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The Food and Population Structure of Perch (*Perca fluviatilis* L.) in Lake Mahinerangi

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Abstract

MONTHLY samples of perch (*Perca fluviatilis*) were taken from Lake Mahinerangi, an artificial hydro-electric impoundment of the Waipori River. Analysis of 82 stomachs showed that Chironomid larvae formed the major part of the annual diet (81%). Other items found were all bottom dwelling species. Analysis of fork-length measurements of 169 perch showed that the mortality was quite high (62%) while the growth rate was low.

INTRODUCTION

THE effect of predation by inland populations of the black shag (*Phalacrocorax carbo*) on freshwater game fisheries have been the subject of controversy for many years. Williams (1945) condemned the bird on account of its trout-eating habits, while Oliver (1955), believes that by preying on eels the shag exerts a beneficial influence on trout populations.

At the moment there is no definite evidence which supports either of these contentions as it is evident that, in order to establish the role the shag plays in freshwater communities, study must be directed to the community of which the shag is a member. The study of the ecological effects of a predator are of no significance without reference to and study of the populations of prey affected by the activities of the predator. Evidence that the major part of the diet of a predator consists of a certain species of prey does not necessarily mean that it is exerting a deleterious effect on that prey species. It can be deleterious in two cases. Firstly, if it eats a sufficient number of the reproductively important individuals (Lokta, 1930) so reducing the reproductive rate and density of the prey species below the optimum. Secondly, if it crops the age group utilised by man. On the other hand it can be beneficial if it crops the surplus individuals from the population, i.e., individuals that (in all probability) would die from some cause other than predation by that particular predator without contributing to the overall

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reproduction of the species or being utilised by man. These individuals of low biological value generally belong to both the young and the old age classes (Fisher, 1929) but also includes a number of unfit individuals from the other age classes. Removal of a proportion of the young classes generally results in an increase in food supply or food availability to the individuals of greater biological value with the result that in many fish populations the average length of the population increases.

The predator can act as a controlling agent to prevent overstocking. Furthermore it can select diseased, malformed or generally unfit individuals so improving the stock. Van Dobben (1952) has presented evidence that the black shag does this in Holland.

The present study was designed to satisfy some of the requirements outlined above. Investigation was directed to supply the essential data on the prey species (trout and perch) as well as the predator (black shag). This paper deals with the perch population. Subsequent papers will deal with the trout and the shag and the control programme.

Morphology and History of Lake Mahinerangi

Lake Mahinerangi is an artificial hydro-electric impoundment of the Waipori River system lying 25 miles west of Dunedin. (South Island, New Zealand. One inch to the mile, topographical map S163 and S162.) The water is slightly alkaline (pH 7.4) but the lake is definitely oligotrophic. The lake lies in a valley at 1,280 feet above sea level. The general area is a tussock grassland with extensive sheep farming and some cultivation and aerial top dressing. In 1862 gold was discovered in the valley (then called "Waipori Flat") and for the next 40 years there was much intensive panning, sluicing and dredging. Various impoundments were built and enlarged in the late 1800's and early 1900's in connection with gold mining as the area is subject to drought. This activity has greatly affected the lake bottom and surrounding area—guts, gullies and gravel pits being common.

The present hydro-electric dam was completed in 1923 (Pairman, 1951). Before this two smaller dams, Loch Luella and Loudon, were built. These remained separated from the main lake until 1946 when the main lake was increased to its present area of 7.6 square miles. Brown trout had been liberated in the Waipori River during the period 1880 till about 1895 (Otago Acclimatisation Society Annual Reports) so that they were already present when the dams were completed. They grew well and Mahinerangi soon became a favourite fishing water.

In the 1930's a landowner liberated some perch in a sluice-hole pond near the edge of the lake. When the size of the lake was increased in 1946 it flooded the sluice-hole and, in spite of considerable efforts by the local Acclimatisation Society, the perch escaped into the lake. They bred rapidly and soon became very numerous. However, their average size is small.

Today they are considered a nuisance since they are too small for sport. Furthermore many anglers believe that they are competing with trout for food and preying on young trout.

Milne (1961) gives as a definition of competition "the endeavour of two (or more) animals to gain the same particular thing, or to gain the measure each wants from the supply of a thing when that supply is not sufficient for both (or all)". The effects of such competition are manifest in such things as reduced mean size, density, natality (or recruitment) or increased mortality. For game fisheries the only factors of direct interest are size and density and so attention was given to these.

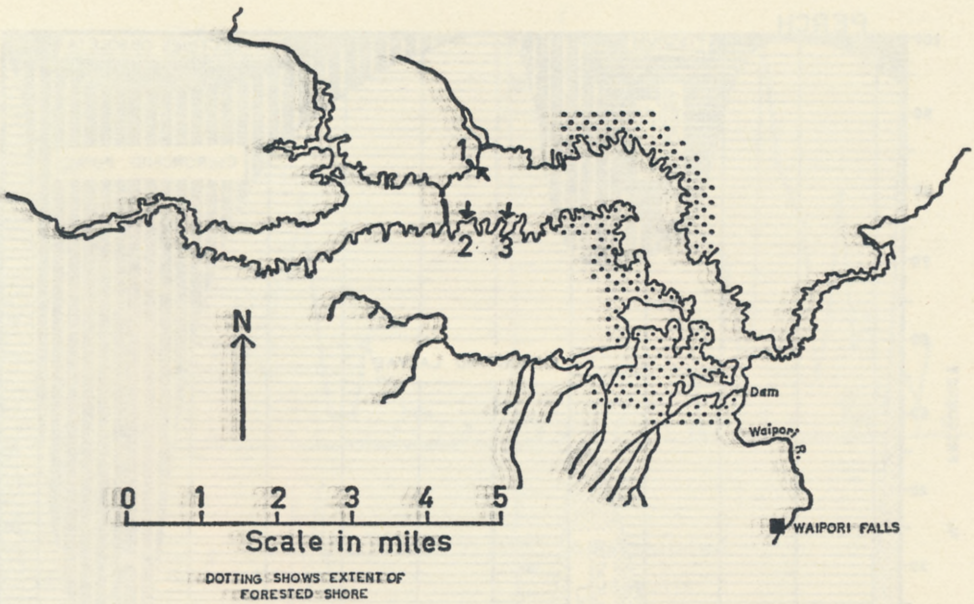

FIG. 1.—Map of Lake Mahinerangi. Sampling stations indicated by an arrow and a number.

Monthly samples of perch were taken with a 2-inch seine net from three different stations. Shore seining sites were severely limited as a pine plantation covers much of the shore line (see Fig. 1) and the lake bottom is not only littered with debris such as trees, fence posts, barbed wire and miner's huts but has also been dissected by the dredging and sluicing operations of the last century.

The fish were sexed, measured for length and weight and their stomach contents analysed. Owing to their habit of migrating to deeper water in winter (Allen, 1935) fewer perch were caught in winter than in summer (see Appendix I).

RESULTS

(a) *Stomach Analysis*

A total of 82 perch stomachs were analysed. The results are presented in Figure 2. Perch under about 12.5cm contained plankton and so were excluded from the figure. The figure is a smoothed graph of the monthly percentage frequency for each of the food species.

(b) *Length Measurements*

The fork-lengths of 169 perch were measured. The results from the three stations are shown in Figure 3. The length distribution of the perch from number one station (mean 16.8cm) were found to differ significantly from the lengths of the other two stations (mean 21.23cm; $P(\chi^2) = 0.001\%$). The area around Station I was probably more suitable in some way for small perch since it is the outlet of North West Creek and food resources (plankton) may be higher there than elsewhere in the lake. It is also a concentrated spawning area. To make the data more homogeneous results from Station I were excluded from the subsequent analysis.

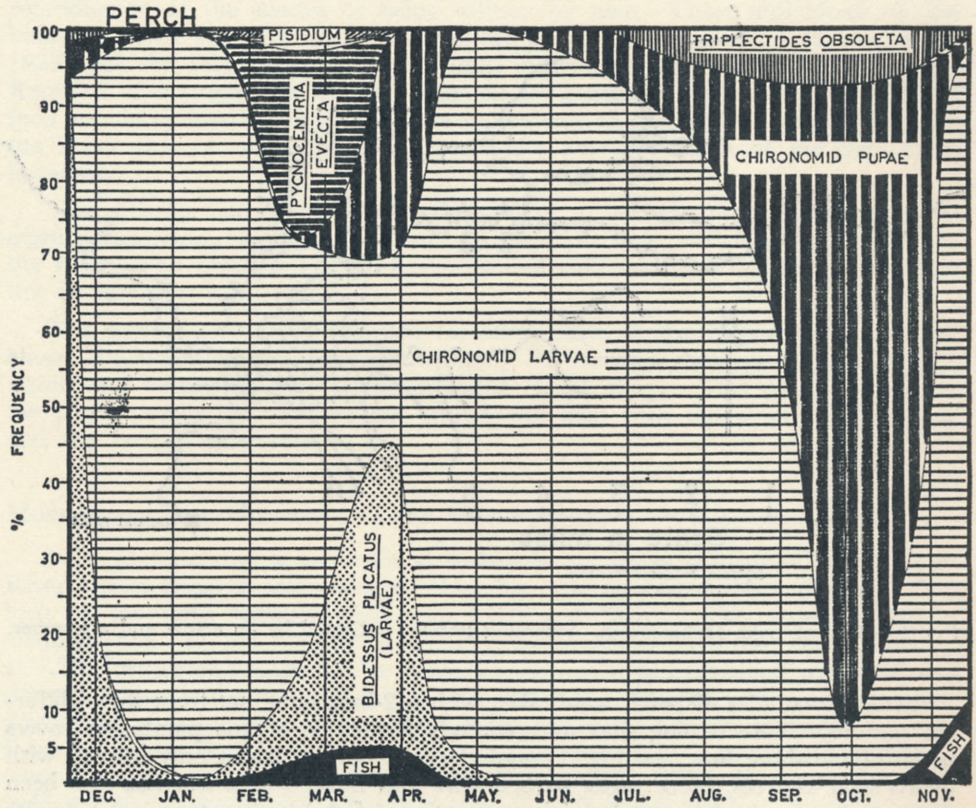

FIG. 2.—Stomach contents of perch.

The length distributions were analysed for polymodality by means of a graphical technique on linear probability paper (Harding, 1949; Cassie, 1954).

The length classes were assumed to correspond to age classes. This assumption may be incorrect as the relation of the relative ages to the absolute ages could not be discovered by aging the scales, otoliths or operculae since these were, in general, unreadable. So it is believed that, in these circumstances, the assumption is justified provided that recognition is made of the possibility that it may be a fallacy.

From this it is possible to estimate mortality rates, growth rates and age distribution (see Table I).

TABLE I.—Polymodal analysis of fork-lengths of perch.

Group	Size of Group as % of Total Pop.	Mean Length (cm)	Standard Deviation	Relative Age
1	10	11.4	1.2	1
2	10	15.75	0.8	2
3	28	18.75	0.8	3
4	29	20.3	0.9	4
5	17	22.6	0.6	5
6	3.5	24.2	0.8	6
7	1.5	26.2	0.8	7

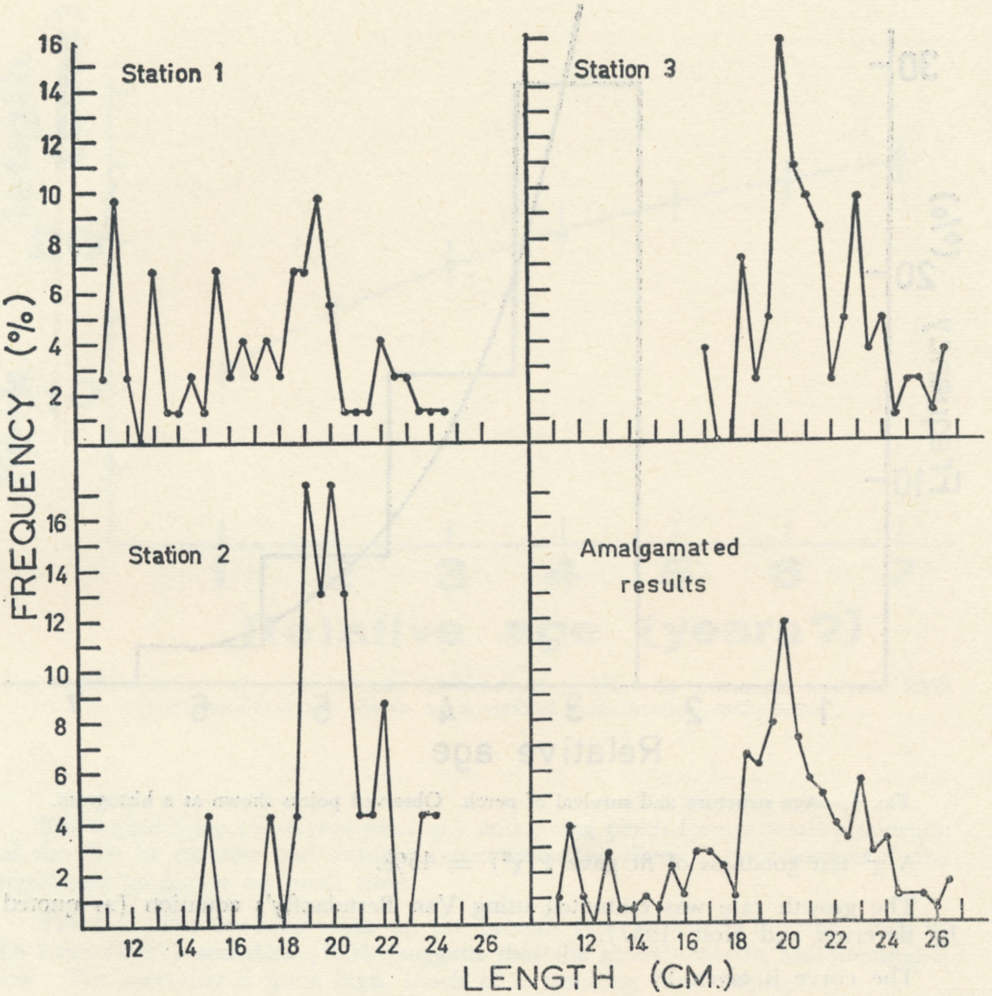

FIG. 3.—Fork-length distributions of perch from three stations.

The mortality rate has been estimated using the equation of Chapman and Robson (1960) which is

$$f(x) = as^x$$

where x is age (in years), s is the annual survival rate, given by

$$s = \bar{x}\,(1 + \bar{x} - n)^{-1}$$

$\bar{x}$ is mean age, n is the number of animals and a is the annual mortality rate given by a = 1–s.

It was suspected that the 2in mesh of the net allowed a proportion of small perch to escape, so groups 1 and 2 of Table I were excluded. The annual survival rate (s) was estimated at 38% and the annual mortality rate (a) at 62%. On substitution we get the curve illustrated in Figure 4.

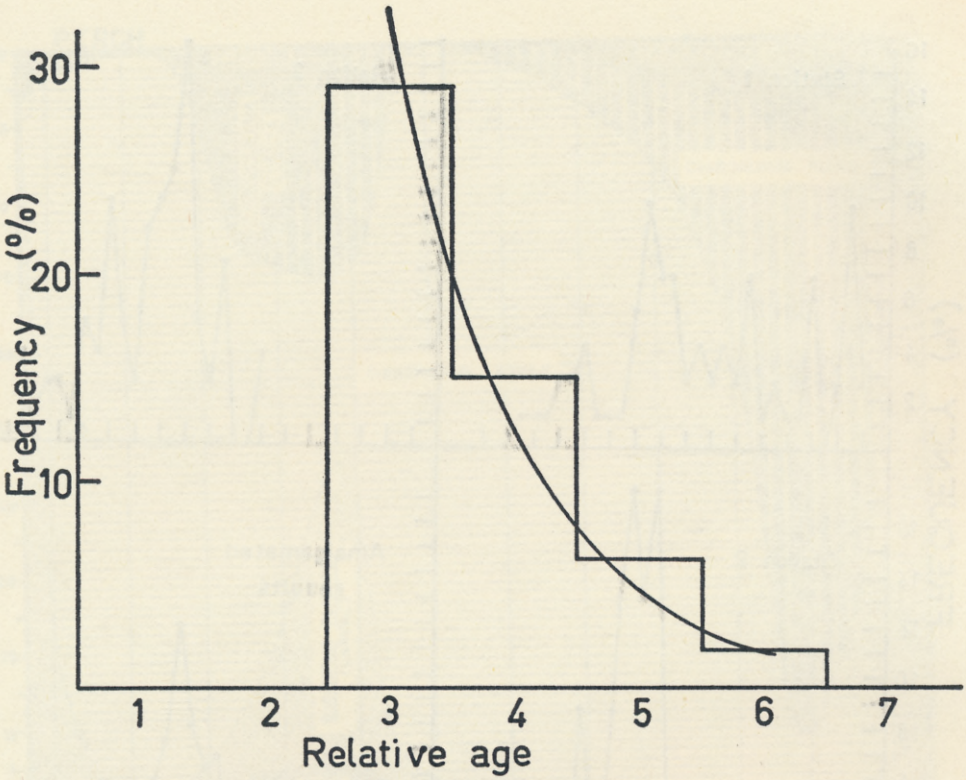

Fig. 4.—Age structure and survival of perch. Observed points shown as a histogram.

A χ^2 test goodness of fit gave $P(\chi^2) = 45\%$.

The growth rate was estimated using Van Bertalanffy's equation (as quoted by Beverton and Holt, 1957).

The curve is given by

$$L_x = L\infty - (L\infty - L_0)e^{-kt}$$

where L is length, x is age (in years), $L\infty$ is the theoretical maximum size as obtained by graphical extrapolation. By trial and error it was found that values of 30cm for $L\infty$ and $k = 0.2387$ gave the best fit (Table II). The theoretical maximum size bears little relation to the actual maximum size as two individuals larger than 30cm were caught—one of 43.1cm, and another of 35.0cm.

The theoretical growth curve and the observed points are shown in Figure 5. $(P(\chi^2) = 90\%)$.

Discussion

Perch feed on only a comparatively small number of bottom dwelling species and they are almost completely dependent on chironomids for most of their food requirements. This is a reflection of the rather small range of organisms found in this oligotropic lake. The seasonal variation in diet follows the availability of the different species to the perch.

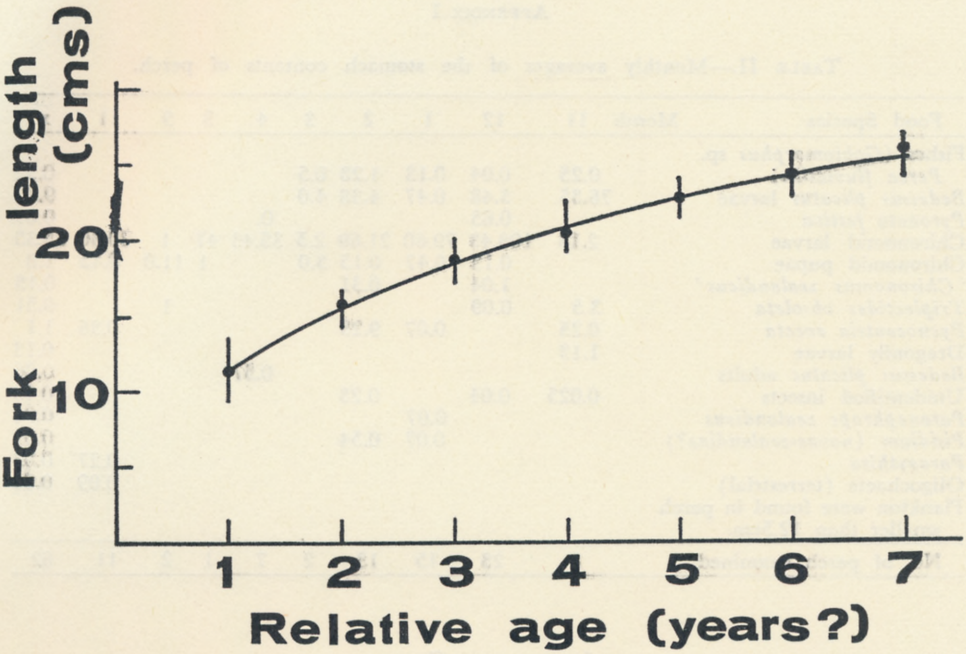

FIG. 5.—Growth rate of perch in Lake Mahinerangi as given by polymodal analysis. 95% confidence limits are shown as a vertical line through each point.

The native bully (*Gobiomorphus* sp.) and young perch form a small proportion of the diet in summer and autumn respectively but there is no evidence of any significant predation on small trout.

There is little available data on the growth rates of perch but the work by Le Cren (1947) and Alm (1951) suggests that the growth rate in Mahinerangi is low. The mortality is quite high, much of it resulting from fishing.

It is evident that some factor is preventing the perch from attaining a better average size. This factor could be the high fishing mortality on the older fishes coupled with overabundant reproduction and subsequent intraspecific competition though it is possible that this oligotropic lake is unsuited for perch on account of either its climate or habitat suitability. It is suspected that there is overabundant reproduction (leading to severe intra-species competition) due to the great number of suitable places for depositing spawn (the branches of submerged trees and shrubs). Further work, as the control programme is carried out, will be directed to this aspect of the problem.

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Appendix I

Table II.—Monthly averages of the stomach contents of perch.

Food Species	Month 11	12	1	2	3	4	5	9	11	$\bar{x}$
Fishes (*Gobiomorphus* sp. *Perca fluviatilis*)	0.25	0.04	0.13	1.23	0.5					0.52
Bedessus plicatus larvae	76.35	3.48	0.47	4.38	4.0					9.72
Pyronota festiva		0.65				0.				0.07
Chironomid larvae	2.13	108.43	79.60	21.69	2.5	35.43	47	1	20.36	35.35
Chironomid pupae		0.13	0.47	0.15	3.0		1	11.0	0.45	1.8
'*Chironomus zealandicus*'		1.04		0.31						0.15
Triplectides obsoleta	3.5	0.09						1		0.51
Pycnocentria evecta	0.25		0.07	9.23					0.36	1.1
Dragonfly larvae	1.13									0.13
Bedessus plicatus adults						0.57				0.06
Unidentified insects	0.025	0.04		0.23						0.13
Paranephrops zealandicus			0.07							0.01
Pisidium (*novae-zealandiae*?)			0.07	0.54						0.07
Paroxythira									0.27	0.03
Oligochaete (terrestrial)									0.09	0.01
Plankton were found in perch smaller than 12.5cm.										
No. of perch examined	8	23	15	13	2	7	1	2	11	82

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