FOLIA PARASITOLOGICA 34: 145–155, 1987.

OCCURRENCE OF PHYLLODISTOMUM UMBLAE (FABRICIUS, 1780) IN THE URETERS OF COREGONIDS OF LAKE YLI-KITKA IN NORTHEASTERN FINLAND

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Abstract. 380 whitefish (*Coregonus* sp.) and 260 vendace (*Coregonus albula* L.) were studied from Lake Yli-Kitka in northeastern Finland during 1980—1982. 33 % of the whitefish and 38.5 % of the vendace were infected with *Phyllodistomum umblae* (Fabricius, 1780), the average intensity of infection being 4.2 and 2.3 per infected fish, respectively. No clear seasonality was observed in either the prevalence and intensity of infection or in the level of maturation and the length of *P. umblae* in both fish species, which points to a continuous invasion and maturation of these trematodes. The prevalence and intensity of *P. umblae* infection was highest in the middle-sized whitefish. Similar results were obtained when the mean number of worms per fish and the level of overdispersion ($S^2/\bar{x}$) are plotted against the length of the fish. With regard to vendace the prevalence and intensity of infection per infected fish and per fish studied increased as the fish length increased: only the variance-to-mean ratio remained constantly low. Overdispersion indices ($S^2/\bar{x}$) revealed that in the whitefish *P. umblae* is more overdispersed than in vendace when studied using data from seasonal periods with size-groups as homogenously infected as possible. The negative binomial distribution gave a good fit in the case of vendace and with one exeption also for whitefish, and the values of parameter k are well within the limits most often found in parasitological studies.

Phyllodistomum umblae (Fabricius, 1780) (syn. *P. conostomum* (Olsson, 1876)) has been found in the ureters of Salmonidae species in Scandinavia and in USSR (e.g. Olsson 1876, Nybelin 1926, Markevich 1951, Pigulewsky 1953, Bakke and Lien 1978, Anikieva et al. 1983, Butorina 1983, Bakke 1984) and also in Ireland (Conneely and McCarthy 1984). Recent work by Bakke (1985) has shown that *P. conostomum* is a junior synonym of *P. umblae*. In Finland *P. umblae* has previously been reported as *P. conostomum* by Hakala et al. (1981) and by Valtonen et al. (1984).

Present study is a larger project on the seasonal distribution of the parasite fauna of the most common fish species in Lake Yli-Kitka, which is a large, oligotrophic lake in natural state in northern Finland. Previous reports on trematodes which mature in fish in northern Finland include that on the seasonal occurrence of *Bunodera luciopercae* (Müller, 1776) by Rahkonen et al. (1984). There are no existing comprehensive ecological studies on *P. umblae* and the life history of this trematode is not completely known.

The aim of this paper is to provide information on the seasonal occurrence of *P. umblae* and the infection in relation to host-size, and to describe the host-parasite relationship in terms of dispersion and frequency distributions of this trematode in whitefish and vendace of Lake Yli-Kitka.

MATERIALS AND METHODS

Lake Yli-Kitka is a part of a larger lake complex, with a total area about 295 km² (GRID 27°E 734: 58). It is located 240 m above sea level and its oligotrophic water runs eastwards to the White Sea via the River Kitkajoki. Lake Yli-Kitka is covered by ice for about eigth months of the year.

Fish samples were caught using seine-nets mainly from two areas (A and D), but also from sites B and C (Fig. 1). It was necessary to catch the fish in different areas mainly, because of their seasonal migrations within the lake. There was, therefore, no point in assessing the differences between the sites. A total of 380 whitefish and 260 vendace were studied taking monthly or bimonthly random samples during the years 1980—1982. The taxonomy of whitefish species in Lake Yli-Kitka is under study (Salojärvi, unpubl. data) and at the moment it is not possible to identify the whitefish material. In addition to the original whitefish *C. pidschian* (Gmelin) stock, other whitefish species have been introduced into the area along with species have apparently been able to hybridize. The number of gill-rakers of whitefish in this material varies between 11 and 34. It is possible that there may be two stocks present in the material, differing in the number of gill-rakers, but impossible to separate in the monthly samples. No significant differences were found between *P. umblae* infections in the two apparent stocks of whitefish; i.e. those with 21 or less gill-rakers and those with 24—34 gill-rakers.

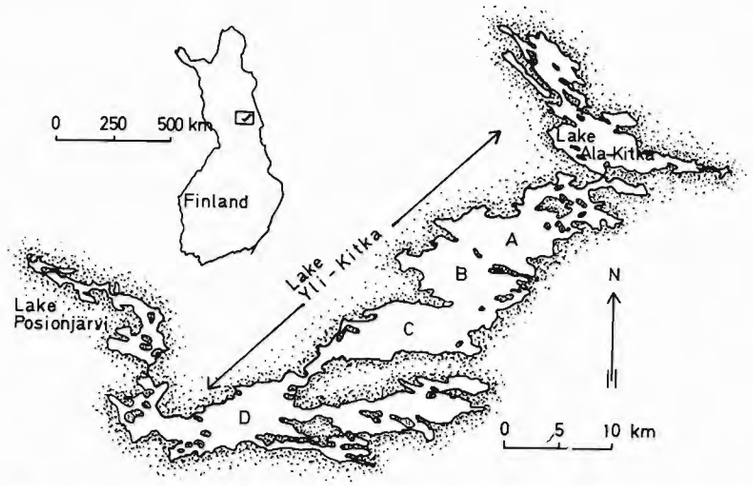

Fig. 1. Location of Lake Yli-Kitka in the lake complex of Suur-Kitka and the study areas.

Live trematodes were fixed in glacial acetic acid and conserved in 70 % ethanol. Worms taken from frozen fish were placed directly into 70 % ethanol. Some of the trematodes were stained with Mayer's paracarmine and mounted in Canada balsam for identification. The identification was carried out by Dr. D. I. Gibson (British Museum). The worms were divided into two categories; immature and gravid. The dispersion of *P. umblae* was studied using variance-to-mean ratio. The implication is that $S^2 < \bar{x}$ for underdispersed, $S^2 > \bar{x}$ for overdispersed and $S^2 = \bar{x}$ for random distributions. Frequency distribution of the whitefish of the size-class 155—194 mm and vendace larger than 90 mm were studied seasonally and negative binomial distribution was fitted to the results. The maximum likelihood method was used to estimate the parameter k of the negative binomial (Bliss and Fisher 1953) and the χ^2 test to assess the accuracy of the fit. For this purpose the classes were combined so that each had an expected frequency of at least 5.

RESULTS

1. Occurrence of *P. umblae* in whitefish and vendace from lake Yli-Kitka

P. umblae occurred quite frequently in the ureters of whitefish and vendace. The prevalence of infection is about at the same level in both whitefish (33.2 %) and vendace (38.5 %), while the intensity of infections was clearly higher in whitefish (4.2 and 2.3 worms per infected fish, respectively) (Table 1).

Table 1. Occurrence of *Phyllodistomum umblae* in whitefish (*Coregonus* sp.) and vendace (*Coregonus albula* L.)

Host	Date	No. of fish	Prevalence %	$\bar{x} \pm$ S. E./inf. fish	Range
Coregonus sp.	VI 80—VI 81, III 82—X 82	380	33.2	4.2 ± 0.5	1—32
Coregonus albula	XI 80—IX 81, III 82—X 82	260	38.5	2.3 ± 0.2	1—8

2. Seasonality of *P. umblae*

No clear seasonality was observed in prevalence and intensity of infection of *P. umblae* either in whitefish or vendace. The prevalence of infection was rather high throughout the study period in both fish species, although in whitefish it seems that level of infection is higher during the first half of the year. The prevalence decreased most clearly in the autumn of 1982. Lower values in April and May in 1981 may be due to small sample sizes at that time (Fig. 2).

In the case of vendace the situation is not so clear. In 1981 the level of infestation was highest in July-September, but in 1982 the results are vice versa, and the infection level is generally higher (Fig. 3).

With regard to the intensity of infection in whitefish, lower values were found during summer months both in 1980 and 1982, while in vendace, the intensity of infection was highest in spring and summer.

Neither the level of maturation nor the length of *P. umblae* followed any clear seasonal pattern. Immature and gravid worms (lengths of 1.0—2.9 and 1.3—6.5 mm, respectively) were found concurrently in most of the samples in both fish species. The proportion of gravid worms was always greater than immature specimens, with the exception of July in 1980 in whitefish when only one immature worm was found (Figs. 2, 3). However, in 1982 the proportion of immature specimens in whitefish increased during June-August as compared to spring and autumn of that year.

3. The level of infection of *P. umblae* in relation to the size and age of whitefish and to the size of vendace

The prevalence of *P. umblae* infection was highest among the middle-sized whitefish (Fig. 4). The fish of the two smallest size-classes always harboured only 1—3 worms per infected fish. In the largest fish, although having as low a prevalence as the smallest size-classes, the parasite load per infected fish was distinctly greater, so that fish larger than 224 mm always harboured 4—10 worms. The highest numbers of worms (> 10) per infected fish, however, were found among the middle-sized whitefish.

The ages were gauged for 132 whitefish during June 1980 — January 1981. The mean age of the material was three years, and the prevalence as well as the intensity of infection were highest in this age class.

With regard to vendace, the prevalence of infection increased very clearly as fish got larger with the exception of the largest size-class. Larger fish were also slightly more heavily infected (Fig. 5).

The same kind of results were obtained when the mean number of worms per fish and the level of overdispersion ($S^2/\bar{x}$) are plotted against the length of the fish, although the variance-to-mean ratio remained constantly low in vendace.

In the case of whitefish the prevalence of infection in three size classes ($\leqq$ 154 mm, 155—194 mm, $\geqq$ 195 mm) was also studied in relation to season. In general, as in Fig. 4, the middle-sized fish were most heavily infected.

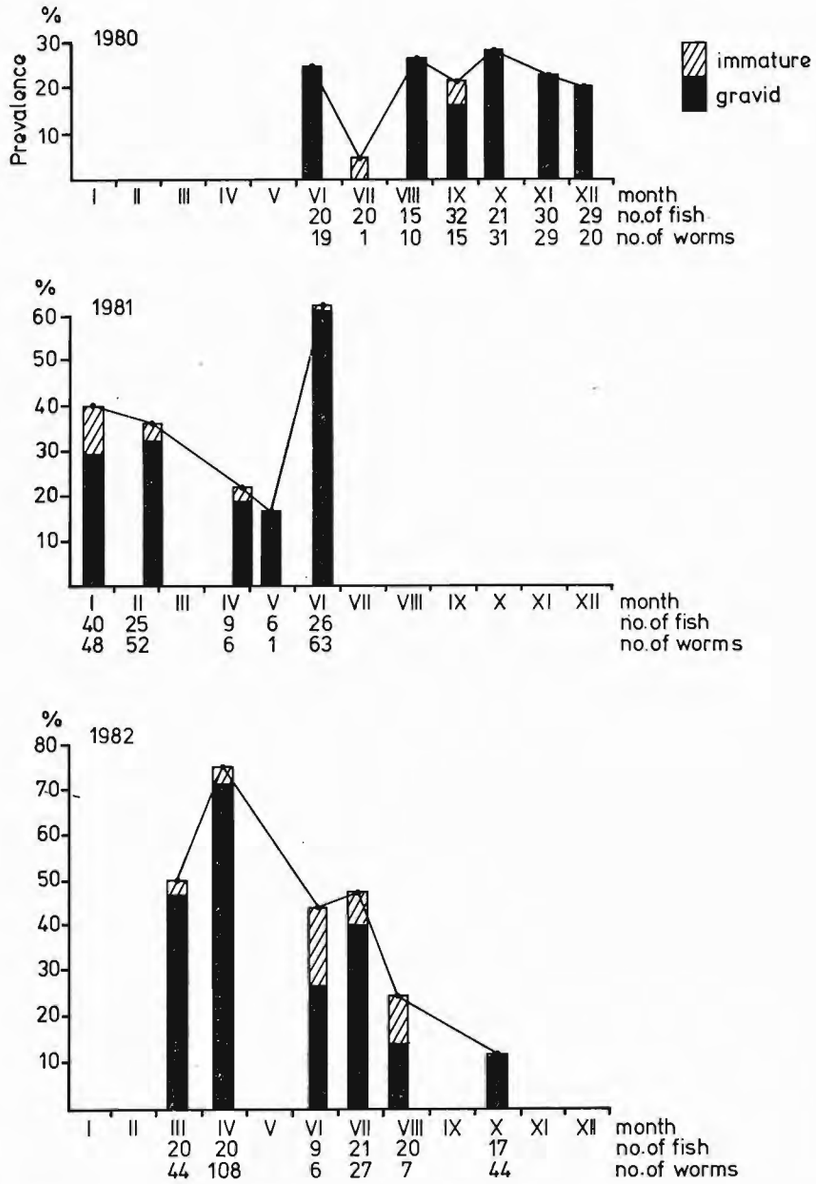

Fig. 2. Seasonal variation in the prevalence of *Phyllodistomum umblae* in the whitefish of Lake Yli-Kitka and the proportion of immature and gravid worms in each sample.

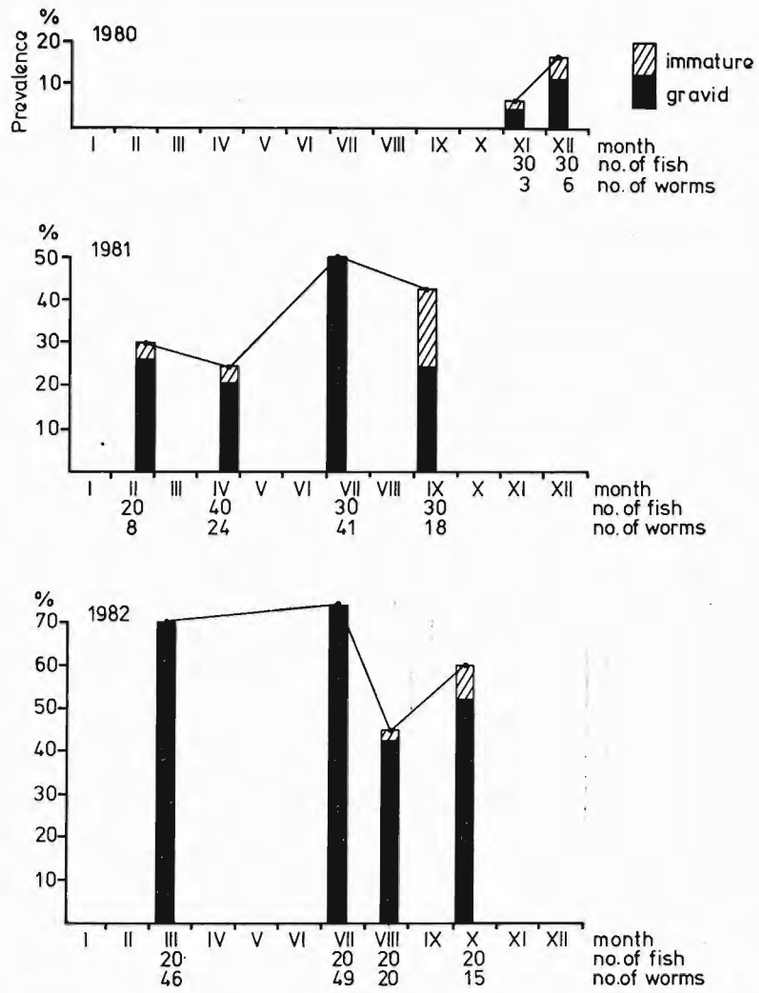

Fig. 3. Seasonal variation in the prevalence of *Phyllodistomum umblae* in vendace and the proportion of immature and gravid worms in each sample at Lake Yli-Kitka.

4. Dispersion and frequency distributions

Dispersion and frequency distributions were studied using data from seasonal periods with size-groups as similarly infected as possible. Overdispersion indices ($S^2/\bar{x}$) revealed that in the whitefish *P. umblae* is more overdispersed than in the vendace, where the index remains close to 2—2.5 throughout the periods studied and even in the combined material. In the whitefish the overdispersion index for the combined material was 9.2 and even higher during March-July 1982 (Tables 2 and 3). The negative binomial distribution gave a good fit in the case of vendace and also, with the exception of the combined material, for whitefish (Fig. 6). In the vendace parameter k was greater (range 0.6—1.2) than that of the whitefish (0.2—0.5).

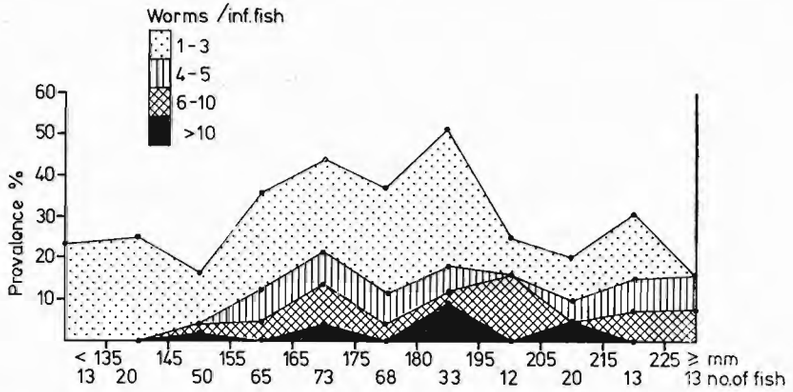

Fig. 4. Occurrence of *Phyllodistomum umblae* in relation to the size of whitefish from Lake Yli-Kitka during 1980—1982.

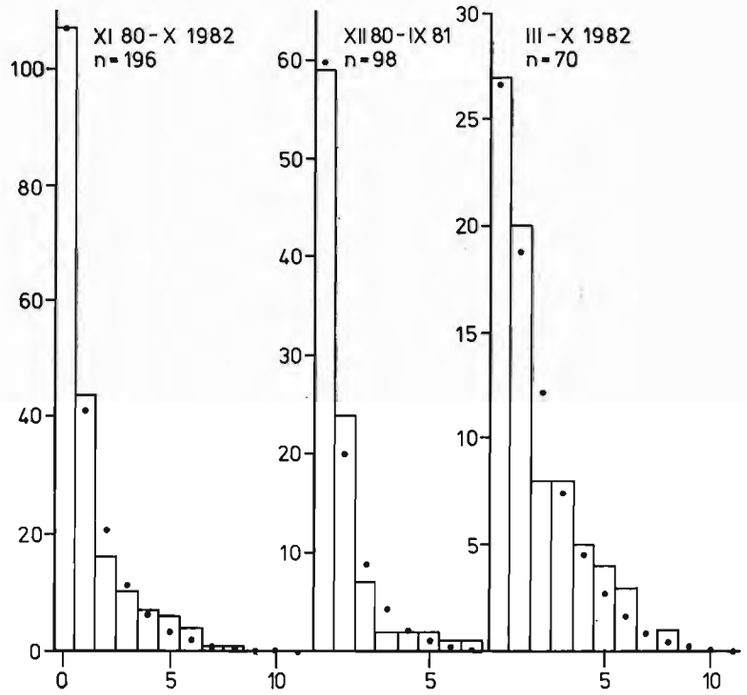

Fig. 6. Frequency distribution of *Phyllodistomum umblae* in vendace from Lake Yli-Kitka of the size group ≧ 90 mm for the combined material and for the seasonal material collected during December 1980-September 1981 and March-November 1982. The dots represent the fitted negative binomial distributions.

Table 2. Data for the frequency distribution of *Phyllodistomum umblae* in the whitefish (*Coregonus* sp.) of the size 155—194 mm and parameters of fitted negative binomials

Date	No. of fish	Prevalence %	Mean $\bar{x}$	Variance S^2	$S^2/\bar{x}$	p	k	pkq	x^2 prop.
VIII 80—V 81	142	33.1	1.23	7.85	6.38	5.6	0.2	8.1	0.02
III 82—VII 82	50	62.0	2.84	28.79	10.14	5.7	0.5	19.0	0.31
VI 80—X 82	236	41.1	1.83	16.83	9.20	6.1	0.3	12.9	0.01

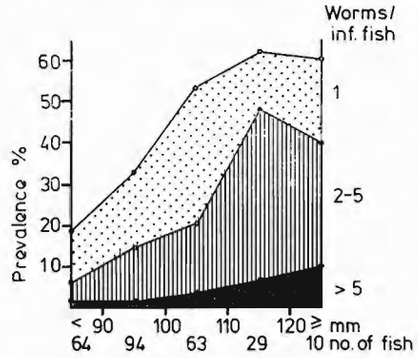

Fig. 5. Occurrence of *Phyllodistomum umblae* in relation to the size of vendace of Lake Yli-Kitka during 1980—1982.

Table 3. Data for the frequency distribution of *Phyllodistomum umblae* in vendace (*Coregonus albula* L.) in fish over 90 mm in length and the parameters of fitted negative binomials; those marked with • are plotted in Fig. 6

Date	No. of fish	Prevalence %	Mean $\bar{x}$	Variance S^2	$S^2/\bar{x}$	p	k	pkq	x^2 prop.
XI 80—X 82	196	45.4	1.04	2.60	2.50	1.7	0.6	2.8	0.51•
XII 80—IX 81	98	39.8	0.77	1.85	2.40	1.3	0.6	1.7	0.25•
VII 82—IX 82	40	60.0	1.73	3.44	1.99	1.5	1.1	4.4	0.09
III 82—X 82	70	64.5	1.66	3.56	2.14	1.4	1.2	3.9	0.41•

DISCUSSION

According to Anikieva et al. (1983) the first intermediate host of *P. umblae* (= *P. conostomum*) may be molluscs of the genera *Pisidium* and *Sphaerium*, the second intermediate host may be lacking and fish become infected directly by eating cercariae leaving molluscs. The intermediate host of *P. umblae* in Lake Yli-Kitka is not known, but sphaerid molluscs are known to occur in northern Finland (Bagge 1968). Butorina (1983) has also found a species of *Sphaerium* to be the intermediate host of this species (as *P. conostomum*) in Kamchatka, USSR. In some other *Phyllodistomum* species it has been noted that cercariae are able to either encyst within the daughter sporocyst in a clam or are shed from the daughter sporocysts and encyst within a second intermediate host, usually aquatic insects (Beilfuss 1954, Thomas 1958, Schell 1967, Chappell 1969, Fallon and Wallace 1977). Chappell (1969), for example, indicated that three-spined stickleback(*Gasterosteus aculeatus* L.) acquires

Phyllodistomum folium (Olfers, 1916) in winter through ingestion of snails harbouring metacercariae encysted within the daughter sporocyst. In spring, summer and autumn, however, infection may be transmitted by insect larvae into which the cercariae have penetrated and encysted. In the case of *P. elongatum* Nybelin, 1926 (Orecchia et al. 1975) and *P. angulatum* Linstow, 1907 (Ivantsiv and Kurandina 1985) the source of infection for fish are the metacercariae encysted inside the caudal part of the free swimming cercariae.

In the whitefish of the Bothnian Bay, Valtonen et al. (1984) found *P. umblae* (as *P. conostomum*) to occur only rarely. Rahkonen (unpubl. data) has, however, found this species to occur frequently in the whitefish and vendace of four lakes in northern Finland, the waterbodies of which are connected via rivers to the Bothnian Bay. In these lakes, two small ones by the River Tornionjoki and two by the River Oulujoki, the level of infections was about the same as in the present case (Rahkonen, unpubl. data). The waters of Lake Yli-Kitka flow via the River Kitkajoki to the White Sea in the USSR. "*P. conostomum*" has also been reported in neighbouring Soviet Karelian lakes (Shulman et al. 1974, Anikieva 1982, Iyeshko et al. 1982, Permyakov and Rumyantsev 1982, Rybak 1982, Anikieva et al. 1983). Lake Yli-Kitka has previously been shown to aspects of its parasitofauna which more closely resemble that to the east rather than that of Scandinavia (Gibson and Valtonen 1981). In the case of *P. umblae*, the prevalence and intensity of infection in most cases in Soviet Karelian lakes are lower than our results (Anikieva 1982, Iyeshko et al. 1982, Permyakov and Rumyantsev 1982, Rybak 1982), although in some lakes Shulman et al. (1974) and Anikieva et al. (1983) report similar or even higher levels of infection than ours.

As to the seasonality of *P. umblae* infections, no clear annual cycle was observed in either the prevalence of infection in the whitefish or the vendace during the present study. Lower values in the intensity of infection during the summer months in the whitefish would have indicated a loss of mature specimens during this period. On the whole, our results point to a continuous invasion and maturation of trematodes. Rahkonen (unpubl. data), however, observed an increasing prevalance and intensity of infection in the whitefish and vendace of Lake Jerisjärvi and Lake Äkäsjärvi during the study period June-September. On the other hand, no seasonal changes were found in the whitefish of Lake Ladoga by Bauer and Nikolskaya (1957) during the period June-November. Elkins and Corkum (1976) found no variation in the prevalences of *P. pearsei* infections in pirate perch *Aphredoderus sayanus* Gilliams, but they only found immature worms between March and May. Similarly, Thomas (1958) found no evidence of seasonal variation in the occurrence of *P. simile* Nybelin, 1926 in brown trout *Salmo trutta* L. An indication of continuous invasion is also given by Chappell (1969) when studying *P. folium* in the three-spined stickleback *Gasterosteus aculeatus* L. According to Chappell the greater proportion of immature worms in the population was recorded in August.

In the present study no clear correlation between *P. umblae* infection and whitefish size and age was found. Bauer and Nikolskaya (1957) and Fallon and Wallace (1977) have presented similar results for the '*P. conostomum*' infection in whitefish of Lake Ladoga and for *P. undulans* Steen, 1938 in mottled sculpin *Cottus bairdi* Girard, respectively. On the other hand, Thomas (1958) found that older brown trout were more heavily infected with *P. simile* than younger fish.

The change in diet and the development of immunity against parasites are the most common explanations for cases where the level of infection does not increase with the increasing age or length of the fish. In our case it is difficult to suggest if either or both of these explanations might cause the situation in the whitefish of

Lake Yli-Kitka. With regard to the vendace the increase in the prevalence as the fish got larger may be due to the small size of the vendace of the area. The vendace of Lake Yli-Kitka are well known for their small size. The dominant age-classes are 1 and 2, but a few fish may reach the age of 5 years (Hyytinen 1985).

Overdispersion in larval trematode infections in the intermediate hosts has been found both under natural conditions (Evans et al. 1981) and experimentally (Anderson et al. 1978). Aggregation of infected intermediate and paratenic hosts may easily cause overdispersion in the definitive hosts also, although as yet we know little about the distribution patterns of adult trematodes in fish.

The overdispersion index of *P. umblae*, unlike that of some other parasites (e.g. Valtonen 1983), only increases with increasing length of the whitefish host until they reach the average length for the population.

The negative binomial distribution usually gives a satisfactory fit to the frequency distributions of parasites as in the present study (see Crofton 1971, Anderson et al. 1978) and the values of parameter k which we calculated are well within the limits most often found in parasitological studies (Anderson et al. 1978).

Acknowledgements. The work was financed by the Natural Sciences Research Council of the Academy of Finland. The authors wish to thank Dr. Juha Viramo, the Head of the Oulanka Biological Station of the University of Oulu for his generous support and help during field work and the fisherman Sulo Peuraniemi for his exellent cooperation in providing us with fish. Dr. D. I. Gibson, British Museum (Natural History), kindly checked the English of the manuscript.

ВСТРЕЧАЕМОСТЬ *PHYLLODISTOMUM UMBLAE* (FABRICIUS, 1780) В МОЧЕТОЧНИКАХ СИГОВ ОЗЕРА ИЛИ-КИТКА В СЕВЕРОВОСТОЧНОЙ ФИНЛАНДИИ

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Резюме. В 1980—1982 гг. авторы провели паразитологические вскрытия 380 экз. *Coregonus* sp. и 260 экз. *C. albula* из озера Или-Китка в северовосточной Финландии. В мочеточниках 33 % *Coregonus* sp. и 38,5 % *C. albula* обнаружили *Phyllodistomum umblae* (Fabricius, 1780) при интенсивности инвазии в среднем 4,2 экз. и 2,3 экз. на рыбу. Сезонные изменения экстенсивности и интенсивности заражения рыб паразитами авторы не наблюдали, молодых и половозрелых сосальщиков встречали в течении всего года. У *C. albula* экстенсивность и интенсивность заражения увеличивается с возрастом хозяина, в случае *Coregonus* sp. повышение зараженности появляется только у рыб длиной 155—194 мм.

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Received 25 June 1986

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