	5	7	–	–	–	2	5	19
	sum total	18	27	–	27	12	31	24	139
1970	full	18	17	27	12	28	33	14	149
	empty	15	4	3	–	1	14	19	50
	sum total	33	21	30	12	29	47	33	199

*In 1969 the representative samples were not collected.

weight of fish. To avoid fractions the values obtained were multiplied by 1,000 (Bogorov 1934).

b. Index of frequency of occurrence (Forbes 1888) – the percentage of intestines with a given food component in relation to the total number of full alimentary canals.

c. Daily index of consumption (Bajkov 1935) which is an index of feeding intensity of the carp (D) calculated acc. to the equation:

$$D = \frac{A \cdot 24}{n}$$

where: A – reconstructed weight of food found in the intestines in grammes, n – the shifting of food in hours at a given temperature of water.

Not having own data, the data of others (Scheuring 1928, Klust 1940, Kempińska 1960, Assman 1962, Krajuchin 1963, Backiel and Horoszewicz 1970, Prejs 1973) were used to assume the values for the time of the passage (n) of carp food at different temperatures of water.

Attempts were also made to find the most important food components and the well known division of Schiemenz (1905, 1924) was used here. Schiemenz distinguishes 5 kinds of food: main (Hauptnahrung), additional (Nebennahrung), incidental (Gelegenheitsnahrung), compulsory (Verlegenheitsnahrung) and of absolute necessity (Notnahrung). With consideration to the criticism of this division (Walter after Sorygin 1952) only the first three food categories were used here. The animal components were treated as main food because they covered over 7.5% of food weight and were found in at least one third of all individuals. The additional food were the animal components found in 5–46.5% of individuals with a weight percentage from 0.1 to 7.5%. The incidental food were animal components of a weight percentage less than 0.1%, found in less than 5% of all fish examined, and all other plant components.

4. RESULTS

4.1. Characteristics of food composition

The analysis of the food spectrum of the carp examined was based on mean data for the years 1969 and 1970 without introducing the division of fish into size classes (P r e j s 1973).

Table II. Weight contribution, frequency of occurrence and the significance of particular components (animal and plant) in the food of the carp in Lake Klawój (mean values for 1969 and 1970)
Contribution to the total food mass: animal components – 94%, plant components – 6.0%

Kind of food	Significance of food components	Food components	Index of frequency of occurrence (%)	Weight of reconstructed food (%)	
Animal food	main food	1. *Gastropoda*	74.9	31.5	83.8
		2. *Chironomidae* (l,p)*	90.0	23.9	
		3. *Bivalvia***	48.0	12.5	
		4. *Trichoptera* (l)	52.0	8.4	
		5. *Sialis* sp. (l)	34.2	7.5	
	additional food	6. *Oligochaeta*	46.5		16.2
		7. *Zygoptera* (l)	21.5		
		88. *Ephemeroptera* (l. im)***	22.9		
		9. *Coleoptera* (l)	16.7		
		10. *Heleidae* (l)	45.4		
		11. *Cladocera*	35.6		
		12. *Copepoda*	32.7		
		13. *Ostracoda*	25.6		
		14. *Hydracarina*	17.0		
	incidental food	15. *Anisoptera* (l)	5.0		
		16. *Diptera* (l)	4.5		
		17. *Diptera* (im)****	3.6		
		18. *Heteroptera* (l)	3.5		
		19. *Nematoda*	3.5		
		20. *Lepidoptera* (l)	3.0		
		21. *Hirudinea*	2.0		
		22. *Gammaridae*	1.1		
		23. *Chaoborus flavicans* (l,p)	+		
		24. *Asellus aquaticus*	+		
		25. *Rotatoria*	+		
		26. *Corixidae*	+		
		27. *Bryozoa* (statoblasts)	+		
		28. Ova *Invertebrata* nd.	18.5		
		total animal food	100.0	100.0	
Plant food		macrophytes	85.5	94.0	
		algae	22.5	2.0	
		seeds, drupels, oogonia	11.0	4.0	
		total plant food	100.0	100.0	

*l,p – larvae, pupae, **including *Dreissena polymorpha* Pall., ***im – imagines, ****excl. *Chironomidae, Heleidae, Culicidae* (*Chaoborus flavicans*), the little cross (%) means less than 0.1%.

Table II shows that animal food, which was on average 94% of reconstructed food weight, was the most important in the food of the two years old carp in 1969 and 1970. The remaining 6% was the food of plant origin.

4.1.1. Main food

Among the 28 components of animal food the most important were *Gastropoda*, *Chironomidae*, *Bivalvia* (together with *Dreissena polymorpha* Pall.), *Trichoptera* and *Neuroptera* (*Sialis* sp.) which were on average 83.8% of reconstructed weight of animal food (Table II).

Mollusca. They were found in intestines of 84.5% of fish and the most frequently found were the representatives of *Gastropoda* (74.9%) of the family *Hydrobidae* (*Bithynia* sp.) and *Planorbidae* (*Planorbis* sp.); less rarely of the families *Viviparidae*, *Valvatidae* and *Physidae*. The majority of bivalves consumed did not exceed 8–10 mm (exceptionally 13–16 mm). As regards the *Bivalvia*, *Dreissena polymorpha* Pall. and representatives of the family *Sphaeridae* they occurred quite abundantly in the intestines of the carp (index of frequency of occurrence – 38% and 36.5%). The majority of bivalves consumed were 3–8 mm in length (exceptionally up to 10 mm). Together with *Mollusca* they covered 44.0% of food weight thus being a dominant group of animals consumed by the carp. A similar contribution of *Mollusca* in the diet of carps was observed by Popovska-Stanković (1971, 1972) in two lakes in Macedonia.

Chironomidae (pupae and larvae). They were the most abundantly (on average 90.0%) consumed group of animals, but the larvae prevailed (98%). The number of *Chironomidae* in one alimentary canal was on average several hundred (maximum 1,500 individuals). As regards the weight the *Chironomidae* were the second (23.9%), after the *Gastropoda*, main food component of the food of the carp examined.

Trichoptera (larvae). They contributed to the food of the carp 8.4% on average and they were found in 52.1% of individuals examined. In this group the larvae of the families *Hydroptylidae* and *Leptoceridae*, 10–13 mm in length, dominated. Representatives of the families *Phrygaenidae*, *Limnophilidae* and *Mollannidae* (*Mollanna* sp.) were sporadically found in the spring.

Neuroptera (larvae). They were relatively frequent in the food of the carp (34.3%), especially the *Neuroptera* of the genus *Sialis* sp. Most frequently found were the larvae 10–23 mm long, the maximum of 33–35 mm, and therefore their weight contribution was quite considerable (7.5%).

4.1.2. Additional food

Of the 9 food components belonging to this group the *Oligochaeta* occurred most frequently – 46.5%. A similar contribution of *Oligochaeta* has been observed by Popovska-Stanković (1971) in the food of the carp in lakes of Macedonia. However, according to the literature data (Sigler 1958, Schoonbee 1969, Prejs 1973) it seems that the significance of *Oligochaeta* in the food of the carp is not sufficiently appreciated because of the already mentioned difficulties in determining their presence and weight in the gut contents.

Odonata (larvae). They were found in the intestines of 21.5% of carps, and the representatives of *Anisoptera* were more rarely found (5%) than those of *Zygoptera* (21.5%). The weight contribution of these groups was also similar (0.7% and 2.1%, respectively). The majority of *Odonata* consumed were species of the subfamily *Caenagrioninae* (*Caenagrion* sp.) and *Libellulinae* (*Libellula quadrimaculata* L., *Aeschna grandis* L.).

Ephemeroptera (larvae). They were consumed to a smaller extent (22.9% of intestines) than it is commonly assumed (Prejs 1973). The majority of *Ephemeroptera* con-

sumed (90%) belonged to the genera *Caenis* and *Cloën*, whereas the remaining 10% were *Ephemera vulgata* L.

Coleoptera (larvae, imagines). They were found in 16.7% of fish examined and the larvae prevailed. About 2/3% of individuals belonging to this group were *Donacia* sp. (*Chrysomelidae*). The representatives of *Hydrophilidae* and *Gyrynidae* were sporadically found. The weight contribution of *Coleoptera* was slight (about 1%).

Heleidae (larvae). They were found in 45.4% of carps and their numbers were only smaller than those of *Chironomidae*, *Gastropoda* and *Trichoptera*. The majority of larvae consumed were small individuals, not more than 4–6 mm in length, mainly *Ceratopogon* sp. Their weight contribution to the diet of the carp was slight (0.8%).

Cladocera. They were consumed by 35.6% of fish examined, and their number in one alimentary canal did not exceed 4,500 individuals. Among the *Cladocera* the following dominated: *Alona* sp., *Bosmina longirostris* O.F.M., *Ceriodaphnia quadrangula* O.F.M., *Daphnia cucullata* Leyd. and *Diaphanosoma brachyurum* Liév. Sporadically occurred *Bosmina coregoni crassocornis* Lill. and *Daphnia hyalina* Sars.

Copepoda. They were found in 32.7% of intestines examined. Species of the suborder *Calanoida* (*Cyclops kolensis* Lill., *Cyclops bohater* K., *Mesocyclops leucarti* Claus., *Thermocyclops cithonoides* Sars.) and *Cyclopoida* (mainly *Eudiaptomus graciloides* Lill.) dominated quantitatively. The representatives of the suborder *Harpacticoida* (*Cynthocampus* sp.) occurred rarely. The adult copepods prevailed. The nauplii stages were very rarely found. The weight contribution of copepods was slight (about 0.3%).

Ostracoda. They were not a very abundant (25.6%) food component of the carp and their weight contribution did not exceed 0.2%.

Hydracarina. Single individuals were found in 17% of intestines. Their weight contribution was not great, on average 0.5% of animal food. In the food of the carp small species (1–2 mm) prevailed and they were usually without a carapace and not brightly coloured (mainly *Limnesia* sp., *Mideopsis* sp.), which is confirmed by the results of Pieczyński and Prejs (1970).

4.1.3. Incidental food

Diptera (larvae, excl. *Chironomidae*, *Heleidae*, *Culicidae*). Among these larvae the species of the family *Tabanidae* (*Tabanus* sp.) and *Tipulidae* (*Tipula* sp.) prevailed, whereas *Cylindrotomidae* were rarer. The representatives of this group were found in 4.5% of fish examined.

Diptera varia (imagines). They were found in 3.6% of carps. The *Chironomidae* dominated (80%), whereas the *Culicidae* (*Chaoborus flavicaus* Meig.) and *Heleidae* were more rare.

Hirudinae. Similarly as the *Lepidoptera*, they were found in the gut contents of 2.0% of carps. Rather small individuals (5–6 mm) prevailed and they were mainly represented by *Glossiphonia* sp. and *Helobdella stagnalis* L. The weight contribution of this group ranged from 0.6% to 0.8% of the animal food of the carp.

Heteroptera (larvae). They were mainly represented by the species *Nepa cinerea* L. (over 95%). Single individuals of the genus *Gerrinae* (*Gerris lacustris* L.) were also found.

Other invertebrates. Non-identified invertebrates were found in 18.5% of carps. A similar value (15%) has been recorded by Prejs (1973) for the carp in Lake Warniak. *Rotatoria*, *Corixidae*, *Gammaridae*, *Asellus aquaticus*, *Chaoborus flavicans* and statoblasts of *Cristatella* were found in minimal amounts (index of frequency of occurrence below 0.1%).

Plant food. The food of plant origin contained algae, macrophytes, seeds, fruits and oogonia (*Chara* sp.). Nevertheless, the macrophytes were the main component found in the intestines of 85.5% of carps, which is about 6% of total food weight (i.e. 94% of the weight of plant food, Table II). The macrophyte elements belonged usually to plants of the genera *Ceratophyllum*, *Potamogeton* and *Chara*. Fragments of leaves and stems of *Elodea canadensis* Rich. and *Lemna minor* L. were also found sporadically. A similar species composition of higher plants consumed by the carp in lakes has been observed by Sigler (1958) and Popovska-Stanković (1971, 1972). Several authors (Wunder 1927, Ball 1948, Gajevskaja 1966, Prejs 1973) pointed out to the presence of macrophytes in the food of this species.

In the intestines of the carp examined there were also seeds and drupels of various aquatic plants (mainly *Potamogeton* sp. and other unidentified species). The number of these components in one intestine usually did not exceed several tens. Slightly greater amounts (about 100) have been found in the American carp by Sigler (1958). Fragments of pond weeds and their fruit found in the alimentary canals of the carp confirm Szlauer's (1971) suggestion about finding better shelter by phytophilous fauna in *Myriophyllum* and *Elodea* than in *Potamogeton* and *Stratiotes*. In the intestines examined there were also single amounts of oogonia of *Charales*. Total contribution of seeds, drupels and oogonia was relatively low (index of frequency of occurrence 11%) and the weight contribution to plant food was about 4%.

The presence of seeds and drupels of aquatic plants in the intestines has been recorded by many authors (Pearse 1918, English 1952, Vass and Vass van Oven 1959 after Prejs 1973, Wolny 1962, Krajuchin 1963, Szumiec 1966, Prejs 1973). Sigler (1958) and others have found these components in the food contents without any other "admixtures" and therefore they are inclined to state that the carp consume them eagerly and on purpose. The observations of Vogel (1913), Walter (1934), Knauth after Walter (1934) and Šusta (1938) and others on the feeding on higher plants and effective digestion of their seeds have provided grounds for introducing on a larger scale the plant fodders into intensive pond farming.

The algae were found in the intestines of 22.5% of carps and their weight contribution was about 2% (Table II). These components were well preserved, which is confirmed by observations of many authors (Šusta 1938, Alikhuni 1952, Karzinkin 1952, Wirszubsky after Prejs 1973).

4.2. Food composition of the carp in 1969 and 1970

In consecutive years of the study (1969, 1970) the changes in the feeding of two year old carp in Lake Klawój were not great (Figs. 4 and 5). In 1969 the dominant groups of animal food of the carp were *Gastropoda*, *Chironomidae* (*l*) and *Trichoptera* (*l*) and *Sialis* sp. (*l*), but the total contribution of bivalves and *Chironomidae* was over 50% of the food consumed by fish. The relatively small changes in the quality of animal food in the first year of rearing the carp in the lake examined prove the good food conditions in that lake (Sorygin 1952).

In 1970, similarly as in the year before, the *Gastropoda* and *Chironomidae* (*l*, *p*[4]) dominated in the carp food, and their frequency of occurrence and weight contribution did not

[4] *p* – pupae.

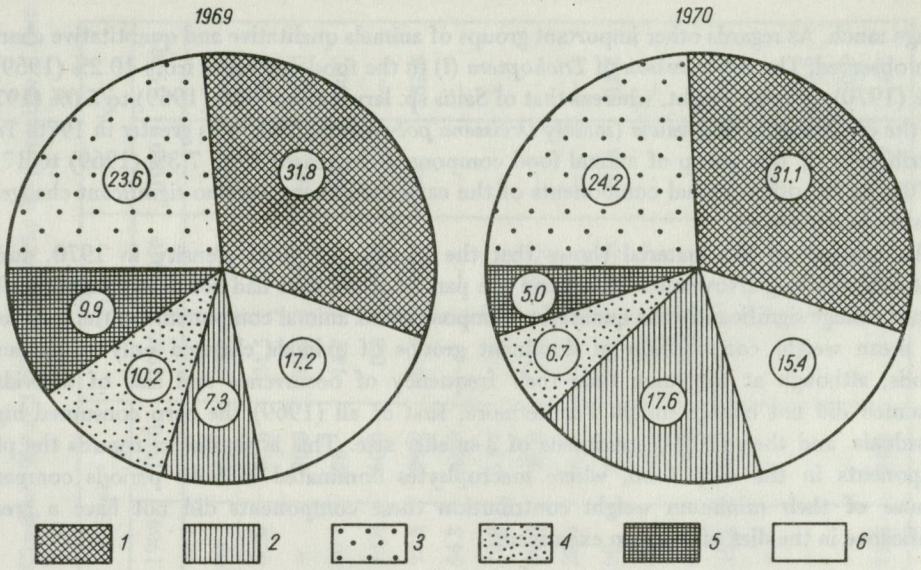

Fig. 4. Changes in main animal food components of the carp (*Cyprinus carpio* L.) in 1969 and 1970 expressed in weight percentage

1 – Gastropoda, 2 – Bivalvia, 3 – Chironomidae, 4 – Trichoptera, 5 – Sialis sp., *6 – Oligochaeta, Zygoptera, Anisoptera, Odonata, Ephemeroptera, Coleoptera, Heleidae, Culicidae, Heteroptera, Cladocera, Copepoda, Ostracoda, Hydracarina, Diptera* excl. *Chironomidae, Nematoda, Lepidoptera, Hirudinea, Gammaridae, Rotatoria, Corixidae, Bryozoa,* Ova *Invertebrata* nd., *Chaoborus flavicans* Meig., *Assellus aquaticus* L.

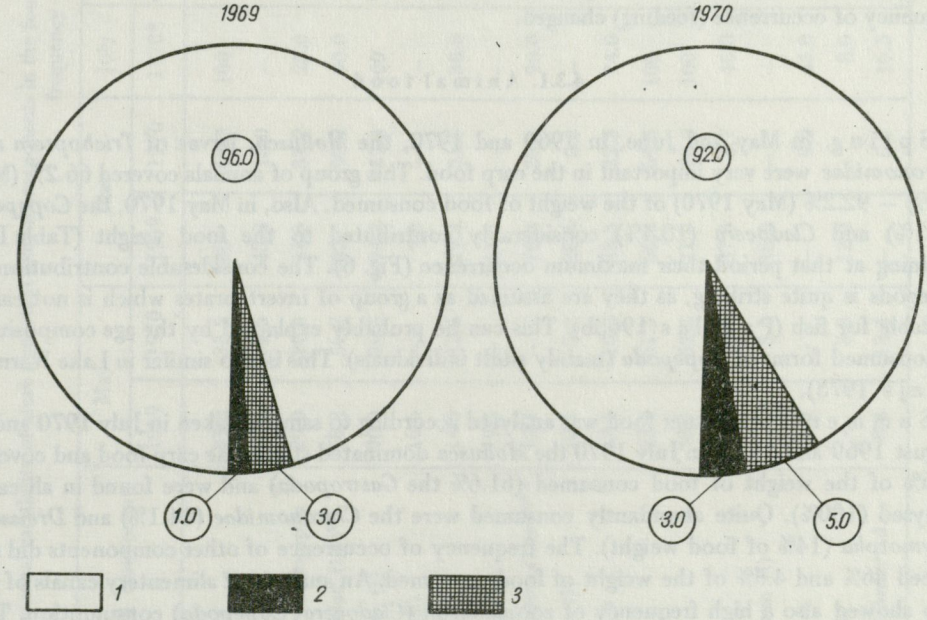

Fig. 5. Contribution of plant components in the food of the carp in 1969 and 1970 expressed in weight percentage

1 – macrophytes, *2* – algae, *3* – seeds, drupels, oogonia

change much. As regards other important groups of animals qualitative and quantitative changes were observed. The contribution of *Trichoptera* (*l*) to the food decreased from 10.2% (1969) to 6.7% (1970) of food weight, whereas that of *Sialis* sp. larvae from 9.9% (1969) to 5.0% (1970). But the contribution of *Bivalvia* (mainly *Dreissena polymorpha* Pall.) was greater in 1970. Total contribution of this group of animal food components increased from 7.3% (1969) to 17.6% (1970). As for other animal components of the carp food there were no significant changes in quantity and quality.

An analysis of the material shows that the increase of stock density in 1970, due to additional stocking (November 1969) and the part of stock that had not been caught in 1969, did not change significantly the qualitative composition of animal components in the carp food. The mean weight contribution of dominant groups of animals changed only in particular periods, although at the same time their frequency of occurrence and size of individuals consumed did not change much. Furthermore, first of all (1969) the carp consumed bigger individuals, and then (1970) specimens of a smaller size. This is similar as regards the plant components in the carp food, where macrophytes dominated in both periods compared. Because of their minimum weight contribution these components did not have a greater significance in the diet of the carp examined.

4.3. Seasonal changes in the food composition of the carp

According to Table III and Figure 6 the variability of the qualitative food composition in particular seasons of the years examined was not great. But in consecutive seasons of the year (spring, summer, autumn) the weight contribution of particular food components and their frequency of occurrence (feeding) changed.

4.3.1. Animal food

Spring. In May and June, in 1969 and 1970, the *Mollusca*, larvae of *Trichoptera* and *Chironomidae* were very important in the carp food. This group of animals covered 66.2% (May 1969) – 92.2% (May 1970) of the weight of food consumed. Also, in May 1970, the *Copepoda* (14.1%) and *Cladocera* (10.4%) considerably contributed to the food weight (Table III), attaining at that period their maximum occurrence (Fig. 6). The considerable contribution of copepods is quite striking, as they are assumed as a group of invertebrates which is not easily available for fish (Patalas 1963b). This can be probably explained by the age composition of consumed forms of *Copepoda* (mainly adult individuals). This is also similar in Lake Warniak (Prejs 1973).

Summer. The summer food was analysed according to samples taken in July 1970 and in August 1969 and 1970. In July 1970 the *Mollusca* dominated still in the carp food and covered 75.6% of the weight of food consumed (61.6% the *Gastropoda*) and were found in all carps analysed (100%). Quite abundantly consumed were the *Chironomidae* (14.1%) and *Dreissena polymorpha* (14% of food weight). The frequency of occurrence of other components did not exceed 46% and 4.5% of the weight of food consumed. An analysis of alimentary canals of the carp showed also a high frequency of zooplankton (*Cladocera*, *Copepoda*) consumption. This group had a minimum contribution to the food weight (Tables III and IV).

In August 1969 the *Chironomidae* (*l*, *p*) dominated in the food (53.3%) and also the *Trichoptera* (*l*) – 28% of food weight. These animals were found in 100% of intestines. In an

Table III. Seasonal variability of more important animal components in the food of the carp in Lake Klawój in 1969 and 1970 expressed by the percentage of their frequency of occurrence

Food components	May		June		July	Aug.		Sept.		Oct.		Nov.	
	1969	1970	1969	1970	1970*	1969	1970	1969	1970	1969	1970	1969	1970
Gastropoda	83.2	33.5	100	69.2	100	16.6	95.3	100	100	71.3	63.3	100	38.5
Bivalvia	63.0	32.5	43.8	13.0	–	16.6	35.0	66.6	80.0	24.5	20.0	–	80.5
Dreissena polymorpha	29.0	27.0	31.3	31.0	25.0		25.0	–	80.0	36.2	78.6	66.7	90.0
Chironomidae (l,p)**	78.2	56.7	100	90.2	90.0	100	95.2	100	100	94.7	100	100	50.0
Trichoptera (l)	90.0	39.5	94.8	57.3	100	100	75.0	14.0	60.0	8.8	39.5	–	–
Sialis sp. (l)	16.6	–	7.8	–	–	–	38.0	92.5	90.0	80.8	62.5	100	51.5
Zygoptera (l)	14.0	12.3	29.3	31.5	30.0	33.3	30.6	54.3	45.0	–	–	–	–
Anisoptera (l)	9.5	–	11.3	–	–	16.5	12.5	10.0	15.0	–	–	–	–
Ephemeroptera (l,im)***	12.1	–	76.3	23.1	90.0	–	11.2	20.0	50.0	8.8	33.2	–	–
Coleoptera (l)	12.1	5.0	28.5	8.3	–	100	22.5	28.4	–	–	–	–	–
Heleidae (l)	42.1	10.0	58.5	22.5	24.0	–	59.7	100	57.5	71.6	55.0	66.3	12.5
Cladocera	42.1	61.5	66.5	64.5	100	33.5	45.0	–	60.0	8.8	–	–	–
Copepoda	33.3	52.5	71.0	70.2	100	33.5	50.6	–	50.0	8.9	–	–	–
Ostracoda	33.5	20.0	37.5	5.7	46.0	50.2	38.0	36.4	65.0	–	–	–	15.5
Diptera varia (l)	–	5.0	18.8	–	–	16.6	–	–	–	–	–	33.3	–
Hydracarina	8.3	–	–	9.0	45.0	100	20.0	–	–	–	–	–	8.5
Oligochaeta	–	5.0	12.0	–	8.0	–	–	–	–	–	25.0	–	10.0
Ova *Invertebrata* n.d.	8.3	12.5	–	6.0	16.5	16.5	19.1	11.5	10.0	–	15.0	8.0	4.0

*In July, 1969, no samples were taken, **l, p – larvae, pupae, ***im – imagines.

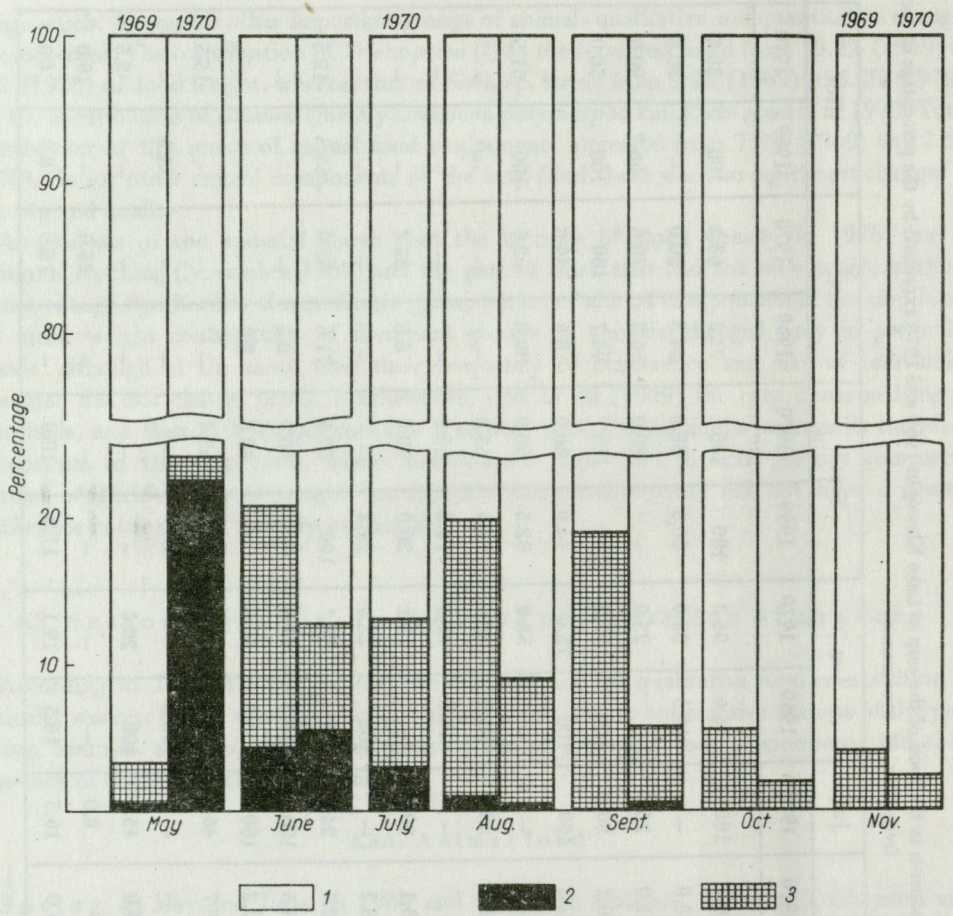

Fig. 6. Contribution of bottom fauna, zooplankton and plant components to the food of the carp in Lake Klawój in 1969 and 1970 expressed in weight percentage
1 – bottom fauna, *2* – zooplankton, *3* – plant components

analogous period in 1970 there was a greater species variety (17) of consumed animal components than in 1969. The most abundantly consumed were then the *Chironomidae* (*l*) and *Gastropoda*. The bivalves, at the time, covered 33.1% of all food, and their frequency of occurrence was 95.3%. The *Chironomidae* covered 32.8% of weight and occurred in 95.2% of fish examined. *Bivalvia* (12.1%) and *Trichoptera* (1–9.0%) also contributed considerably to the weight.

A u t u m n. According to Tables III and IV and Figure 6 the *Mollusca* (mainly *Gastropoda*), larvae of *Sialis* sp. and *Chironomidae* were the main food of the carp in autumn. The weight contribution of *Mollusca* ranged from 85.3% in September to 96.9% in October. The bivalves were most abundantly consumed in September and October (index of frequency of occurrence 100%), but in September the *Gastropoda* covered 50.2% of food weight and in November 53.8%. In October the dominant group in the carp food were the larvae of *Sialis* sp. covering

Table IV. Weight contribution of more important animal components of the food of the carp in Lake Klawój during the vegetation season of 1969 and 1970 (in per cents)

Food components	May		June		July	Aug.		Sept.		Oct.		Nov.	
	1969	1970	1969	1970	1970*	1969	1970	1969	1970	1969	1970	1969	1970
Gastropoda	20.3	26.3	34.5	40.4	61.6	2.5	33.1	50.2	30.6	29.2	14.2	53.8	11.3
Bivalvia	14.0	5.2	3.4	5.1	–	1.2	7.0	5.2	7.6	4.4	1.1	–	54.0
Dreissena polymorpha	2.3	2.0	7.2	2.8	14.0	–	5.1	–	21.3	11.4	13.0	13.0	6.8
Chironomidae (l,p)**	35.0	24.7	13.6	26.6	14.1	53.3	32.8	15.0	18.8	19.6	33.5	5.2	18.6
Trichoptera (l)	22.3	8.0	9.8	12.6	4.5	28.0	9.0	0.5	3.2	0.8	9.4	–	–
Sialis sp. (l)	0.3	–	3.8	–	–	–	2.5	14.9	9.3	32.3	21.0	22.5	3.8
Zygoptera (l)	2.0	6.0	3.8	0.6	2.0	3.5	4.8	3.4	2.2	–	–	–	–
Anisoptera (l)	+****	–	1.8	–	–	5.0	1.2	1.2	0.8	–	–	–	–
Ephemeroptera (l,im)***	0.3	–	10.7	1.2	0.5	–	0.5	0.6	2.2	0.3	–	–	–
Coleoptera (l)	2.0	0.9	4.5	1.7	–	4.4	1.7	1.8	–	–	–	–	–
Heleidae (l)	0.5	0.9	0.2	0.2	+	–	0.5	1.4	0.5	1.4	0.2	1.2	0.2
Cladocera	+	10.5	2.7	1.5	2.4	0.3	0.2	–	0.3	+	–	–	–
Copepoda	0.2	14.1	1.4	3.8	0.1	0.2	0.1	–	0.1	+	–	–	–
Ostracoda	+	+	0.1	+	+	0.3	0.8	0.4	0.4	–	–	–	0.1
Diptera waria (l)	–	0.6	1.6	–	–	0.1	–	–	–	–	–	2.0	–
Hydracarina	+	–	–	0.2	0.2	0.9	+	–	–	–	–	–	0.1
Ova *Invertebrata* nd.	0.5	0.8	–	3.3	0.5	0.3	0.7	5.4	2.5	–	4.3	2.3	–
Others	0.3	0.6	1.0	0.2	+	–	–	+	0.2	0.6	+	+	5.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*In July, 1969, no samples were taken, **l, p – larvae, pupae, ***im – imagines, ****the little cross (+) means less than 0.1%.

32.3% of food weight and found in 80.8% of fish examined. The weight contribution of *Chironomidae* larvae was the highest in October (19.6%) and the lowest in November (5.2%) which is connected with their autumn emergence. In the autumn of 1970 the *Gastropoda, Bivalvia* and *Chironomidae* dominated and the weight contribution of the *Mollusca* was twice lower than at the same time in 1969. In September 1970 the *Mollusca* and *Chironomidae* (the total of 78.2% food weight) were most abundantly consumed by the carp. Also, the larvae of *Sialis* sp. (9.3%) and *Trichoptera* (3.2%) and *Odonata* (3.0%) contributed considerably to the food weight during that period. In October, the main food component of the carp were the larvae of *Chironomidae* (33.2% food weight) which attained then their maximum of occurrence similarly as the larvae of *Sialis* sp. (21% of food weight, found in 62.5% of fish examined). The *Mollusca* were then hardly 28.3% of the weight of food consumed. Among other components of animal food of the carp (12 groups) the most abundantly consumed were the *Trichoptera* (9.4%) and ova *Invertebrata* (4.5%). In November the *Bivalvia* (60.8) were the main group of animals in the food of the carp and this was the period of their maximum occurrence. *Chironomidae* and *Gastropoda* also contributed considerably to the weight (18.6% and 11.3%, respectively) (Tables III and IV).

4.3.2. Plant food

The contribution of plant food, both in 1969 and 1970, was the lowest early in spring (May) and late in autumn (November) being 2 to 6% of total food weight. The contribution of plant components was the highest in June, August and September 1969 (16–19% total food wt). At the same period in 1970 the contribution of these components was twice lower and ranged from 5–10% of total food weight consumed by the carp (Fig. 6).

4.4. Feeding intensity of the carp

In the majority of cases the feeding intensity of fish is determined using the index of filling the guts (Blegvaad 1917) or index of consumption (Fortunatova 1964), but according to many authors (Sorygin 1952, Wojno 1961, Marciak 1962) one cannot fully rely on these indices.

Seasonal changes in the value of mean index of consumption by the carp in 1969 and 1970 are presented in Figure 7. The plotted curves show two characteristic peaks, in 1969 in the spring (May), and in 1970 in the summer (July) and in the autumn (November 1969 and 1970). The lack of a distinct spring maximum in 1970 can be probably explained by increased stock numbers and a slightly higher temperature of water than in 1969 (Fig. 3). Whereas the high index of consumption in July 1970 (6.9) was probably caused by considerable cooling of water at that time (16.9°C as compared to 22°C in 1969 – Fig. 3) and the food remaining in the intestines of the carp.

As shown in Figure 7 the seasonal changes of the average amount of animal food (index of consumption) of the carp caught in 1969 are similar to changes recorded in 1968 for the carp from Lake Warniak (Prejs 1973).

As the temperature of water (Fig. 3) and other food conditions vary in particular years of investigations (Guziur and Wielgosz 1975) the comparison of indices of consumption from analogous seasons of the year does not illustrate fully the feeding intensity of the carp examined in this lake. The relative consumption rate of food in a unit of time (Strodtman 1897

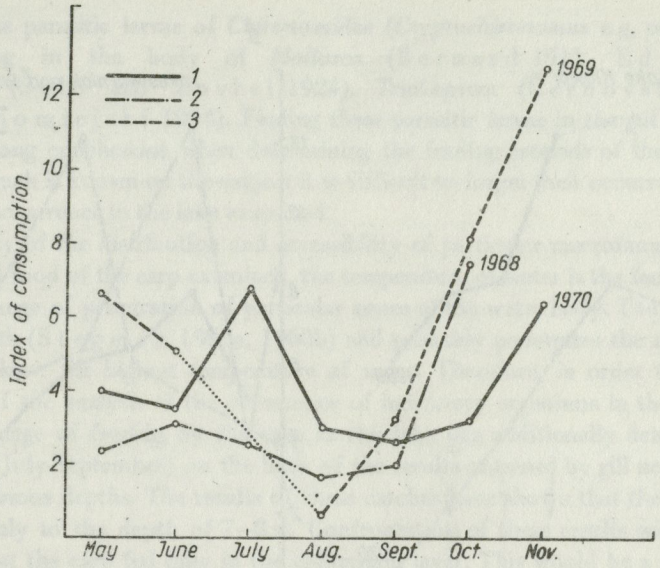

Fig. 7. Seasonal changes of the index of consumption by the carp in lakes Klawój (*1*, *2*) and Warniak (*3*)

after Pavlovskij 1961) is a more objective method as it characterizes the seasonal dynamics of feeding intensity by fish.

Bajkov (1935) has used the results of a study on the feeding by *Coregonus clupeaformis* Mitchill. from the Caspian Sea in an equation (Chapter 3) for calculations of the daily food ration of a fish. This equation is based on an assumption that the fish is feeding constantly, with an equal intensity and the passage of food consumed has an even rate in 24 h. Apart from the problem of daily fluctuations of water temperature in the lake which is considered as insignificant (Gieysztor 1960) the problem of daily rhythm in the feeding by the carp may be a matter for discussion according to many authors (Wunder 1927, Contag 1931 and Van Dobben after Prejs 1973, Klust 1940, Szumiec 1966, Niculescu-Duvaz 1970, de Groot 1969, Lukowicz 1973). But as the comparison of the relative degree of filling the intestines of the carp caught in Lake Warniak between 10.00 and 16.00 h (Prejs 1973) during the entire period of catches (April-November) did not show any distinct differences in quantity the own material obtained between 9.00 and 16.00 h was treated as representative for 24 h. Also, according to Letičevskij (1953) the filling of intestines of the carp in these hours may be assumed as average and representative for 24 h. Thus the equation of Bajkov (1953) was used without corrections.

The feeding intensity of the carp expressed by the amount (reconstructed weight) of animal food consumed during 24 h in relation to the unit of carp weight is presented in Figure 8. Both in 1969 and in 1970 the highest feeding intensity of the carp in Lake Klawój was from June to August, but in 1969 it was almost twice higher than in the following year. In autumn (September-November) the amount of food consumed by fish in 24 h decreased gradually together with the drop of temperature of water (Fig. 3). These relations are confirmed by the results on the feeding intensity of the carp in Lake Prespansko (Popovska-Stanković 1971, 1972, Fig. 8). The feeding intensity of the fish examined

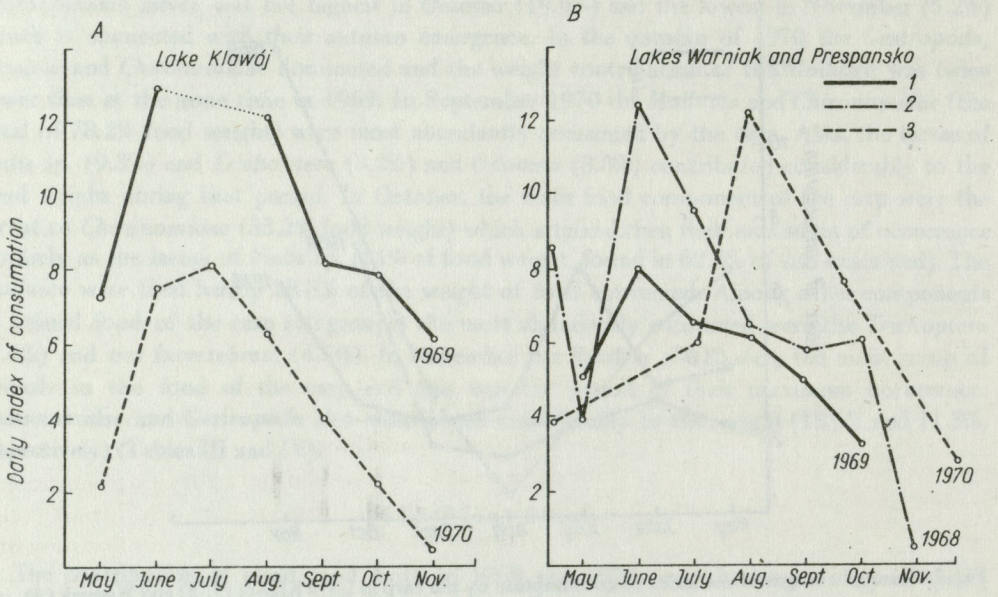

Fig. 8. Seasonal changes in the feeding intensity of the carp
The curves for Lake Warniak (*1*, *2*) are after Prejs 1973, the curve for Lake Prespansko (*3*) is after Popovska-Stanković 1972

varied in particular years of the study. In 1969 the carp fed intensively almost during the entire growth season, both in May (7.2) and in late autumn (6.2). The intensive feeding by the carp in spring and autumn, despite the relatively low temperature of water (below 12.6°C – Fig. 3), is also proved by the low number (12 cases – 19%) of empty alimentary canals (Table I). The poorer feeding by the carp during the entire growth season in 1970 as compared to 1969 can be explained by worse food conditions in the lake (Guziur and Wielgosz 1975) which are caused, among other things, by an increased density of the carp stocks and by low temperature of water (especially in July and August). The number of empty guts (49 specimens – 24%) was also twice higher than in the analogous period of the year before (Table I).

4.5. Distribution of feeding grounds of the carp in the lake

The range of feeding by fish in the lake in particular periods of the vegetation season can be determined according to the consumed specimens of fauna and flora (Stangenberg 1936, Laskar 1941, Pliszka 1953a, 1953b, Patalas 1963a, 1963 b). Still there were some difficulties in determining the feeding grounds of the carp in Lake Klawój. One of the many reasons for this was the occurrence in the food of several animal organisms, frequently of high nutritive value, both in the shallow (litoral) and deeper (profundal) parts of the lake (*Procladius* Skuze, *Chironomus* f.l. *plumosus*, *Ch.* f.l. *thummi* Kieff., *Cryptochironomus* e.g. *defectus*, *Ceratopogon* sp., *Tubifex tubifex* Müll., *Limnodrillus hoffmeisteri* Clap. and others – Guziur and Wielgosz 1975). Furthermore, the literature mentions a quite numerous groups of parasitic aquatic organisms (mainly larvae) living in the body of other animals. These

are primarily the parasitic larvae of *Chironomidae* (*Cryptochironomus* e.g. *pararostratus* and *Tendipes*) living in the body of *Mollusca* (Bernard 1911, Edwards 1929), *Ephemeroptera* (Šulc and Zavřel 1924), *Trichoptera* (Černovskij 1932) and *Bryozoa* (Wolnomiejski 1964). Finding these parasitic larvae in the gut contents of fish may lead to wrong conclusions when determining the feeding grounds of the fish examined. Although not much is known on the subject it is difficult to forget their occurrence considering their abundant occurrence in the lake examined.

Independently of the distribution and accessibility of particular macrofauna groups, which are the potential food of the carp examined, the temperature of water is the factor significantly affecting their range of penetration of particular zones of the water body. The carp is a species preferring warmth (Stegman 1960a, 1960b) and probably penetrates the zones of feeding grounds which have the highest temperature of water. Therefore, in order to confirm this, independently of the analysis of the occurrence of indicatory organisms in the lake and food examined, the range of feeding by the carp in this lake was additionally determined for the summer period (July-September) on the basis of the results obtained by gill net catches placed "stepwise" at various depths. The results of these catches have shown that the carp penetrates then the lake only to the depth of 7–8 m. Confrontation of these results with thermal data (Fig. 3) show that the carp fed only in the epilimnion layer. This would be a confirmation of earlier assumptions of Cady (1945) and McConnel, Clark and Sigler (1957) that the thermocline can be a thermal barrier limiting the range of feeding by the carp in the lake.

An analysis of the occurrence of benthic indicatory organisms on the basis of places where they are most frequently caught (Guziur and Wielgosz 1975) and of the thermal systems (Fig. 3) and the literature data show the following distribution of feeding grounds of the carp in Lake Klawój:

a. The littoral zone. It covers 51.9% (15.2 ha) of the lake surface and is overgrown mainly by submergent vegetation (Guziur, Lossow and Widuto 1975) and is the main feeding ground of the carp examined. This is proved by finding in the intestines of the carp of some *Diptera* larvae of the families *Cylindrotomidae*, *Tabanidae*, *Tipulidae* and of representatives of *Coleoptera* of the families *Chrysomelidae* (*Donacia* sp.) and *Gyrynidae*. Furthermore, the cases of occurrence (especially in spring) of planktonic forms (*Cladocera*, *Rotatoria* and *Copepoda*) in the intestines of the fish examined are treated as the index of feeding in this zone. This zone was penetrated all the vegetation season in the years of the study (May-November) also in spring and at the beginning of summer (May-June) and in autumn (September-November) it was the only feeding ground of the fish examined. Such structure of feeding ground is also confirmed by best results in catches of the carp where the trammel net is used (Guziur unpubl.). As the thermal-oxygen conditions were better, the stock not too numerous and the food conditions satisfactory, the penetration of the littoral in 1969 was more intensive than in 1970.

b. The sublittoral zone. It is within the sublittoral and covers 22.5% of the lake surface area. It was used by the carp to a smaller extent than the littoral zone. The index of feeding by the carp in this zone were some amounts of mollusc shells and the characteristic sand in the food, but there were no plant components. The sublittoral was penetrated by the carp sporadically examined during the summer stagnation and at the beginning of autumn mixing of waters in the lake.

c. The profundal zone. It covers 25.6% of the lake surface area. Because of the low temperatures of water (below 10°C – Fig. 3) and the periodical summer decrease in oxygen content in the near bottom water layers (Guziur and Wielgosz 1975) this zone

was not penetrated intensively by the carp, but only sporadically. These assumptions are also confirmed by analyses of gut contents of the carp, where both in 1969 and 1970 the characteristic for this zone small-grained, grey-blackish mud did not occur. On the other hand, the remains of *Chironomus* f.l. *plumosus* and *Ch.* f.l. *thummi* found in the alimentary canals do not exclude totally the occurrence and consumption of these components in the deep zone of the lake. Nevertheless, this complicated problem requires an additional study

d. The pelagic zone. This zone, similarly as the profundal, was the least utilized by stocks of two years old carp. It was only penetrated in the spring-summer period when the fish move from the feeding grounds of the shallow littoral to deeper parts of the lake. This is proved by the planktonic forms (*Cladocera*, *Copepoda*, *Rotatoria*) found in the intestines of the carp. Still, these cases were so numerous and representative as to affect basically the estimation of the character and places of feeding by the carp in this lake. Such phenomena may be, amongst other things, the result of specific food conditions in the lake (e.g. *Cladocera* concentrations – Polakov 1958 after Prejs 1973) under which the fish examined lived at the moment. Furthermore, Wunder (1949) and others claim that the zooplankton is of secondary significance as the feeding there (mainly in the case of older fish) is purely mechanical as the plankton stops on the filtration outgrowths.

5. CONCLUSIONS

1. In the food of two years old carp the most important was the animal food (Fig. 6, Tables III and IV), which is on average 94% of reconstructed food weight. The remaining 6% was the food of plant origin (Table II).

2. Of the 28 components of animal food the most significant were: *Gastropoda*, *Bivalvia*, *Chironomidae*, *Trichoptera*, *Neuroptera* (*Sialis* sp.) which were on average 83.8% of reconstructed food weight (Table II) and were the group of animals most frequently consumed by the carp (Tables II and III).

3. In particular seasons of the years under study the quality of consumed food did not change much. In consecutive seasons of the year (spring, summer, autumn) only the weight contribution of some food components and frequency of their occurrence changed (Tables III and IV).

4. The carp primarily consumed the biggest specimens and then the smaller ones.

5. The temperature of water is the basic and decisive factor which limits the feeding intensity of the carp in the lake (Fig. 3). Both in 1969 and in 1970 the period between June and August was the period of the highest feeding intensity (Figs. 7 and 8).

6. Smaller feeding intensity of the carp in 1970 was due to higher numbers in stocks, worse food conditions in the lake and a relatively lower temperature of water (Fig. 3).

7. The thermocline is a thermal barrier significantly limiting the vertical feeding range of the carp in the lake. The knowledge of the range of the thermocline in a lake may be used to increase the catching efficiency in vendace and bream lakes.

8. The littoral zone is the main and almost only feeding ground for two years old carp during the entire vegetation seasons in the years under study. Other zones are sporadically penetrated by the carp.

6. SUMMARY

The carp is usually introduced into shallow and fertile lakes where it is usually reared intensively in mixed stocks as in pond-farming. This species has been introduced, sometimes accidentally, into many deeper water bodies (over 4–6 m deep) with a poorer food base. As carp-farming in deeper water bodies does not give the expected results, it is necessary to know more as regards, for example, the feeding of carp on natural food. This is why the experiments were conducted in a considerably deep Lake Klawój (over 17 m) which is a type of vendace lake with moderate degree of eutrophication (Guziur, Lossow and Widuto 1975).

The complex study on the fishery and limnological aspects of the water body (Guziur, Lossow and Widuto 1975) was used to observe the behaviour of carp stocks (C_2) in two successive annual cycles where the fish stocks in autumn varied in numbers (1968 – 33 ind./ha, 1969 – 128 ind./ha). The aim of the study was to determine: (1) the qualitative and quantitative composition of natural food of the carp in stocks varying in numbers, (2) seasonal changes in the composition of food consumed, (3) seasonal feeding intensity, (4) distribution of feeding grounds of the carp in the examined type of lake.

According to the study conducted in Lake Klawój (Guziur and Wielgosz 1975) it can be said that in lakes of vendace type the littoral is the most valuable and abundant zone in the lake as regards the biomass and number of bottom fauna and also the main feeding ground of two years-old carp almost during the entire season.

It has been determined that the temperature of water is a decisive factor limiting the feeding intensity of the carp in the lake (Figs. 3, 7, 8). Both in 1969 and in 1970, the period between June and August was the period of the highest feeding intensity of the carp measured by the consumption index (Figs. 7, 8). The lower feeding intensity of carp stocks in 1970 was caused by more numerous stocks, worse food conditions in the lake (Guziur and Wielgosz 1975) and the relatively low temperature of water (especially in the epilimnion). The thermocline is a thermal barrier significantly limiting the vertical feeding range of the carp in the lake. The data on the distribution feeding carps in lakes of this type can be used to increase the efficiency of catches.

Animal food dominated in the diet of the carp in both years under study (Fig. 6), covering on average 94% of reconstructed food weight. The remaining part (6%) was the food of plant origin (macrophytes, algae, seeds – Table II). Of the 28 components of animal food the most significant were the *Gastropoda*, *Chironomidae*, *Bivalvia*, *Trichoptera*, *Sialis* sp. which were on average 83.8% of reconstructed animal food and were the most frequently consumed group of bottom fauna (the so-called main food). Furthermore, the carp primarily grazed bigger individuals of the zoomacrofauna available and then the smaller ones. In both years of the study (1969, 1970) the qualitative composition of the food consumed by the carp did not differ much (Figs. 4, 5). In consecutive years and seasons of the year only the weight contribution of particular food components and the frequency of their occurrence changed (Tables III, IV).

7. POLISH SUMMARY (STRESZCZENIE)

Karpie najczęściej wprowadzane są do jezior płytkich i żyznych, w których z reguły prowadzi się ich intensywny chów w obsadach mieszanych na wzór rybactwa stawowego. Gatunek ten wprowadzony został – nie zawsze planowo – do wielu zbiorników głębszych (ponad 4–6 m głębokości) o nieco uboższej bazie pokarmowej. Ponieważ gospodarka karpiowa prowadzona w głębszych zbiornikach z reguły nie przynosi spodziewanych rezultatów, zachodzi konieczność poznania szeregu zagadnień, m.in. zagadnienia odżywiania się karpia pokarmem naturalnym. Stąd też wybór do doświadczeń dość głębokiego (ponad 17 m) jeziora Klawój jako rybackiego typu jeziora sielawowego o umiarkowanym stopniu zeutrofizowania (Guziur, Lossow i Widuto 1975).

Podstawę do badań zasadniczych (1969–1971) stanowi kompleksowe studium rybacko-limnologiczne zbiornika (Guziur, Lossow i Widuto 1975). Na jego tle prześledzono zachowanie się obsad karpi (C_2) w dwóch kolejnych cyklach rocznych z zastosowaniem jesiennego zarybiania o zróżnicowanej liczebności obsad (1968 – 33 szt./ha, 1969 – 128 szt./ha). Celem podjętych badań było poznanie: (1) składu jakościowego i ilościowego pokarmu naturalnego karpi przy różnych liczebnie obsadach, (2) zmian sezonowych w składzie spożywanego pokarmu, (3) intensywności odżywiania się w sezonach, (4) rozmieszczenia żerowisk karpi w badanym typie jeziora.

Na podstawie badań przeprowadzonych w jeziorze Klawój stwierdzono, że w jeziorach typu sielawowego najcenniejszą i najzasobniejszą pod względem biomasy i liczebności fauny dennej strefą jeziora (Guziur

i Wielgosz 1975) oraz podstawowym żerowiskiem dwuletnich karpi w czasie całego niemal sezonu jest litoral.

Ustalono, że temperatura wody jest decydującym czynnikiem ograniczającym intensywność żerowania karpi w jeziorze (fig. 3, 7, 8). Zarówno w 1969 jak i w 1970 r. okresem najwyższej intensywności żerowania karpi, mierzonej wskaźnikiem spożycia, był okres od czerwca do sierpnia włącznie (fig. 7, 8). Słabsza intensywność żerowania obsad karpi w 1970 r. spowodowana była zarówno zwiększoną liczebnością obsad, gorszymi warunkami pokarmowymi w jeziorze (Guziur i Wielgosz 1975), jak i niską stosunkowo temperaturą wody (zwłaszcza epilimnionu). Stwierdzono, że termoklina jest termiczną barierą ograniczajacą ograniczającą istotnie pionowy zasięg żerowania karpi w badanym jeziorze. Dane dotyczące rozmieszczenia żerowania karpi w jeziorach tego typu mogą być wykorzystane do podniesienia efektywności połowów.

Dominującą rolę w odżywianiu się karpi w obu analizowanych latach odgrywał pokarm zwierzęcy (fig. 6), stanowiący średnio 94% zrekonstruowanego ciężaru pokarmu. Pozostałą część (6%) stanowił pokarm pochodzenia roślinnego (makrofity, glony, nasiona; tab. II). Spośród 28 składników pokarmu zwierzęcego największe znaczenie miały *Gastropoda, Chironomidae, Bivalvia, Trichoptera, Sialis* sp., stanowiące średnio 83,8% zrekonstruowanego pokarmu zwierzęcego i będące najczęściej spożywaną przez karpie grupą fauny dennej (tzw. pokarm główny). Stwierdzono ponadto, że karpie w pierwszej kolejności wyżerowywały największe osobniki z dostępnej zoomakrofauny, a następnie okazy o mniejszych wymiarach ciała. W obydwu latach badań (1969, 1970) nie stwierdzono dużej zmienności w jakościowym składzie spożywanego przez karpie pokarmu (fig. 4, 5). W kolejnych latach i porach roku zmieniał się jedynie wagowy udział poszczególnych komponentów pokarmowych oraz częstotliwość ich występowania (tab. III, IV).

8. REFERENCES

1. Alikhuni K. M. 1952 – On the food of young carp fry – J. Zool. Soc. India, 3/4: 77–89.
2. Angelov A. 1971 – Beitrag zur Kenntnis der Pissidiumfauna (*Mollusca, Sphaeridae*) Mazedoniens – Fragm. balcan. 7: 53–55.
3. Andronikova I. N. 1971 – Individualnye vesa massovych vidov zooplanktona ozer Karelskogo perešejka – Min. rybn. chozj. 6: 52–55.
4. Assman A. V. 1962 – Vyjedanie estestvennych kormov karpami pri rozličnom kormovom režime i različnoj plotnosti posadki – Trudy Inst. Morf. Život. 42: 62–119.
5. Backiel T., Horoszewicz L. 1970 – Temperatura a ryby – Instytut Rybactwa Śródlądowego Olsztyn-Żabieniec, 25 pp.
6. Bajkov A. D. 1935 – Now to estimate the daily food consumption of fish under natural conditions – Trans. Am. Fish. Soc. 65: 288–289.
7. Ball L. C. 1948 – Relationship between available fish food, feeding habits of fish and total fish production in a Michigan lake – Tech. Bull. Mich. (St. Coll.) agric. Exp. Stn. 206: 1–59.
8. Balon E. K. 1967 – Ryby Slovenska – OBZOR Bratislava, 412 pp.
9. Baudonin M. F., Ravera O. 1972 – Weight, size and chemical composition of some freshwater zooplankters – Limnol. Oceanogr. 17: 645–649.
10. Bernard K. H. 1911 – Chironomid larvae and water snails – Entomologist's mon. Mag. 47: 76–78.
11. Blegvaad H. 1917 – On the food of fish in the Danish waters within the Skaw – Rep. Dan. biol Stn. 24: 19–72.
12. Bogorov V. 1934 – Issledovanie pitanija planktonojadnych ryb – Bjull. vses. Inst. ryb. Choz. Okeanogr. 1: 21–43.
13. Boruckij E. V. 1939 – Dinamika biomasy *Chironomus plumosus* profundali Belogo ozera – Trudy limnol. Sta. Kosine, 22: 156–195.
14. Boruckij E. V. 1958 – K metodike opredelenija razmerno-vesovoj charakteristiki bezpozvonočnych organizmov služaščich piščej dla ryb – Vop. Ichtiol. 11: 181–187.
15. Boruckij E. V. 1960 – O kormovoj baze – Trudy Inst. Morf. Život. 13: 5–61.
16. Braun G. 1905 – Gruppe der Legiener Seen – Ber. Fisch. Ver. Provinz. Ostpreusen, 30.
17. Cady L. C. 1945 – Fish distribution, Norris Reservoir, Tennessee – Tenn. Acad. Sci, 20: 103–138.
18. Ciborowska J. 1970 – Wpływ głębokości przesadek I na skład pokarmu naturalnego zjadanego przez wylęg karpia – Roczn. Nauk roln. H, 92: 7–16.
19. Černovskij A. A. 1932 – K issledovaniju ličinki *Parachironomus* – Issled. Ozer SSSR, 1: 76–79.

20. Čislenko L. L. 1969 – Nomogramy dla opredelenija vesa vodnych organizmov po rozmeram i forme tela – Izd. Nauka, Leningrad, 125 pp.
21. Dyk V. 1956 – Ryby našich vod – Orbis, Praha, 339 pp.
22. Edwards F. W. 1929 – British non-biting midges (*Diptera, Chironomidae*) – Trans. R. ent Soc. London, 77: 279–430.
23. English Th. S. 1952 – Growth studies of the carp, *Cyprinus carpio* Linnaeus, in Clear lake Iowa – Iowa St. Coll. J. Sci. 24: 527–540.
24. Forbes S. A. 1888 – On the food relation of fresh water fishes, A. Summary and discussion – Bull. Ill. St. Lab. nat. Hist. 2.
25. Fortunatova K. R. 1964 – Ob indeksach pitanija ryb – Vop. Ichtiol. 4: 188–190.
26. Gaevskaja N. S. 1966 – Rol vyssich vodnych rastenij v pitanii životnych presnych vodoemov – Izd. Nauka, Moskva, 132 pp.
27. Gieysztor M. 1960 – On the thermal conditions of the littoral zone of Lakes – Pol. Arch. Hydrobiol 7: 171–193.
28. Groot S. J. de 1969 – Digestive system and sensorial factors in relation to the feeding behavior of plat-fish (*Pleuronectiformes*) – J. Cons. perm. int. Expl. Mer. 14: 385–395.
29. Gurzęda A., Wolny P. 1962 – Pokarm i wzrost narybku karpia na tle dynamiki bazy pokarmowej – Roczn. Nauk roln. B, 81:251–258.
30. Guziur J., Lossow K., Widuto J. 1975 – Wybrane elementy charakterystyki hydrobiologicznej jeziora Kławój – Zesz. nauk. Akad. roln.-techn. Olsztyn, 4: 3–33.
31. Guziur J., Wielgosz S. 1975 – Wpływ różnych liczebnie obsad karpi na rozsiedlenie makrobentosu w jeziorze Kławój – Acta hydrobiol. 17.
32. Harlan J. R., Speaker E. B. 1956 – Iowa fish and fishing – Iowa St. Cons. Comm. 85–87.
33. Jablonskaja E. A. 1953 – Bentos nerestovo-vyrastnogo chozjajstva Azovo-Dolgij – Trudy vses. naučno-issled. Inst. morsk. ryb. Choz. Okeanogr. 24: 71–101.
34. Karzinkin G. S. 1952 – Podstawy biologicznej wydajności zbiorników wodnych – PWRiL, Warszawa, 386 pp.
35. Kempińska H. 1960 – Gatunkowo swoista reakcja narybku siei, sandacza i karpia na warunki termiczne i tlenowe – Zesz. nauk. Akad. roln. Warszawa, 2: 33–62.
36. Klust G. 1940 – Über Entwicklung, Bau und Funktion des Darmes beim Karpfen – Int. Rev. Hydrobiol. 39: 488–498.
37. Krajuchin E. V. 1963 – Fizjologija piščevarenija presnovodnych ryb – Moskva, 139 pp.
38. Lapinskaite J. S. 1959 – Pišča segoletok karpa v prudach rybnogo chozjajstva „Rita Ausma" – Trudy Akad. Nauk Lit. SSR, B, 3: 183–189.
39. Laskar K. 1941 – Die Ernährung des Brasserß – Fisch. Ztg. 51/52: 339–344.
40. Leszczyński L. 1963 – Charakterystyka pokarmu jazgarza *Acerina cernua*(L.) z Jeziora Kortowskiego – Roczn. Nauk roln. B, 82: 251–271.
41. Letičevskij M. H. 1953 – Opyt vyraščivanija molodi vobly v nerestovo-vyrostnych chozjajstvach delty Volgi – Trudy vses. naučno-issled. Inst. morsk. ryb. Choz. Okeanogr. 24: 141–177.
42. Lukowicz M. 1973 – Aufnahme von Trockenfutter im intensiv bewirtschafteten Karpfenteich – Fischwirt-Beitrage Allg. Fisch. Ztg., 1: 79–83.
43. Marciak Z. 1962 – Sezonowe zmiany w odżywianiu się i wzroście sielawy (*Coregonus albula* L.) z jez. Pluszne – Roczn. Nauk roln. B, 81: 335–355.
44. Marsilius A. F. C. 1726 – De Piscibus in aquis Danubii viventibus (In: Danubius Pannonico-Mysicus, observationibus geographicis, astronomicis, hydrographicis, historicis, physicis perlustratus et in sex Tomos digestus. IV) – Hagae Comitum, Amsterdam.
45. Mc Connell W., Clark W. I., Sigler W. F. 1957 – Bear Lake, its fish and fishing – Idaho and Utah Dept. Fish and Game, Utah St. Un. 76 pp.
46. Mc Crimmon H. R. 1968 – Carp in Canada – Bull. Fish. Res. Bd Can. 165: 93.
47. Merla G. 1959 – Gesichtpunkte zur Nahrungaufnahme von K_2 und K_1 – Dt. Fisch. Ztg, 6: 210–220.
48. Morduchaj-Boltovskoj F. D. 1954 – Materialy po sredniemu vesu vodnych bezpozvonočnych bassejna Dona – Trudy probl. temat. soveščč. zool. Inst. 2: 223–241.
49. Niculescu-Duvaz M. 1970 – Ecologia alimentatiei naturale si suplimentare la crapul cultura – Bul. Inst. Cerc. pisc. 29: 29–56.
50. Nümann W. 1962 – Untersuchungen an Karpfen verschiedener anatolischer Seen – Z. Fisch. 11: 261–277.

51. Olszewski P., Tadajewski A. 1965 – Morfometria Jezior Legińskich – Zesz. Nauk. wyższ. Szk. roln. Olsztyn, 20: 261–277.
52. Patalas K. 1963a – Pionowe rozmieszczenie skorupiaków planktonowych w morfologicznie różnych jeziorach okolic Węgorzewa – Roczn. Nauk roln. B, 82: 195–204.
53. Patalas K. 1963b – Sezonowe zmiany w pelagicznym planktonie skorupiakowym sześciu jezior Węgorzewa – Roczn. Nauk roln. B, 82: 205–231.
54. Pavlovskij E. N. 1961 – Rukovodstvo po izučeniju pitanija ryb v estestvennych uslovijach – Moskva, 263 pp.
55. Pearse A. S. 1918 – The food of the shore fishes of certain Wisconsin lakes – Bull. Bur. Fish., Wash. 35: 245–292.
56. Pekař C., Krupauer V. 1966 – Potravni vztahy dvouletých kaprů a linů ve smišené vicedruhè obsàdce – Práce VÚHR, Vodňany, 8: 29–54.
57. Pieczyński E., Prejs A. 1970 – The share of water mites (*Hydracarina*) in the food of three species of fish on Lake Warniak – Ekol. pol. A, 18: 445–452.
58. Pliszka F. 1953a – Dynamika stosunków pokarmowych ryb jeziora Harsz – Pol. Arch. Hyrobiol. 1: 271–300.
59. Pliszka F. 1953b – Zmienność charakteru żywienia się ryb, jako czynnik stabilizujący zespoły ichtiofauny – Pol. Arch. Hydrobiol. 1: 301–315.
60. Popovska-Stankovič O. 1971 – Za ishranata na krapot (*Cyprinus carpio* L.), crvenoperka (*Rutilus rutilus dojranensis* Kar.) i perkijata (*Perca fluviatilis* L.) od Dojraskoto Ezero – Folia balc. 2:8.
61. Popovska-Stankovič O. 1972 – O ishranii sarana (*Cyprinus carpio* L.) u Prespanskom Jezeru – Acta biol. Jugosl. Ser. E, Ichth. 4: 67–76.
62. Prejs A. 1973 – Experimentally increased fish stock in the pond type Lake Warniak. IV. Feeding introduced and autochthonous non-predatory fish – Ekol. pol. 21: 465–505.
63. Scheuring L. 1928 – Beziehungen zwischen Temperatur und Verdaungsgeschwindigkeit bei Fischen – Z. Fisch. 26: 193–215.
64. Schiemenz P. 1905 – Über die Nahrung unserer gewöhnlichen Wildfische – Dt. Fisch Ztg 23/26.
65. Schiemenz P. 1924 – Über den Wert des Auftrichs als Fischnahrung zur Bonieterung von Karpfenteichen – Dt. Fisch Ztg, 4/6.
66. Schoonbee H. J. 1969 – Notes on the food habits of fish in Lake Barberspan, Western Transvaal, S. Africa – Verh. int. Verein. theor. angew. Limnol. 17: 689–701.
67. Shafer M. J. 1972 – Production of a natural population of *Bithynia tentuculata* L. (*Gastropoda, Mollusca*) – Ekol. pol. 20: 525–539.
68. Sigler W. F. 1958 – The ecology and use of carp in Utah – Bull. Utah agric. Exp. Stn. 405: 1–63.
69. Šorygin A. A. 1952 – Pitanie i piščevye vzaimootnošenija ryb Kaspijskogo Morja – Piščepromizdat., Moskva, 169 pp.
70. Špet G. I. 1961 – O pojedanii molljuskov karpjami – Zool. Ž. 40: 939–941.
71. Stangenberg M. 1936 – Szkic limnologiczny na tle stosunków hydrochemicznych Pojezierza Suwalskiego – Spraw. IBL A, 19: 7–85.
72. Stegman K. 1960a – Wpływ temperatury środowiska w granicach optimum fizjologicznego na wzrost karpia – Zesz. nauk. Szk. głów. Gosp. wiejsk. 67–84.
73. Stegman K. 1960b – Temperatura wody w miesiącach letnich decyduje o naturalnych przyrostach karpia – Gospod. rybna, 12: 14–16.
74. Šulc K., Zavřel J. 1924 – O epoikickych a parasitických larvàch Chironomidů) – Acta Soc. Sci nat. moravo-siles. 1: 353–391.
75. Šusta J. 1938 – Výživa kapra a jego družiny rybičné – Nakl. Česk. Akad. Zem. Praha, 221 pp.
76. Szlauer B. 1971 – Wyjadanie fauny fitofilnej przez karasia (*Carassius carassius* L.) – Zesz. nauk. Wyższ. Szk. roln. 35: 85–103.
77. Szumiec J. 1962 – Zwierzęta zasiedlające skoszoną roślinność w stawach – Acta hydrobiol. 2: 119–149.
78. Szumiec J. 1963 – Wpływ roślinności wynurzonej i sposobu jej koszenia na faunę denną stawów rybnych – Acta hydrobiol. 5: 315–335.
79. Szumiec J. 1966 – Udział pokarmu naturalnego przy żywieniu karpi – Acta hydrobiol. 8: 199–253.
80. Vogel P. 1913 – Neues illustriertes Lehrbuch der Teichwirtschaft – E. Hübners Verl., Bautzen, 656 pp.

81. Walter E. 1934 – Grundlagen der allgemeinen fischereitlichen Produktionslehre – Handb. Binnenfisch. Mitteleur. 4: 480–662.
82. Wojno T. 1961 – Odżywianie się troci w jeziorze Wdzydze – Roczn. Nauk roln. D, 93: 681–702.
83. Wolnomiejski N. 1964 – Larwy *Tendipedidae* minujące w koloniach mszywiołów *Plumatella fungosa* Pall. – Acta hydrobiol. 6: 219–226.
84. Wolny P. 1962 – Przydatność oczyszczonych ścieków miejskich do hodowli ryb – Roczn. Nauk roln. B, 81: 231–249.
85. Wunder W. 1927 – Binnenphysiologische Untersuchungen über Nahrungsaufnahme bei verschiedenen Kochenfischen – Z. vergl. Physiol. 6: 67–95.
86. Wunder W. 1949 – Fortschrittliche Karpfenteichwirtschaft – Stuttgart, 186 pp.

Paper prepared by J. Stachowiak

AUTHOR'S ADDRESS:
Dr inż. Janusz Guziur
Instytut Ichtiobiologii i Rybactwa
Akademii Rolniczo-Technicznej
10–957 Olsztyn 5
Poland