Differences in growth of perch (*Perca fluviatilis* L.) in two small forest lakes

Martti Rask
Lammi Biological Station, University of Helsinki, SF-16900 Lammi, Finland

Keywords: forest water ecosystems, perch, growth, forest lake, population density, bottom fauna, zooplankton

Abstract

Growth patterns and food composition of perch, *Perca fluviatilis* L., was studied in two small forest lake populations in southern Finland. Size and morphometry of the lakes and physical and chemical properties of water are similar. There is a clear difference in the growth rates of perch between the two lakes. The difference in growth is highly significant in all age groups. In the first lake there is a perch population of 2 000 (1 750 ind $\cdot$ ha^{-1}) adult fishes. In the second lake there is a small population of pike, that keeps the perch population down: 200 adult perch (530 ind $\cdot$ ha^{-1}). The main food items of perch are crustacean zooplankton, *Asellus aquaticus* L. and Trichoptera larvae in the first lake and zooplankton, Odonata larvae, Ephemeroptera larvae and Heteroptera in the second.

It is concluded that the main reason for the growth difference of studied perch populations is the different population density. There are also differences in species composition of bottom fauna of the lakes, maybe owing to the floating Sphagnum peat moss vegetation in the second lake. This can also affect the growth difference between the two populations of perch.

Introduction

The perch, *Perca fluviatilis* L., is widely distributed from sea level to over 1 000 m altitude in Eurasia. It has been introduced into Australia and New Zealand (Jellyman 1980) and South Africa. According to Thorpe (1977) it seems prudent to regard Eurasian perch and American yellow perch, *Perca flavescens* Mitchell, as functionally the same.

Perch is adapted to different inland watercourses (Hartmann 1975) as well as Baltic archipelagoes (Neuman 1976). In many small forest lakes perch is the only fish species (Nyberg 1976). In several small forest lakes the fish fauna is represented by only two sizes of perch: small ones feeding on zooplankton and benthos near the shore and larger ones cannibalizing the small ones. Perch is often a source of food for larger predators (Popova & Sytina 1977). In Finnish Baltic archipelago perch can be predator during its first summer, 5 cm long, feeding on gobies (Koli *et al.* 1978). Food items vary among populations and are probably largely dependent on availability of the organisms (Elrod *et al.* 1981).

The growth of perch varies widely between the watercourses. Tesch (1955) grouped the growth rate of perch into 5 categories from very poor, all individuals smaller than 16 cm, to very good, age group 2 over 20 cm.

Small polyhumic forest lakes have some typical features that affect the ecology of perch: small area, dark water, scarcity of nutrients which affect the productivity of the lake and poor oxygen conditions in the hypolimnion. There are few appropriate food species and the perch is often the only species of fish. Since the ecosystem of these lakes is often relatively simple, they present good opportunities to study the interactions between a species and its environment, such as, in this work, the factors affecting the growth of perch.

Hydrobiologia 101, 139–144 (1983).

The lakes

The study lakes are small, polyhumic forest lakes in southern Finland (cf. Arvola, in press) with areas 1.1 and 0.4 hectares and the oxic epilimnion is on average two meters thick.

In the first lake, Lake Horkkajärvi, there is a small population (200 transplanted in 1978) of whitefish, *Coregonus peled* Gmelin, the mean length of which was about 30 cm after the growing season of 1980. No reproduction of whitefish occurs in this lake.

In the second lake, Lake Nimetön, there is a small population of pike, *Esox lucius* L., besides the perch. In the spring of 1979 and 1980, 5–10 individuals ofer 20 cm total length (max. 42.6 cm) were captured and mostly released. Smaller pike (10–20 cm) occurred in both summers, indicating reproductive success in both years.

Material and methods

Fish samples were taken in the ice-free period of 1979 and 1980 at intervals of two weeks from both lakes. Traps were used with a mesh size of 1 cm. Such a trap takes perch of more than 8.5 cm total length. Because of the small size of the lakes, no special fishing places were used. In Lake Horkkajärvi fish were captured along the whole shoreline. In Lake Nimetön there are only two possible places for traps, the rest of the shore is steep with no oxygen at the bottom.

From every catch samples of 10–20 perch (300 in total) from Lake Horkkajärvi and 5–10 (95 in total) from Lake Nimetön were taken for determination of age, growth and food. The length distributions of the samples corresponded to those of catches. Total length (mm) and weight (g, wet weight) were measured, opercular bone for age and growth and stomach for food analyses were collected.

Plots of fish length against opercular bone length were drawn separately for both populations and the procedure given by Le Cren (1947) was followed in determining the growth. In food analyses a volumetric points method was used with a scale of 0–24 points (0 = empty, 12 = half full, 24 = full). The size of populations was estimated in spring 1979 by mark and recapture. The left pectoral fin was cut and length of the marked individuals was measured for length distribution.

Results

1 480 perch were captured and marked from Lake Horkkajärvi in May 1979. Recapture after 3 days gave an estimation of population number 1943 ± 45 (95% conf. limits). The recapture was repeated three days later and the corresponding numbers were 1913 ± 54 (95% conf. limits). The density of perch was thus 1 750 individuals per hectare. No mortality due to marking was observed, the relation of marked fishes to unmarked remained the same during the whole growing season. Later in the summer of 1979 the young of the year class 1978 (1+) grew to catchable size and became the largest length group in the population.

From Lake Nimetön 103 perch were marked, and recaptured in relation 1:1 to unmarked. The estimate of population number 212 ± 53 (95% conf. limits) is the mean of four separate recaptures. The population density was 530 individuals per hectare. Sumari (1971) has given a density value of 700 individuals per hectare as the mean of 22 ponds in Finland. In Lake Suomunjärvi, eastern Finland, the density of perch population is 248 individuals per hectare (Viljanen 1978). There is a clear difference between the size- and age distributions of the studied populations (Fig. 1).

The growth of perch is faster in Lake Nimetön

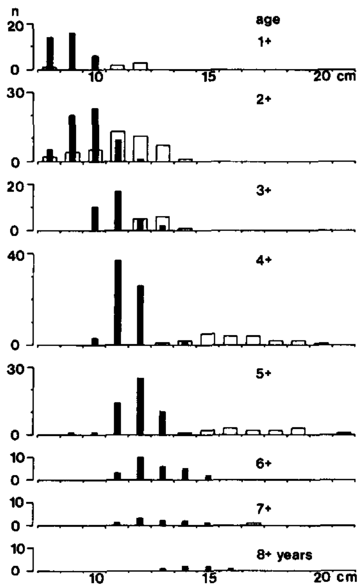

Fig. 1. The age and length distributions of perch. Dark columns Lake Horkkajärvi; white columns Lake Nimetön.

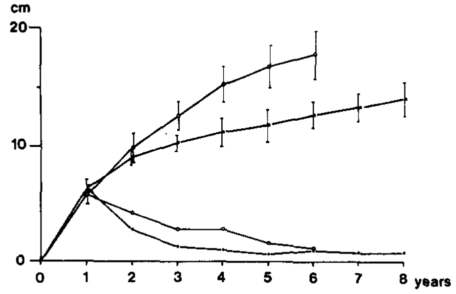

Fig. 2. The growth of perch in Lake Horkkajärvi (dots) and in Lake Nimetön (open circles) and annual length increments.

than in Lake Horkkajärvi except in the first year of life (Fig. 2). The mean weight of 3-year old individuals is 11 g in Lake Horkkajärvi and 21 g in Lake Nimetön, and of 6-year old 22 and 62 g respectively. The difference in growth was highly significant in all age groups (Student's t test, $p < 0.001$). The growth rate is low in both lakes in comparison to several European lakes (Deelder 1951). In growth category (Tesch 1955) the growth of perch is very poor in Lake Horkkajärvi (all fishes smaller than 16 cm) and poor in Lake Nimetön (the mean length of age group 3 less than 16 cm). The interpretation of fish age from the opercular bone of perch from Lake Horkkajärvi was difficult because of many false annual marks which seem to be related to the slow growth rate. This problem did not exist in Lake Nimetön. In both lakes males grow faster during the first two years. After that the growth rate of females is higher. Alm (1959) and Nyberg (1976) have observed the same feature of perch growth. Males attain sexual maturity at the age of two years having a length then of 8–10 cm. Females mature on average a year later, 10–11 cm long in Lake Horkkajärvi and 12–13 cm in Lake Nimetön.

Production and biomass of perch was estimated from population size and growth rate. In 1979 in Lake Horkkajärvi they were 7.9 and 25.0 kg (0.7 and 2.3 g $\cdot$ m^{-2}) and in Lake Nimetön 2.6 and 6.6 kg (0.6 and 1.7 g $\cdot$ m^{-2}, ww.). Corresponding P/B relations were 0.3 and 0.4. In these values the effect of age groups 0+ and 1+ is excluded. The values agree with those reported from Swedish forest lakes (Nyberg 1976). The production and biomass of perch in forest lakes vary from year to year owing to different occurrence of the two youngest age groups, which have relatively better growth and production than the older ones. In Lake Horkkajärvi for example in 1979 the production of the age group 1+ was about the same as the total production of 2+ and older.

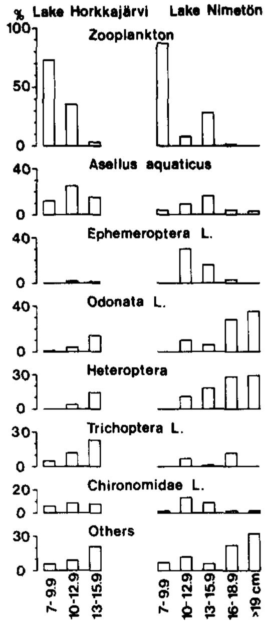

Fig. 3. The food of perch of different length in studied lakes. The values are percent of the total amount of fullness points per length group.

The mortality of 2+ and older perch in Lake Horkkajärvi was 0.3. Mortality in Lake Vitalampa, Sweden, was 0.3 in age group 2+ and 0.26 in older age groups (Nyberg 1976). Craig *et al.* (1979) have given estimates of the proportion of the adult perch population dying per annum varying between 0.34–0.72 during the period 1949–1975 in Windermere.

The main food items of perch are crustacean zooplankton, *Asellus aquaticus* L. and Trichoptera larvae in Lake Horkkajärvi and zooplankton, Odonata larvae, Ephemeroptera larvae and Heteroptera (mostly Corixidae) in Lake Nimetön. Chironomid larvae have equal significance in both lakes (Fig. 3).

The most important groups in benthos are *Pisidium* sp. *Asellus aquaticus* and Trichoptera larvae in Lake Horkkajärvi and Ephemeroptera larvae (especially during early summer) and Odonata larvae in Lake Nimetön (Hiisivuori, unpublished data).

Little cannibalism occurs; only two cases per lake were observed. Zooplankton is most important for small individuals up to 10–12 cm. Zooplankton has a maximum importance in the diet of perch in Lake

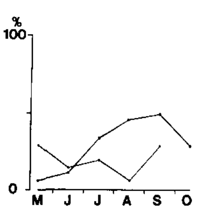

Fig. 4. The share of crustacean zooplankton in the diet of perch in Lake Horkkajärvi (open circles) and Lake Nimetön (dots).

Horkkajärvi in August-September but is less important in the early summer and later autumn. Such a clear variation has not been recorded in Lake Nimetön (Fig. 4). The importance of *Asellus aquaticus* and Ephemeroptera and Chironomid larvae is greatest for fishes 10–16 cm long. The portion of Odonata larvae, Heteroptera and Trichoptera larvae in the diet increases with the size of fish.

In both lakes the food of perch and composition of benthic fauna correspond to each other with a few exceptions. In Lake Horkkajärvi the most abundant species of benthic fauna, *Pisidium,* is not eaten by perch. In Lake Nimetön the importance of Heteroptera as food is greater than one could expect from the composition of the benthic fauna.

Whitefish in Lake Horkkajärvi feed on zooplankton, *Hydracarina* and *Pisidium*. Pike in Lake Nimetön has perch as food.

Discussion

The optimal environmental conditions for perch in lakes are equivalent to those in large, temperate rivers in littoral and sublittoral zone (Kitchell *et al.* 1977). Environmental conditions in small polyhumic forest lakes studied in this work are far from optimal, which can be seen as low growth rates of perch.

The perch population of Lake Horkkajärvi is a stunted one, the population of Lake Nimetön is not. Poor food supply and lack of appropriate prey fish are given as causes of stunted growth by several authors (Alm 1946; Deelder 1951). The latter explanation is not suitable here, because there is no appropriate prey fish population in either of the lakes. The main reason for different growth of perch in these lakes is the different food conditions. This can be caused by different conditions for biological productivity in the lakes, different population densities of perch owing to the existence of pike in Lake Nimetön and different composition and abundance of benthic fauna in the lakes.

The conditions for biological productivity in the lakes are equal (nutrients, oxygen and temperature stratification, etc.). The rate of planktonic primary production is nearly the same (Arvola, in press). So this can not explain the growth difference of perch.

In Lake Horkkajärvi the predation by the perch population on the bottom fauna is stronger than in Lake Nimetön because of its high density (1 750 individuals per hectare). One of the most important food items of 2+ and older perch, *Asellus aquaticus,* has a shift of generation at the beginning of July. When the adult generation of *Asellus* dies, the food supply to perch decreases. The poor availability of Trichoptera larvae at the same time for perch has the same impact. In midsummer only in 1.5 m layer of surface water is there enough oxygen for perch, which makes the littoral zone, the feeding area of perch very narrow. Thus the adult perch must feed on zooplankton more than in the spring or later in the autumn. This is very inefficient because of the feeding habit of perch, 'snipping' one by one, and the high metabolic rate of fish in warm water. Consequently growth is slow or ceases in late summer. Conditions for growth in Lake Horkkajärvi resemble those in Lake Vitalampa in Sweden (Nyberg 1976). The most important food item of whitefish is zooplankton, but the high growth rate of perch of age groups 0+ and 1+ in comparison to those in Lake Nimetön shows that no serious competition of food affecting the growth of perch occurs. Because the optimal growth of perch in these circumstances is unknown, one can not say anything exact about the impact of whitefish on the growth of perch. One can conclude that there is enough food (zooplankton) for the youngest fishes in lakes of that kind, but a severe shortage of food can occur, when the fish, here perch, should change their diet to benthic fauna.

In Lake Nimetön there is no such strong predation on the bottom fauna owing to the smaller density (530 individuals per hectare) of the perch population. Clearly pike predation controls the population density of perch and thus prevents their overgrazing the benthic fauna. The floating Sphagnum peat moss is an inverted bottom which offers a favourable environment for Odonata larvae, Ephemeroptera larvae and Corixidae, which are the most important food items of perch here. Most Ephemeroptera larvae hatch in June–July and are not available for perch in late summer, but according to life cycles of Odonata (Macan 1962) and Corixidae (Pajunen 1977) they are available for perch during the whole growing season. In Lake Nimetön there are enough benthic food organisms throughout the summer. So the portion of zooplankton in the diet of perch is not so significant as in Lake Horkkajärvi. The growth conditions and also the growth, are better during the whole growing season.

References

Alm, G., 1946. Reasons for the occurrence of stunted fish populations with special reference to the perch. Rep. Inst. freshwat. Res. Drottningholm 25, 146 pp.

Alm, G., 1959. Connection between maturity, size and age in fishes. Rep. Inst. freshwat. Res. Drottningholm 40: 5–145.

Arvola, L., in press. Seasonal succession of phytoplankton in two small, polyhumic forest lakes in S. Finland.

Craig, J. F., Kipling, C., Le Cren, E. D. & McCormack, J. C., 1979. Estimates of the numbers, biomass and year-class strengths of perch (Perca fluviatilis L.) in Windermere from 1967 to 1977 and some comparisons with earlier years. J. anim. Ecol. 48: 315–325.

Deelder, C. L., 1951. A contribution to the knowledge of the stunted growth of perch (Perca fluviatilis L.) in Holland. Hydrobiologia 3: 357–378.

Elrod, J. H., Busch, W.-D. N., Griswold, B. L., Schneider, C. P. & Wolfert, D. R., 1981. Food of white perch, rock bass and yellow perch in eastern Lake Ontario. N. Y. Fish Game J. 28: 192–201.

Hartmann, J., 1975. Der Barsch (Perca fluviatilis) im eutrophierten Bodensee. Arch. Hydrobiol. 76: 269–286.

Jellyman, D. J., 1980. Age, growth, and reproduction of perch, Perca fluviatilis L., in Lake Pounui. N. Z. J. mar. freshwat. Res. 14: 391–400.

Kitchell, J. F., Johnson, M. G., Minns, C. G., Loftus, K. H., Greig, L. & Olver, C. H., 1977. Percid habitat: The river analogy. J. Fish. Res. Bd Can. 34: 1936–1940.

Koli, L., Aro, E. & Rask, M., 1978. Tvärminnen ahvenen populaatiotutkimus. Loppuraportti Suomen Akatemian luonnontieteelliselle toimikunnalle. A preliminary research report (in Finnish). Helsinki. 12 pp.

Le Cren, E. D., 1947. The determination of the age and growth of the perch (Perca fluviatilis) from the opercular bone. J. anim. Ecol. 16: 188–204.

Macan, T. T., 1962. Ecology of aquatic insects. Ann. Rev. Ent. 7: 261–288.

Neuman, E., 1976. The growth and year-class strength of perch (Perca fluviatilis L.) in some Baltic archipelagoes, with special reference to temperature. Rep. Inst. freshwat. Res. Drottningholm 55: 51–70.

Nyberg, P., 1976. Production and food consumption of perch in two Swedish forest lakes. Scripta Limnol. Ups. 421, Klotenprojektet Rap. 6: 1–97.

Pajunen, V. I., 1977. Population structure in rock-pool corixids (Hemiptera, Corixidae) during the reproductive season. Ann. zool. fenn. 14: 26–47.

Popova, O. A. & Sytina, L. A., 1977. Food and feeding relations of Eurasian perch (Perca fluviatilis) and pikeperch (Stizostedion lucioperca) in various waters of the USSR. J. Fish. Res. Bd Can. 34: 1559–1570.

Sumari, O., 1971. Structure of the perch populations of some ponds in Finland. Ann. zool. fenn. 8: 406–421.

Tesch, F.-W., 1955. Das Wachstum des Barsches (Perca fluviatilis L.) in verschiedenen Gewässern. Z. Fisch. 4: 321–420.

Thorpe, J. E., 1977. Morphology, physiology, behaviour, and ecology of Perca fluviatilis L. and P. flavescens Mitchell. J. Fish. Res. Bd Can. 34: 1504–1514.

Viljanen, M., 1978. Population studies of vendace (Coregonus albula L.) and perch (Perca fluviatilis L.) in a mesohumic oligotrophic lake. Verh. int. Ver. Limnol. 20: 2103–2110.