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Diurnal feeding rhythm of the bleak (*Alburnus alburnus* L.) fry (O+)

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The feeding peculiarities of Lake Vajuonis (Švenčionys district; length 4.1 km; width 1.4 km; depth 20 m) bleak fry (0+) are discussed, as well as the quantitative (consumption intensity of different diet components and feeding rate) and qualitative (the spectrum of diet, the preference of prey by size) aspects of diurnal feeding rhythm of bleak fry are evaluated. 244 guts of this species and 36 zooplankton samples were analysed. The results, have shown that 8 food components assigned to rotifers, planktonic crustaceans and insects compose the diet spectrum of the bleak. Also, detritus was found in the guts. Prey of different size are part of the diet. The body size of the bleak and of the prey showed a weak statistically reliable ($r = 0.36$, $p < 0.05$) correlation. The ingestion consumption of certain zooplankton groups varies during the different diurnal periods. A statistically reliable close negative correlation was defined only between the biomass of the *Daphnia* genus crustaceans in the environment and in the bleak gut ($r = -0.84$, $p < 0.05$). When the consumption of water fleas grows, their biomass in the environment decreases. The feeding of the bleak is periodical, with the intensity peaks in the mornings and evenings.

Key words: fish fry, bleak, *Alburnus alburnus* L., feeding rhythm, gut fullness, prey size

INTRODUCTION

The bleak (*Alburnus alburnus* L.) is one of the most popular fish of the carp family in Europe. It inhabits both stagnant and flowing waters. This fish is a fine object of business and amateurish fishing (Virbickas, 2000). Their resources in the inland Lithuania's waters, especially in lakes, grow. It has been found that predatory fish are bleak feeders (especially zanders) (Politou et al., 1995; Specziar, 2002), therefore, it is purposeful to breed zanders, pikes or any other predatory fish in the places where bleaks are abundant(Virbickas, 2000).

It is typical of carp fish fry to feed on zooplankton (Persson, Hansson, 1999). With age, the growing body mass and mouth size, the feeding spectrum gradually become wider, and it is possible to find benthic macroinvertebrates (Specziar et al., 1997; Persson, Hansson, 1999), detritus (Michelsen et al., 1994), algae and fragments of macrophytes (Brabrand, 1985) in the diet. However, the bleaks' feeding habits with age change insignificantly, and feeding on zooplankton continues life-long (Herzig, 1994; Politou et al., 1995; Vinni et al., 2000).

Changes of fish activity in time are closely connected with feeding. However, studies of the diurnal feeding rhythm of the majority of fish are not frequent and usually give no details because of the complicated catch during 24 hours (Vasek, Kubecka, 2004). Therefore, data on the carp fish diurnal feeding rhythm with zooplankton are scarce (Politou et al., 1995). The mentioned researches are very important, because when the fish feeding rhythm is known it is possible to foresee their rates of growth, influence upon prey communities, and the matter rotation in an ecosystem.

MATERIALS AND METHODS

Fish samples were collected with a horizontal gill net in the littoral zone of Lake Vajuonis (Švenčionys district; length 4.1 km; width 1.4 km; depth 20 m) frequently over a 24-h period every other hour (2 ± 0.4 h). Three replicate samples were taken each time. The mean depth in the sample collection site was 0.4 ± 0.13 m. The temperature dynamics during the study period was 18.45 ± 0.76 °C. Samples were preserved in 70° ethanol. In the laboratory, all fish were identified (Virbickas, 2000; Pinder, 2001), counted, measured (mm; error 0.1 mm) and weighed (g; error 0.1 mg). The content in of the digestive tract was analysed under a stereo microscope (40×), and each prey was determined to the lowest possible taxonomic level (Определитель..., 1977; Цалолихин, 1995).

Zooplankton samples were collected at 2-hour intervals simultaneously with fish sampling (i. e. 3 samples per station per 24 hours), using vertical hauls of an Apstein plankton net (diameter 20 cm, mesh size 200 µm).

A total of 244 digestive tracts of bleak and 36 zooplankton samples were analysed.

Zooplankton biomass was calculated according to the allometric body length–weight relations,

$$W = gl^b,$$

where W is the body mass, mg; l is the length, mm; g is the mass, when body length is 1 mm (Салазкин и др., 1984).

The frequency of occurrence of different food components was estimated using the equation:

$$X = (n/m) \cdot 100\%,$$

where n is the number of individuals that use a resource category, m is the total number of individuals studied (Hyslop, 1980).

In sampling occasions when fish were caught frequently over a 24-h period, we attempted to estimate the daily food consumption of fish individuals by the method of Elliott & Persson (1978). The amount of food consumed was estimated for each 2-h interval using the equation

$C_t = (F_t - F_0 e^{-Rt})\, Rt\, (1 - e^{-Rt})^{-1}$,

where C_t is the mean amount of food (mg wet weight per 100 mg wet weight of fish) consumed during a sample interval t (2 h); F_0 and F_t are, respectively, the mean gut fullness at the beginning and end of a sample interval t, and R is the instantaneous gastric evacuation rate. Gastric evacuation rate was estimated from the decrease in gut fullness observed for all cyprinids after the onset of darkness and during the night-time. It was assumed that the fish did not feed over this period and the decline in gut fullness therefore reflected only food evacuation.

Relative daily food intake, *DI* (mg wet weight per 100 mg wet weight of fish) was calculated as the sum of C_t over a 24-h period (Vašek, Kubečka, 2004):

$$DI = \sum_{i=1}^{n=24} C_t .$$

The Kolmogorov–Smirnov test, Spearman's correlation, regression analysis were also used.

RESULTS AND DISCUSSION

Bleak diet composition

Analysis of bleak guts content revealed 8 components assigned to different ecological groups, taxonomic units; the detritus was also found (Table). However, the frequency of food components differed in the digestive tract and in the environment. The representatives of macrozoobentos and detritus, in comparison with zooplankton, were found rarer in the bleak guts.

Similar results have been reported by other authors (Jamet, 1994; Horppila, 1999); they mention that in the carp fish (roach, bream, bleak) fry diet zooplankton prevails. The mentioned authors note that zooplankton frequency in the guts of fish strongly exceeds the frequency of macrozoobenthos representatives. It has been noted that bleaks, in contrast to other carp fish, the whole life remain plankton feeders (Politou et al., 1995; Vinni et al., 2000).

Prey size

The bleak fry of different size feed on prey of different size. The Kolmogorov–Smirnov test with the Spearman correlation revealed a weak positive correlation ($r = 0.36$; $p < 0.05$) between bleak size and prey size. As is shown in Fig. 1, with the bleak size increasing twice or more, the prey size practically doesn't change.

Bleaks selectively choose larger preys (*Daphnia longispina*), and therefore the community structure of lake zooplankton changes (Langeland, Nost, 1995; Chappaz et al., 1998; Pont, Amrani, 2003).

Diurnal feeding rhythm

For the different zooplankton groups, the relative biomass diurnal dynamics both in the environment and bleak guts is typical (Figs. 2 and 3).

As is shown in Fig. 2, in samples from Lake Vajuonis, Cladocera (*Daphnia* sp.) and Copepod (*Cyclops* sp.) planktonic crustaceans prevailed by biomass. The average diurnal biomass of the mentioned crustaceans was respectively 4.33 ± 0.03 mg l^{-1} and 3.78 ± 0.004 mg l^{-1}. The largest *Daphnia* sp. biomass was fixed in the mid-second day (17.00–19.00 o'clock) and the least in the morning (5.00–7.00 a.m.) and was respectively 6.68 ± 0.03 mg l^{-1} and 3.19 ± 0.004 mg l^{-1}. At the same time, the peak of *Cyclops* sp. biomass was noted at 05.00 a.m. (6 ± 0.001 mg l^{-1}) and the least biomass at 19.00 p.m. (2.28 ± 0.006 mg l^{-1}).

The diurnal biomass of *Chydorus* sp. varied insignificantly, except at 13.00 and 15.00 h when the biomass increased twice and made 0.79 ± 0.005 mg l^{-1}. The biomass of *Bosmina* sp. and rotifers (*Keratella* sp. and *Brachionus* sp.), in comparison with other planktonic groups, was very low, except at 07.00 a.m. when *Keratella* sp. biomass made even 1.47 ± 0.0003 mg l^{-1}.

Table. **Frequency of diet components in the gut and in the environment**

Diet composition	Diet component frequency of occurrence in the gut, %	Diet component frequency of occurrence in the lake, %
Zooplankton		
Rotifera		
Keratella sp.	100	86
Brachionus sp.	100	91
Cladocera		
Chydorus sp.	100	65
Bosmina sp.	100	57
Daphnia sp.	39	29
Copepoda		
Cyclops sp.	8.3	17
Ostracoda	–	15
Zoobentos		
Chironomus sp.	6.9	–
Ephemeroptera	4.5	–
Detritus	8.5	–

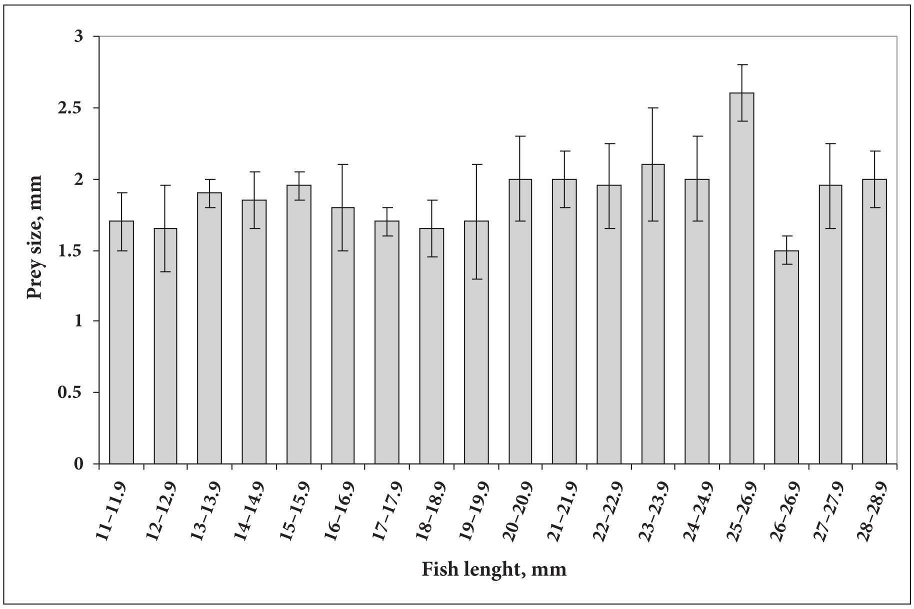

Fig. 1. Mean body size (± S.D.) of different prey organisms in diets of bleak classes

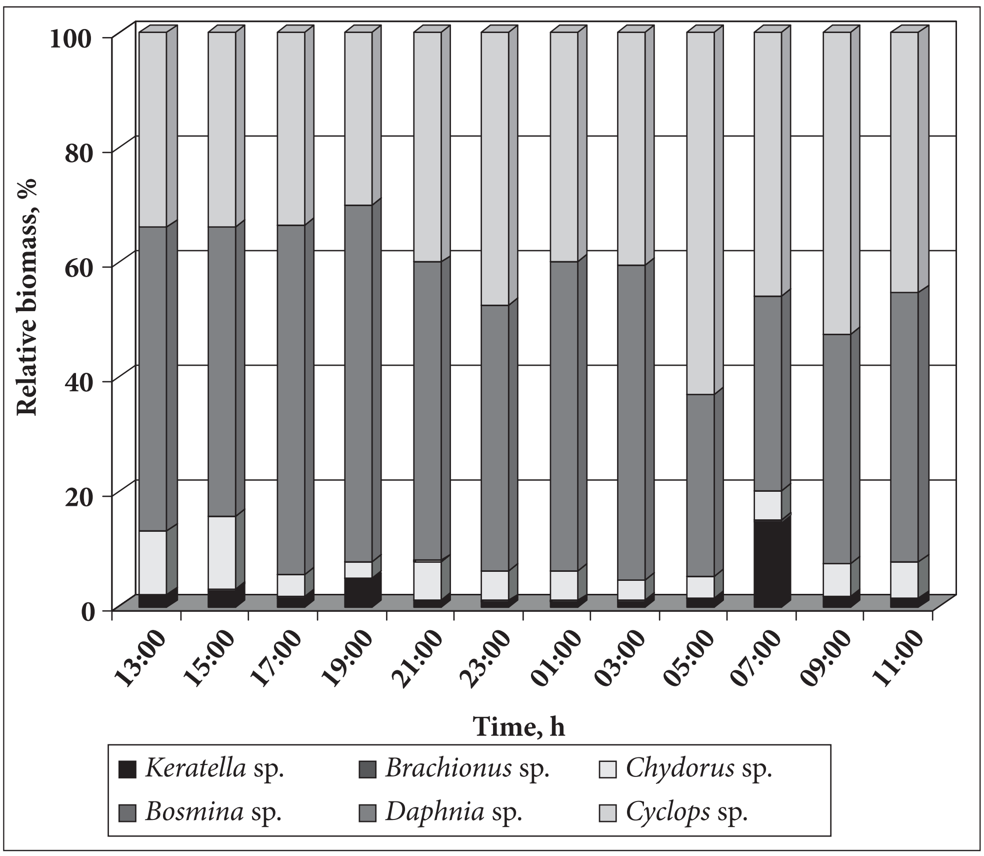

Fig. 2. The diurnal dynamics of zooplankton relative biomass in Lake Vajuonis

It is mentioned in the literature that the diurnal migration in time and space is typical of zooplankton (Jappesen et al., 1998), butin the present study we found that for all the 24 hours of sampling, by the biomass, two groups of planktonic crustaceans – *Daphnia* sp. and *Cyclops* sp. – dominated. It can be explained by the typicality of seasonal succession for planktonic crustaceans (Gasiunaite, Razinkovas, 2000), when in the second part of summer the second peak of zooplankton is observed, and in the beginning of autumn large crustaceans (*Daphnia* and *Mesocyclops*) dominate.

As is shown in Fig. 3, the main content of biomass of bleak guts is composed of *Daphnia* sp. and *Cyclops* sp. The relative biomass of prey in the guts diurnally changed insignificantly. In comparison with other prey, *Cyclops* sp. relative biomass slightly increased at 09.00 a.m. and 17.00 p.m. and made 18% of all prey biomass found in the gut. At the same time, the biomass of *Daphnia* sp. composed almost 100% of bleak gut content at 05.00 a.m. and 13.00 p.m.

Discussing the bleak feeding rhythm in Lake Vajuonis, the differences between zooplankton biomass in the environment

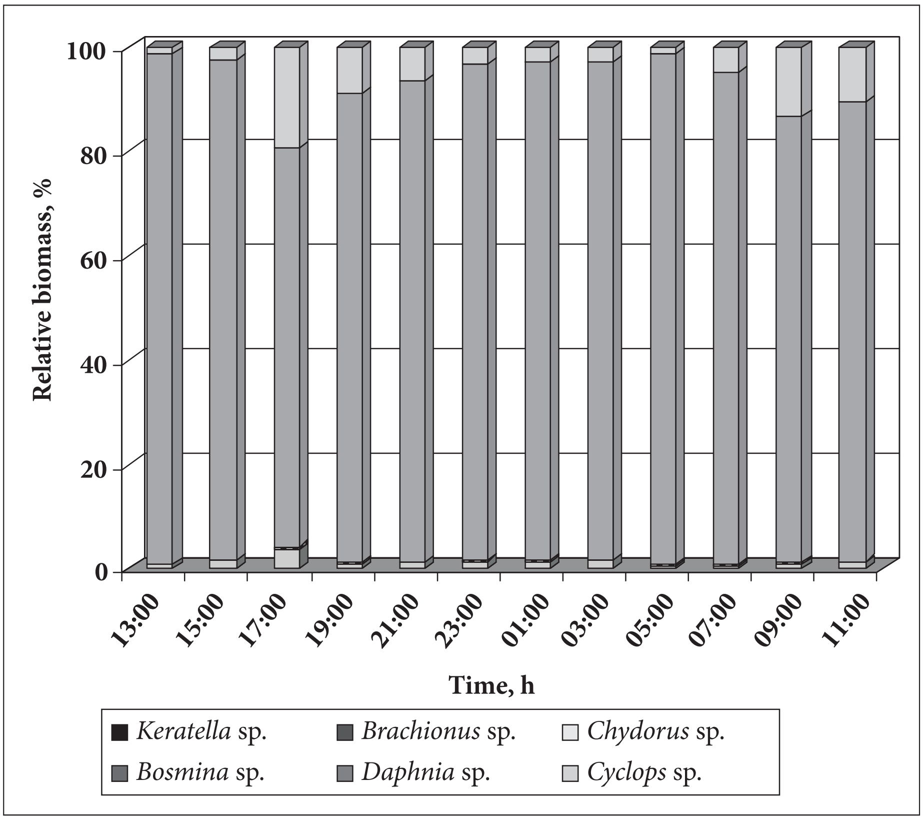

Fig. 3. The diurnal dynamics of zooplankton relative biomass in the digestive tract of the bleak

and its consumption at a certain time of the day can be observed (Fig. 4).

As regards the consumption of every component separately, the largest biomass of the *Keratella* sp. in the gut was found at 23.00 p.m. and the least at 13.00 and 21.00 o'clock. During these time periods, the biomass of rotifers in the gut was respectively 0.00024 ± 0.0000135 mg and 0.00007 ± 0.000005 mg. A very week statistically negative correlation was detected between the biomass of rotifers in the environment and in the bleak gut ($r = -0.18$, $p < 0.05$). When the consumption of rotifers grows, their biomass reduces very insignificantly.

Similar amounts of eating out were found also for another group of rotifers – the *Brachionus* sp. At 07.00 o'clock the biomass in the gut was the largest and composed 0.00003 ± 0.0000002 mg. However, a very weak positive correlation was established between the biomass of rotifers of this group in the environment and in the bleak gut ($r = 0.16$, $p < 0.05$). When the ingestion of rotifers grows, their biomass in the environment reduces very insignificantly.

The largest eating out of two Cladocera planktonic groups – *Chydorus* sp. and *Bosmina* sp. – is similar in the aspect of time – at 15.00–17.00 o'clock. At this moment, the biomass of the mentioned crustaceans comprised 0.5 ± 0.01 and 0.004 ± 0.001 mg, respectively. A weak positive correlation was ascertained between the *Chydorus* sp. biomass in the environment and in the bleak gut ($r = 0.24$, $p < 0.05$). The correlation between the *Bosmina* sp. biomass in the environment and in the bleak gut wass stronger ($r = 0.43$, $p < 0.05$). When the consumption of these planktonic crustaceans grows, their biomass in the environment changes insignificantly.

The largest biomass of *Cyclops* sp. was observed at 09.00 and the smallest – at 23.00–05.00 o'clock. At these time periods, the biomass of the crustaceans in the gut composed 0.07 ± 0.003 mg and 0.004 ± 0.002 mg, respectively. A statistically reliable positive correlation of average strength was detected between the biomass of this zooplankton group in the environment and in the bleak gut ($r = 0.41$, $p < 0.05$). When the consumption of the *Cyclops* sp. grows, their biomass in the environment changes insignificantly.

The situation is different when the consumption of *Daphnia* is examined both the aspects of time and quantity. The largest biomass of water fleas in the gut is observed at 13.00 and the smallest at 23.00–03.00. All the 24 hours round the biomass of these crustaceans in the environment and in the gut correlates – a close negative statistically reliable correlation between the mentioned parameters was found ($r= -0.84$, $p < 0.05$). When the consumption of water fleas grows, their biomass in the environment decreases. This tendency is described by a regression curve very well (Fig. 5).

Most of the literature sources mention that the fish are visual predators, therefore, because of low visibility, the hunting slows down or completely stops at night-time (Horppila, 1999; Manderson et al., 2000). This hypothesis has been confirmed also in this work, as at the night-time the biomass of the prey was smaller than in the the day-time.

When the biomass of preys in the environment is large, its consumption is intensive, because a predator spends little time to find the prey (Mehner et al., 1996). For this reason, the biomass of *Daphnia* sp. decreases in the environment. When the consumption reduces, the biomass of zooplankton restores.

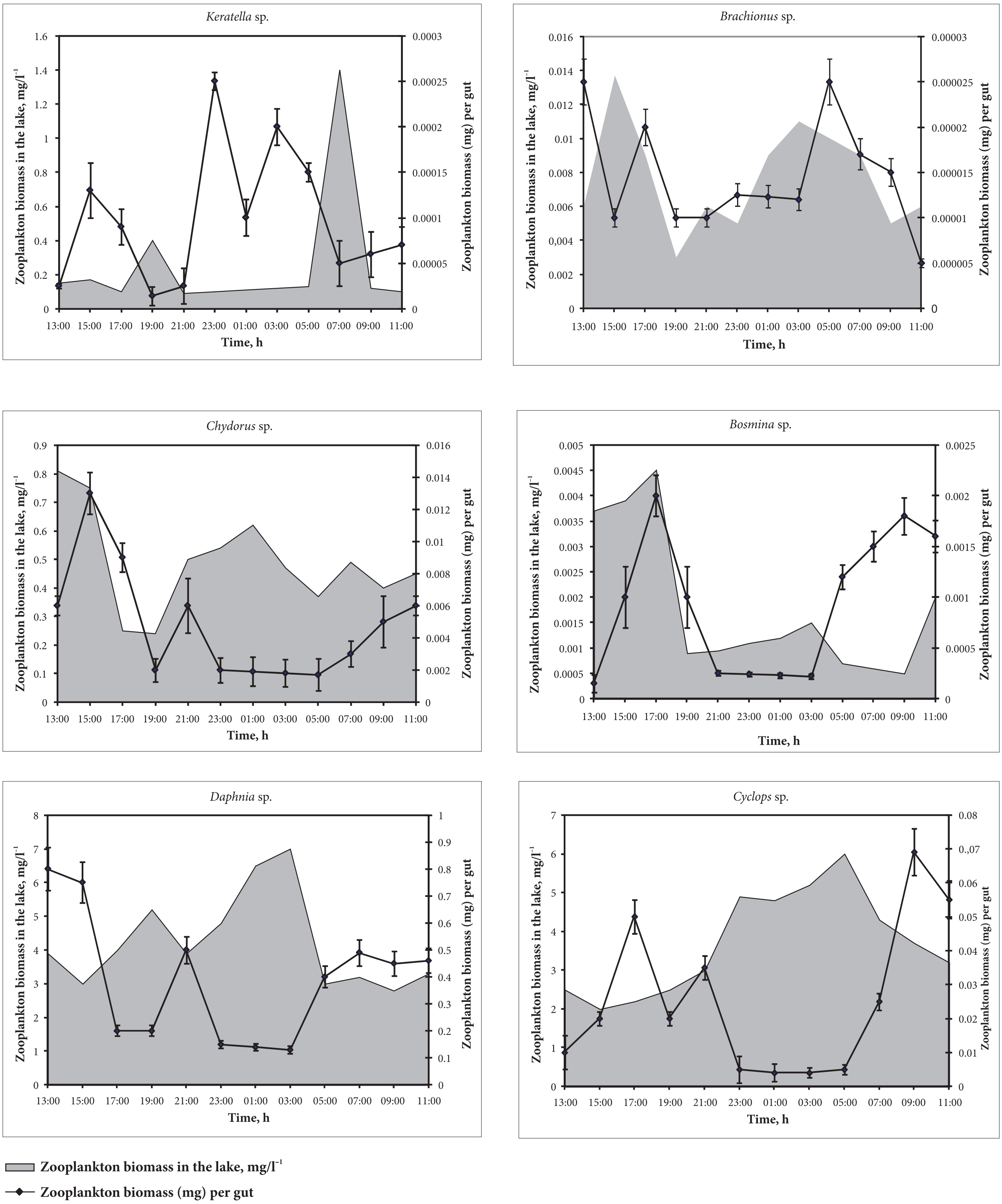

Fig. 4. Mean prey consumption (± S.D.) diurnal variation in the bleak. Shaded parts mark of zooplankton biomass in Lake Vajuonis

Vasek and Kubecka (2004), discussing the feeding of carp fish (roach, bream and bleak), have also obtained similar results – the feeding drops down in the night-time and reaches the maximum in the day-time. The mentioned authors conclude that such feeding behaviour is typical of fish as plankton feeders which find the prey with the help of eyesight. In this way, fish usually find larger preys or when their density is small (Lammens, Hoogenboezem, 1991). However, the author notes that if the prey size is small and there is plenty of them, they can get into fish digestive tract accidentally during water filtration. The results of this work can be explained by this fact when the biomass of the rotifers as compared with other prey at night and day time differs much less. Van den Berg et al. (1994) have also reported about this feature of carp fish – to feed on zooplankton by filtering the water.

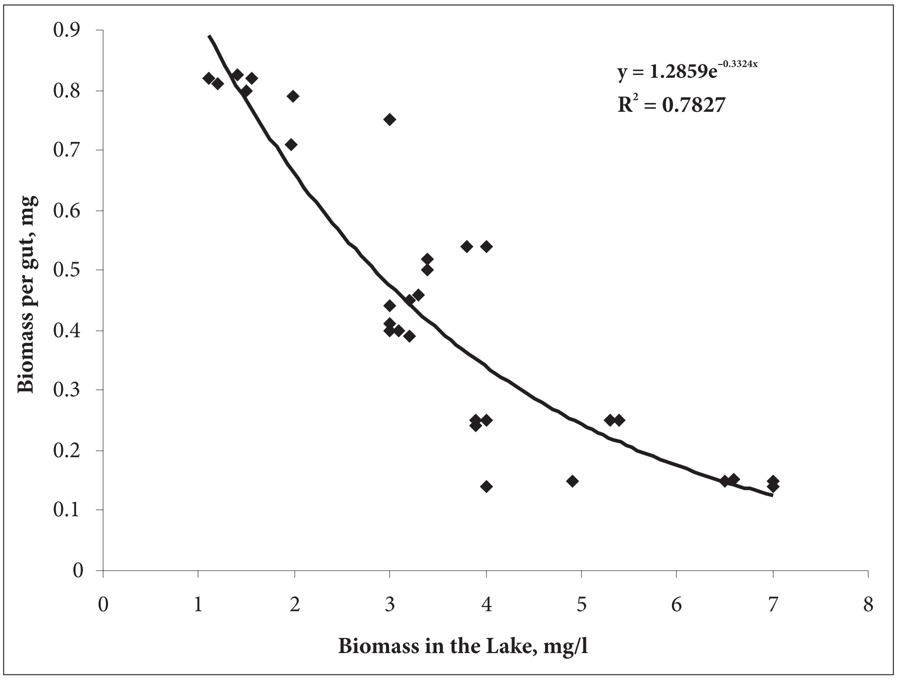

Fig. 5. Relationship between *Daphnia* sp. biomass and its consumption in Lake Vajuonis

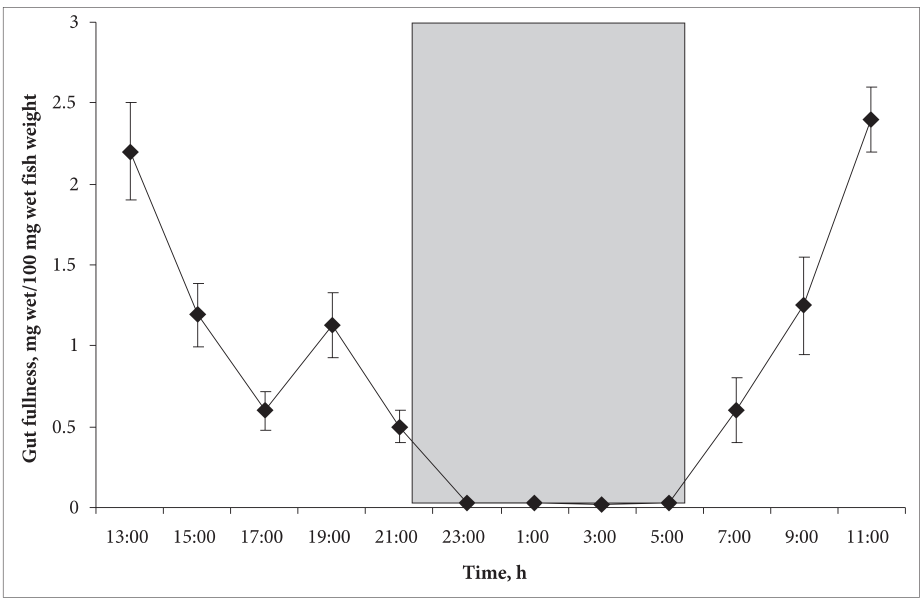

Fig. 6. Mean gut fullness (± S.D.) diurnal variations in the bleak. Sunset and sunrise time is indicated by shaded parts

Diurnal food consumption

It is known that the intensity of feeding of the majority of hydrobionts is influenced by different environmental factors, including photoperiodism, water temperature, prey size, etc.

Specziar et al. (1997) who have studied the feeding strategy and growth of fish fry indicate that feeding takes place periodically, with intensity peaks in the morning and in the evening. As long as prey is found with the help of eyesight, the intensity of light limits prey catching, and the stopping of feeding at night-time is a common feature for the majority of fish species (Huusko, Sutela, 1998).

Grant and Kott (1999) while researching the intensity of feeding of carp fish fry have not that the filling of their stomach with food is more intensive at day than at night.

The predatory feeding is also to a great extent modified by environmental temperature. The maximal stomach fillings found in the interval of optimal temperatures can be explained by the increased rapacity of hydrocole (Gaudy et al., 1991). The average diurnal water temperature defined in this work was 18.45 ± 0.76 °C. The speed of rapacity changed with changes of prey swimming speed. Certain zooplankton species swim quickly when the temperature is 10–14 °C, but the water temperature limits optimal for predators' feeding are not favorable for prey: they begin swimming slower, and the probability of the collision of prey and predator grows (Chigbu, Sibley, 1994).

Thus, it is possible to summarize that the feeding peculiarities of bleak fry in Lake Vajuonis are similar to the feeding of carp fish fry in other natural water sources. In the diet of these fish, zooplankton is found in abundance, and the fish feed on it rhythmically, with intensity peaks in the morning and in the evening.

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PAPRASTOSIOS AUKŠLĖS (*ALBURNUS ALBURNUS* L.) JAUNIKLIŲ (0+) PAROS MITYBOS RITMAS

S a n t r a u k a

Straipsnyje nagrinėjami Vajuonio ežere surinktų paprastosios aukšlės jauniklių (0+) paros mitybos kiekybiniai (atskirų dietos komponentų suvartojimas, mitybos intensyvumas) ir kokybiniai (dietos spektras, aukų pasirinkimas pagal dydį) pokyčiai. Išanalizuoti 244 aukšlių žarnynai ir 12 zooplanktono mėginių. Iš gautų rezultatų nustatyta, kad paprastosios aukšlės dietos spektrą sudaro 9 maisto komponentai, priskirtini verpetėms, planktoniniams vėžiagyviams ir vabzdžiams. Taip pat žarnynuose aptiktas detritas. Nustatytas paprastosios aukšlės kūno dydžio ir aukos kūno dydžio silpnas statistiškai patikimas ($r = 0{,}36$, $p < 0{,}05$) koreliacijos ryšys. Skirtingu paros metu atskirų zooplanktono grupių suvartojimas įvairuoja. Statistiškai patikimas stiprus neigiamas koreliacijos ryšys nustatytas tik tarp *Daphnia* genties vėžiagyvių biomasės aplinkoje ir aukšlių žarnyne ($r = -0{,}84$, $p < 0{,}05$). Didėjant dafnijų suvartojimui, jų biomasė aplinkoje mažėja. Paprastosios aukšlės mityba periodiška su intensyvumo pikais rytą ir vakarą.

Raktažodžiai: žuvų mailius, paprastoji aukšlė, *Alburnus alburnus* L., mitybos ritmas, žarnyno pripildymas, aukų dydis