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(Department of the Marine)

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H. A. Dauod, T. Bolger and J. J. Bracken

Zoology Department, University College, Dublin 4.

ABSTRACT

From April to October 1983 monthly samples, totalling 343 trout, were taken from the two reservoirs at Roundwood, Co. Wicklow, using a range of gill nets. In 1984 an extensive electro-fishing programme was carried out in the Vartry River and three other feeder streams, in which 605 trout were obtained. The age data, determined from the scales, showed that there were six year classes in the South Lake and five in the North Lake. The fish from the river and feeder streams were less than 4 years old, 90% belonging to 0 + and 1 + age groups. Trout from the South Lake showed faster growth, attaining 28.7 cm at year 5, compared to 23.2 cm in the North Lake. Only six trout were over over five years old. Sexual maturity was reached during the third year.

The dominant food organisms were trichopteran larvae and pupae (*Limnephilus vittatus*), molluscs (*Potamopyrgus jenkinsi* and *Sphaerium corneum*) and chironomid larvae (*Endochironomus* sp. and *Tanytarsus* sp.).

The species composition of the fauna of both lakes was almost identical, but biomass was greater in the South Lake where the trout populations appeared to be numerically smaller.

The high female to male ratios in the lakes, varying between 1.37 and 1.67 to 1 did not appear to be age related. In the Vartry River and other feeder streams the fish were young, immature and predominantly male. These fish contained many more ephemeropteran nymphs than the lake trout.

The oligotrophic state of the lakes, combined with the fluctuations in water level make it unlikely that any steps can be taken to improve the sport fishery using the native trout. Development of a put and take fishery is recommended.

INTRODUCTION

In recent years decreased catches of brown trout, taken on rod and line, from the Roundwood Reservoirs, have caused anxiety among the Wicklow Anglers who have fished these waters for over fifty years. The present paper reports part of an extensive study which has been carried out in an attempt to explain the poor catches. Two previous papers (Dauod *et al* 1986a, b) have discussed the biology of the minnow and the stickleback within the system. This paper deals with the trout.

The angling club stocked these waters prior to 1961 with a strain of Lough Leven brown trout. Since then the fish in the North Lake have managed to maintain themselves naturally but additional autumn fingerlings from Irish hatcheries have been released in the South Lake on a number of occasions (1968, 1971, 1972 and 1978). Gill net returns indicate that there are still more trout in the North Lake. There is little doubt that the water level fluctuations are likely to cause serious problems for the fish in both reservoirs. The system, which is oligotrophic, is being denuded annually and much of the littoral fauna lost.

Apart from the Vartry River the feeder streams are all very poor in terms of size, suitable feeding and dry flow rates. Little can be done to improve this situation. The slow growth of the trout is directly attributable to these factors. The l_1 values are all small and extremely poor by Irish standards.

One of the major drawbacks with the current investigation was the almost complete lack of scientific data prior to 1982. It is not possible to say how much damage has been caused to the flora and fauna by the fluctuating water levels, nor is it possible to surmise whether or not community structures have altered.

MATERIALS AND METHODS

The Site

The Roundwood reservoir system consists of two man-made impoundments and the feeder streams which serve them. Much of the background information on the two reservoirs has been supplied in Dauod *et al* (1986a) together with details of the fish and flora present, topography and sampling sites.

Fish Data

Braided gill nets, which conform to the specifications listed in Table 1, have been used extensively to sample fish populations from Irish lakes. One train of nets was fished in each lake at Roundwood, once a month, for a twenty four hour period, during the April to October period, 1983. Each train consisted of six nets of varying mesh size which were hung in a random order. Sampling sites were also randomly selected and varied each month (c.f. Fig. 1).

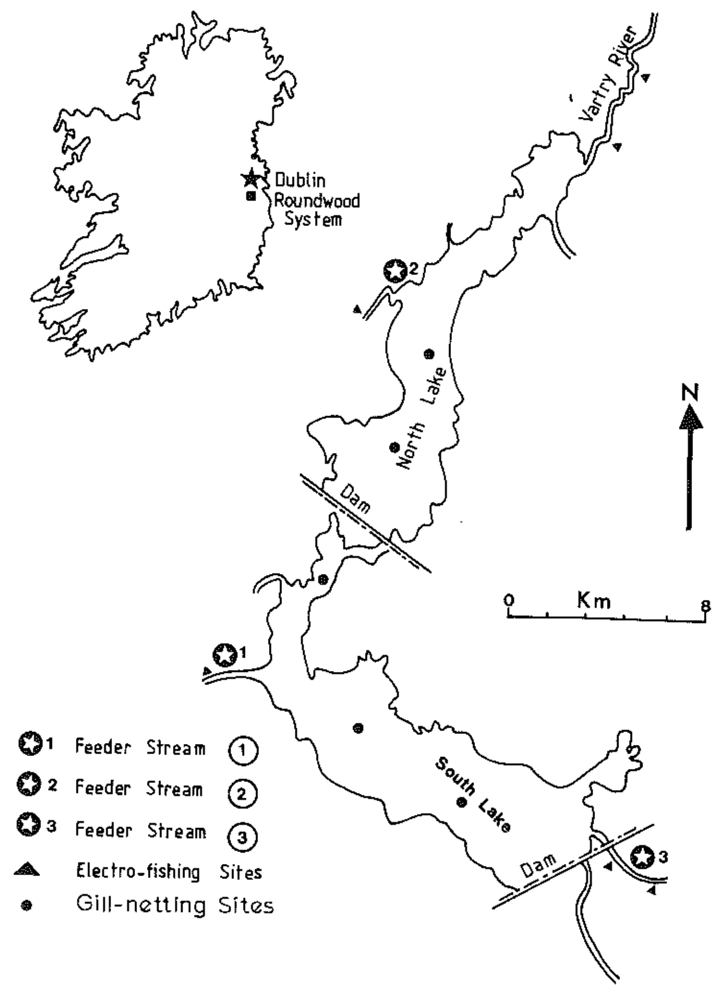

Figure 1. Location map indicating areas sampled using gill nets.

Electro-fishing equipment was used to sample the Vartry River and a number of the main nursery feeder streams entering each lake. The apparatus consisted of an electrical A/C generator (220/230 watts) and a metal framed dipnet (mesh size 7.5 mm.) attached to the unit by an electric cable, thus allowing 30 m. of river to be sampled at a time.

Trout were measured from the tip of the snout to the fork of the caudal fin and then weighed. Scales, which had been removed from in front of the commencement of the dorsal fin, were retained for age analysis. Sex, maturity stages of the gonads and flesh colour were also recorded. The maturity stages were recorded according to Kesteven (1960). Stomachs were removed and placed in 5% formalin. Each food item was later identified and placed into one of thirteen categories whose contribution to the diet of the trout was investigated using the three methods described by Dauod *et al* (1986a), i.e. frequency of occurrence in stomachs, proportional importance based on numbers, and an estimate of "bulk". The weights of a range of individuals of each species were measured and, based on these, weighted averages were calculated for each category. The weight of an individual cladoceran was then taken as the basic unit and appropriate conversion factors (Table 2) used to estimate the relative "bulk" of each category.

Analysis of invertebrate populations

Littoral samples were collected from both lakes during September 1982, June and September 1983 and June and September 1984. A Surber sampler (1/16 m^2 or 0.0625 m^2) was used to collect these samples from five stations in the North Lake and four in the South Lake. A range of station types was selected to cover the different types of habitat available and four replicate samples were taken at each. The range included (1) macrophytic vegetation, (ii) a mixture of sand, gravel and stone substrate, (iii) mud and (iv) stones only. All material was preserved in 5% formalin in the field.

Benthic macroinvertebrates were also sampled on the same dates using an Eckman grab (1/40m^2 or 0.02m^2). Four stations were selected: (i) in the deepest sector of each reservoir, (ii) close to the dam walls, (iii) approximately at the centre of the widest transect and (iv) in the shallow inshore bays. Six replicates were taken at each station.

To supplement the littoral and benthic sampling a scuba diver swam long stretches of the littoral and sub-littoral regions. Additional information on the most abundant food organisms occurring in the stomachs of the brown trout – *Limnephilus vittatus* (Fbr.) (The Cinnamon Sedge) and *Potamopyrgus jenkinsi* Smith – was collected by the scuba diver.

Finally, samples of plankton were collected at four stations in each reservoir using plankton nets (mesh – 0.515 mm.). Vertical and horizontal hauls were taken during June and September 1983 and 1984. As plankton only occurred sporadically in the trout stomachs this section of the programme was not expanded.

RESULTS

Age Structure

Numbers of trout sampled are shown in Table 3. The age structure of the populations, sampled by gill nets of varying mesh sizes in the two lakes, is given in Fig. 2. It is obvious that the nets are selective in the components of the population they sample and it is therefore impossible to determine the age structure of the population from such samples. It is apparent, however, that the population in the North Lake is dominated by three and four year old fish while individuals are more evenly distributed among age classes in the South Lake.

Fish captured by electro-fishing give a more accurate indication of the age structure of a population. The distributions found in the streams are given in Table 4. These differ significantly from one another (X^2 = 87.22, p<.001),the Vartry River having more older fish than the other streams.

Length and Growth

The nmbers of fish examined in each lake, the mean lengths per age class and their ranges are shown in Table 5. These data were analysed using a two-way analysis of variance (Sokal and Rohlf 1981) the results of which are summarised in Table 6.

The largest fish caught were 32.8 cm. (North Lake) and 42.9 cm. (South Lake) respectively. The mean lengths for trout were not significantly different at the end of either their first or second years growth. However, the l_1 values decrease in older fish as did the l_2 values ($p<.05$). From then on lengths appear to be influenced by the lakes in which the fish were caught but the significant interaction terms in the ANOVA make such interpretations difficult. Inspection of the data suggests that these lengths are greater in the South Lake.

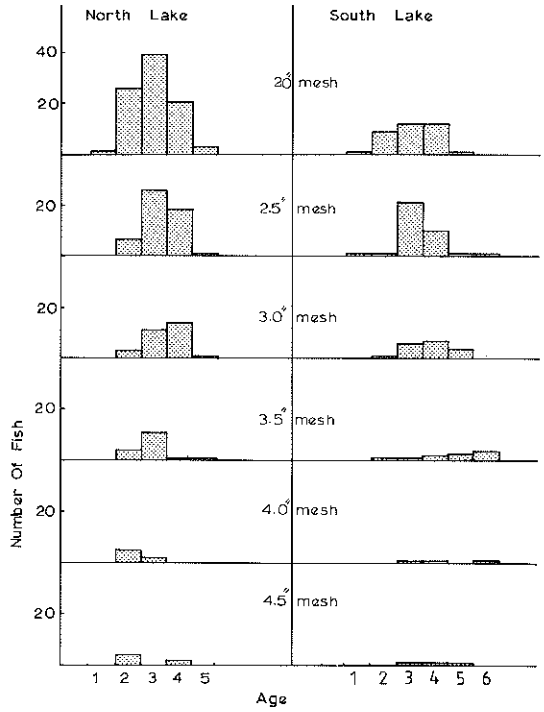

Figure 2. Age structure of brown trout captured using a range of gill nets.

The average growth of fish in both lakes is illustrated in Fig. 3 and Table 7 gives estimates of the true individual growth rates of the fish. These estimates are considered preferable to mean population growth rates because they take the effect of selective mortality of larger individuals into account (Ricker 1975).

A mathematical description of fish growth was calculated using Beverton's approach as described by Ricker (1975). This provided the von Bertalanffy equations given below:

North Lake

$$l_t = 28.5\,(1 - e^{-.45\,(t-.62)})$$

South Lake

$$l_t = 44.5\,(1 - e^{-.23\,(t-.54)})$$

where l_t is the length of fish at time t and e is the base of natural logarithms. The constants 28.5 and 44.5 are the asymptotic lengths, ∞ for the fish in the two lakes. These agree quite closely with the maximum lengths quoted earlier.

Most of the fish captured in the rivers were in their first or second years (Table 4), therefore only their lengths at the end of their first year could be compared. The mean lengths and standard errors are given in Table 8. The l_∞ of fish from the Vartry River and Feeder Streams 2 and 3 are significantly larger than those from Feeder Stream 1 ($F = 7.88$, $p<.001$). This is thought to be related to the fact that this stream has a muddy substratum which may be unsuitable for many of the trout food items.

Length – Weight Relationships

The length – weight relationships were analysed by comparing the geometric mean regression coefficients of $\log_{10}$ weight on $\log_{10}$ length using the approximate method of Gabriel (Sokal and Rohlf 1981). The relationship varied significantly among the six sampling sites (Table 9), fish from the North Lake being heavier at a given length than those from other sites. The relationship was also affected by age, stage of maturity and sex. The largest regression coefficients were found for four year old fish (Fig. 3) and those at earlier maturity stages (Fig. 4). However, it is believed that the latter effect arises because the fish feed most actively at the times of year when they are not reproducing. The effect of sex differed among the sampling sites. In the South Lake, Vartry River and Feeder Stream 3 the coefficients were larger for females but the opposite was true in Feeder Stream 1. No significant differences were found at the other sites (Table 10).

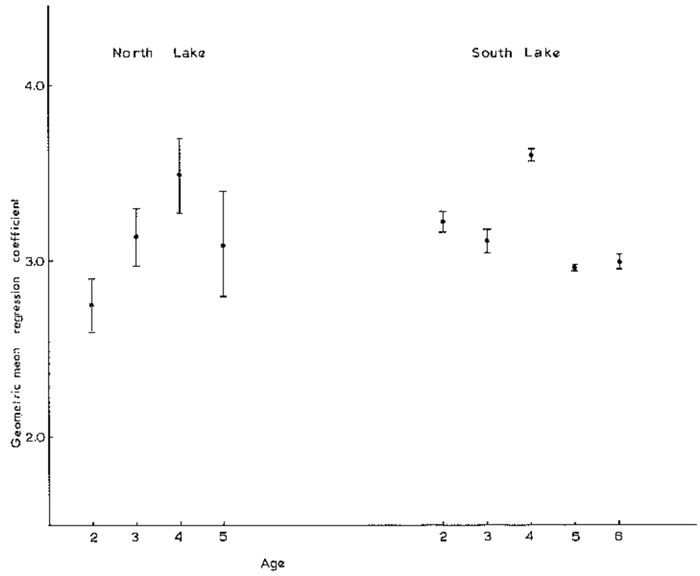

Figure 3. Geometric mean regression coefficients of $\log_{10}$ weight on $\log_{10}$ length ($\pm$95% comparison intervals) for brown trout from the North and South Lakes, Roundwood, related to age group.

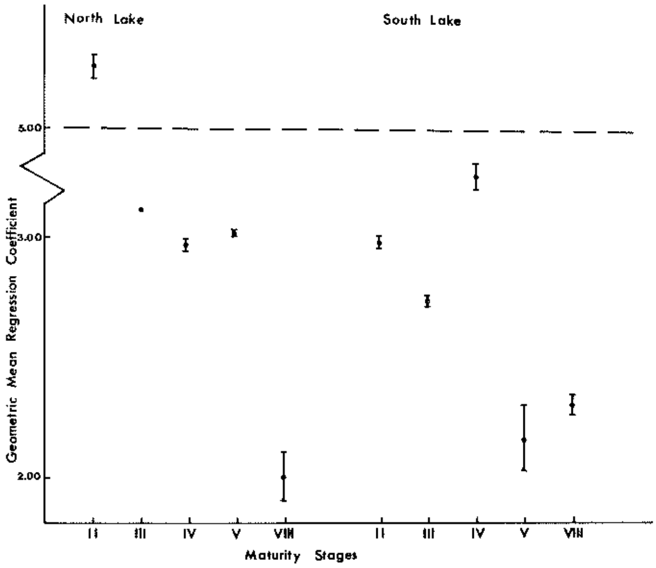

Figure 4. Geometric mean regression coefficients of $\log_{10}$ weight on $\log_{10}$ length ($\pm$95% comparison intervals) for brown trout from the North and South Lakes, Roundwood, related to maturity.

Sex Ratios

The sex ratios off the fish from both lakes are given in Table 11. In the North Lake the ratio differs significantly from 1:1 (X^2= 15.4, p<.001) but no such difference was observed in the South Lake (X^2= 4.65, n.s.).

Sex ratios were similar in all four rivers (X^2= 4.65, n.s.) all of the sites being dominated by males (Table 12).

Maturity Stages

The maturity stages of the fish from the lakes on each sampling occasion are given in Table 13. It is obvious that the fish mature late in the season, stage IV appearing in July and stage V in August. Stage VII was not observed as no sampling took place between October and April.

In the Vartry River 74.4% of the sampled fish were in Stage I and a further 17.2% were at Stage II. Only in October 1983 and September 1984 were more mature fish encountered.

Flesh Colour

All the fish from the feeder streams were white fleshed but those from the lakes were a mixture of pink or white fleshed individuals. In the South Lake 59.1% of the fish were pink fleshed while a significantly smaller proportion (44.3%) occurred in the North Lake (X^2= 4.78, p<.05).

Food and Feeding

Table 14 lists the frequency of occurrence of the food categories. All thirteen categories appeared in the diets of fish from the lakes. Surface insects were adults of aquatic species such as Corixids and non-aquatic species such as the Coleoptera, *Philonthus* sp. and *Aphodius* sp., and the dipteran, *Dilophus febrilis* (L.). Larval and pupal chironomids were mainly *Endochironomus* sp., *Tanytarsus* sp. and *Procladius* sp. The dominant zooplankton were *Daphnia* sp. while *Caenis* spp. were the most important ephemeropteran nymphs. Trichopteran larvae were represented by *Limnephilus vittatus* (Fbr.) and *L. lunatus* Curt. The most frequently encountered molluscs were *Potamopyrgus jenkinsi* (Smith), *Lymnaea peregra (Muller), Physa fontinalis* (L.) and *Sphaerium corneum* (L.). The category "chance food" was made up of items such as earthworms, nematodes, fish lice, plant parts and the empty cases of caddis fly larvae. Four fish species, stickleback, minnow, trout and stoneloach, were found in the stomachs, however, only the first two of these were of any importance.

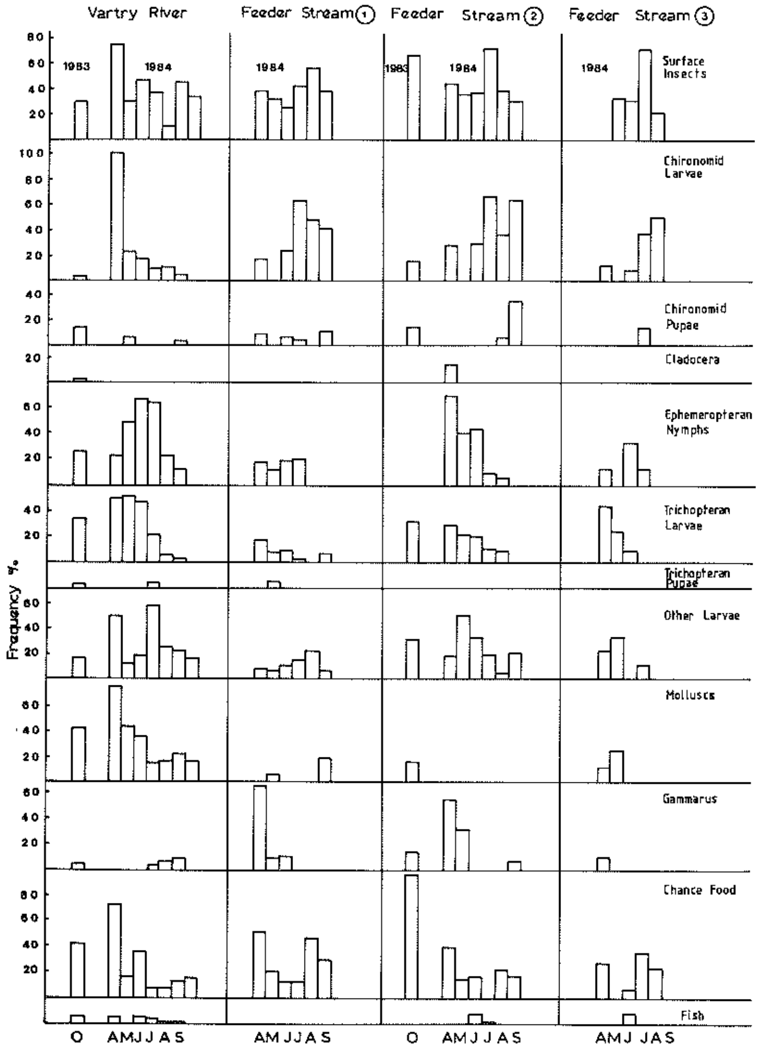

Figure 5. Frequency of occurrence of each food category in fish which were feeding in the North and South Lakes, Roundwood.

The most frequently occurring food items in the stomachs of the lake trout were trichopteran larvae, molluscs and chance food (Table 14). The former two categories however, occurred more frequently in the fish from the South Lake ($p<.05$). Fish, because of their size, made up 1.8% of the food "bulk" in the North Lake and 5% in the South Lake. The seasonal changes in the proportional composition of the diet are illustrated in Figs. 5, 6 and 7. The most significant of these is the change over from trichopteran larvae and pupae to zooplankton which occurs in both lakes when the caddis emerge in late June and early July.

Surface insects, ephemeropteran nymphs and other insect larvae occurred more frequently in the diets of the fish from the feeder streams but Copepoda did not occur at all. Categories such as trichopteran pupae and Cladocera, which occurred regularly in the diet of fish from the lakes, were virtually absent (Table 15). There were different dominant dietary items recorded from the stomachs examined for each stream and at different times of the year (Figs. 8, 9 and 10).

The major difference in terms of numerical importance between the rivers is that chironomid larvae are important in the three feeder streams while other dipteran larvae are important in the Vartry River.

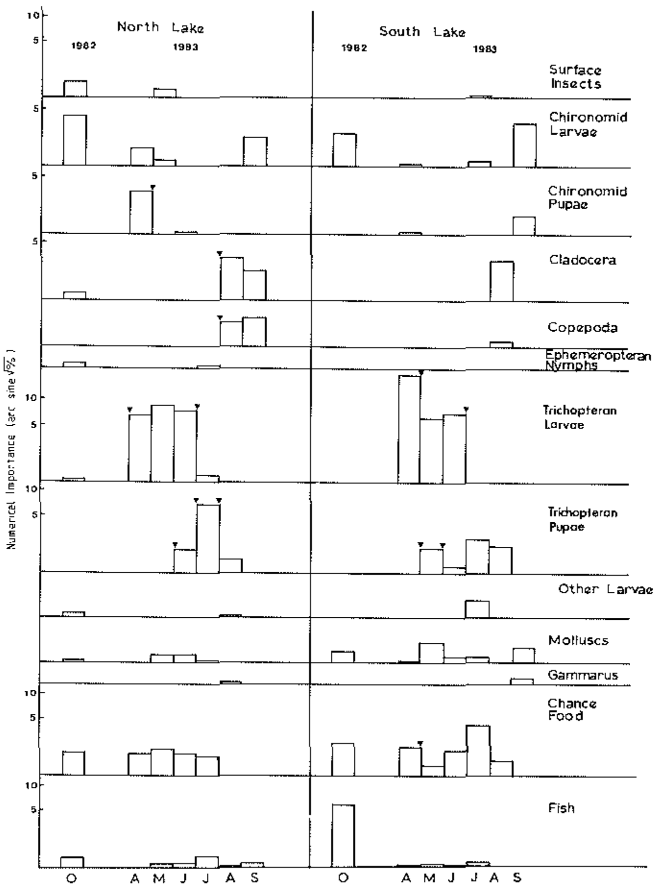

Figure 6. Numerical importance (arc sine √%) of each food category in the diet of the brown trout from the North and South Lakes, Roundwood.
▼ = Significant difference between consecutive dates (p<.05), tested using Bonferroni t-statistic.

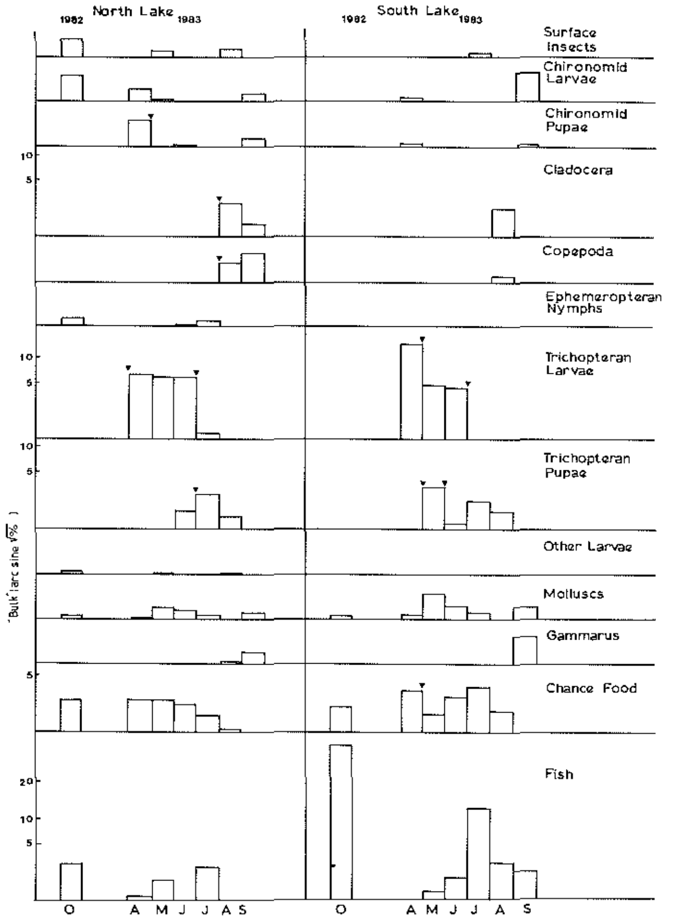

Figure 7. Contribution of each food category to the "bulk" (arc since√%) of the diet of the brown trout from the North and South Lakes, Roundwood.
▼ = Significant difference between consecutive dates (p<.05), tested using Bonferroni t-statistic.

Faunal Collections

A list of the species obtained is given in Table 16. As would be expected the list is almost identical for both reservoirs and is reasonably typical of the Wicklow area (O'Connor and Bracken 1978). *L. vittatus, P. jenkinsi* and *Endochironomus* sp. were predominant and this is reflected in the diet of the trout, meaning that the trout are mainly bottom feeders. The distribution of these species was examined by a scuba diver who swam large sections of the littoral and sub-littoral regions of the North Lake. In retrospect the date on which this was carried out was too late as *L. vittatus* tends to hatch from mid-June to mid-July. Nevertheless the results are of interest *L. vittatus* was present in large numbers only at the mud interface. It was totally absent from the weed. High numbers occurred in the 6 - 7m. region (10 - 20 per (m$_2$) but they were aqbsent from 9m. onwards, the numbers tapering off with depth. Low numbers of *L. vittatus* occurred on the gravel and stones (2 - 10 per m^2) but the numbers of *P. jenkinsi* were quite high (< 50 per m$_2$). Similar results were obtained from the littoral samples where over 70% of molluscs were *P. jenkinsi* and *S. corneum, L. vittatus* accounted for more than 80% of the trichopteran larvae and *Endochironomus* sp. and *Orthocladius* sp. made up over 70% of the littoral chironomids.

In the benthic samples *Endochironomus* sp. *Orthocladius* sp. and *Procladius* sp. dominated.

DISCUSSION

By Irish standards the growth of the trout in the two reservoirs is extremely poor. This is not unexpected as, like most of the waters in Co. Wicklow, both lakes are oligotrophic. Wicklow trout are amongst the smallest lake trout in Ireland exhibiting slow growth patterns. Most Irish workers including Southern (1932a, b, c, 1935), Frost (1939, 1945), Went and Frost (1942), Went (1943), Kennedy and Fitzmaurice (1971), Whelan (1974) and O'Grady (1981) agree that optimal trout growth is achieved in limestone waters. Raymond (1938) had already established this fact for trout in the British Isles. It is also generally accepted that where trout are plentiful, as well as fast growing, there is always an abundant food supply. The lack of calcium in the water and the paucity of the invertebrate fauna militate against the Roundwood fish. One further complication in Roundwood is the severe water level fluctuations which occur annually in both reservoirs. These fluctuations adversely affect the productivity of macroinvertebrates. Much has been written on this topic. Rawson (1958), Miller annd Paetz (1959), Grimas (1961), Hynes (1961), Fillion (1967) and Hunt and Jones (1972) have commented on major changes in the community structure of the littoral and benthic fauna resulting from such fluctuations. The severity of the damage depends on the morphology of the lake basin. Small changes in water level may sometimes uncover large stretches of the littoral zone. This in turn causes extensive damage to the macrophytes thus reducing the extent of available habitat for the aquatic organisms. During 1983 and 1984 most stretches of the inshore areas of the Roundwood lakes were uncovered causing widespread damage to the already poor, oligotrophic fauna. The low water levels also forced the cessation of angling long before the end of the season. All feeder streams were reduced to mere trickles.

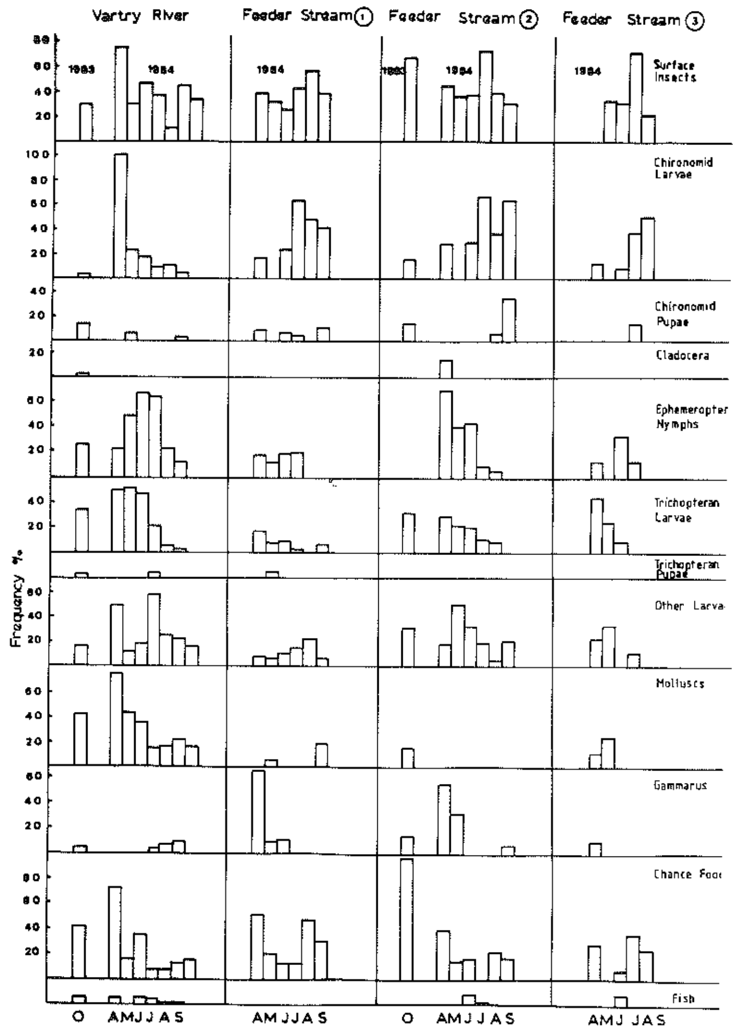

Figure 8. Frequency of occurrence of each food category in fish which were feeding in the feeder streams of the Roundwood Reservoir System.

The comprehensive review papers of Frost and Brown (1967), Campbell (1971) and Kennedy and Fitzmaurice (1971) for trout from the British Isles agree that few trout survive beyond five years. The Roundwood fish conform with this general pattern, however, their growth rates are slow and lie at the lower end of the scale. The growth is amongst the poorest recorded from ninety Irish lakes and compares with data from certain northern Scottish Lochs. The l_1 values are especially poor, a factor thought to be correlated with the limitations placed on the fish during their early development in the feeder streams.

Campbell (1957) has shown that most trout in Scotland spend the first two years of life in the nursery streams before migrating downstream into the lochs. Upon arrival in the lochs most of the trout tend to feed heavily on a planktonic diet, particularly Cladocera. They are rarely taken by anglers using artificial flies at this stage of the life-cycle. They are forced, because of the increased spacing of their gill rakers, to change gradually to a diet of macroinvertebrates. This diet would include a wide variety of food items such as molluscs, gammarids, asellids and aquatic insects (nymphs and larvae). Seasonal variation in the abundance, size or vulnerability of some food organisms often cause trout to concentrate on intensive intermittent feeding followed by spells of inactivity. This occurs during periods of insect emergence and when large shoals of fish fry appear. It often leads to a situation where many available food organisms are left uncropped.

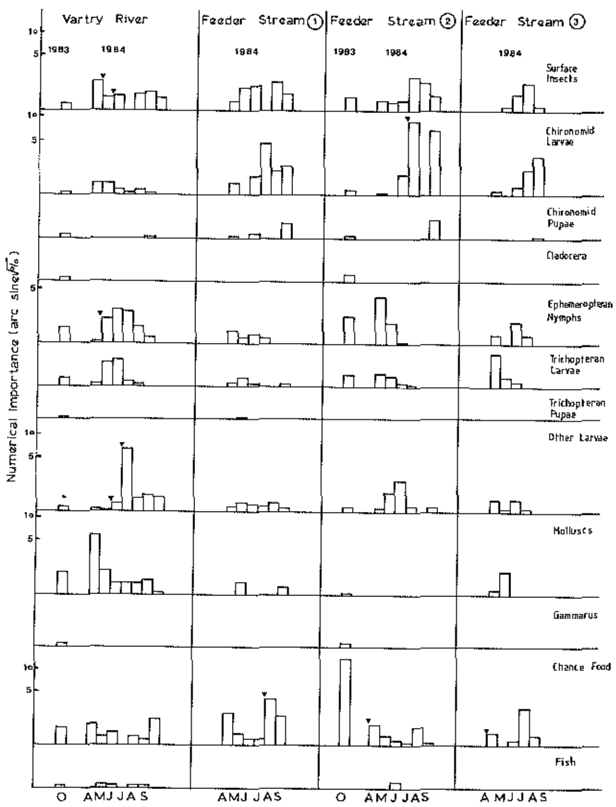

Figure 9. Numerical importance (arc sine √%) of each food category in the diet of the brown trout from the feeder streams of the Roundwood Reservoir System.
▼ = Significant difference between consecutive dates (p<.05), tested using Bonferroni t-statistic.

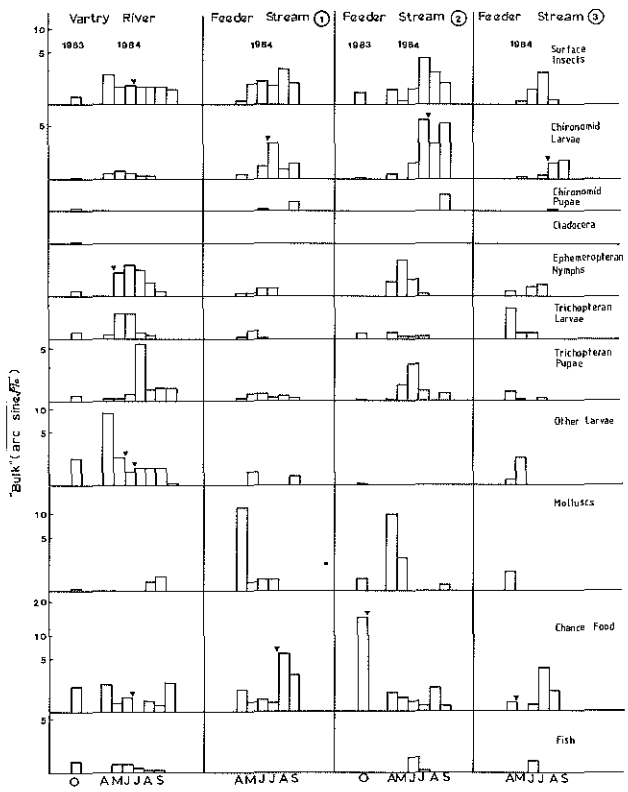

Figure 10. Contribution of each food category to the "bulk" (arc sine √%) of the diet of the brown trout from the feeder streams of the Roundwood Reservoir System.
▼ = Significant difference between consecutive dates (p<.05), tested using Bonferroni t-statistic.

At Roundwood most of the trout move into the lake at two years of age but they do not feed on cladocerans as has been described for other waters. The dominant food organisms found in the trout from April to July included trichopteran larvae and pupae (*L. vittatus*), the mollusc (*P. jenkinsi*), and chironomid larvae (*Endochironomus* sp. and *Tanytarsus* sp.). After the emergence of *L. vittatus* a dramatic change occurred whereby 23% and 50% of the trout stomachs from the North and South Lakes respectively, were empty. Many stomachs contained fish (minnow and stickleback). Surprisingly the diet in August was mainly cladocerans and copepods in both lakes, irrespective of fish size or age. Trout in the North Lake fed on plankton and chironomids during September, while in the South Lake they concentrated on *S. corneum* and chironomids. Essentially this means that the fish were bottom feeders with a brief switch to plankton feeding during August. *Mystacides longicornis* L., a second trichopteran, was abundant in each lake after the emergence of *L. vittatus* but was ignored by the trout. This is thought to be related to its small size. Minnow on the other hand fed heavily on this small caddis fly (Dauod *et al* 1986a). The preponderance of *L. vittatus* in the reservoirs and in the diet of the trout is coupled with the high numbers of the species readily available in the littoral zone, together with its obvious ability to cope successfully with the fluctuating water levels.

Dauod, *et al* (1986b) demonstrated that sticklebacks were not obvious competitors for food with either trout or minnow. Both these species do however, share to some extent the same food organisms for at least half of the feeding season. The minnow concentrate on cladocerans and surface insects for longer periods of the season than do the trout. In an oligotrophic system, such as Roundwood, the presence of large populations of minnow could be considered problematical where the food chain is so meagre. Their contribution to the diet of brown trout appears to be minimal and confined to a short period following the emergence of *L. vittatus*.

In terms of fishery management it is difficult to see how any major improvement may be made while the system is subjected to such severe annual water level fluctuations. The analysis of the diet shows that the vast majority of the trout are bottom feeders and rarely feed on surface insects. With the disappearance annually of the littoral zones in each lake large numbers of macroinvertebrates must be killed off.

The high female to male ratio in the North Lake appears to be exceptional for brown trout. In most cases such ratios are in the region of 1:1 to 1:1.6 (Stuart 1953, Munro and Balmain 1956, Treasurer 1976, Campbell 1977) and in many cases these are not significantly different from 1:1 (McFadden *et al* 1962). The most commonly cited cause of high female to male ratios is the progressive decrease in the proportion of males in older age groups (McFadden *et al* 1962), however, no such decrease was observed in this instance and ratios did not change as the fish aged (Table 11).

The study has shown that the brown trout populations of the reservoirs are slow growing. The oligotrophic state of the lakes combined with the damage to the littoral fauna from fluctuationns in water level means that it will not be possible to improve fishing by managing the native stocks. Better angling results would be achieved by selective restocking with low numbers (not exceeding 250 fish) of yearling trout twice or three times a year in each lake. It is appreciated that such a recommendation is repugnant to most off the anglers. Nevertheless it would provide better returns and should at least be given a trial as it is the only course of action which will improve the current situation until the fluctuating water levels are corrected.

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TABLE 1. Data on the nature and construction of the gill-nets used.

	Stretched mesh size – cm (ins.)					
	5.08 (2.0)	6.35 (2.5)	7.62 (3.0)	8.89 (3.5)	10.16 (4.0)	11.43 (4.5)
Hanging Coefficient	1 : 125	1 : 1.6	1 : 1.3	1 : 1.6	1 : 1.3	1 : 1.5
Net Length (Hung) (m.)	27.5	27.5	27.5	27.5	27.5	27.5
Depth (Hung) (m.)	2.0	2.0	2.0	2.0	2.0	2.0
Twine size	1.5 Z Nylon netting twine for all mesh sizes.					
Breaking Strain	13 lbs.					
Colour	Green (Bridport Gundry Dye Code 24)					

Hanging Coeficient – Ratio of completed net to stretched length

TABLE 2. Weighted averages for weights of each food category and the conversion factors used in estimating their "bulk".

Food Category	Weighted Average Weight per item (g)	Conversion Factor
Cladocera	2.95×10^{-4}	1
Copepoda	3.35×10^{-4}	1
Chironomid pupae	4.00×10^{-3}	14
Chironomid larvae	4.13×10^{-3}	14
Ephemeropteran nymphs	6.51×10^{-3}	22
Other larvae	7.16×10^{-3}	24
Trichopteran larvae	8.10×10^{-3}	27
Trichopteran pupae	8.00×10^{-3}	27
Surface insects	1.10×10^{-2}	37
Mollusca	1.30×10^{-2}	44
Chance Food	1.39×10^{-2}	47
Gammarus duebeni	9.58×10^{-2}	317
Fish	2.00	6780

TABLE 3. Sample sizes on each sampling date at each site.

	North Lake	South Lake	Vartry River	Feeder Stream 1	Feeder Stream 2	Feeder Stream 3
9 October '82	39	9	15	–	–	–
28 April '83	19	24	–	–	–	–
17 May '83	30	29	–	–	–	–
14 June '83	53	20	40	16	11	–
12 July '83	43	18	–	–	–	–
16 August '83	43	11	–	–	–	–
16 September '83	15	10	–	–	–	–
14 October '83	–	–	35	–	7	–
10 April '84	–	–	4	23	7	10
22 May '84	–	–	19	15	6	4
14 June '84	–	–	17	25	11	12
11 July '84	–	–	26	37	44	16
15 August '84	–	–	52	25	28	7
7 September '84	–	–	43	17	26	–
10 October '84	–	–	7	–	–	–
Totals	242	121	258	158	140	49

TABLE 4. Age structure of brown trout populations in the Vartry River and in the main feeder streams of the Roundwood system.

	Age Class			
Location	0	I	II	III
Vartry River	51	87	30	10
Feeder Stream 1	57	69	1	0
Feeder Stream 2	87	35	2	1
Feeder Stream 3	22	21	2	0
Totals	217	212	35	11

TABLE 5. Means and ranges of lengths of brown trout at the end of each growth period.

Age	Number of Fish	Length at Age 1	2	3	4	5	6
North Reservoir							
5	5	4.2 (3.2-5.1)	8.1 (6.6-9.0)	11.6 (9.6-14.0)	18.6 (15.5-21.0)	23.2 (18.5-26.3)	—
4	55	4.4 (2.6-7.2)	10.3 (5.8-17.3)	17.3 (12.0-28.5)	2.4 (18.2-31.4)		
3	90	4.9 (2.9-8.1)	12.8 (6.0-22.0)	20.5 (12.8-28.0)			
1	1	5.2 (5.2-5.2)					
Overall		4.8 (2.6-9.0)	12.5 (5.8-22.0)	19.0 (9.6-28.5)	22.2 (15.5-31.4)	23.3 (18.5-26.3)	
South Reservoir							
6	6	4.0 (2.8-6.0)	8.8 (6.4-12.3)	15.0 (9.9-19.7)	21.5 (15.0-28.5)	26.0 (18.8-31.4)	30.7 (23.0-36.5)
5	10	4.8 (3.0-7.2)	10.9 (7.9-15.1)	20.4 (13.4-27.0)	26.1 (19.8-29.8)	30.4 (23.6-34.5)	
4	33	4.6 (2.9-8.2)	10.6 (5.8-19.2)	18.0 (9.0-25.0)	24.3 (14.1-29.5)		
3	42	5.0 (3.0-8.3)	13.6 (6.0-21.8)	21.7 (14.0-27.2)			
2	12	5.5 (2.8-7.8)	13.5 (9.2-18.1)				
1	2	5.7 (5.2-6.1)					
Overall	4.9	12.1 (2.8-8.3)	19.7 (5.8-21.8)	24.3 (9.0-27.2)	28.7 (14.1-29.8)	30.7 (18.8-34.5)	(23.0-36.5)

TABLE 6. Summary of analysis of lengths of brown trout (F-values).

	Source of Variation		
Variable	Lake	Age	Interaction
Length at Age 1	1.922 n.s.	5.34 (p<.001)	.11 n.s.
Length at Age 2	1.166 n.s.	24.05 (p<.001)	1.69 n.s.
Length at Age 3	9.97 (p<.001)	28.47 (p<.001)	8.00 (p<.001)
Length at Age 4	18.36 (p<.001)	.11 n.s.	10.86 (p<.001)
Length at Age 5	4.53 (p<.05)		

TABLE 7. Mean individual growth rates in length of brown trout.

	Age Interval				
	1-2	2-3	3-4	4-5	5-6
North Lake	1.03	0.47	0.25	0.22	—
South Lake	0.90	0.47	0.30	0.15	0.50

TABLE 8. Mean lengths of fish from the feeder streams at the end of their first years growth.

	Mean	Standard Error	Number of Fish
Vartry River	5.60	0.09	178
Feeder Stream 1	4.88	0.09	84
Feeder Stream 2	5.42	0.17	49
Feeder Stream 3	5.44	0.22	23

TABLE 9. The geometric mean regression coefficients of $\log_{10}$ weight on $\log_{10}$ length and 95% comparison intervals for the trout from the six sampling sites.

Site	GMR	Comparison Intervals
North Lake	3.81	.32
South Lake	2.91	.19
Vartry Rvier	3.04	.03
Feeder Stream 1	2.99	.07
Feeder Stream 2	3.05	.05
Feeder Stream 3	3.03	.12

TABLE 10. The geometric mean regression coefficients of $\log_{10}$ weight on $\log_{10}$ length and 95% comparison intervals for trout at each sampling site, related to sex.

Site		GMR	Comparison Intervals
North Lake	Male	3.3035	.085
	Female	3.054	.013
South Lake	Male	2.827	.007
	Female	2.943	.011
Vartry Rvier	Male	3.027	.005
	Female	3.065	.008
Feeder Stream 1	Male	2.997	.009
	Female	2.930	.001
Feeder Stream 2	Male	2.967	.002
	Female	2.964	.002
Feeder Stream 3	Male	2.962	.018
	Female	3.054	.028

TABLE 11. Sex ratios of brown trout from North and South Lakes related to age.

Age	North Lake Males	North Lake Females	South Lake Males	South Lake Females
1	0	1	2	0
2	26	34	9	10
3	33	76	17	25
4	25	34	13	21
5	4	4	5	6
6	1	0	3	3
	χ^2 = 6.70 n.s.		χ^2 = 3.37 n.s.	
Not Aged	1	2	2	5
Total	90	159	51	70
Male : Female Ratio	1 : 1.67		1 : 1.37	

TABLE 12. Sex ratios of brown trout from the feeder streams of the Roundwood reservoir system.

Site	Males	Females	Ratio	χ^2
Vartry River	150	53	1 : .35	46.35 (p<.001)
Feeder Stream 1	77	29	1 : .37	21.73 (p<.001)&
Feeder Stream 2	64	38	1 : .59	6.63 (p<.01)
Feeder Stream 3	19	10	1 : .52	2.79 n.s.

TABLE 13. Maturity stages of brown trout on each sampling date.

	North Lake					South Lake				
	II	III	IV	V	VIII	II	III	IV	V	VIII
Cctober 1982	6	0	0	27	6	7	0	0	2	0
April 1983	18	0	0	0	1	15	0	0	0	9
May 1983	13	17	0	0	0	13	16	0	0	0
June 1983	5	48	0	0	0	2	17	1	0	0
July 1983	20	16	7	0	0	5	10	3	0	0
August 1983	17	3	22	1	0	3	2	6	0	0
September 1983	6	0	0	9	0	6	0	0	4	0

TABLE 14. Frequency of occurrence (%) of each food category in the stomachs of trout from the lakes.

Category	North Lake	South Lake	χ^2
Surface insects	10.4	5.3	1.36 n.s.
Chironomid larvae	17.4	10.6	1.63 n.s.
Chironomid pupae	9.3	9.5	0.00 n.s.
Cladocera	6.1	2.1	1.33 n.s.
Copepoda	5.5	1.1	2.08 n.s.
Ephemeropteran nymphs	4.2	0.0	2.68 n.s.
Trichopteran larvae	45.4	60.2	4.62 (p<.05)
Trichopteran pupae	20.7	33.7	4.42 (p<.05)
Other insect larvae	4.2	6.3	0.20 n.s.
Molluscs	15.2	32.3	9.38 (p<.01)
Gammarus	3.6	2.1	0.99 n.s.
Chance Food	46.0	51.6	0.55 n.s.
Fish	9.9	15.7	1.31 n.s.
Number of Stomachs	242	121	

TABLE 15. Frequency of occurrence (%) of each food category in the stomachs of trout from the feeder streams.

Category	Vartry River	Feeder Stream 1	Feeder Stream 2	Feeder Stream 3	χ^2
Surface insects	35.2	39.0	50.0	29.4	8.50 (p<.05)
Chironomid larvae	14.7	34.1	43.9	17.1	37.56 (p<.001)
Chironomid pupae	7.8	6.3	8.1	2.6	1.67 n.s.
Cladocera	.4	0.0	0.8	0.0	0.0 n.s.
Ephemeropteran nymphs	36.9	13.9	14.8	13.3	35.08 (p<.001)
Trichopteran larvae	24.2	9.2	11.5	15.8	17.37 (p<.001)
Trichopteran pupae	0.9	0.7	0.0	0.0	1.35 n.s.
Other insect larvae	27.6	12.9	22.5	13.5	12.57 (p<.01)
Molluscs	31.0	3.5	0.8	5.3	84.19 (p<.001)
Gammarus	7.0	16.2	8.1	2.6	11.20 (p<.05)
Chance Food	30.8	30.7	24.6	20.0	3.02 n.s.
Fish	4.0	0.0	1.6	2.8	6.68 n.s.
Number of Stomachs	258	158	140	49	

TABLE 16. Macroinvertebrates and zooplankton from the North and South Lakes.

	North Lake	South Lake
Littoral Samples		
Tricladida		
Polycelis nigra (O.F.M.)	–	+
Mollusca		
Potamopyrgus jenkinsi Smith	+	+
Bithynia leachi Sheppard	+	+
B. tentaculata L	+	+
Ancylus fluviatilis Müller	+	+
Lymnaea peregra Müller	+	+
Pisidium sp.	+	+
Sphaerium corneum L.	+	+
Oligochaeta		
Lumbriculus variegatus (Müller)	+	+
Stylodrilus heringianus Clap.	+	+
Limnodrilus hoffmeisteri Clap.	+	+
Aulodrilus pluriseta (Pig.)	+	+
Immature Tubificidae	+	+
Enchytraeidae	+	+
Eiseniella tetraedra (Savigny)	+	+
Hirundinea		
Glossiphonia complanata (Linnaeus)	+	+
Helobdella stagnalis (Linnaeus)	–	+
Isopoda		
Asellus meridianus Racovitza	+	+
Amphipoda		
Gammarus duebeni Lillj	+	+
Ephemeroptera		
Baetis rhodani Pict.	+	–
Centroptilum luteolum Müller	+	+
Caenis horaria L	+	+
C. moesta Bengtss	+	+
Caenis sp.	+	+
Leptophlebia vespertina L.	+	–
Trichoptera		
Rhyacophila dorsalis Curtis	–	+
Polycentropus flavomaculatus Pictet	+	+
Limnephilus lunatus Curtis	+	+
L. marmratus Curtis	+	+
L. rhombicus L.	+	+
L. vittatus Fabr.	+	+
Grammotaulius atomarius (Müller)	+	+
Mystacides azurea L.	+	+
M. longicornis L.	+	+
Sericostoma spp. including *S. personatum* K.	+	+
Chironomidae		
Macropelopia sp.	–	+
Procladius sp.	+	+
Trissopelopia sp.	+	+
Prodiamesa sp.	+	+
Orthocladius sp.	+	+
Endochironomus sp.	+	+
Microtendipes sp.	+	+
Polypedilum sp.	+	–
Benthic Samples		
Mollusca		
Potamopyrgus jenkinsi Smith	+	+
Bithynia leachi Sheppard	+	+
B. tentaculata L	+	+
Physa fontinalis L.	–	+
Ancylus fluviatilis Müller	+	+
Lymnaea peregra Müller	+	+
Pisidium sp.	+	+
Sphaerium corneum L.	+	+
Benthic Samples (continued)		
Oligochaeta		
Lumbriculus variegatus (Müller)	+	+
Stylodrilus heringianus Clap.	+	+
Limnodrilus hoffmeisteri Clap.	+	+
Aulodrilus pluriseta (Pig.)	+	+
Immature Tubificidae	+	+
Hirundinea		
Glossiphonia complanta (L.)	+	+
Helobdella stagnalis (L.)	+	+
Isopoda		
Asellus meridianus Racovitza	–	+
Trochoptera		
Polycentropus flavomaculatus Pictet	+	–
Limnephilus lunatus Curtis	+	+
L. vittatus Fabr.	+	+
Mystacides azurea L.	+	+
M. longicornis L.	+	+
Chaoboridae		
Chaoborus sp.	+	+
Chironomidae		
Macropelopia sp.	+	+
Procladius sp.	+	+
Tanypus sp.	–	+
Trissopelopia sp.	+	+
Prodiamesa sp.	+	+
Brillia sp.	+	–
Orthocladius sp.	+	+
Chironomus sp.	+	+
Endochironomus sp.	+	+
Microtendipes sp.	+	+
Polypedilum sp.	+	+
Tanytarsus sp.	+	+
Zooplankton		
Cladocera		
Acroperus angustatus Sars.	+	+
Alona guadrangularis (O.F. Müller)	+	+
A. affinis (Leydig)	+	+
A. guttata Sars.	+	+
A. intermedia Sars.	+	+
Alonella nana (Baird)	+	+
Chydorus sphaericus (O.F. Müller)	+	+
Bosmina coregoni Baird	+	+
Daphnia hyalina Leydig	+	+
Copepoda		
Diaptomus gracilis Sars	+	+
Cyclops vicinus Uljanin	+	+
C. minutus (Claus)	+	+

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