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# FEEDING OF VENDACE IN LAKE MIEDWIE (NW POLAND)

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## ABSTRACT

The Lake Miedwie vendace feeding was studied in summer 2000. The vendace food was found to contain 7 zooplankton species, *Leptodora kindtii* being a clear dominant in terms of weight, abundance, and frequency. The *L. kindtii* domination was maintained throughout the period of study. In late summer, stomachs of females contained less food than those of males did. The observations are discussed against a backdrop provided by results of an earlier zooplankton study.

**Key words:** vendace, food composition, feeding, zooplankton, *Leptodora kindtii.*

## INTRODUCTION

During the period following World War II, the trophic status of Lake Miedwie underwent a pronounced change, from the original oligotrophy to strong eutrophication visible in mid–1980s [15]. The change resulted from intensified anthropogenic pressure and affected, i.a., the composition of the Miedwie's fish fauna and catches. Since mid–1970s, the lake had been yielding primarily less valuable cyprinid species; the eel the Miedwie had been intensively stocked with was also a frequent catch. A certain improvement in the Miedwie water quality, due mainly to reduction in the pollution load carried by River Płonia and to a decreased fertilisation of arable

fields surrounding the lake, was recorded within the last decade. However, the Miedwie's eutrophication still remains an unsolved problem. Its scale is evidenced by a strong chlorophyte bloom in spring 1997, as a result of which the Miedwie water was, for a short period of time, classified with quality class III. On the other hand, the improvement symptoms include a recovery of the coregonid population. Commercial catches have been bringing vendace again, the 1998 catches landing in excess of 8 tonnes (about 20% of the total catch) of the species, and even include – although in trace amounts – the famous Miedwie whitefish (*Coregonus lavaretus maraena* Bloch, 1779), a form regarded as already extinct. The current vendace yield is estimated at 1 kg $ha^{-1}$, i.e., a third of that recorded in early 1960s. Because prospects for developing vendace fishery in the Miedwie are brighter as the lake's water is improving, it was thought purposeful to initiate research on vendace feeding habits. The present paper summarises results of a preliminary study that marks an introduction to a comprehensive research programme which will deal with the vendace growth and condition. It is in the context of the preliminary nature of this study that the relatively low amount of the materials analysed should be viewed. The observations made were confronted with results of an earlier zooplankton studies conducted by Szlauer [14].

### Area of study

Lake Miedwie, covering 3.5 thou. hectares, belongs to the largest Polish lakes; it is located 30 km to the south–east of Szczecin. The Miedwie serves as a drinking water reservoir for the Szczecin conurbation, covering largely the entire demand. The Miedwie is a typical trough lake, with a poorly developed shoreline. Arable land covers more than 60% of the Miedwie drainage; the runoff, together with the nutrient load of the Miedwie tributaries (rivers: Płonia, Ostrowica, and Gowienica) are mainly responsible for the increased fertility of the lake. The shape and orientation of the lake's basin relative to the wind rose result in a stable stratification of the water column in summer, thus favouring development of hypoxia in the lower hypolimnion. The hypoxic layer begins at the depth of about 30 m; it should be noted, however, that the recent years witnessed a reduction in the hypoxic layer thickness (unpuiblished data of the District Environmental Protection Inspectorate, DEPI). An estimated 30% of the lake's bottom area is active, which enhances its susceptibility to degradation [15].

## MATERIALS AND METHODS

The study involved 4 vendace samples obtained in summer 2000 from gillnet catches (Table 1). Fishing operations were carried out at night, the nets (24 mm mesh diameter) being retrieved at about 7.00 a.m. The fish were picked out once the catch had been landed. A total of 128 individuals were examined; they were weighed, measured (l.c.), and sexed, their gonad maturity stage being determined and the digestive tracts removed. The latter were preserved in 95% ethanol. The contents of the foregut, extending from the stomach to the pyloric caeca inclusive, were examined. Food items were identified in a plankton counting chamber, under × 100 or × 250 magnification; identification was aided by the keys published by Kiefer and Fryer [6]. The food composition was analysed by determining contributions – by numbers, weight, and frequency – of individual items [17]. Standard weights [16] were used to determine weight contributions. Feeding intensity is presented as consumption index expressed in per cent fish body weight. All the graphs were plotted and calculations made with Statistica 5.1 computer package.

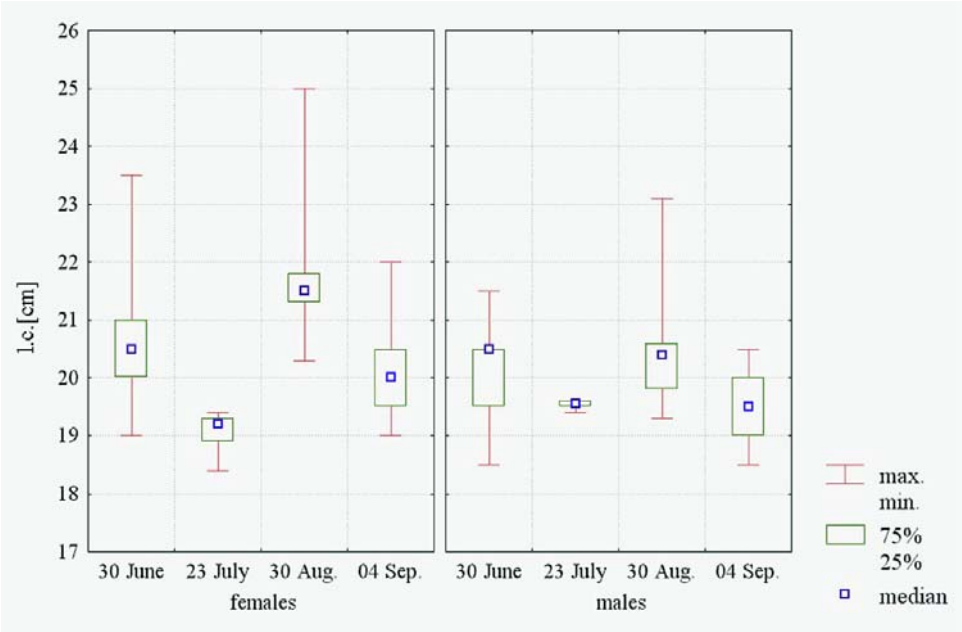
**Table 1. Summary of fish sample size data**

| Date | Empty and filled stomachs | Females | Males | Total |
|---|---|---|---|---|
| 30 June | empty | 8 | 7 | 15 |
| | full | 21 | 14 | 35 |
| | total | 29 | 21 | 50 |
| 23 July | empty | 5 | 3 | 8 |
| | full | 8 | 5 | 13 |
| | total | 13 | 8 | 21 |
| 30 August | empty | 5 | 2 | 7 |
| | full | 13 | 12 | 25 |
| | total | 18 | 14 | 32 |
| 4 September | empty | 1 | 1 | 2 |
| | full | 13 | 10 | 23 |
| | total | 14 | 11 | 25 |
| Total | | 74 | 54 | 128 |

**Fish length and weight ranges**

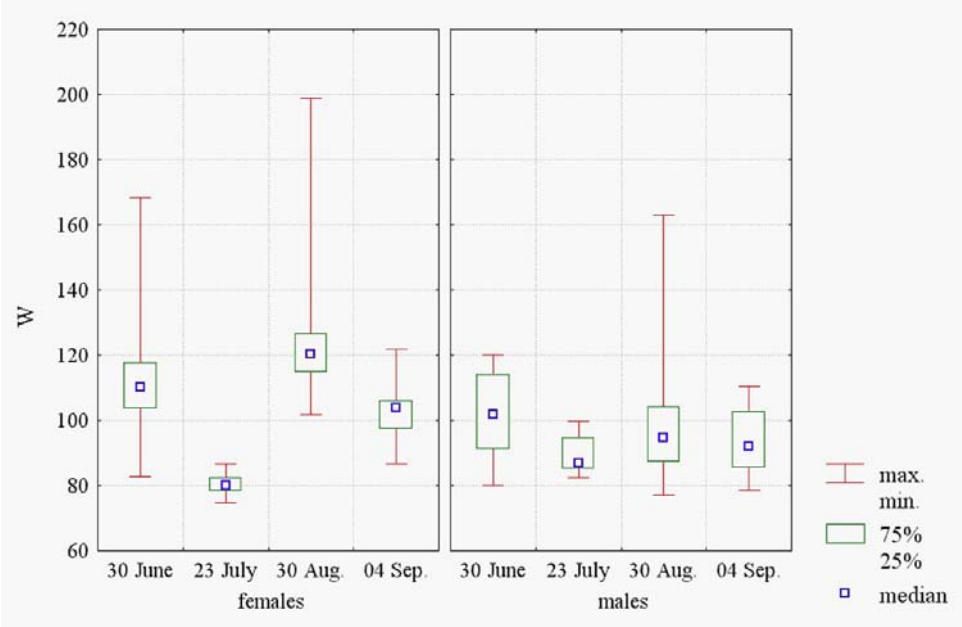
The feeding vendace were basically uniform in terms of both their length and weight. Females were somewhat larger than males and measured 18.4–25 cm, the quartile range being narrow (19.5–21.3 cm) and the median length amounting to 20.5 cm. Males measured from 18.5 to 23.1 cm, the quartile range being still narrower (19.5–20.5 cm) and the median length being 20 cm. Except for the July sample, females in individual samples showed wider length ranges and higher medians (Fig. 1).

**Fig. 1. Vendace length ranges**




The females proved also heavier than males and weighed from 74.6 to 198.9 g (quartile range: 95–118.4 g; median: 107.9 g). The males weight ranged within 77.1 – 163.1 g (quartile range: 86.7–105.5 g; median: 94.1 g). Except for July, females in individual samples showed wider weight ranges and higher medians (Fig. 2). The weight quartile ranges were larger in males in all the samples.

**Fig. 2. Vendace weight ranges**



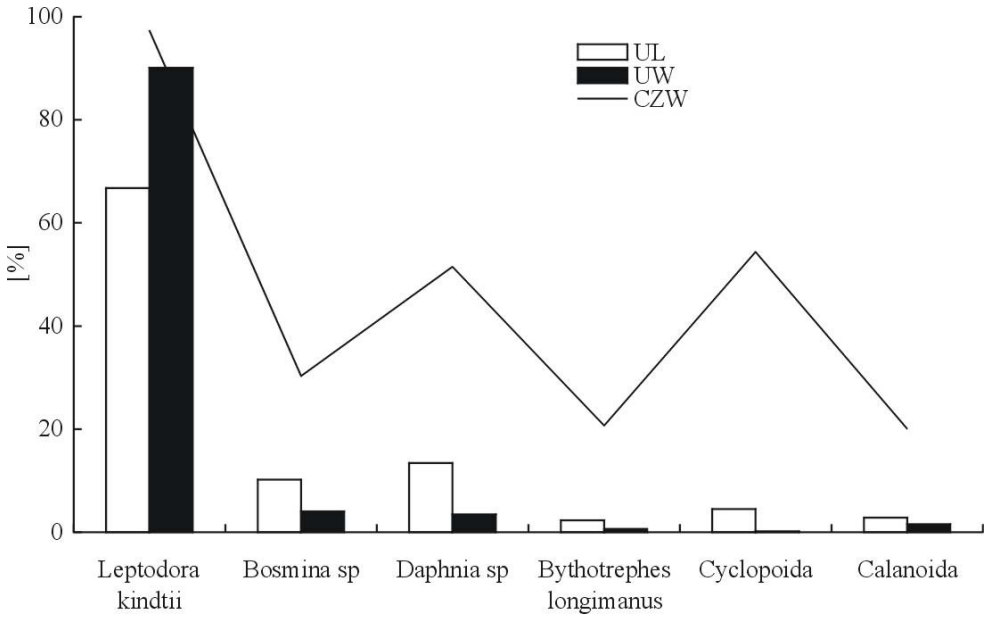
## RESULTS

### Vendace food composition

Stomachs of the feeding fish (75% of all the individuals examined) were found to contain representatives of at least 7 zooplankton species: *Bosmina longirostris* (Mueller), *B.coregoni* Baird, *Leptodora kindtii* (Focke), *Bythotrephes longimanus* Leydig, *Daphnia cucullata* Sars, *Mesocyclops leuckarti* (Claus), *Thermocyclops oithonoides* (Sars); representatives of the genera *Eudiaptomus* and *Cyclops* were identified as well. As some stomach contents were greatly digested (fishing operations were carried out in summer, the nets remaining in the water for many hours), it was frequently necessary to make do with identifying food items to higher taxa. For the same reason, no naked planktonic rotifers could be identified in the samples, those rotifers being otherwise known as the Medwie zooplankton dominants in the growing season [14].

In terms of numbers (UL in Fig. 3), the dominant food item was *L. kindtii*, the mean contribution of which amounted to 66.8%. The remaining cladocerans, dominated by the Daphnidae, contributed 25.9%. Copepods contributed the lowest number of individuals to the food (7.3%). As a result of its numerical domination, *L. kindtii* was also the food dominant by weight (UW in Fig. 3), with a contribution of 90.1% to the total stomach content weight. Other cladocerans contributed 8.2%, while copepods made up 1.7%. *L. kindtii* was found in almost all the food–containing digestive tracts; its frequency (CZW in Fig. 3) was 97.4%. Cyclopoids and daphnids were found in more than half the feeding fish. Calanoids were relatively rare (20% frequency).

**Fig. 3. Lake Miedwie vendace food composition**




Throughout the period of study, the food composition remained stable in terms of numerical and weight contributions of various items (Figs. 4 and 5). The numerical contribution of the dominant *L. kindtii* did not deviate much from the mean, the combined contribution of daphnids and *Bosmina* spp. not exceeding 20%. In terms of weight contributions, the difference was still larger: while the *L. kindtii* weight contributions were almost 88 and 94% in June and July, respectively, *Bosmina* spp., the second most important item, contributed as little as about 2–5%.

**Fig. 4. Changes in contribution of various food components by numbers**

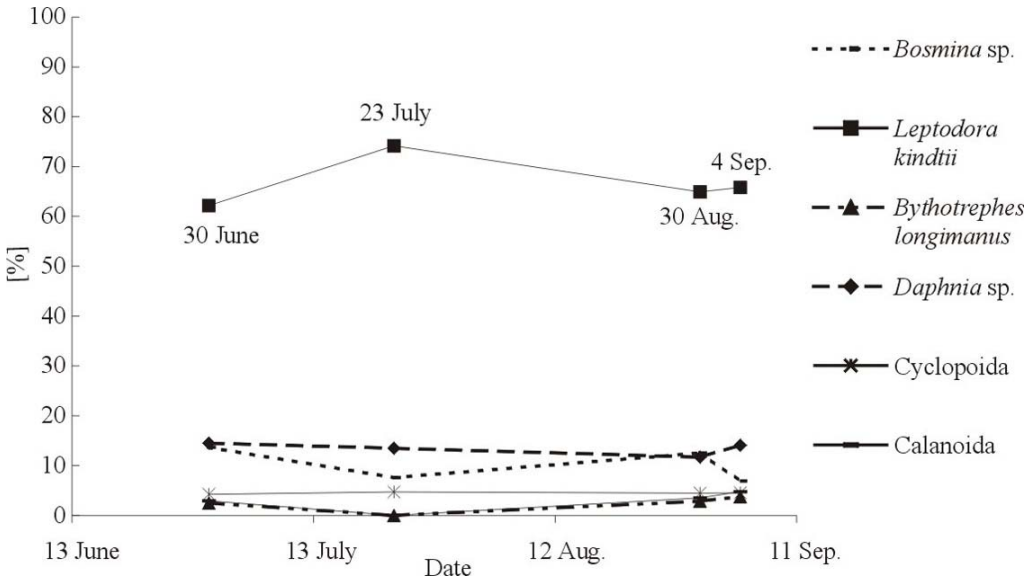
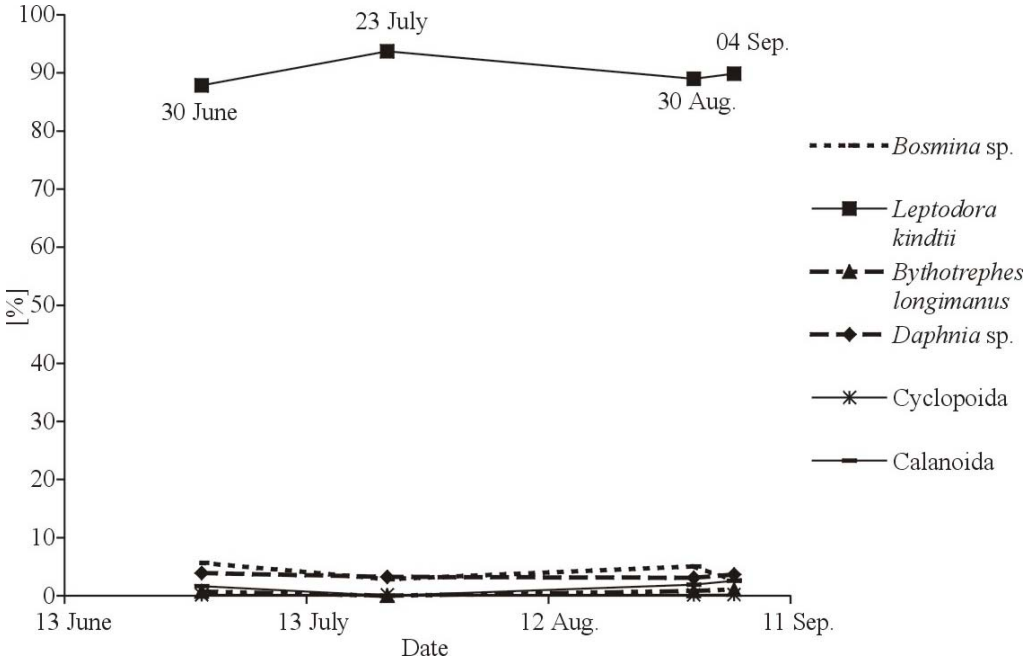


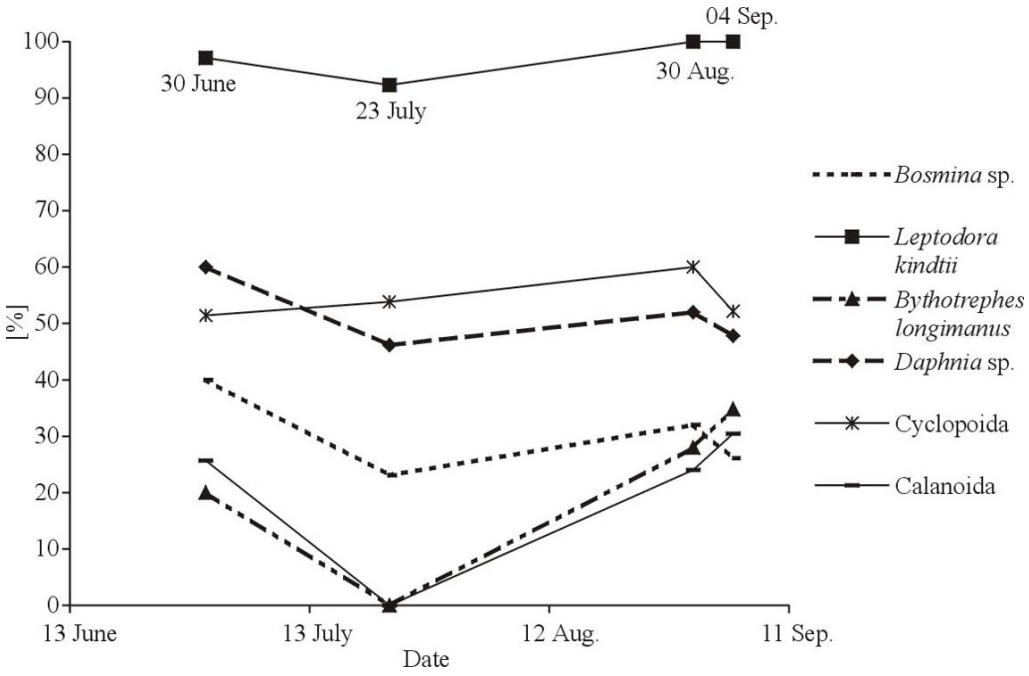

**Fig. 5. Changes in contribution of various food components by weight**




No greater changes in the frequency of occurrence of individual food items was found (Fig. 6). The most frequent item in all the samples was *L. kindtii*, present in all the fish examined in the last two samples. The July samples lacked calanoids and *Bythotrephes longimanus.*

No benthic animals were identified in the food contents examined.

**Fig. 6. Changes in frequency of occurence of various food components**




## Vendace feeding intensity

Feeding intensity is reflected in the consumption index (ws in Fig. 7), expressed in per cent fish body weight [16]. While the mean feeding intensity of all the fish taken together did not changed much throughout the period of study, there was a clear sex–dependent difference (Figs. 7 and 8). Males were found to have fed with a higher intensity as from July when the difference between the male and female feeding coefficients proved statistically significant (Table 2). Significant differences were recorded in subsequent samples as well.
Variability of the feeding intensity – presented as the standard error (boxes in Fig. 8) – increased somewhat in late summer, which was related to a higher variability in gonad maturity at that time as the sample contained both immature and fully mature individuals (Fig. 9).

**Fig. 7.Indices of consumption of Lake Miedwie vendace**

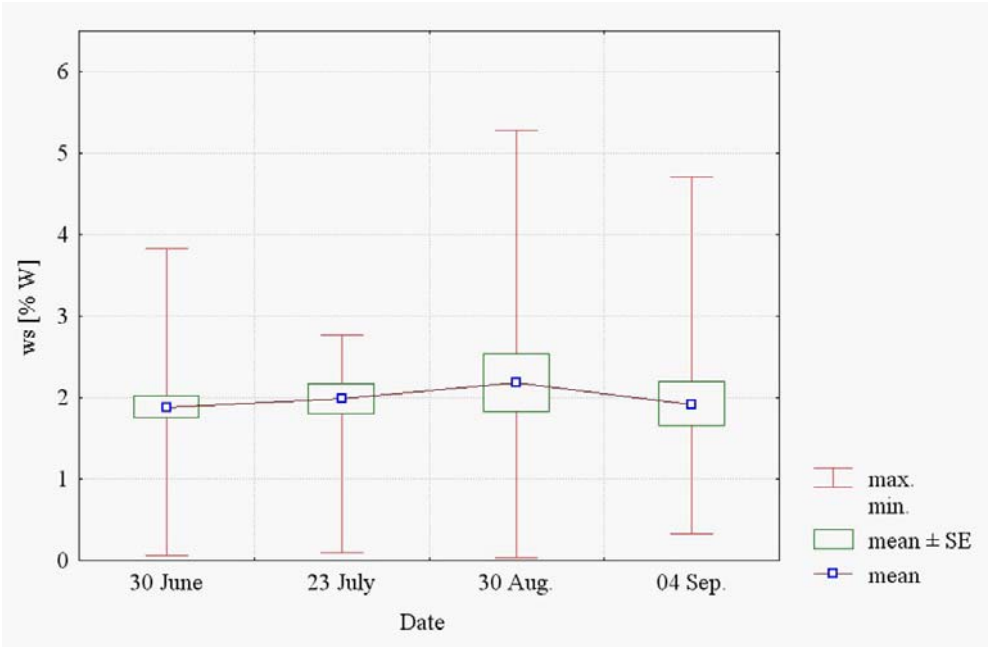


**Fig. 8. Indices of consumption of Lake Miedwie vendace by sex**

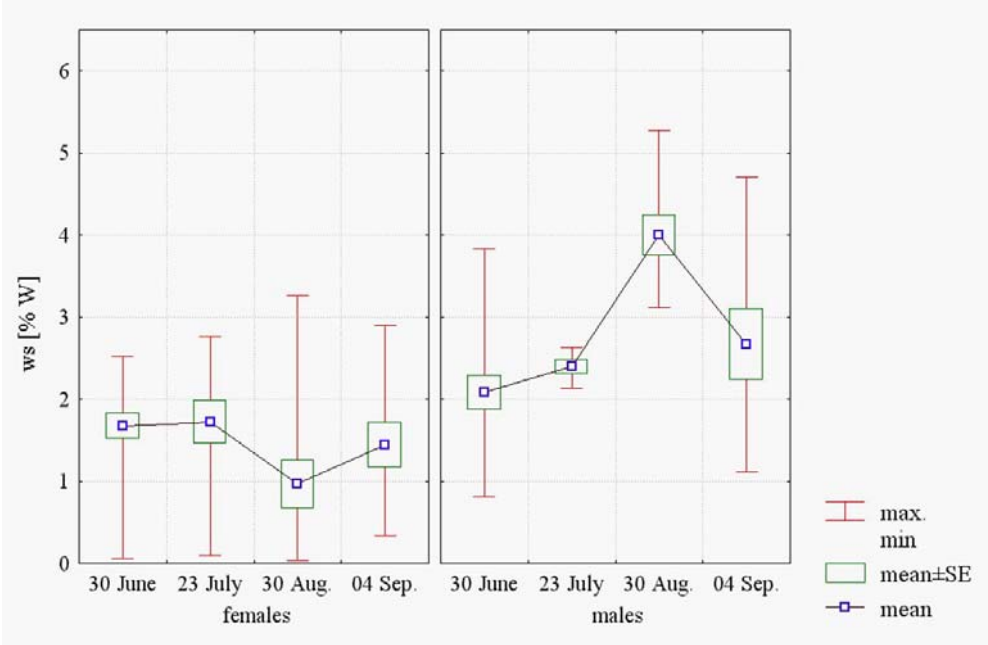
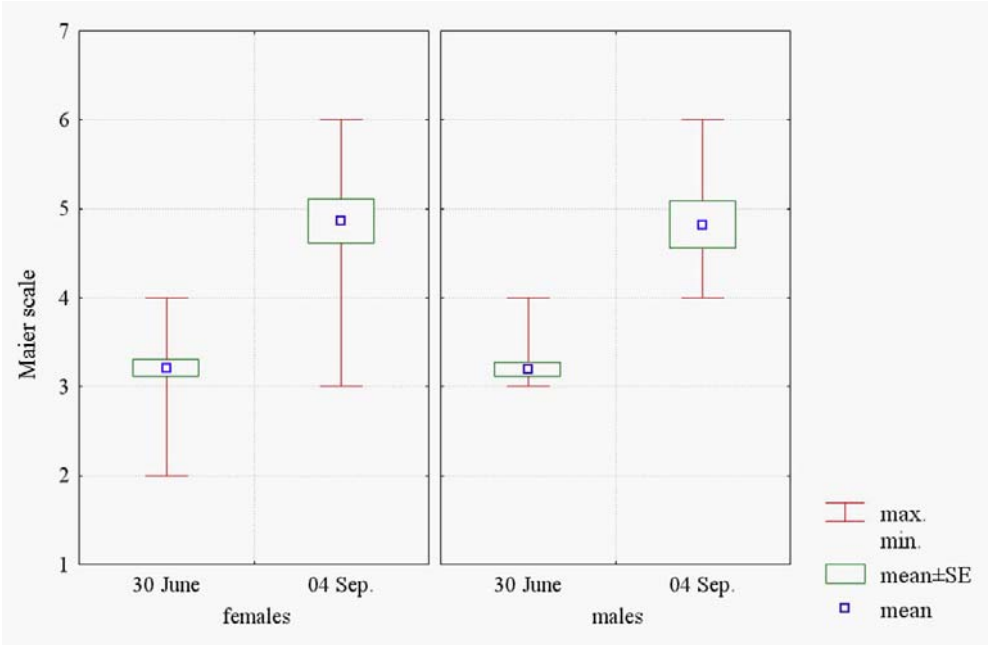



**Table 2. Comparison of male and female feeding intensity coefficients (Mann-Whitney U-test)**

| Date | Sum of ranks | | U | p level | N, females | N, males |
|---|---|---|---|---|---|---|
| | females | males | | | | |
| 30 June | 280 | 350 | 127 | 0.39 | 17 | 18 |
| 23 July* | 41 | 50 | 5 | 0.03 | 8 | 5 |
| 30 August* | 122 | 203 | 2 | <0.01 | 15 | 10 |
| 4 September* | 129 | 147 | 24 | 0.02 | 14 | 9 |

*** denotes statistically significant difference.**

**Fig. 9. Variability of vendace gonad maturity**



## DISCUSSION

The observations described in this paper were made during the major period of growth and most intensive feeding of the Lake Miedwie vendace, as indicated by the fact that the fish gains as much as 70% of its annual body weight increment in June and July alone [7]. The pronounced domination of *L. kindtii* in the Miedwie vendace food, coupled with a low (about 0.5%) contribution of the species to the summer zooplankton [14], demonstrates a strong selectivity in favour of the cladoceran in question. This is in agreement with the optimal foraging theory [10] stating that, when the food is abundant, coregonids will primarily feed on large and easily digestible plankters which will guarantee a higher energy gain [3]. While such selectivity was reported by numerous authors [2, 5, 9, 16], the Miedwie vendace selectivity towards *L. kindtii* is strongest. The Ivlev coefficient, estimated from data published by Szlauer [14], was higher than 0.95, while the values of 0.8 and as low as 0.2 were obtained for vendace of Lake Tolvuyskaya Onega [1] and the dysoligotrophic Lake Suomunjarvi [18], respectively. Even if the *L. kindtii* resources in the Miedwie were underestimated by Szlauer [14], due to the propensity of large cladoceran to avoid sampling gear [13], the very high frequency of occurrence of *L. kindtii* in the vendace food is an indirect evidence of good feeding conditions the fish enjoys in the Miedwie. Such a high selectivity in favour of *L. kindtii* is most probably a direct result of reduced water transparency due to eutrophication. In the translucent waters of the re–oligotrophic Lake Lucerne, the transparent body of the cladoceran remains invisible to the coregonids, hence the cladoceran is not preyed upon by the local vendace population [8].

In her study of the Miedwie zooplankton, Szlauer [14] found cladocerans to make up 90% (an average of 0.87 mg $dm^{-3}$) of the zooplankton biomass in the epilimnion (down to 8 m depth), *L. kindtii* being a subdominant (with a biomass of 2.6 mg $dm^{-3}$) in a local cladoceran peak at the depth of 6 m (B. Szlauer, personal communication). During the morning hours, the species was virtually absent at depths exceeding 8 m. As *L. kindtii* is known to perform very limited diurnal migrations [8] and because the species was found in the stomach contents of all the fish examined, it can be concluded that no Miedwie vendace fed in the lower epilimnion, i.e., at depths typical of vendace feeding elsewhere (in summer 1996 and 2000, the border between the epi– and metalimnion was located at 13 and 15 m, respectively; unpublished DEPI data). This is particularly interesting in view of the fact that in August, when zooplankton is still abundant in the subsurface water of the lake, diurnal migrations of vendace are less extensive and the feeding becomes less intense. This is usually interpreted as a pre–spawning behaviour, related to intensive gonad development [8, 11]. In the present case, however, the less intense feeding observed towards the end of the growing season was not accompanied by cessation of vertical migrations, the vendace still migrating as far up as the upper epilimnion. Thus, despite the fact that light conditions, as a proximal factor limiting migrations, were changed [4], another stimulus could have prevailed on the vendace to continue migrating. Such a stimulus may be looked for in a very specific Miedwie's limnology (cool epilimnion, limited amount of mixing of surface water supporting vertical stratification), because diurnal migrations of the adult vendace (aged 1+) did not reach beyond the thermocline [12]. Obviously, the line of reasoning pursued above is based on the assumption that both the limnology of the lake and the species composition of zooplankton in the Miedwie were similar in 1996 and 2000. The unpublished DEPI data seem to confirm the similarity between the two summer seasons, while studies carried out over a few recent years show the lake's zooplankton to undergo no substantial changes (Szlauer, personal communication). The much lower contributions of the remaining planktonic crustaceans in the vendace food, except for the specially "selected" *Bythotrephes longimanus*, reflected the structure of the zooplankton community to some extent [14].

## SUMMING UP

In summer, the cladoceran *Leptodora kindtii* was the major component of the vendace food. The cladoceran was a clear dominant in terms of abundance, weight, and frequency in the food. Daphnid cladocerans and *Bosmina* spp. played a very minor role in the food.

No major between–months differences in the vendace food species composition were found.

In late summer (end of August, September), the digestive tracts of males contained more food than those of females did.

Compared to the situation in June and July, the vendace feeding intensity in late summer was more variable.

## ACKNOWLEDGEMENTS

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