difference in the productions of the windward and leeward groups, the only possible natural division of the Archipelago." In attempting to throw light upon the remarkable difference in the inhabitants of the different islands, he points out that, as the Archipelago is free, to a most remarkable degree, from gales of wind, neither the birds, insects, nor lighter seeds, would be blown from island to island, and that the profound depth of the ocean between them and their apparently (in a geological sense) recent volcanic origin, rendered it highly unlikely that they were ever united, a consideration far more important than any other with respect to the geographical distribution of the inhabitants of the group.

But although certainly less striking than that of the Galipagos, the New Zealand case, when carefully examined, and taken with especial reference to the very narrow strait which separates the two islands, and the probability that they were once united, is one of great peculiarity, masked however by the greater extent of the flora, and of the number of orders represented in proportion to the number of genera and species of each.

Without going more at length into this subject, which might be wearisome, I think I have shown sufficient to excite the attention of naturalists, and to induce such observations as may help us to a clue to the special causes, which, under the law of natural selection, have brought about these remarkable results.

ART. LV.—*On the Brown Trout introduced into Otago.*—Paper No. 2.

By W. ARTHUR, C.E.

[*Read before the Otago Institute, 13th November*, 1883.]

Plates XLIII. and XLIV.

THE first paper of this series I read to this Institute in 1878,* and the results of my observations continued since then I now propose to lay before you. My chief object in so doing is to record the effects (if any) consequent on the acclimatization of trout (*Salmo fario*) in our waters; on their growth, habits, and structure, as bearing on the theory of the variation of species. Dr. Francis Day, late Inspector-General of Fisheries for India, has made public his investigations on trout in England,—carried out about the same time as my first observations,—and which bear out, to a great extent, the fact that the anatomical distinctions laid down by Dr. Günther in his catalogue, between some of the species of Salmonidæ, are not altogether to be depended on. Professor Huxley also has recently commenced an examination into the distinguishing marks of the young of the British Salmonidæ,—

* See Trans. N.Z. Inst., vol. xi., art. xxiv.

a difficult problem to settle satisfactorily. It thus appears that the need for careful revision of those distinctions is recognized by these two eminent authorities on ichthyology.

My subject naturally suggests for its elucidation such considerations and facts as explain the distribution, growth, habits, and structure of our trout. Besides many trout which I have handled and observed as to external markings during the past five years, the evidence I shall give (particularly on their structure) is more strictly confined to my examination of seventy-five specimens, taken from nineteen different rivers and waters, including one interesting trout from a Canterbury stream. The fish were of both sexes, and varied in weight from ¾ lb. to 17 lbs. In the appendix to this paper I shall give some particulars of each fish as noted on examination of a certain number.

I.—*Distribution.*

Absolute precision in ascertaining the facts in the life-history of our trout in their *wild state*, so as to deduce from these the general laws to which they are subject, would necessitate so much positive labour, inspired by enthusiasm, that I despair of its attainment in New Zealand. Neither am I aware that such has been attempted in older countries, as England, Germany, and North America, where the social advantages are more favourable towards supplying the necessary leisure and means. For these observations include such as refer to the *geological formation surrounding a river or lake*, the *chemical constitution of the water*, the *supply and variety of food*, and the *meteorological conditions of the atmosphere*, with the *marking, recapture, and examination of the trout*, also their *natural enemies*. Many different rivers also would require to be included, owing to their varying characters, and the observations should extend over many years. Many may think this programme of work superfluous, and may here ask, have we not the experience of aquaria and of fish-hatching establishments to guide us? Quite so, but it must be remembered that the habits of fish so situated are of fish in *confinement*, where it is impossible to afford them the advantages of nature, so that their habits must, to a considerable extent, be forced and unnatural, and therefore misleading. Such being the position of matters, the best that one can do at present is to lay under contribution such information as may be at command, imperfect though it may be. What then are the circumstances of our rivers and lakes, and what the effects so far on introduced trout?

Geological formation.—Nearly all our rivers originate among mountains of gneiss and conglomerate, which drain the country from the Waitaki River on the northern boundary of Otago, southwards to a line drawn from Balclutha on the Clutha River, to the Mataura River passing over Popotunoa

Hill. From this line, southwards to the coast, the rivers rise among older or trap formation, and flow more or less through a wooded country. Among the former, as a rule, the higher parts of the rivers are rock-bound, while the lower reaches and mid portions pass over alluvial flats, the shingle and gravel in their channels being the *débris* of their parent rocks with more or less quartz pebbles and fine sand. Among the latter class the gravel is almost wholly trap with a little quartz, while very few streams among either have beds entirely of clay or loam. A great number, especially of our smaller rivers, are rock-bound in their entire course, and so, having a scanty supply of gravel, are deficient in breeding capabilities; but perhaps two-thirds of all the rivers are well adapted for spawning, so far as gravel and sand can contribute to that end. One curious exception, however, must not be overlooked here, viz., the Water of Leith, which, possessing a rocky channel full of volcanic boulders, particularly in its lower course, and a scanty supply of gravel, yet for several years subsequent to 1874, when it was opened to anglers, produced an astonishing number of trout. It has not maintained this character, but that is due to excessive fishing and poaching.[6] Rivers to the west of the Mataura are not included in the above references, as the stocking of these has not been kept up; and I have only examined one trout taken there, viz., from the Oreti, a snow-fed water.

The banks of the rivers are very much yet in their natural state, covered by native grasses, and in some cases, bush; but cultivation has overtaken all the lower plains of the main streams to within a few yards of the water. Cultivation no doubt affects the character of the food-supply, and quantity also; so do grass fires around the upper waters, while both lower the mean flow of water in the rivers, directly and indirectly, also causing floods to become much more violent, high and mischievous, although shorter in duration than they used to be. During a residence of twenty years in Otago I have seen quite enough evidence of the latter of these facts, as for example in Shag Valley.

The mouths of the principal rivers which enter the sea directly have estuaries, protected by sandy bars. In the case of the Kakanui, Shag, and Waikouaiti Rivers the tide has a course of a mile and a half or more, upwards from the sea; while the tidal way of the Mataura may be estimated at five miles at the very least. Some of our best trout streams do not discharge directly into the sea, but are feeders of larger rivers, having tidal estuaries. So much then for a general definition of the geological conditions of our trout rivers that relate to distribution.

It only remains in this connection to mention that the lakes into which trout have been placed are the Wakatipu, Wanaka, Hayes Lake, Waihola, and Tuakitoto. The surroundings of the three former of these lakes are

decidedly alpine. Gneiss, slate, and volcanic rocks hem them in; they are very deep, abysmal in fact, and have very few shoals, such as exist being the *débris* of slate or shingle. The Wakatipu and Wanaka are exclusively snow-fed waters, the supply being the drainage of the nearest ranges of the Southern Alps. Hayes Lake receives very little snow-water. All three lakes are situated about 1,000 feet above sea-level, and bottom has been found in the Wakatipu by Dr. Hector at 1,300 feet, and by Mr. Connell in the Wanaka at 600 to 1,000 feet. On the other hand, the Waihola and Tuakitoto Lakes are of a totally opposite character. They occupy the middle of alluvial flats nowhere 50 feet above sea-level, in fact they are affected by the tides; their bottoms are mud or silt, and they have nowhere a greater depth than 12 or 15 feet of water, if so much.

Chemical Constitution of the Water.—This is the next consideration bearing on the well-doing and distribution of our trout. But I regret that as yet it is a field for inquiry almost wholly neglected. Dr. Black, of the Otago University, has very kindly analyzed several waters for me, viz., waters from the Opoho Creek where our local fish-rearing ponds are placed, from the Wakatipu Lake, Rowell's Spring, and from the Wallacetown salmon ponds; but beyond these I do not think that the water of any of our rivers has been examined, so that for the present we are tied down to the general and negative evidence that where the trout do well the water must be suitable in chemical constituents, other things being equal. I may, however, repeat here the Wakatipu analysis, which I have already given in a former paper on fish culture* as it has a direct connection with facts I shall have occasion to mention when I come to describe the habits of our trout. It is this :—

	Organic matter in solution.	Degrees of hardness.	Table salt.
Wakatipu water,	·5 grs. per gal.	3·1	Scarcely a trace.

The absence of salt in this water is not conducive to health in trout. I hope some day to be in a position to get these desiderata; meantime the only other fact of a chemical nature which suggests itself is, that our rivers divide themselves into two classes—those still in their condition of native purity, and those more or less polluted by the mud and silt from our gold mines.

Meteorological Conditions of our Rivers.—By this I mean such influences as affect our waters through their connection with rainfall and snow, frost and heat, winds and atmospheric pressure. And here the *snow-fed* rivers at once stand out with more or less distinctness as apart from non-snow-fed rivers; just as the muddy gold-mining waters differ from the clear streams. With one exception (that of the Oreti River) all the snow-fed rivers of Otago, both within and beyond the limits I

* Trans. N.Z. Institute, vol. xiv., p. 200.

have already assigned to my enquiries, have their sources in large inland lakes, and include the Waitaki, Clutha, and Waiau Rivers. At the same time I think that the Pomahaka and Mataura Rivers may be said to be partially snow-fed; but the other rivers and streams from the Mataura to the Waitaki may very properly be regarded as not coming within that designation. The lakes also of the interior, lying at altitudes above sea-level of 1,000 to 1,400 feet, and surrounded by steep snow-clad mountains from 5,000 to 9,000 feet in height, in the spring and early summer become charged with an excess of snow-water, which raises the rivers which are the effluents of these lakes to the greatest height they attain during the year. And warm rain, with a north-west wind under such conditions invariably causes very heavy floods, sometimes disastrously so. Perhaps scarcely less important in their bearings on trout are droughts with warm low water in summer, and frosts in winter, but these latter I consider do not affect our rivers much. The greater proportion of the Otago rivers are not affected by snow during the spring, summer, and autumn months, and so are all the better adapted for affording a food supply, as well as more suitable water for the growth of the young trout fry.

Added to the above considerations the winds, temperature of the water, and atmospheric pressure also combine to exercise their influence on the breeding, food-supply, growth, and habits of our trout. For example, a clear rapid snow-fed river produces, with a light-coloured bottom, silvery trout, while the food cannot be very abundant or varied, and the chances of the ova hatching out are not great. Very cold water, with too rapid a current and shifting shingle, is eminently unfavourable to the reproduction of food and growth of fishes. Such a river is the Clutha in its upper waters. On the other hand such trout as it could support would probably escape fungoid growths. Of an opposite class is the Waiwera or Waipahi—with an average flow of water, dark bottomed, good pools and reaches, with plenty of shelter under the banks, and much vegetation on these banks, abundance of food from the land, from aquatic plants, and from the gravel and rocks, also at a certain season from the sea even—where we find trout fairly plentiful, brown coloured, with golden bellies and scarlet spots, of immense strength and most excellent flavour.

At this point I might be asked to explain more fully what on earth trout have to do with gneiss and conglomerate, with the chemistry of water, with the temperature of water, or with the particular compass-bearing of the wind that may blow over the water? And yet these things not only affect them directly through their organs of breathing and secretion, but what is even of greater importance, indirectly through their stomachs. Well aerated water is very necessary to a trout's vitality, but that is of no use

unless it has plenty to eat. But my difficulty is, within reasonable bounds, in such a paper as this, to do justice to what I have sketched out in my preceding remarks. And not only so, but without a knowledge of what I have yet to say, and which overlaps in many ways the former, these former statements themselves would be practically unintelligible. I may, however, here describe as shortly as possible these relationships between inert matter and trout life, and leave further and fuller details to what has to follow when they become necessary in dealing with the growth and habits of our trout.

The *geological* formation of a river's water-shed, then, is the basis or origin of nearly all loose rocks, stones, gravel, sand, clay, and loam, which form the banks or bed of that river. According to the nature of the soil in the vicinity of a river, so is its fertility or otherwise—altitude, climate, and exposure being also factors. The fertility determines the abundance of vegetation, on the land and in the water, and that the supply of insect life, of molluscs, crustaceans, etc., all the staple food of our trout.

Again, the *meteorological* influences at work are by no means contemptible. Heavy floods in the spring or winter before the ova begin to hatch out are believed to tear up and wash away the spawning beds or "redds." Lowness of rivers, with frost, after spawning, is also fatal to ova, but that is not likely to affect many of our waters. Floods, however, must also wash away and kill the eggs or larvæ of aquatic insects, as well as of the Ephemera and Diptera (the flies of our summers), so injuring the food supply of the future. On the other hand, droughts during summer in very warm weather, result in the growth of low organisms, Fungi, and Algæ, especially, but not necessarily, where there is bed-rock. Anglers know too well here the ugly green weed they name "blanket weed," which entangles their lines at every cast; and although it may contribute to the production of minute species of fish food, it must sicken and cannot improve the health of our trout. Wind, too, by its agitation of long deep pools, causes a muddiness of water, and drives all surface food to leeward, killing it at the same time. Certain winds on some waters have a marked effect in contributing to the feeding or the prevention of feeding in trout.

In like manner much might be written on the consequences of changes in atmospheric pressure, which there is reason for thinking have a good deal to do with the times when trouts are on the move. So, also, as to the essential health-preserving qualities of water which contains plenty of air in solution, and of common salt. But I must now proceed from these considerations, to gather together and lay before you the actual position of the trout experiment in our waters at the present time under these conditions.

Growth.

It is of the first importance, at this stage, to be sure of the real species of trout which has been introduced into Otago—the progeny of the original lot got for us in Tasmania by Mr. G. P. Clifford, in 1868. Now, Mr. Clifford has told me there could be no crossing with *S. salar* or *S. trutta* at the breeding ponds on the Plenty, in Tasmania, as the trout there were carefully kept separate, and in ponds by themselves. So far, good; and as I stated in my previous paper, the original ova from England were taken from three rivers, the Weycombe, Buckinghamshire, and the Wey, by Mr. Francis Francis; and from the Itchen, by Mr. Frank Buckland. The Salmon Commissioners of Tasmania, however, so far as I could find out, have not placed on record the precautions taken, if any, to keep the lots separate in the hatching-boxes, or to say what proportion of each were reared and produced ova. All I have been able to learn is that many ova died, and that it is impossible to determine which English river or rivers may be represented by the progeny. However, taking Dr. Gunther's arrangement of species as my guide, it determines the trout from any of the above-named rivers to be *S. fario ausonii*, or the southern form, which I take to be the same as the Thames trout. It is capable of growing to a large size in its native streams, or may be called a large-framed trout, and is believed by good authorities to drop down into brackish water sometimes, or even as far as the sea itself. While it may be admitted readily that this trout does sometimes migrate in this manner, I must remark that I have never seen any absolute demonstration of the fact adduced by any author. But I shall have occasion again to offer my own observations on this point, and so shall leave it alone now.

The period of *hatching* at our Opoho hatchery may be seen from the following examples:—

Year and Locality Trout Ova got in.	Last Ovum Hatched.	Time of Hatching in days.	Temp. of Water. Fah.
1868 Ponds at Plenty, Tasmania	October 30th	About 70	
1869 " " "	" 14th	" 70	
1878 Otago Rivers	..	" 78	42°—52°
1879 "	" 23rd	78—88	41°—50½°
1880 "	" 30th	80—95	40°— 57°
1881 "	" 20th	64—75—77	41°—53°
1882 "	" 30th	70—80	39°—50°

The Tasmanian ova may properly be omitted in determining the ordinary time taken for hatching, as they were subjected to unusual vicissitudes before reaching Otago. The mean time of the other lots taken from trout in Otago waters is 78 days, or, leaving out the manifestly abnormal durations of 64 and 95 days, we get a range of 70 to 88 days, or, on an average,

78 days, which is very nearly the same as an average of all the days from 1878 to 1882, including these abnormal numbers. Among the 1880 ova, the lot which took 95 days to hatch are thus referred to by Mr. Deans, the local society's manager:—"They were impregnated on July 27th, and on October 30th I preserved a few eggs, which were still unhatched;" while his note on the other abnormal case in 1881 is this:—"Boxes 9 and 12 impregnated August 17th, hatched out on October 20th, 64 days." The first of the season's ova were impregnated July 12th, 1881, from which date to August 17th, the water in the hatching-boxes showed an average of 43° by Fah. thermometer; while from August 17th to October 20th, the thermal readings, I have gone carefully over, and find that they also give an average of 43° exactly; so we may conclude that the temperature of the water had nothing whatever to do with the rapidity of this particular hatching. Much more complete observations would have been required than have ever been kept, to detect the real reason of this, but the parent fish of this 64 days' lot were late spawners. Mr. Deans has found that 1½° Fah. difference of temperature makes 10 days' difference in the time of hatching at Opoho in the creek water.

It is of interest to compare the time of development from impregnation to hatching in England with the above. In a report on the Cray Fishery, Kent, I find the time given at from 70 to 84 days,* practically the same as our experience in Otago has proved it to be. But this does not show what the time has been in other English hatcheries, and is much longer than that given by Yarrell as the result of an experiment in Germany, where it was found to be only 35 days. We find, however, that temperature affects the time very much, and probably late spawners too. Among all the authorities on fish within my reach, there are but two others who make mention of the period of trout hatching, viz., Rev. W. Houghton, in "British Fresh Water Fishes," 1879, where he gives it as 60 days, and the temperature 40° to 45°; and Mr. Francis Francis, in the "Practical Management of Fisheries," 1883, where 63 days is, as nearly as I can make out, the mean time recorded. From the above cases, it would seem that the average duration in Europe is somewhat shorter than in Otago by about three weeks; but whether this is corroborated by the experience of fish-culturists generally at Home is more than can be readily found out. The three English examples quoted, however, show a mean of 67 days, or 10 days shorter than we have it here; and there is no alteration in the time observable during the past five years in our Opoho hatching-boxes, from what it was prior to 1878. But our trout can only properly be compared with their

* "Illustrated Sporting and Dramatic News," February 24th, 1883.

immediate ancestors in England; and as Mr. Francis, in above treatise, tells us that Thames trout spawn early, or in November, and are correspondingly early in getting into edible condition in the following spring, I presume I am correct in taking 63 days as the average duration for the hatching of these, and November as their spawning month. If this is so, then this same trout species in Otago takes 78 days to hatch out, and spawns from the middle of June to the end of September, according to locality—the coast streams from June 1st to end of August, and the Wakatipu streams in September. In other words, the same species of trout here is about two months later in spawning, and the ova ten days to a fortnight longer in hatching than in England.

Growth in the Shag River, Leith, Lee, Deep Stream, and Upper Taieri, 1875 to 1883.

The weight, as a measure of the growth of our trout, must next receive some attention, and the first question one naturally wants answered is, Have the trout maintained their previous rate of growth during the last five years? Well, in my first paper, bringing down observations to 1878, five rivers are mentioned, with their heaviest recorded trout as:—Shag River, female trout 16½lbs., yearly growth 2¾lbs.; Water of Leith, male 12½lbs., yearly growth 1½lbs.; Lee Stream, 5lbs., yearly growth 1lb.; Deep Stream, 8lbs., yearly growth 1⅓lbs.; and Upper Taieri, female 6lbs. 6oz., yearly growth 1lb. Now it is extremely difficult to compare with the foregoing the growth of trout in the same waters during the past five years. This arises from the principle that it would be hardly correct to assume that the heaviest fish weighed since 1878, were part of the original stock put into those rivers in 1869, unless their extraordinary size should render that supposition probable. The only other possible solution is one which has not been tried, at least not on a scale sufficient to give any results, and that is such proof as may be got by marking a great number of fish, returning these to the water after being weighed, and re-weighing the same fish years after when again caught. This is the best and most unquestionable test, but until it is made we are constrained to appeal to such approximations as may be got from the average weight of fish per day taken by anglers for each year. From one angler's diary I can give this; only, however, as regards the Lee and Deep Streams. Before doing so I may as well mention the weight of the heaviest single fish killed in each of above rivers from 1878 to March 1883; also the mean weight of a number of the heaviest, from actual notes of the fish weighed, and in one or two cases from memory. They are these:—Heaviest trout, Shag River, 14lbs., in 1879; Leith, 17lbs., in 1880; Lee, 10lbs., in 1882; Deep Stream, 10lbs. (seen but not caught), in 1882; and Upper Taieri River, 20lbs., in 1880,

caught by Mr. Grieve. The yearly increase in weight of these, supposing them to be 1869 fish, will be, deducting half a pound for 1868:—1·22, 1·41, 0·71, 0·71, and 1·66 lbs. respectively. This is a decrease in the rate of growth for each of these rivers, except the Upper Taieri, since 1878, while the actual weight of the fish under consideration has increased, excepting in that of the largest from the Shag River. At the same time I think these rates too low, as the most of the trout in all likelihood were not of those turned out in 1869. Then the mean or average weight of all the heaviest trout for the period 1878 to 1883 I find to be as follows:—Shag River, 11·4 lbs.; Leith, 14·6 lbs.; Lee, 5·6 lbs.; Deep Stream, 6 lbs.; and Upper Taieri (one fish), 20 lbs. Now, the evidence of each of the three preceding results is as a whole, that the weight of the *largest* trout has increased, while I may add their numbers have undoubtedly decreased in these rivers. This agrees generally with the belief of anglers who have fished the same waters.

The average weight of *all* trout taken per day together with their numbers, in the Lee and Deep Streams, may now be examined. This, as before explained, I can only give from the angling diary of one fisher, as those of others are very incomplete. From 1875 to 1883, then, the average number and weight of all trout caught per day for the two periods or divisions was:—

Lee Stream.	*Deep Stream.*
1875 to 1878, trout per day, 2·67; average weight, 1·25 lbs.	Trout per day, 3·66; average weight, 1·20 lbs.
1878 to 1883, trout per day, 1·50; average weight, 1·52 lbs.	Trout per day, 2·56; average weight, 1·86 lbs.

This example is so far confirmatory of above evidence, and shows that the stock of trout in these two streams has certainly become fewer in number, but heavier in average weight, during the latter period.

It will be remarked by anyone examining carefully the weights of trout I have given, that the heaviest were taken in the Shag River, Water of Leith, and Upper Taieri River. The two former of these waters differ greatly from one another in the geological character of their channels, and also from the latter river; but they also appear to possess a more abundant and varied supply of food than it; nevertheless, the heaviest fish have been both seen and caught in the Upper Taieri River, which raises a curious question as to the food-supply of that river. The upper waters, by a rapid descent to the Serpentine Flat, drain the slopes of the Rock and Pillar and Lammerlaw Mountains. Trap and gneiss may be taken as the rock formation of these ranges, their flat tops being also distinguished by immense bogs and morasses. The Serpentine Flat is about 10 miles long, with a heavy

loamy soil, in some parts marshy, and has a fall of only 4 feet to the mile. The river-bed consists of clay, overhanging banks, and a gravelly bottom, and in its course is extremely tortuous. It has also plenty of fine weed-beds, as nurseries for fish-food. The water is deep and has very little current and no stream, consequently there is an extraordinary range of water. It is discoloured sometimes by gold-mining works slightly. This is the Upper Taieri, where most of the great trout are, and it has an altitude of 1,800 feet above sea-level. The food-supply is not as yet well ascertained. It certainly does not include our smelts and whitebait (*Retropinna richardsonii* and *Galaxias attenuatus*), which are anadromous, and only found within a certain distance from the ocean; but I believe I am correct in saying that it consists of crayfish, fresh-water molluscs (*Limnæa*), flies with their larvæ, beetles, grasshoppers, and of fish, bullies and minnows (*Eleotris gobioides* and *Galaxias fasciatus*). So far as my own knowledge goes, I am satisfied there is not by any means a great number of these two latter fishes in the Upper Taieri, and bottom feed generally is not superabundant. The great weight attained by the trout must evidently then be the consequence of a fair supply of food, both surface and bottom food, but more particularly the unusual range of water and the excellent shelter afforded by the river's banks. The Shag River, in its upper waters, flows over slate formation, being a good deal affected by silt from gold-mining operations; and in its lower waters over shingle, gravel, and sand, with good pools and plenty of range; while the whole course of the Water of Leith is over trap boulders, and it has few pools, with little shelter except from bush, and no range of water. The food in both is generally similar to that in the Upper Taieri; but besides that they have the great advantage of an endless supply of the migratory fish, the smelts and whitebait. The Shag River fish, living within the limits of migration, therefore, of these little visitors, are fat and well-formed and still fairly plentiful, the largest trout being near the tidal way, and small trout numerous above. The larger trout, however, are not now found in the Leith except during the spawning-time. Fishing has fallen off very much during summer; and this winter, for example, although Mr. Deans searched the Leith several times carefully, he found no large fish till a big flood had come down. This proof is of course negative, yet when the smallness of the stream, and want of water and shelter are considered, it seems reasonable to believe that as large trout are not now seen in the Leith except during winter, they must live in the brackish water at its mouth or in the bay itself, for nine months out of the twelve. And this is further borne out by the fact of many large fish being netted by fishermen in the bay, with the characters more or less of the brown trout.

Fishing has not been much practised in the Upper Taieri, owing to its inaccessibility, so the progress or falling off in its stock of trout cannot well be compared with what it was previous to 1878. At the same time both large and small fish have been seen about Patearoa, which is ten miles below where any were liberated. These were in considerable numbers and in weight from 1 lb. to 10 lbs. Also the numbers and weight through the Serpentine Flat keep up well. But the Lee and Deep Streams have been regularly fished, untill 1882–3, when they were nearly forsaken by anglers, owing to the lamentable decrease in the number of fish and the consequently poor fishing. Now these streams are to a great extent alpine and rock-bound, and the water of the Deep Stream is greatly affected by snow water till the end of November, so that they cannot contain a very great food supply, so far as bottom feeding goes, while the surface food has diminished to an extraordinary extent by the almost total disappearance of the previously innumerable hosts of grasshoppers. The bottom food of these two streams consists mainly of larvæ, fresh water whelks (*Limnæa*) and crayfish, and the great numbers of these which must have been devoured by the trout, during the first few years after these waters were stocked with trout, must inevitably have reduced the breeding numbers on which the succeeding food supply depended. The disappearance of the grasshoppers may be the result of grass fires and the presence of starlings, but there is no great certainty about the matter, as grass fires were just as common before as after angling commenced, and I have never seen starlings feeding among the native grasses. There are other causes in operation which I believe have had their effect too. Neither stream seems to contain good breeding ground, although there is plenty of gravel in their upper waters, and the local Society has made a mistake in turning out the thousands of young trout too small and helpless (half inch to three quarters in length). It was only last summer that Mr. Deans, watching a number of these baby trout he had just put into a stream in the Oamaru District, actually saw the native bullies seize and eat or rather swallow some of them! The first trout ever liberated in these streams were strong and well-grown, from two to three inches long, and they as we know thrived admirably, as in six years they became numerous and had attained a weight in some individuals of 5 and 6 lbs. Pollutions from gold-mining have occasionally spoiled the angling, and probably the hatching of the ova too. Then we have shags or cormorants haunting the Lee and Deep Streams, as well as almost all our other waters. These birds live solely on fish, and as the two streams I am at present referring to have few native fish, and no migratory smelts at all, the wholesale destruction of trout up to a pound in weight is a sad certainty. I have never myself convicted any of these villains from positive proof, unless on one occasion, when

one of them actually seized my artificial minnow under the water when quietly spinning it in a deep pool in the Lee Gorge! But others, as Mr. Peat and Mr. Clifford, have told me they have seen them at work, or actually cut the trout out of their stomachs, as many as fourteen in one bird being found by Mr. Peat. It is a curious fact, also, that the only places where young trout can be seen at all plentiful are close above and below the accommodation houses on the Lee and the Deep Streams. The reason of that is, I have little doubt, the constant presence and passing of human beings at these places tending to scare the shags from the immediate vicinity, so that at these parts the trout enjoy comparative protection. The destruction of trout by only fifty shags during a year on one river, allowing each bird five young trout per day, a very moderate allowance, would amount to 91,250. I do not, as a matter of fact, believe they are quite so successful in plundering, but it gives their capabilities an alarming reality to consider these figures. Lastly, this variety (*S. fario ausonii*) evidently requires more range of water, and a greater food supply than these two streams afford it; for it has been matter of observation for years that the bulk of the trout have been working down stream. Almost every good basket for the last three years has been taken in the lower gorges, while very few fish have either been caught or seen in the upper waters. There can be no doubt also, that constant fishing has reduced the stock, for in angling everyone here has found that the biggest fish in a pool "rule the roost," and these are to a certainty the fish which take fly or bait first. For example, I killed in one pool in the Deep Stream, with grasshopper, first a three and a half pounder, and then, within a few minutes, two trout, one pound each, or about that weight. So that when a large trout is killed in a pool, it not only takes longer to supply its place by the natural growth of another which might be smaller, but there is also the loss of the greater number of ova that a large trout can produce beyond what a smaller one can, if a female.

A careful consideration of the facts I have just mentioned has led me to the following conclusions: The Shag River has plenty good spawning beds, abundance of range in its pools, and a good supply of bottom feed, supplemented from October to April by immense shoals of smelts and whitebait. Although not quite so large as formerly, its trout remain fairly plentiful, the small ones very plentiful, and are very fat and in good condition, and very silvery in appearance. During the last fishing season, the "takes" were not nearly so good as in the preceding years, still I regard the Shag as one of our best trout rivers and one not likely to be soon fished out. Some idea of the best takes of trout in the Shag may be gained from two days' fishing by Captain Fullarton, in the season 1880–81. On one of these days,

at Rich's Ford, he killed four trout with minnow, weighing respectively 12lbs., 10lbs., 3lbs., and 1lb., and the other day, up at Hunter's, he got nine trout from 2lbs. to 7lbs. in weight. But as regards the Water of Leith the case is very different, for year after year the fishing has fallen off, and so have the weight and numbers of trout taken during the fishing or summer season. Running as it does through the city of Dunedin, and fished every day by dozens of anglers, so small a stream possessing such indifferent cover and range of water is bound to suffer, and indeed it is hardly now worth fishing in. It is only during the spawning time that the great trout now appear (as I have already stated) and this winter we took out of it for stripping very fine fish of all weights from 2lbs. up to 16lbs. There is not enough food even including whitebait to maintain such heavy fish, so they must frequent the tidal and salt water, where the food supply is much more plentiful. That is the only explanation I can offer to account for their great weight. Many thousands of young trout are put into the Leith yearly, so the falling off in its productiveness I do not doubt is mainly due to excessive fishing and also poaching during the spawning season, of which latter fact there is no lack of proof. The Upper Taieri River I need hardly almost refer to again, as I have already said that its wonderfully big trout are consequences of great range of water and a fair supply of food. It is a trout stream, however, sure to suffer from the depredations of shags, which are too numerous on the rocks at different points on its banks. The Lee and Deep Streams not having the benefit of fresh shoals of migratory smelts every season, have deteriorated so as to be very inferior as trout producers to what they were five years ago. For their natural food supply being limited, while anglers and shags have both fished them incessantly, the stock of trout is not equal to the struggle (at present at all events), hence their disappearance to a great extent. Both streams have also been much polluted at times by gold-mining, which must destroy the ova as well as fish food. The rate of increase in weight of the trout in the above waters yearly is still greater than in England, but as a whole it is falling off. Mr. F. Francis says that a three-year-old Thames trout will weigh one pound. This must suffice for the present regarding the distribution and growth of trout in the Shag, Water of Leith, Upper Taieri, Lee and Deep Streams, during the past five years as compared with the preceding ten years.

Growth in other Otago Waters, 1878 *to* 1883.

I must now proceed as shortly as possible to record similar facts about other Otago waters not dealt with in my first paper, and from which we will see how the trout have fared in these since 1878 down to the present year. I shall take the rivers from the north end of the province down to the south end in succession.

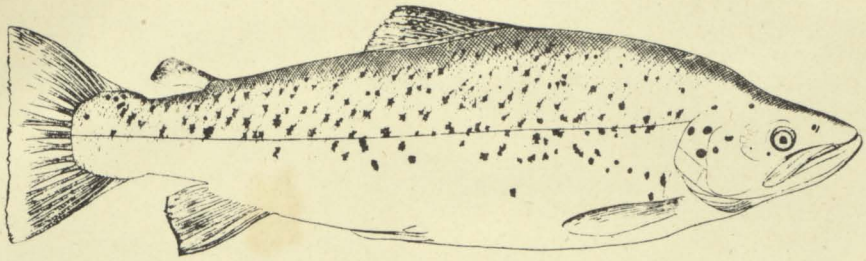

FIG 1

SHAG RIVER — male 4½ lbs., length 20⅞ in.

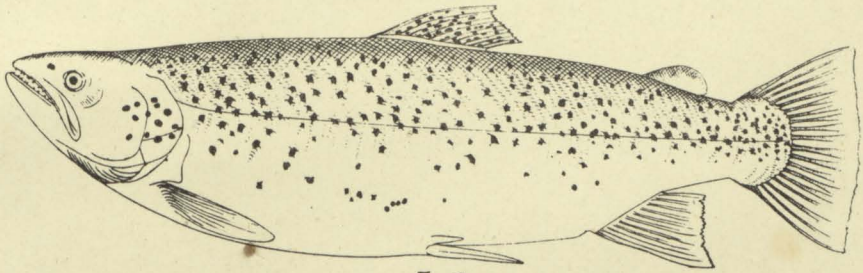

FIG 2

WAIKOUAITI RIVER female 13 lbs 11 oz., length 28½ in.

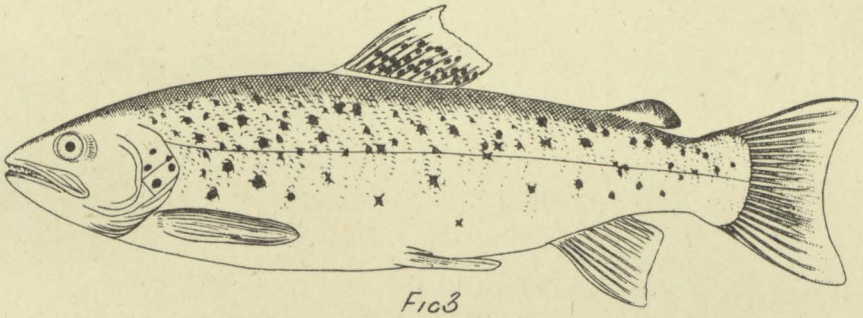

FIG 3

LEE STREAM 1 lb 6 oz., length 13⅓ in.

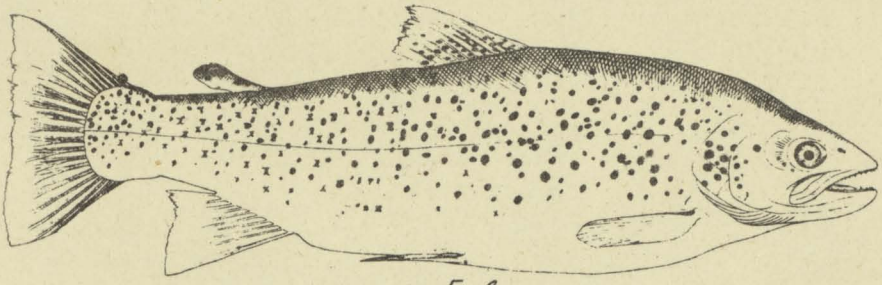

FIG 4

WAIWERA female 2 lbs 13 oz length 18 in

OTAGO TROUT (*S. fario Ausonii*) from different rivers.

W.A. del.

The *Omarama River*, a tributary of the Ahuriri, was first fished by Mr. J. A. Connell, in December, 1879, and the following is the result of several day's good sport, but subsequent trials were not so successful. During one day, two evenings, and an afternoon, he caught 14 trout, weighing 27½lbs., or an average weight of 1·96lbs., heaviest fish 7lbs. During the same month I fished the Omarama also, two and a half days, and killed 5 trout, weighing 13¼lbs., or an average of 2·7lbs. each. I also lost a trout after playing him out, which I believe, from his size (having seen it) and its strength, must have been 8lbs. Mr. Connell's take would average altogether, including his clean days, about three fish a day, so far as I can now judge; while mine was two trout per day. This river is shingly and snow-fed during part of summer, and lies about 1,400 feet above sea-level. Its banks are covered only with native grass, and its trout were remarkably strong and very fat, giving abundance of play. As trout were first placed in this river in 1875 their yearly growth is about 2lbs. increase in weight. The food-supply is very likely identical with other inland streams, but I have no precise information about it. Lately Captain Fullarton, of Palmerston, has told me of many large trout being seen in this river during last season, as well as in the Ahuriri and Waitaki. Mr. Begg reports small trout as very numerous.

The *Otekaike River*, another feeder of the Waitaki, was fished by Mr. A. C. Begg in February, 1881, when he caught two trout, total weight 5½lbs. This river flows over slate formation in its upper waters and shingle in its lower waters. It is partly snow-fed, like the Omarama, but in summer lower parts disappear under the gravel.

The *Kakanui River* has for years been unprofitable so far as angling goes, but Dr. de Lautour, of Oamaru, and Mr. Statham Lowe, during last summer, had some wonderful sport in it with minnow, both natural and artificial. The former, fishing at night with natural minnow, had the following luck:—December 3, 1882, two trout, weights 12½lbs. and 3lbs.; and on the next night five trout, weights 13lbs., 8lbs., 7½lbs., 3lbs., and 3lbs.; being 7 trout altogether, weighing 50lbs., or the very extraordinary average of fully 7lbs. each! The night of the 4th December was very dark when the doctor was fishing, and the locality was a mile and a half above Maheno. He informed me that the trout were rising in all directions, and when he hooked his fish it took him from twenty minutes to an hour and a half to land them—hooking his first at 9.15 p.m., and landing his last at 1.30 a.m. Of course anglers imagine the time very long when holding on to a big trout; the excitement and anxiety causing one's mind to measure the minutes by the intensity of their feelings; a thing which is, I fear, rather misleading. The fish were all very fat and handsome looking, but

the doctor found very little in their stomachs, only a few bullies and shrimps, and he thinks they must have disgorged considerably from the length of time he had to take playing them with a very light rod. I have frequently observed, however, that the fattest trout when caught have very little or nothing in their stomachs, and it is a circumstance hard to explain. I have likewise pretty often found a trout's mouth full on landing it, and its stomach also. When a trout, further, is hooked by the tongue or any fleshy part of the mouth, it seems to close its jaws firmly as if in a vice, for I have seen their jaws almost locked on landing them. On the other hand, when the hook gets among the branchial arches, or made fast to the gullet, I should expect vomiting to result, and I have seen it repeatedly in such circumstances. As to deducing any average per day of the number of trout and of the weight from these two nights' fishing in the Kakanui, I feel convinced it is unnecessary, as the take was evidently very exceptional. Neither can the yearly increase of weight in the trout be fairly ascertained, for the first were put in in 1869, and with the abundance of smelts, whitebait, and other food obtainable, also plenty range of water, which are the conditions of this river, they have had every advantage of growing more than at the rate of only one pound per annum. The higher parts of this stream lie among fearfully rocky gorges of slate and gneiss, and the lower parts on shingly, gravelly flats, amid limestone formation and rich soil. It is a river also not much affected by snow water I should think. I am informed that the settlers destroy many very large trout by poaching, which, if not put an end to, will deplete the river entirely of its stock.

The *Waikouaiti River* also has been a very unsuccessful water as yet. The first trout were put into it in 1869, and a great many thousands during the last five years, yet they do not seem to make head as a stock, there being only a few very large fish in a certain number of pools about Cherry Farm. Anglers from Dunedin have repeatedly fished it without getting or even seeing a single trout. Mr. Orbell and Mr. Buckland, however, two seasons back killed some very large trout, night-fishing. One of these fish, a beautiful female of about 14 lbs., was kindly sent me by Mr. Orbell in February, 1882. It was remarkably fat, and the belly protruded so as to distort the cleft of the mouth to an angle of nearly forty-five degrees with the vertical. It was very silvery, and, although within easy access of the sea, did not appear to have migrated, its fins being all dark or olive colour, and its spots black and round or square. The stomach was empty. When boiled this fish ate exceedingly well. The mouth of this river, also of the Kakanui, is tidal, but its upper waters are often polluted by gold-mining works.

The *Waitati River* has not been in much repute for years, having fallen off in productiveness. The best day's fishing I know of got in it, was in November, 1879, by Mr. S. Thompson. On that occasion he caught 22 trout, weighing 23½ lbs., or an average of 1·06 lbs. each. The water was low and he fished with fly and maggot. It was first stocked in 1869, and again in 1874, so taking Mr. Thompson's largest trout, which was 5¼ lbs., as one put in during the latter year, its yearly rate of growth would be 1·15 lbs. In Blueskin Bay, into which the Waitati flows, there are frequently trout seen and netted which may probably have come out of this river. It has a good supply in the season of smelts and whitebait, and its bed consists of trap boulders; its banks are covered with bush.

Fulton's Creek is a small stream, the upper part of which descends rapidly from the mountains through bush, and its lower waters flow gently through the alluvial plain of the Taieri in deep long reaches. It has a good stock of trout, and very large ones frequent its lower waters. Trout were first put into it in 1869, none since then, and in July, 1881, Mr. Deans caught two beautiful females, 18 lbs. weight each, on which occasion he reported very few males to be seen. The least possible annual growth of these two fish would therefore be 1·5 lbs. It has fine gravel beds, and seems to be a good breeding water, small trout being numerous.

The *Tokomairiro River* has not as yet got up a good stock of trout, although more than 9,000 have been liberated in the north branch alone since 1869. In November, 1882, Mr. Burt caught one of 7¼ lbs., in fairish condition. It has a long reach of ten miles tidal water from its mouth, so it should have an excellent supply of food of the migratory kind.

Lovell's Creek, which empties itself into the Tuakitoto Lake, is a small river, but remarkable for containing a considerable number of large trout. A good number of these have been caught, and in July, 1882, one of 15 lbs. was found dead in it. It was a female and was very fat, and must have grown yearly 1·66 lbs., as the first trout was put into this stream in 1873. I have no doubt this stream contains an abundant supply of the migratory fishes which visit all waters so near the sea or so accessible from it. After spawning the large trout in all probability descend to the lake to recuperate themselves.

Kaihiku River is the first stream within the trap-rock region between the Clutha and Mataura Rivers, and, like the most of them, it has a more or less northern course, facing the sun. Judging from the baskets of trout taken from it, I should consider it a very well stocked little river. It is very full at present of small trout. I have, however, only one angler's record available for reference, which gives for two days' fishing, 28 trout, of a total weight of 17 lbs. This is equal to 14 trout per day of an average

weight of 0·6 lbs., or a little over half a pound each. I have no information as to the heaviest trout in it, but I believe they have been caught nearly 6 lbs. in weight. As it flows into the Clutha River below the Waiwera, it must be visited by smelts and whitebait. Here I ought to notice in passing that Mr. M'Kinnon, hotel-keeper, in March, 1883, killed with native minnow in the *Puerua* a trout of 22 lbs. As trout were first turned into this little river in 1873, the least possible yearly growth of this fish would be 2·2 lbs.

The *Waiwera River* is four times as large as the Kaihiku, and was in great repute among anglers for the size and excellence of its trout a few years ago; but, owing to the hotel on its banks having stopped business, not many have fished it during the two last summers. It is situated a few miles west of the Kaihiku, and flows over a similar formation. There is good shelter, plenty range, with rocky reefs crossing the stream in many places. There are also plenty of weeds in the reaches, which become long and affect the surface. Several takes by anglers I know of, which are these:—

1879, one angler fishing two days; result, 2·5 fish per day; average weight, 2·65 lbs.

1879 to 1881, another fishing nine days; result, 1·77 fish per day; average weight, 1·56 lbs.

1882, a third fishing a day and a half; result, 8·0 fish per day; average weight, 2·41 lbs.

Previous to last season I know of no trout over 6 lbs. being caught, but on January 18th, 1883, two magnificent female trout were exhibited in Melville, the fishmonger's window, Dunedin, said to have been taken by a Mr. Miller in the Waiwera, which weighed 14¼ lbs. and 10¾ lbs. respectively, and of these dimensions:—Length, larger, 28½ inches, depth 8¾ inches, girth 20½ inches; smaller 27½ inches in length, depth 7½ inches, and girth 15½ inches. These trout were in colour dark along back, shaded off into a yellow and then white towards the belly, fins all dark, and spots black, large and round like most Waiwera fish. They were so small in the head and also so deep in the side, being about one-third of total lengths, as to have quite the shape of perch, but were not correspondingly thick across the back. In fact their unusual depth of side was evidently attained at the expense of their thickness, for neither fish had as great a girth as an ordinary well-filled-up plump trout, and which I have found to be as nearly as possible two and a half times the depth. For all that, they were the finest-looking specimens of brown trout I have seen in Otago, and the growth of the larger one could not be less than 1·45 lbs. yearly, as trout were first put in Waiwera in 1873. The stomachs of such trout as I have opened from

this stream contained crayfish, fresh-water whelks (*Limnæa*), algæ, flies, and larvæ; but much of the food consists of smelts and whitebait, which swarm in it during the summer. For edible qualities the Waiwera trout stand deservedly high.

The *Kuriwao River* is a small branch of the Waiwera, which, after passing through the Popotunoa Gorge, joins the latter river on the plain 7 miles below. It is a very stony water, but has excellent shelter and plenty of food, including smelts and whetebait; indeed, the same food-supply as the Waiwera, and the same trap formation. About the end of 1878, one day Mr. Statham Lowe fished it for curiosity, when waiting for the train at Clinton, and had such wonderful luck with the fly as to remain a week. But now it has sadly degenerated in the number and size of its trout. Unfortunately, I have lost his letter, but speaking from memory, I believe his best take was seven trout, weighing in all 15 lbs., and ranging from 1½ lbs. to 5 lbs. In 1881 Mr. Lowe and another in one day killed twelve trout, which weighed 12 lbs.; Mr. Lange, half a day, seven trout, weighing 6 lbs. 10 ozs.; Mr. McCulloch, one day, five trout, weighing 5 lbs.; Mr. Lange, one day, fifteen trout, weighing 9 lbs. 11 ozs.; and Mr. A. C. Begg, three days, twenty-one trout, weighing 12 lbs. 8 ozs. In 1882 the latter angler caught one, 6 lbs., above the Popotunoa Gorge, and several other good fish. Five years ago the yearly increase in weight of the trout I found to be 1½ lbs. Poaching and excessive fishing have not only reduced the stock of trout, but caused many anglers to forsake this stream altogether. I have heard of boxes of trout, illegally caught, being sent by coach to Dunedin. The above figures show a steady decrease in the average weight of trout yearly. I have only examined the contents of the stomach of one trout from this water, and found these to be the larvæ of aquatic insects, and fresh-water whelks, but the stream is also full of whitebait. This same trout ate exceedingly well when cooked.

The *Waipahi River* is undoubtedly a very beautiful trouting stream, as it has abundance of shelter and plenty of range of water; reefs of rock and weeds also. It is situated about 8 miles west by rail from the Kuriwao, and flows over a similar trap formation, has a good supply of the ordinary river food, with thousands of smelts and whitebait also in the season. It has few good spawning-beds, is not affected by snow water, is low-lying in its course, and is an early river, like the two last-mentioned. In the middle of October many of its trout are in fine condition, and generally they have the golden and brown tints of the typical brown trout; the spots also being mostly round. In the season 1881–82, Mr. Begg, in six days' fishing, killed fifteen trout, weighing 24½ lbs, the heaviest being 8 lbs. The largest trout I have known caught in this river was nearly 9 lbs., and was taken at

night in February, 1882, with natural minnow, by Mr. Bull, of Auckland. It was excellent eating. During two half-days in November, 1882, I killed four trout, of a gross weight of 10 lbs. 10 oz., the largest being 4 lbs. 8½ ozs. Mr. Statham Lowe, one day, five trout, weighing 16lbs. But the fairest idea of the productiveness of this river may be gathered from Mr. W. Mark Elliott's fishing during last season, of which this is the result:—He had seventeen and a half blank days, twenty-eight days when he caught fish, seventy-six trout taken, and a total weight of 210½ lbs., the largest being 6½ lbs. Taking all his fishing-days together (45½), gives an average catch of 1·7 trout per day, weighing 2·76 lbs. each, all trout under ½ lb. being returned to the river. He fished mostly with fly during the first half of the season, but with cricket and minnow during the latter half. The first trout placed in the Waipahi were only seventy-six in number in the year 1873, but 300 the following year. Taking the 9 lb. trout as possibly one liberated during the latter year, would give its yearly growth as 1 lb.; but, from the abundance of food in this river, I am pretty sure the actual yearly growth of its trout is more like 2 lbs. The flesh of the trout for the table can generally be depended on as of the finest quality which are caught in the Waipahi. I have found in the stomachs of Waipahi trout, fresh-water algæ, larvæ of insects, whelks, flies, and insects, one minnow (*G. fasciatus*), and, in the case of one trout, no less than thirty-eight whitebait! Gravel also I have found. In appearance the trout are well-shaped and yellow-sided.

The *Otaria Stream* is a small tributary of the Waipahi, and, like it, has many bars or reefs of trap rock crossing its bed transversely. It has excellent banks and good shelter, but from actual observation I cannot give the varieties of its food-supply. I have no doubt at the same time that it corresponds to that found in the Waipahi. One day at the latter end of March, 1883, Mr. Elliott fished it with no success till evening, when, with minnow, he caught five trout of a total weight of 15 lbs., the largest being, I believe, 5 lbs. As trout were first put into it in 1875, the yearly growth of this largest fish was ¾lb. Poaching of a very undisguised kind is much practised in this stream. The quality of its trout for the table is unusually excellent.

The *Mimihau*, a feeder of the Mataura River, flows mostly past and through bush and over trap rock. I do not know the precise nature of the food-supply, but necessarily the flies and grubs must be very abundant and its trout for the table are said to be unsurpassed. In March of this year, Mr. Maitland killed in one day 6 trout weighing 17½ lbs., the heaviest being 4 lbs. Two years ago, in 1880, Mr. Thornhill killed one 5 lbs. weight, which must have increased yearly in weight at least three-quarters of a pound, as trout were first put in it in 1875.

The *Pomahaka River* is a very large tributary of the Clutha River, rising in the snowy ranges of the Umbrella Mountains and flowing in a south-easterly direction. It is, therefore, without the trap region, unless towards its mouth, and is partly snow-fed during the summer, besides being frequently muddy from the gold-mining operations on its upper waters. Possessing numerous gravelly reaches it is a good breeding water, but it is a late river, and its fish take a long time to get up in condition in the summer. Occasionally the trout in it are of good quality, but as a rule they are not to be compared in that respect with those of the Waiwera or Waipahi. In colour they are light and silvery. Night fishing with minnow is very successful, but any lure may be used during the day. The stomachs of those trout which I have opened I found contained larvæ, creepers, beetles, whelks, minnows, crayfish, and small stones, but the whitebait are very plentiful also in this river. There are quite a number of records of fishing in my possession, but one may suffice to mention, that of Mr. Elliott. During the summer and autumn of 1882–83 he had three blank days, 23 good days, and caught 135 trout, weiging 236½ lbs., or 5·2 trout daily of an average weight of 1·75 lbs. The largest trout that I know of was 7 lbs. and caught by an angler in 1882, but one of 6½ lbs., taken in 1879, gives a yearly rate of growth of 1·08 lbs., which is probably as much as can be expected in the Pomahaka.

Of the interior streams and lakes where fish have been taken the Waitahuna, Teviot, Manuherikia, Butel's Creek, Lochy, and Wakatipu Lake, also the Oreti River merit a little notice.

The *Waitahuna* can only be fished in its upper parts owing to pollutions from gold-mining. It flows from the Lammerlaw Mountains behind the town of Lawrence over a slate and gneiss formation in a south-east and then a south-west direction till it joins the Clutha. It has good spawning beds, trout are numerous but not large, rather poor in condition, but take fly readily, and are good eating. The result of two half days in November, 1881, when I fished it, the water being in splendid order, was 15 trout, weighing 8¾ lbs. gross, no trout being over a pound or so. This is a fair sample of its fishing capabilities, but the largest fish taken was one of 4½ lbs. by Mr. Coghill in October, 1879, and I have heard of other large ones being seen. As trout were first put into the Waitahuna in 1875, the yearly growth of Mr. Coghill's fish would be 1·12 lbs. Stomachs opened by me showed flies, shellfish, larvæ, creepers, crayfish, and small stones as their contents. In colour these trout are silvery.

The *Teviot River* is a small tributary of the Clutha River which rises in the Lammerlaw Mountains and after flowing in a westerly course through rocky gorges joins the Clutha at Roxburgh. Its rocky bed is formed of

slate and gneiss, it has not many good spawning beds but seems to have a good flow of water during the first half of summer. Its trout are mostly small, but they take the fly readily, and are possessed of good edible qualities. They are brown on back and golden on the sides, with black and crimson spots. In December, 1880, I had a day's fishing in it above the washpool hut, and killed with fly 17 trout weighing 11½ lbs. I lost more than half-a-dozen, including several fish over 2 lbs., but of those I caught 8 weighed about 1 lb. each. I had no opportunity of examining the stomachs of these trout, but probably their food consists of shellfish, larvæ, and flies.

In March, 1879, two anglers fishing the *Manuherikia River* at Hawkdun Station killed 8 trout from 1 lb. to 2 lbs. in weight. They were fat silvery fish and proved very good eating. Below the station the pollutions from gold-mining render this river useless for trout, but above it is beautifully clear, and has plenty of good spawning beds. This part of the river is about 1,500 feet above sea-level, and in spring must carry off a large amount of snow water. I heard of a trout of 7 lbs. weight being caught in it, during this same year, so that its yearly growth would be fully 1 lb., as the stream was first stocked in 1873. I have no information as to its food supply.

Butel's Creek, which feeds Hayes Lake is a very small stream, but it is well stocked, especially below the waterfall, which is impassable for trout, being nearly 200 feet high. Hayes Lake is very full of trout, some being supposed to be over 20 lbs. in weight, and these having for their spawning ground only the mile and a half from the lake to the waterfall of this creek, it gets very crowded during the spawning season. I have heard of one trout poached out of this stream in 1882 which weighed 28 lbs., and these great fish are known to have been actually caught, and removed in cart loads, being afterwards salted and sold among the surrounding gold diggings. The Lake Society has done almost nothing to prevent the poaching. Now, trout having first been put into the streams about the Wakatipu in 1874, this very large trout must have grown yearly at the astonishing rate of 3½ lbs.! The trout in the creek are mostly small, running from ½ lb. to 1½ lb., although they have been taken with the rod up to 5 lbs. It is only during winter that the very large fish push their way up. Mr. Paterson, a neighbouring settler, has told me he has seen the stream as "thick as porridge" owing to the numerous spawning fish turning up the same redds successively! The bed of this stream is very gravelly and sandy, and it is the only water entering the lake fit for spawning in. Such trout as I have seen taken out of it are very silvery in appearance. In November, 1880, Mr. A. C. Begg killed 15 trout in this creek in one day, their total weight being 8 lbs. From observation I cannot say what the food-supply is on

which the trout feed, in the creek or the lake, but it must be unusually good and abundant, especially in the lake, where the trout are said to be numerous and large. I have not yet known of any angler succeeding in catching a single trout fairly with rod and line in Hayes Lake. They are manifestly too well fed to care for artificial baits.

The *Wakatipu Lake* has a stock of trout from 2 lbs. to 20 lbs. in weight; I estimate the weight from seeing them. These large trout frequent certain parts on the margin of the lake in shoals, as Queenstown Bay, near the Town Creek, the Peninsula Reef, Frankton Arm, and generally the vicinity of the mouths of the streams into which young trout fry were originally put by the late Mr. Worthington. Until lately, they have not been caught by rod and line; but during March, 1883, some were with minnow, and very long lines being run out from the boats. The trout are very fat, but what their food consists of beyond *Galaxias* I have not yet found out; the stomachs of four which I examined being empty. In one case only two small fish and insect remains were found in the stomach by me. In colour these trout are mostly dark on back and silvery towards the belly, some however are very silvery. Unfortunately there is much fungoid disease in the shoals at Queenstown Bay, and a considerable number have died from it. One female I found dying from fungus, I have previously described.* Mr. Worthington, in 1881, reported that he had only seen male fish affected with the disease. Probably the absence of salt from the Wakatipu water is one of the chief causes of the malady. It does not appear, however, to injure the edible qualities of the fish, which are most excellent. In November, 1880, a trout was caught at the head of the lake which weighed 16 lbs. 4 ozs.; and, as it may probably have been one of those liberated in 1874, its yearly growth would be 2·73 lbs. or 2¾ lbs. nearly. A number of trout have been taken weighing 11 lbs., 13 lbs., and 15 lbs.

In March, 1882, I got a most beautiful female trout from the *Oreti River*, weighing 5 lbs., which was in splendid condition, and was the finest fish of the kind to eat I ever partook of. It was almost as good as a fresh run sea-trout. In its stomach I found one minnow and a small grub. At the same time, I handled an ugly male trout from the same water, not fat, which weighed 10 lbs. Its average yearly growth would be 1¼ lbs., as trout were first liberated in the Oreti in 1874.

The *Canterbury* specimen I have previously made reference to was sent to me by the Christchurch Society in February, 1881, on the supposition that it might possibly be a Californian salmon; but in what river caught I was not informed. It was 2 lbs. in weight, silvery in appearance, with a few dark and red spots, mostly x-shaped, and had a very small head, less

* Trans. N.Z. Inst., vol. xv., p. 198.

than a fifth of the total length of the fish. The anal fin had ten rays, also two spines or rudimentary rays; the abdominal and anal fins were white. So extraordinarily fat was this fish, that the cleft of the mouth was distorted or drawn very much down, while the snout was very like that of the genus *Oncorhynchus*. The fin-rays and gill-covers, etc., however, convinced me that it was a brown trout (*S. fario*), while its general appearance was suggestive of some duration of residence in brackish water. The stomach contained a little mucus, but I took a native minnow three inches long out of its gullet. It was too much decomposed for me to examine the cæca, which I have observed decay sooner in hot weather than the other viscera; in fact they are very perishable.

The yearly rate of growth in the most of the streams above recorded, from 1878 to 1883, and which I cannot compare with their growth prior to 1878, from want of sufficient data, may be seen more readily from the following table:—

Yearly growth of Trout, 1878 to 1883.

	lbs.
Oamarama	2·00
Kakanui	1·00
Waikouaiti	1·07
Fulton's Creek	1·50
Lovell's Creek	1·66
Puerua	2·20
Waiwera	1·45
Waipahi	1·00
Otaria	0·75
Mimihau	1·00
Pomahaka	1·08
Waitahuna	1·12
Manuherikia	1·00
Hayes Lake	3·50
Wakatipu Lake	2·73

Of course I do not claim more for this table than that it shows what the least possible growth of the trout per annum may be. Likely in some cases it is more, although it would be difficult to find any growth of trout to exceed that in Hayes Lake. I cannot from exact information as yet decide the interesting question of what the Hayes Lake trout fatten on; and mere inferences, even when probably correct, should not be depended on.

As to the *edible qualities* of the trout in these rivers, a fair proportion of good eating trout can be got in most of them. The best I have partaken of was a single 5 lb. female trout from the Oreti River as already stated; a finer one could not be desired. Next to it I have found the Waipahi and

Waiwera fish the best; but I have heard that the Otaria and Mimihau fish are better still. The Wakatipu trout are also particularly fine, perhaps the best. Of course the single example from the Oreti cannot be held as proof that its trout will all be as good; and, indeed, the 10 lb. male which was got at the same time was not fit to eat, I was informed by the gentleman who had it cooked for dinner. It is likewise difficult, I find, to predict from its appearance how a trout will eat in Otago. We have them both pink, red, orange, and white in the flesh-colour. Most anglers think a fat trout is sure to be good, and, as a general rule, I will not dispute it may be so. I certainly find that, when the pyloric cæca are covered with much fat, the trout may be depended on as good, unless it happens to have been grubbing among clay or moss for larvæ, when it will have an earthy taste. But I remember on one occasion getting a 4½ lb. male trout from Shag River, which was very fat, sent me by a settler, and which ate nearly as well as a sea trout, while an exactly similar fat trout, sent by the same settler, at the very same time, from the Shag River to a friend of mine in town, proved quite earthy in flavour when boiled, and anything but palatable. My fish, I found when examining it, had four large native minnows in its stomach. In October, 1880, I killed a female trout in the Lee Stream of 1 lb. 9 oz. (not sexually developed so far as I could make out) which was very fat, and had its stomach very full of flies, also five large grubs or creepers, with remains of others. This fish was equally good to eat with the one sent me from Shag River. Now, the Shag River fish, both fat, with access to the same food probably, viz., minnows and whitebait, differed entirely as to quality; while the Lee trout, also fat, but feeding on widely different food, proved the finest of eating, just as one only of the two Shag River fish did! In addition to fat around the cæca, I find that thin skins and deciduous scales, also orange-coloured flesh, are pretty good indications of quality in trout. On the other hand, I must not forget to mention that I have known cases of trout only half-fat, which were excellent, and, indeed, this is characteristic of the Teviot trout, and also those of Waitahuna River. So much for the quality of our trout in connection with the kind of food and the external appearance of the fish.

The general superiority of the trout in the Waiwera, Waipahi, Otaria, and Mimihau over those say of the Pomahaka and many other rivers, must have some other cause than such as I may have previously hinted at. These rivers are all situated within the trap district, defined by me at the commencement of this paper, are low-lying, and, excepting the Mimihau, flow towards the sun, and so get their waters well exposed. The banks are good, and well covered by vegetation, as grass, flax, scrub, or even bush. Also they may be regarded as early rivers, for Messrs. A. C. Begg,

W. Mark Elliott, and J. A. Connell have found in the beginning and middle of October that the trout were fat and in good condition in the Waiwera and Waipahi. It seems to me then that the trap formation is eminently suitable to the abundant growth of insects and other minute food, and that, from situation and exposure to the sun in early spring, the eggs and larvæ of these insects must hatch sooner than in snow-fed waters of Otago. This early supply of the finest of food must, together with the excellent shelter of the banks of these rivers and warmth of the water, be the explanation of the goodness of the trout and their appearing in condition in spring so soon. The Pomahaka's trout, on the other hand, are long of getting into condition, and poor then with some exceptions; the river itself, besides being snow-fed half the summer perhaps, is frequently polluted by gold-mining works, and has a very shingly bottom. It has plenty of the coarser food, as the whitebait; but its water comes from a cold region, and flows away from the sun. I can recollect very well in Scotland I have found the same rule; the best trout were those I caught in streams flowing over trap and old red sandstone; the worst in the shingly, slaty, mountain streams.

Generally our low-lying streams and those freest from snow-water are the ones where trout are soonest in edible condition. Still, even for these, the fishing season begins too soon and ends too late, being from October 1st to March 31st. It is true that, in some years, owing to a mild winter, the trout may be fairly fat by middle of October, but not as a rule; while, by the middle of March they are black, lazy, and gravid. This season, 1883, they are in poor condition, even in November. The fishing season should be shortened by six weeks.

The *food* of our trout may properly here claim a few remarks in connection with growth. Since 1878, I have examined the contents of the stomachs of 62 trout. Frequently I found those of very fat trout quite empty, saving a quantity of white sticky mucus. This was more noticeable in Shag River and Wakatipu fish than in those from other waters. Three or four Wakatipu fish, which were very fat, and almost the only ones I have looked at, had nothing in their stomachs. So, also, with a large trout taken from the Leith, and another from the mouth of that stream in Otago Harbour during the spawning season. But among the other trout I found flies and their larvæ in great abundance, algæ very common, beetles, grasshoppers, crickets, shell-fish, crayfish, bullies or bullheads, native minnows, whitebait, small stones, and grass. I have never found any earthworms; neither in large male trout, even when lean and poor, a single case of a small trout having been swallowed. In those streams furthest removed from tidal estuaries, and consequently from a supply of whitebait,

I commonly find a large quantity of shell-fish (*Limnæa*) in the stomachs of the trout; and many of our rivers are teeming with these curious little molluscs. That the milky-like and sometimes yellow mud from gold diggings is unwholesome for trout, and destructive to a great extent of insect larvæ, I have no doubt. The upper waters of the Shag, the Waitahuna, and Pomahaka are more or less so affected; and there the trout are comparatively poor in condition, particularly at the beginning of summer; notably also on the Deep Stream, for half a mile or so below where some Chinamen were digging five years ago or more, the trout all disappeared, and I question whether any have come back again; I have seen none at all events. At the same time, I am aware that there are trout in the muddy parts of the Taieri River; but these are large fish which, I think, have gone there not from choice, but seeking heavier water and more range than existed in the streams they had left. Trout of half a pound, I find, can swallow other fish, as whitebait and crayfish, and feed on them just as comfortably as fish of 5 lbs. or 10 lbs. weight. As to smaller trout than half a pound here, I have never investigated the contents of their stomachs. As no food has yet been found by me in most Wakatipu trout opened, the mystery of their fat condition and excellent taste cannot easily be made out, and its solution must be deferred.

It is difficult to say what *proportion between the sexes* of our trout exists; the question, however, has been forced on my attention owing to the males which I have caught being so few compared with the females. During one season I estimate the males taken by me did not exceed a quarter of the females! For the last two or three years, therefore, I have made special notes of the sexes; but while this is comparatively easily done as regards trout over 2 lbs. in weight from their external markings, those of half a pound to a pound I very often found puzzling, and when dissected even, had not sufficient sexual development to make the sex certain. On two occasions in the Deep Stream I killed one male and five female trout, but six days scattered over 1880–81–82 gave 11 males and 17 females. In the Lee Stream also, in four days, from 1879 to 1882, the results were also 11 males and 17 females. On the other hand, when I have fished the Shag River at night the trout taken were always males, so far as I recollect. Mr. W. S. Pillans, when taking spawning fish in Lovell's Creek in 1882, got 7 males and only 3 females! Mr. Deans explains this latter case by the circumstance of the females always going away from the redds when spawned, while the males hang about long afterwards. Whatever may be generally the rule here, at present I am of opinion that the females greatly outnumber the other sex. The effect of the disproportion, in whichever way it really lies, on the stock in a river would probably be the same, that is,

damaging. For where there are few males, the females would naturally, one would expect, look for their mates near the redds. The same redds, as a consequence, would get ploughed up and disturbed a good many times, to the destruction of the ova by exposure to light, to the hungry stomachs of the males, and in other ways; while with too many males there would be a greater devouring by these of the ova, and more deaths among the same sex through fighting. Excessively lean and attenuated male trout caught sometimes in our rivers are very likely such as have contracted constitutional maladies during spawning. These may be parasites, or fever induced by injuries from fighting with other males. At all events the main evidences of disease are wasting away of the tissues of their bodies and a voracious appetite, while their colours remain as bright as during the spawning season.

II.—*Habits.*

Of the *spawning* season and time of incubation of our trout I have already treated, showing the latter to be 78 days—the same as I found it prior to 1878. The number of eggs we find to be 800 to 900 for every pound weight of the spawner. During our stripping in August of this year the eggs of fish 1½ lbs. to 2 lbs. were straw-coloured and small, while those of the larger females up to 16lbs. were dark pink and much larger. In 1880 one trout yielded about 30 eggs double the size of all the other eggs she passed, and they hatched out just the same as the rest. The late Mr. Worthington informed me that the ova of trout in Queenstown Creek in 1881 were very light straw-colour, almost white, but those from Butel's Creek, ten miles off, were pink as usual. One season he found the ova in the former stream light straw-colour, light brown, and pink. A female of 12 lbs. weight, which he caught while it was attempting to ascend this creek, was stripped by him. The eggs all went white, and became bad. Long after spawning I have sometimes found empty eggs in the cavity of the body in clusters in the same fish, and often a few single ova. But the most extraordinary state of a female trout which has ever come under my notice was that of a 6 lb. fish sent to me by Mr. Lowe from the Waipahi, on October 25th, 1882. It was in good condition, and the cæca were surrounded by plenty of fat, yet it had about three-fourths of its old ova still in the ovaries, while the next season's eggs, about the size of turnip seed, were spread all through and around the old eggs. The latter, the old ones, were mostly empty and of different colours—red, yellow, and white. The left ovary sac was ruptured, and twenty old collapsed ova were in the abdominal cavity. The only other abnormal appearance was the excessive thickness and toughness of the coverings of the air-bladder and the dorsal artery.

I have already given my ideas on the effects of excessive sludge from gold-mining on trout and their food-supply, so that here it is only necessary to observe that it must retard, if it does not also extinguish the vitality of the ova, where much exposed to its influence.

There is some reason to think that we have a proportion of both older and younger trout which do not spawn, at least not every year. In the Lee, for example, which is not an early river, I have known very fat trout taken in October, and these may have fed all winter through not spawning. Also, I have opened a number of trout half-a-pound to a pound, if not larger, from different rivers, which had neither milt nor ova in them. But, beyond this, I have no evidence to adduce in support of the theory except great similarity in the snouts of the sexes in the case of these barren fish.

The *feeding times* of our trout, however, are more abundantly evident, and in my first paper I gave some particulars of these in our rivers: as that during the day, the middle portion in particular, when the sun is brightest and everything apparently against the angler, he finds by far the most trout come to his lures. I have also mentioned the effects of meteorological disturbances. Trout at Home are usually very shy and knowing, and I assume that the Thames trout or southern form is equally so with his more northerly cousin, which I know best. As a general rule they are shy here too (or lazy it may be), in the morning and evening. Also, towards the end of March, as they begin to get blackish in colour and into spawning condition, they do not rise to feed unless the day be such as suits their fancies—warm and bright, with a fair supply of surface food. I have remarked that at the end of the fishing season, when they do not move during the day, they wake up for an hour or so about sunset, and then may be seen rising all over the river. Excepting, then, in such rivers as the Kakanui, the Shag, and Water of Leith, which are well stocked with whitebait, and which yield good sport all night, as well as day sport, there is no doubt the chief feeding time in all our streams is during broad daylight. Also, when really on the "take," our trout, big and little, seem to abandon all caution, and come boldly at a fly or bait if not very clumsily presented to them; the largest trout in a pool exercising its prerogative, and coming first. They have often followed the fly or grasshopper to within a few feet of the angler, and will sometimes take a bait a second time, after being hooked and running for a while previously. In the Lee Gorge one day I hooked, with a big green grasshopper, in the head of a pool of back-water which was slightly discoloured, as I thought from seeing it a 3 lb. trout. It was on for some time, and I could see it plainly as it struggled about the pool till it got off. Very much disheartened, I gave it a rest for a little, and finding it would

not again look at the big sort, I put on two lively little grasshoppers and cast well up into the stream, letting them gradually sink as they were borne towards its lair. It took them at once for I felt the line tighten; so I gave it plenty of time and then struck well, when the running began in earnest. Being a strong fish, and in a pool with bad stones and boulders, I had much trouble in playing it, but at last managed to net it, and found it a great deal heavier than I had thought, as it weighed 5 lbs. 6 ozs.! On another occasion in the same water, while fishing close to the bank in some broken streams, I hooked up above me a good trout, which got off. Several casts in succession thereafter failing to start it, I gave it up as a hopeless case, and started to walk up the bank past the trout, within three yards of where it lay. In doing so, however, I let the bait drop in and float down, when he took it at once, and I killed the fish, which weighed over 2lbs. Just one other instance (and I have more I could mention), must suffice, as illustrative of the boldness of these trout. This occurred in the Lee Gorge also, to a friend of mine, on a day when the water was very clear, with not a ripple on it. In a broad smooth pool a good trout was rising in the middle. Walking down to the edge, this fisher cast with a cricket right over the fish, which took it at once, and when killed it was found to weigh over three pounds. The trout were not at all on the take that day. On the other hand their shyness or laziness is just as extraordinary as their boldness. I remember, for example, in the Deep Stream, when the fish would not move, fishing down stream behind another angler, who fished pretty carefully, but, as I noticed, missed a yard or two of the very shallowest parts at the top of streams, which are usually thought to be barren spots. He also raised nothing at a deep corner of Pillan's Pool. In both places I gave the water time to rest, or rather the fish, if any, and then fished very carefully the aforesaid shallow parts with cricket, and also the deep corner. After repeated throws, and sinking the bait well in the shallow, I killed a good trout in each, weighing 3 lbs. 6 ozs., and 2 lbs. 10 ozs. respectively. This was in February, 1882.

There is another thing worthy of remark in the feeding habits, which is, that not only do the trout change their feed, so to speak, on different days, but even during the same day. In October, 1877, in the Lee Stream, water in good order, and the forenoon warm, but after a night's snow, with a strong west and north-west wind blowing, I fished down below Snow's with small phantom minnow, about 50 yards behind Mr. A. Campbell, who had on fly. This was before noon, and Mr. Campbell killed several trout of a pound weight before I got any. Then, in the very same places, one above, and the other in the Ledge Pool, which he had cast over without raising anything, I got two with the minnow, weighing 2¼ lbs. and 2½ lbs. After

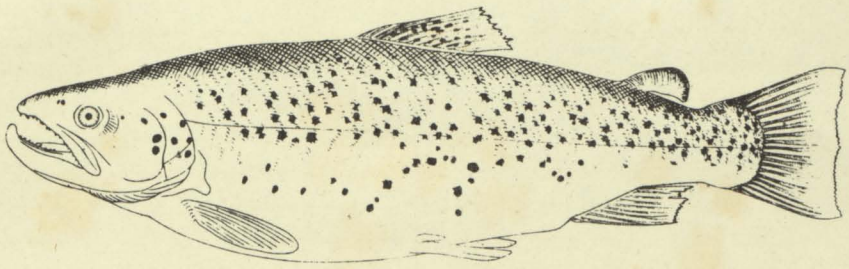

Fig 5
WAIPAHI — male 8 lbs. 10 oz., length 24 ¾ in.

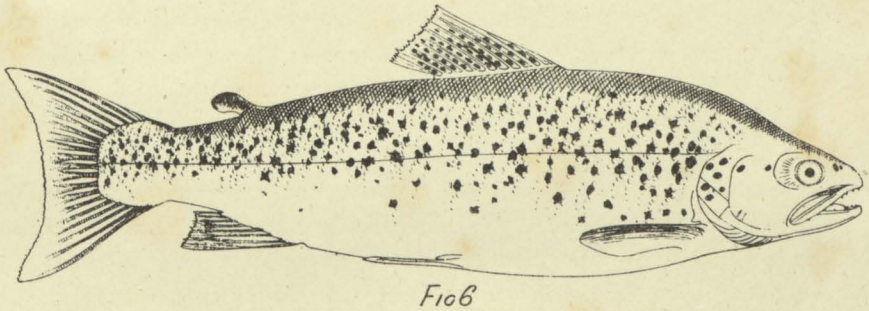

Fig 6
WAIPAHI — female 2 lbs., length 16 inches

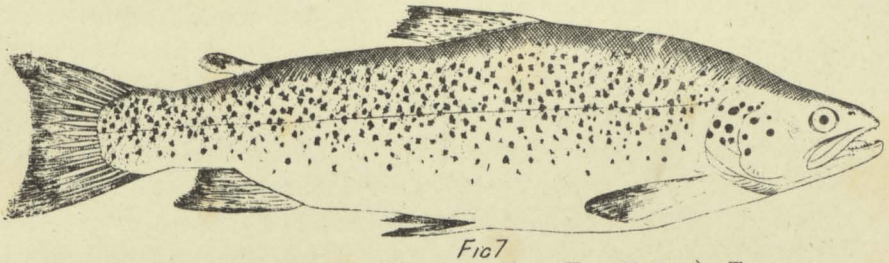

Fig 7
POMAHAKA female 3 lbs 2 oz., length 13 ½ inches.

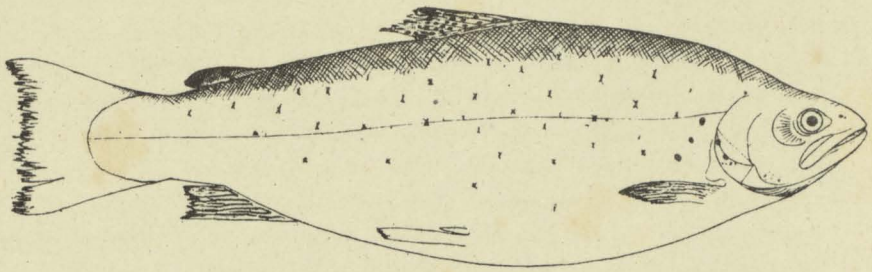

Fig 8
CANTERBURY TROUT — female 2 lbs., length 15 6/10 in

OTACO TROUT (*S. fario Ausonii*) from different rivers.

W.A. del.

one o'clock the trout would not look at minnow, but I killed a large fish, 4½ lbs., with fly, and also some smaller ones. I remember, subsequently, in the Deep Stream, above the Strath crossing, plenty of water and a north-west gale blowing, fishing two days, or rather, parts of two days. On both days I used exactly the same fly, cast with three flies on. The stretcher had on it a creeper, first dropper, which was black hackle, a gentle, and top dropper bare. The one day I killed seven trout, all with the hackle and gentle, and but one, a 2 lb. fish, which was on the creeper. The other day I got five trout, every one on the creeper, and which weighed nearly 15 lbs. gross, the water being rather clearer.

The alteration in the time of daily feeding, from that observed at Home among the trout is puzzling, and angling alone may not disclose all the facts. Still, a very superficial observer of nature must admit that as yet our streams possess a much greater food-supply, and more variety in it, than the streams of the Old Country do. The more open winters we experience will likewise permit a certain amount of insect life to come within reach of feeding trout, and so prevent these getting much reduced in condition. These two circumstances are sufficient to show, that, possessing more available food than their ancestral stock, our trout do not require to be so constantly feeding, and when so engaged have the extra temptation of variety, to make them as capricious as we find them. So, therefore, they choose their own time for satisfying their hunger, and select different food at short intervals. But why mid-day should be preferred by them as their banqueting hour is not so readily explained as their not feeding in early morning or in the evening, which I have proved to be mainly owing to the coldness of the air at these times. It is probable, however, that as most insect life will be on the water during the warmest part of the day, it is then, of course, that feeding trout show most on the surface, while at other times they may be busy grubbing on the bottom for larvæ and shellfish, in the absence of the more dainty surface diet. That the air immediately in contact with the stream must have had a certain quantity of heat and light imparted to it from the morning sun before trout will rise, I have seen attested, by the trout beginning to take hours sooner on an open part of the river than they did on a portion shut in by rocky gorges from the sun's rays. Repeated examples of this have convinced me of the fact. These remarks must be understood to apply to ordinary states of most of our rivers. When in flood, our trout do not take readily, nor, indeed, till the river has fallen to a certain state. It is very likely at such times the fish are partly driven from their haunts by the strength of the stream, and partly, are feeding on the bottom on insect larvæ, which the disturbance of the gravel there has revealed to their keen eyesight.

The *positions* in a large pool taken up by trout are only to be found out by experience of the fish, and of the particular river. For while small trout, of half-a-pound weight and less, locate themselves in every part, the heavier fish, from 2 lbs. upwards, select particular sites for their lairs. Some of these sites are the very last an angler would anticipate, as exposed shallows above the head and at the tail of a pool, and bends of dead backwater, almost stagnant. Sometimes, also, a heavy fish will rest in very strict running water above a pool, and when hooked by a fisherman it often seems as if the line were fast to a rock, so closely does the fish hug the bottom. Then, when fairly "struck," the astonished angler finds his supposed rock dart with alarming velocity into the depths of the main pool below. I have often lost my chance of good fish by not fishing the very last yard or two of a long reach, for, on taking to the bank, I have seen, when too late, a big trout sail away quietly up stream, from below my feet almost, making waves like a steamboat. These remarks, again, are correct as to the state of the case when our rivers are low; but when in spate, the trout are everywhere, and their ordinary habits are not observed. So, also, at night in such waters as the Shag and Kakanui, when a few old stagers keep to their beats, but the multitude of fishes spread over every part, and wake the stillness by splashing out of the water in all directions, and each fish almost simultaneously,—then a quiet spell succeeds for a quarter of an hour, to be followed by another chorus of splashes, and so on, until the moment the first symptoms of dawn are felt, when all become quiet, and will look at no bait, natural or invented, for hours afterwards.

When a river is low and clear, I have often known trout to be disturbed by the vibrations in the water caused by the angler wading, and so make off long before he himself was visible to the fish. This applies to up-stream fishing, as well as to down-stream fishing.

The shelter of flax-bushes, Veronicas, or even a good rock, are appreciated, and much used by our trout; but as yet there are not enough of fish to occupy every sheltered retreat. Hence, where small creeks join the main stream, trout are not so commonly seen as one would expect.

Another very marked evidence of the trout's appreciation of sunlight and warmth is, that black, rocky, dark pools in the Lee Gorge and other streams, have no trout in them at all. I and others have, again and again, thrashed such pools, and never seen a fin in one of them.

Cannibalism among our trout is a practice denounced by many fish-men in language expressing the axiom "the big trout eat the little ones." I have frequently listened to such common cant, and when I have asked for proof, the best reply to be got was,—"Oh, it is a well-known fact." Now having taken some pains to test this opinion, by a reference to the fish

themselves, I do not find, as yet, that they have so far corroborated the libel as to justify so sweeping an assertion. In confinement, or in barren water where food is scarce, a big trout may very likely grab at its own youngsters, or even larger ones if he be starving, as we have found them do here; but let him have a good lair in a river with plenty of food, and I don't believe he will touch them. An examination of the stomachs of more than seventy trout of both sexes, taken out of a score of different waters, and in size ranging from ½ lb. to 14 lbs., has resulted in not a single young trout being found by me in any of them. The only case I know of is a doubtful one, and it was on the 14th February, 1881, when Mrs. Walsh, at the Deep Stream, told me she had found a trout 4 inches long in the stomach of a 4 lb. trout. As I do not recollect having seen this 4-inch unfortunate trout, I may be allowed to suggest that it possibly was a cock-i-bully! At all events, granting it to have been a veritable trout, still there are 70 to 1 trout in our streams which decline at present to be convicted as cannibals!

Migration appears to be the refuge of trout in Otago when planted in a stream deficient in size and range of water, and of food. Hence the disappearance of the largest trout from the Water of Leith, except during the spawning season. They evidently resort to the salt-water of Otago Harbour in search of more water and more food than can be got in the Leith. For trout of the common *S. fario* species are being constantly caught in fishermen's nets in the bay. These show a tendency to acquire a sea-trout appearance, as they are usually very silvery, and the black spots are often, but not always, x-shaped. The belly fins also become very white, and the head gets sharp and fine. Of course I give this as an opinion, because unless the fish themselves are marked for identification, and examined again after capture in the sea, there can be no absolute proof. I may at the same time say, that other trout taken in the nets are so similar in markings to sea-trout, that I consider they are of that species. These are, however, becoming scarcer year by year. For years past in the experience of anglers, the large trout have been found more towards the mouths of the Deep Stream and Lee Stream. This, with the simultaneous appearance of large trout in the Taieri River below the mouths of the above two streams, may be regarded as additional corroboration of my statement. In Queenstown Bay, Lake Wakatipu, the trout are not migratory, but hang about the creek mouth and Peninsula Reef. This is, at least, partly because they have plenty of water; and although I have not as yet found food in the stomachs of more than one of these trout, their prime condition indicates abundant nourishment of some kind in the waters of the Lake. I might quote other cases of migration towards heavier water, but space will not admit of this.

I come now to notice the *vagaries* of trout, if such an expression can be permitted in connection with fish. There are two or three trout in the ponds in the Botanical Gardens, Dunedin, from 2 to 3 lbs. in weight, which live there from year to year, among ducks, swans and other fishes, and seem to get past the spawning season without any inconvenience. They have, also, lost much of their natural shyness and are comparatively tame. The trout, also, in Mr. Pillans's private ponds are so tame as to come quite close to him when feeding them. Mr. Connell, Mr. Digby Smith and Mr. Maitland have each mentioned instances to me of a large trout following close behind a good trout, when hooked and before landing it—no timidity shown but the greatest boldness. Very likely the two fish were mates. One day in December, 1881, Captain Fullarton and I were fishing below Rich's Ford in Shag River. I was trying to catch mullet with fly and maggot, when I saw the mullet scatter repeatedly when near my hooks, as if scared. Presently a large trout became visible swimming round in circles, and, as it came nearer the surface each turn, I cast over it in the vain hope of seeing it take the fly. This it did not do, but it seemed once inclined to take my companion's natural minnow. Gradually it came closer to the bank and began to get its head above water as it swam round, seemingly in distress and wanting more air. It could see us plainly, and indeed appeared to invite our assistance, for it came so near us gasping for breath, that at last Captain Fullarton gaffed it. It was a 5 lb. female trout, fat, with plenty of curd, and ate well when boiled. There was no trace of fungus on any part of the fish, and its viscera were quite healthy, only the gills were too highly coloured; but on the lateral line on both sides on the tail portion, between the anal and caudal fins, a patch of scales of the size of a shilling had been rubbed off apparently, and had small black hairs growing about $\frac{1}{20}$ inch long. These, under the microscope, had a root-like or star-like structure, branching out from a centre, and were brownish in colour, probably parasites. As the weather for days had been very warm, and the water was low and heated, we both concluded that this trout was suffering from the heat, and was either sick or fevered.

The *enemies* of the trout in our streams may here be summarized. There are native bullheads which attack the young fry, and eels, as both these fish have been proved to eat trout. Large smelts, also, are probably offenders. Among birds—kingfishers (where bush is plentiful), gulls, and shags or cormorants. The cormorants are by far the most destructive, and do more harm to a stream in a season than all the anglers who may fish it. Their favourite stations are a rock in mid-stream, or cliffs overhanging a pool. Instances have been told me where at least a dozen trout have been taken

out of their stomachs, as related by me above, and they are known or supposed to have killed and eaten trout about 2 lbs. in weight. The ordinary shag of our rivers is about as big as a tame duck, but much thinner in body having a long sinewy neck and a dreadful bill with a hook at the point.

Disease at our Opoho hatchery among the ova is unknown. Dead eggs have been found to be unimpregnated, and no loss has resulted from silt, of which there is always a good deal. Deaths among the young fish have been consequent on a dropsical affection of the umbilical sac, and of monstrosities. Having already made some remarks on very thin male trout which appeared to be "dying by inches," in consequence of their flesh and fat consuming away, I will not add more than the suggestion that fever would account for the symptoms or effects of their ailment. Several specimens of trout found dead in our rivers have come under my notice. Dissection showed that some internal organ as the intestine was ruptured, but how occasioned it would be hard to say. For several years Mr. Nelson has seen trout in Lovell's Creek which were quite blind. This he proved repeatedly by trials; yet when a worm or bait was thrown into the water they took it at once. These trout were of both sexes, 4–5 lbs. in weight, not by a long way the largest trout in the stream, and their eyes had white opaque spots on each. In the case of females, the ova were found at the spawning season to be bad, although the fish were in good condition. No cause has been found out for this singular eye affection, but probably its origin is parasitic. *Fungus*, unfortunately, is not unknown in Otago waters. It was noticed first on trout in confinement at the Wallacetown ponds, by Mr. Howard, about 1874 or 1875. During spawning it has been seen on trout in Fulton's Creek; but in Queenstown Bay, Lake Wakatipu, it is very prevalent among the shoals of trout there, as formerly described by me.* The pathology (to borrow a medical expression) of this disease has not yet been worked out exhaustively, and it is surrounded by many difficulties. At the same time I may be pardoned if I again give my opinion, that all the exciting causes of the affection may be narrowed down to two conditions, viz.:—the absence of sufficient salt in the water inhabited by the fish, and of sufficient oxygen in the blood of the fish itself. Salt has been found to be a wonderful health promoter among the Salmonidæ; and oxygen, in the necessary proportions in the blood of the fish, is indispensable to secure it from fungoid attacks. Trout in Shag River have died, as supposed, because of excessive heat.

III.—*Structure.*

Although external *colour and markings* can scarcely be referred to structure, yet these come more naturally under that heading than any other. Specimens of trout from High Wycombe, Bucks, are thus described by Mr.

* Trans. N.Z. Inst., 1882, vol. xv., p. 198.

Francis Francis :—"They are more like salmon than the common brown trout, and are brilliantly silver in colour, very short and thick in make, and weigh heavier for their length than almost any fish I know." Otago trout, of the same species as those referred to by Francis, show great variations in colours, and that not confined to age or sex; yet these variations appear to be limited. At the same time, they evidently depend on the colour of the water and river bottom, mainly; but very little, if at all, on the nature of the food-supply. A general feature, and the most noteworthy, is that the females, of any age and from any stream, are silvery with black spots, red ones seldom present or numerous, while the males are darker, with a tendency to yellow on sides and belly, at times very golden, and they have always, or nearly always, red spots, sometimes large and numerous. The shape of the black spots, always round on the gill covers, shoulders, dorsal, and adipose fins, varies on the body from round to rectangular and x-shaped towards the tail. The theory that residence in salt water is shown by the black spots assuming the x shape, is not altogether borne out by facts. For example, trout of both sexes, in such water as the Shag river, Pomahaka, and Wakatipu Lake, where there is clear or white water and a light bottom, are silvery, and have black spots mostly x-shaped; indeed I have often seen bright silvery females with fine heads and x spots that might easily be taken for sea-trout; while the Waiwera and Waipahi Rivers, which have dark bottoms, produce trout of the golden variety, with most of the black spots rounded in form. The food in these four rivers is much the same. Brown trout taken in Otago Harbour show a tendency to acquire x-shaped spots, and take on a sea-trout appearance, but not always. On July 2nd, 1883, among the trout taken out of the Leith for stripping, we had a beautiful silvery female of about 16lbs., which I have no doubt had been resident in the harbour; yet the black spots on it, which were large and numerous, were of a *rectangular* shape. During the spawning season the males show much brighter colours, and extra red spots appear faintly which at other times might not be discernible; white the deciduous scales give place to thick fleshy ones. The females, also, at that season, and when young, show reddish spots, which might be very hard to distinguish during the summer, or when older. The red and some of the dark spots are sometimes beautifully ocellated, or surrounded by a lighter ring of colour. The fins, too, vary apparently with age and water within certain limits. The adipose nearly always has a pink edge or margin; the pectoral fin is generally olive brown in adults and olive yellow in young specimens, while the ventral and anal fins are of the same hue but lighter, and sometimes almost white. In dark individuals the anal and ventral fins have occasionally a white anterior margin.

The *form* of the head, body, and tail fin is subject to considerable modifications. In females, more particularly adults, the head is smaller and finer in shape than in males. In females the head is usually in adults one-fifth of total length, and in males, one-third to one-fourth, among my specimens. It is very difficult in young trout up to half a pound in weight, to tell the sex from the head and spots. Even dissection sometimes has shown me no sexual development sufficient to determine the question. But usually, in trout from half a pound upwards, it may be seen from the size of the head, form of mandible, and presence or absence of red spots. The male is most commonly to be recognized by its large head and fins, the hook on the lower jaw, and the red spots on its body. In one or two rare examples I have found a male of 2lbs. to 4lbs. with very little of a hook at all, while I have seen a female of similar size with quite as large a hook on its mandible. These cases are, however, very exceptional among Otago trout.* The

form of the maxillary is not very constant, being broad and fine or coarse, narrow and fine or coarse, always however, in adults having its posterior end in line of, or behind line of, a vertical from posterior margin of orbit. The opercula seem inconstant in shape within certain limits. The preoperculum in our trout has always, contrary to his description of non-migratory trout, what Dr. Günther calls a "lower limb," generally very pronounced in outline, and with three or more striæ on the surface of the bone. The suboperculum of our Otago trout is *generally* of a trapezoidal form, as in fig. 1 in the attached woodcut, with the exterior angle more or less circular, or it might be called roughly rectangular. Fig. 2 is a case of a young female trout from the Waipahi, in which the rectangular form is very decided. It approaches nearer to Mr. Yarrell's typical form (fig. 4) than in any other trout yet seen by me; although one other trout I have examined had nearly the same form of this bone. But fig. 3 is a very common shape in the old male trout. There is sometimes, but not often, a slight difference in outline between the subopercles on either side of the head in the same fish. In young examples the margins of the opercula are rounded and graceful, but in old fish

* In such specimens the head is small like a female, and no development of either melt or roe of a decided character.

they are found by me to become angular in the subopercle, and sinuous in the operculum and preoperculum. A careful comparison of trout heads preserved by me, shows that sex has no influence on the form of the subopercle; or that the particular form does not indicate the sex. Neither does residence in brackish or salt water appear to affect the shape of that bone; but I have not as yet had more than a few specimens to examine, taken in salt water.

The branchiostegal rays which I have carefully counted in many of our trout are pretty constant at 10 in number. They vary, however, sometimes from 9 to 11, and it is a common occurrence to find one more on the left side than the right or *vice versâ*.

The *eye* in females is relatively nearer to the snout than in males.

The *teeth* of the vomer have been regarded by Dr. Günther and others as a good character to fix the *S. fario* species as distinct from the *S. trutta species*. That is, while the vomerine teeth in the latter are deciduous, those of *S. fario* are described by Dr. Günther as "persistent through life." Now, whatever the case may be in the trout of Home rivers, I have abundant proof in my notes, made when examining the teeth of Otago trout, that they are very far from being persistent on the vomer. On the head of the vomer (excepting in the case of a trout from the Wakatipu, got in January, 1880) I have always found the teeth present. But, on the shaft of that bone, the gradual disappearance, year after year, of the teeth, is from behind forwards, and appears to be mainly a consequence of the increased age of the individual trout.

The *body* of the trout in outline is much more varied than one would suppose, and this is, I venture to think, the explanation of the difficulty anglers find in guessing correctly the weight. Thus, taking the case only of trout when in good or fair condition, the back is sometimes so slightly arched as to be nearly straight, the belly in such a case being very deep and full (see fig. 2, pl. xliii.); so much so, indeed, as (with exceedingly fat fish) to distort the mouth, and throw the ventrals nearer the tail. Then our best-shaped trout are hog-backed from the head to the dorsal fin—both back and belly being properly balanced in their curves. There are also two distinct forms when viewing trout transversely: the one is narrow and deep in section, the other broad across the back, and not at all deep in section. As already mentioned, I find in good fat fish the minimum ratio of depth to girth should be as 1–2¼. I have not much to say about the form of the fins, excepting that as regards the tail, or, as I should perhaps name it, the caudal fin, I find it forked in our young trout; in mature fish of 2 lbs. it often is forked also; but, in heavier and presumably older fish, it varies from slightly emarginate to straight, and sometimes even truncate. I have

also frequently seen the upper lobe larger than the under one. The least depth of the tail is pretty constant, being from a tenth to a twelfth of the total length of the trout, or about that ratio.

But, as the *size of the fins* is thought by naturalists to have a direct relation to the depth of water and nature of the bottom, it may be well to see what evidence my specimens can give on that point. Dr. Günther says:—"Those individuals which live in rapid streams, being in almost constant motion, and wearing off the delicate extremities of the fins, have the fin-rays comparatively shorter and stouter, and the fins of a more rounded form, particularly at the corners, than individuals inhabiting ponds or lakes." * The number of trout I have measured with particular reference to this question is not, in my opinion, sufficient to test the case fairly in Otago waters. Out of 13 rivers, I have had 19 males and 6 females under measurement, also 2 males from Lake Wakatipu; these are all. I have classified them, however, distinguishing fish from rapid and rocky streams, as separated from those frequenting larger and stiller water; and I find that the evidence is very puzzling and contradictory, so that different theories might easily be based on particular cases. I have therefore prepared a large table, showing the ratio which each fin bears to the total length of the fish—measuring the base of the single or median fins and the longest ray of the double fins, as representing the lengths. The result on the whole, and taking it for what it may be worth, is corroborative of the above quotation from Günther. Three of the fins, viz., the dorsal, pectoral, and ventral, I find shorter in the rough, quick-running rivers, than in the stiller, heavier streams, or in the lake; but the anal is doubtful. While, therefore, my experiments on this point are not so complete as could be desired, they have brought out other facts curious and interesting, and which are not so open to dubiety. Thus I find the females have all smaller fins than the males, excepting the anal, which is larger. Then, among the females, the range of difference or variation in the size of fins is very great as between different individuals, and also between the different fins of the body themselves. But, among the males, the range is not nearly so great; neither is there the great difference of size between the body fins themselves. These latter facts will appear more clearly from this short table:—

Range in ratio of fins to total length of trout.

	D	P	V	A
Females	.. 1·48	.. 1·93	.. 2·10	.. 4·86
Males	.. 0·93	.. 0·91	.. 1·44	.. 0·94

* Study of Fishes, p. 634.

This table means that among females the least variation is among the dorsal fins, which variation goes on increasing to a maximum in the anal fins. Among males the variation is nearly the same among all the fins but the ventral, and not at all to be compared in amount with that of the females as before stated.

In the fin rays, nothing in the way of change has been seen by me during the past five years, so that I can but repeat that I find the dorsal and pectoral fin rays vary by one or two in number; the ventral and the caudal appear to be constant, while the anal differs by one ray at times. Thus 12–14 D; 13–14 P; 9 V; 10–11 A; and 19 C, will be the fin ray formula; and I may explain the numbers in the dorsal and anal fins include simple spines, but those of the caudal do not, there being usually four to six spines additional on either side supporting the base of the fin. The caudal seems absolutely invariable as to number of bony and feathered rays, 19 being constantly found by me. Then the ventral is almost as constant, as I have never seen more than one or two cases where the rays differed from 9, and then only by one ray. The dorsal and pectorals may be taken as invariable within the limits of one to four rays; and, in short, within these limits all the fin rays appear to be fixed in number. It is also to be remarked that a comparison of the fin ray formula above with those given by Yarrell, Günther, and others, shows no practical difference. Neither is the difference greater when compared with the formula of the *S. salar* and *S. trutta*, so that the number of fin rays is really of no specific value as a distinction among these closely-allied species.

Scales.—The most constant in number are those in a row from adipose fin back, or forwards to lateral line—probably, however, apparently so only, because they are more easily counted—those taken along whole length and breadth of body being very hard to see at head and tail, and along back and belly. Twenty-three female trout and nine males I found to have 14 to 18 scales from the adipose back to lateral line. Lat. L. 117 to 128, and Trans. L. 48 to 66. The trout having these scales were from 14ozs. to 14lbs., taken from fourteen different rivers or waters. Neither sex nor age showed any real difference in the numbers.

The *Vertebræ* of our trout, so far as I can make them out, are fixed in number; that is, they only vary from 56 to 60. As, however, I have found great difficulty in deciphering the terminal bones at the head and tail, I cannot claim greater accuracy than to within one or two. Out of sixteen trout examined, one had 56 vertebræ, three 57, two 58, seven 59, and three 60. There does not appear to be any correlation between the sexes and the number of vertebræ; thus the mean number among eleven females was 58·5, and among five males, which are all I have a record of, was 58·4.

Neither as yet have I discovered any cases of two or any bones of the vertebræ coalescing or subdividing. Whether young trout have fewer vertebræ than older ones, has not been examined into by me, but I suspect it may be so.

The *Pyloric cæca* situated at the end of the stomach where it forms a second bend in joining the great intestine or gut, appear to possess the functions of assisting in absorbing and assimilating the food from the stomach, and of secreting fat. In external colour they possess a rosy flesh tint, when the trout is in good health and on its natural food, and in form are exactly like miniature sausages. But I recently examined the intestines of a trout taken from a pond, where the trout had been fed largely on curdled milk, and where they were fat, strong, and in good condition, when I found the cæca perfectly white, while the other organs were more or less of the same colour. The interior of the cæca, I have often remarked, contains an opaque fluid or juice, of an orange, red, or paler hue as the case may be, and very much the same as is present in the intestine itself; while the exterior is covered by more or less fat, at times indeed smothered in fat, which is tied and laced in a most intricate and secure fashion to the stomach and cæca by strong fibrous tissues like threads. The fat is whitish in colour. From twenty-one female and seven male trout examined, and which were taken from nine different rivers, a lake, and from Otago Harbour (two from each of the latter), the number of cæca was found among the females to range from 33–61, the mean number being 47·3; while among the males the range was from 37–55, with a mean of 48·7. This shows that while the range in number is great (but among males not so much so as among females, just as with the fins), the mean number does not seem to vary much over the whole, or as between the sexes. But undoubtedly as a means of distinction between the *fario and its nearly related species*, a comparison of the above figures with those given in Günther's "Catalogue of Fishes," will prove to anyone curious on the subject that they are of no use whatever. I except, of course, the Loch Leven trout from this category.

Ichthyologists say, and with apparent reason, that marine fishes are furnished with more cæca than fresh-water forms as a general rule, because they have a wider field to range over for their food, and are in so doing exposed to more numerous and varied enemies than in fresh waters; and that this necessitates the rapid digestion of food, and quick locomotion. Applying this rule to such a restricted field as our trout supply—or rather, I should say, applying to our trout for such contribution as their limited circumstances can afford to our knowledge on this point—I cannot find that the theory is supported as yet, our brown trout having nearly as many

cæca as sea-trout. Neither is there evidence that the superabundance of food here has resulted in a rise in the average number of cæca during the past five years or previously. By referring to my first paper of 1878, it will be seen that the mean number for all the trout examined, was 48·3 while now the number is, as above given, for females, 47·3, and for males, 48·7. Thus it is plain the normal average number of cæca is neither on the increase nor the decrease in our waters, whatever may be said of their range varying. Then, as the same variety of *fario* in England is said to have from 38–47 cæca (although the average is not stated, see Dr. Day on the *Salmonidæ*), it would seem at first sight as if our trout had suddenly developed an increased number of these organs, or in other words, had experienced a rise from 42·5 to 48. But the comparison cannot be held to be satisfactory unless all the particulars as to age, weight, sex, stream, and feeding are also known. And just as the parr marks, scarlet spots, and teeth are affected by age, may not the cæca be subject to a similar law? Of course it is impossible to tell to a year or two the age of trout taken in a wild state; at least I do not know any rule at present that can give us this. So in the absence of any better guide, I have taken the weights of the trout as the index of their age, and I find this:—Among eight female trout from various rivers, in weight from 1lb. to 2½lbs., the cæca ranged from 33–55, with a mean of 42·5 in number; and among fourteen female trout, from 3lbs. to 10lbs. in weight, the cæca ranged from 44–61, with a mean number of 50·5. Now Günther's largest trout was 15 inches, which at Home means a trout of about the same age as my 2½lbs. trout; while the approximate mean number (42·5) of the cæca observed by him is exactly the same as the mean here, for trout of the corresponding age. I have not enough examples from males to warrant me as yet in saying how the case is with them; but what I have just now stated, proves that variation in the number of the cæca may be quite as much due to age (the number increasing with age), as to change of habitat from England to Otago, with, in our case, great increase in the food-supply. And there is another principle which seems to have something to do with the number of these organs. The cæca of the trout which had 61 were unusually small, not over one inch in length, while those of trout having 40 and 46 were large, in the latter ranging from half-an-inch to two and a half inches long. If subsequent researches bear me out in these facts, then it will be tolerably evident that while their numbers and size are exceedingly variable, there probably may be a fixed relation between the extent of the absorbing surface of the pylorics, and the weight or age of the trout itself.

Our heavier still rivers do not appear, with their grand stock of smelts and whitebait, etc., to cause any increase in the number of the pyloric cæca, over those of trout in our rougher and poorer streams. This I have proved from a careful examination of a fair number of specimens. And, it is also curious, that a sea-trout caught in Sawyer's Bay, which I opened, had only 40 cæca, while it must have had the finest possible range of feeding ground.

What I have now said regarding these organs in our trout amounts to this:—The actual number of cæca observed in Otago is greater than Günther's recorded number of them at Home; but the evidence I have adduced shows that this increase in number is not owing to an additional demand on the cæca to work, necessitated by the presence of more food, but in all probability to a difference in age of the fish examined. Or, more plainly, there has really been no alteration in the number of the pyloric cæca, or in the extent of their absorbing surface.

There remain but one or two observations which I have to make on structure before finishing my paper, which has expanded into dimensions I did not anticipate, so much so that I may have to reduce the appendix I thought of, if I do not omit it altogether. The first is, that in nearly every female with developed ovaries the left lobe is much longer than the right lobe. And, as to the theory of the thickness of coating in stomachs of trout, (as the Gillaroo trout of Ireland), being a consequence of the food being shellfish, this I must say—that most of our rivers contain a wonderful number of the previously mentioned *Limnæa*, an active little mollusc, which I have found in our trouts' stomachs in incredible numbers. At the same time there are parts of some rivers where they are absent, and where of course the trout cannot get them to eat. I have not paid particular attention to the action of any food on trouts' stomachs as yet; at the same time, had there been any difference between those of trout from either feeding grounds, it is probable that I should have noticed it. And, I certainly have not seen either a thickening or hardening of the walls of the stomach.*

Remarks on Variations.

1. The first variation is a decided one in the spawning season, being two months later, and the duration of hatching a fortnight longer, than in England. But what may be the cause of this I cannot explain.

* Since writing above, I have found this shellfish at the head of the stomach, and near the vent in great intestine of a one-pound trout from Waipahi River, and in both cases the living animal was digested out of the shells, while these were not broken or affected in any other way.

2. The great increase in the yearly growth of our trout, compared to that of trout in a wild state at Home, is neither a new nor so very wonderful a variation. It seems to me to be due entirely to new and abundant food, and it may to some extent be to new water, also to the constitution or stock of trout. The same has occurred in Scotland, and with a warning note too to us in New Zealand. Mr. J. A. Harvie Brown, of Dunipace, stocked a loch in the north of Scotland, which had no trout in it at all. In two years they multiplied and attained a weight of 4½ lbs. So soon, however, as the trouts' numbers exceeded the food supply, or in two years, they fell off in condition, colour, etc., and latterly were not worth catching. Like cases have occurred elsewhere at home.

3. The colour and markings seem to be controlled, to some extent, by the nature of the water and bottom, among trout of equal age and the same sex, and to be partly an individual quality. But, as to food affecting the colours, I cannot at present offer a very decided opinion; but will mention this—that the Shag River trout are all silvery, while those of the Waipahi are mostly dark and golden, the food being the same, but the geological formation and water very different in these two rivers. I have seen a like variation in colour in two different parts of the *same* river (the Endrick) in Scotland, with presumably one and the same sort of food.

4. There does appear to be a considerable difference in the form of the suboperculum between our trout and Yarrell's typical specimen; but it is not by any means certain that the latter was of the same species. Also, while the form, with our trout, of this bone varies greatly, one or two examples (fig. 2, p. 503), got by me within the last year or two, show a decided tendency to revert to Yarrell's form. On the other hand, his drawing of *S. fario ausonii*, p. 261, vol. i., shows this bone very much as it may be seen in the great majority of our trout; so that there is hardly any ground for believing that a new form or shape of bone has been induced by a change to the antipodes.

5. There is no alteration in the number of fin rays of any moment; but whether the variation in size of the fins is the same as at Home, is a matter which I have scarcely the means of deciding.

6. The scales appear to be more plentiful than in trout described by Dr. Günther, but I can only repeat that probably no two observers would find the same number, owing to their disappearance on the outlines of the body.

7. The vertebræ are not practically different in number from those recorded of the progenitors of our trout.

8. Neither is there any real variation in the pyloric cæca, excepting in the range of numbers; if my explanations given above are borne out by future research.

The numbers of our trout are increasing in such good breeding waters as the Shag, Kaihiku, and Waiwera Rivers, but they are not so heavy by a great deal as in former years. Poaching and fishing are no doubt largely the cause of this; but some other rivers show a diminution in the numbers, with a rise in the average weight of the trout caught. Bad spawning and plundering of shags are no doubt the prime causes.

APPENDIX.

Table of numbers of Scales, Pyloric Cæca, and Vertebræ of Otago Trout, 1883.

LOCALITY.	SEX.	Wght.	SCALES.			Pyloric C'ca.	Vertebræ.	REMARKS.
		lb. oz.	Adipose to lateral line.	Lat l.	Tr. l.			
Kakanui River ..	F	8	..	124	65	49	58	Caught by Mr. S. Lowe.
Shag River ..	F	3	17	..	..	54		
,, ..	M	4·8	15	124	..	..	..	Sent by Mr. J. Muir.
,, ..	F	2·4	..	117	48	36	54	
,, ..	F	1·14½	17	120	60	45	57	
,, ..	F	2·8	..	..	..	40	53?	Large cæca.
Waikouaiti River ..	F	14	17					
Water of Leith ..	F	6	15	..	..	50	54	
Lee Stream ..	F	2	15					
,, ..	F	1·1½	..	..	..	33	59	
,, ..	F	1·4	16					
,, ..	F	1·1	..	..	..	46	60	
,, ..	F	4·8	14	..	..	46		
,, ..	F	3·10	17	..	..	44	56	
,, ..	F	4·8	17	..	..	50		
,, ..	F	1·9	17	..	..	55		
,, ..	M	1·6½	..	..	..	54	59	
,, ..	M	2·12	..	119	55	44	59	
Deep Stream ..	M	3	14	..	..	53		
,, ..	M	3·4	..	..	..	..	59	
Tokomairiro River	F	7·4	..	121	53	61	59	Very short and thin cæca.
Waiwera River ..	F	2·13	16	128	66			
,, ..	F	5	17	..	..	50		
Waipahi River ..	M	4·2	17	..	..	..	..	Sent by Captain Fullarton.
,, ..	M	4·8	..	..	..	37	57	,, ,,
,, ..	M	5·8	14	..	..	..	..	,, ,,
,, ..	M	8·10	16	..	..	..	..	Caught by Mr. Bull.
,, ..	F	1·8	..	..	..	39		
,, ..	F	6·1½	18	120	55	50		
,, ..	F	3·2½	..	..	..	54		
,, ..	M	4·8	16	120	60	55	58	
,, ..	M	1·7	..	..	..	49		
Kuriwao River ..	F	1·12	14	..	..	46		
Kaihiku River ..	F	5·5	..	..	..	46	..	Large cæca, ½ to 2½ inches.
Otago Harbour ..	F	5	16	124	55	52	57	
Wakatipu Lake ..	M	11	..	117	53	47	..	Sent by Mr. Dalgleish.—
,, ..	M	10	..	..	..	49	..	Large cæca ⅜ to 2½ in.
,, ..	M	12	15	..	..	36	..	long, and 1·10 to ¼ in.
,, ..	M	9·4	..	..	..	..	59	thick.

Table of Lengths of Fins in Inches of Otago Trout, 1883.

Locality.	Sex.	Wght. in lbs. & ozs.	D.	P.	V.	A.	Total Lngth.	Least depth of tail.	Remarks.
Kakanui River ..	F	8	3·3	3·5	2 6	2·4	24·5	2·2	Caught by Mr. S. Lowe.
Shag River ..	F	4·12	3·0	3·0	2·6	..	23·0	2·0	„ at Rich's.
„ ..	M	4·8	2·8	3·0	2·2	1·8	20·7	1·8	„ at Muir's.
„ ..	F	5	3·0	3·0	2·5	2·0	22·0	..	„ at Rich's.
„ ..	F	2·4	2·2	2·6	2·1	1·7	18 0	1·5	„ at Kitchener's.
„ ..	F	2	2·0	2·3	1·8	1·4	16·5	1·5	„ „
Waikouaiti River	F	14	3·75	4·5	3·4	2·7	28·5	2·5	„ by Mr. H Orbell.
Water of Leith ..	F	17	3·75	4·0	3·25	4·0	33·0		
„ ..	F	5	2·5	2·8	2·2	2·0	21 25	1·7	Harbour, mouth of Leith.
Lee Stream ..	F	1·9	2·0	2·3	1·9	2·2	15·5	..	Gorge water.
„ ..	F	3·10	2·8	2·8	2 3	2·5	20·5	..	„
„ ..	M	2·12	2·4	3·0	2·2	1·6	18·5	1·6	„
Tokomairiro River	F	7·4	3·6	3·5	2·8	2·7	26·5	2·2	Caught by Mr. J. Burt.
Waiwera River ..	F	2·13	2·2	2·2	2·2	2·6	18·0	1·6	
Teviot River ..	F	0·14	1·7	2·1	1·6	1·3	14·0	1·3	
Boat Harbour Creek	F	3·4	2·5	2·9	2·0	2·0	20·5	1·75	Found dead.
Pomahaka River	F	2·6	2 3	2·5	2·0	1·6	18·0	1·6	
„ ..	F	3·2	2·4	3·0	2·3	2·0	19·5	1·75	
Waipahi River ..	M	4·2	2·8	3·0	2·5	2·0	21·25	1·75	
„ ..	M	5·8	3·0	3·7	3·0	2·2	24·0	2·0	
„ ..	M	8·10	3·5	3·75	3·0	2·3	24·75	2·2	Caught by Mr. Bull.
„ ..	F	6·1	3·25	3·5	2·75	2·25	24·5	2·25	
„ ..	M	4·8	3·0	3·4	2·7	2·0	21 05	2 0	
Kaihiku River ..	F	5·5	3·25	3·25	2·7	2·25	24·25	2·0	
Oreti River ..	F	5·0	2·75	3·0	2·2	2·0	20 75	1·9	
Wakatipu Lake ..	M	8·4	3·2	3·8	2·7	2·4	25·5	2·3	
„ ..	M	9·4	3·8	4·0	3·0	2·8	26·0	2·6	
„ ..	M	12·0	3·75	4·0	3·1	2·5	26·5	2·5	Sent by Mr. Dalgleish.
(Canterbury fish)	F	2·0	2·0	2·1	1·6	1·8	15·5	1·6	„ Mr. S. C. Farr.

Note.—The proportion or ratio which the length of any fin bears to total length of the fish as expressed by L—D, L÷P, etc., has been used by me for ascertaining the differences in the length of the fins between individual fish and between the sexes, and may be readily deduced from above table.

Art. LVI.—Sorghum *Experiment*, 1882–83. By Mr. Justice Gillies.

[*Read before the Auckland Institute, 20th August*, 1883.]

Having no land of my own fit for growing *Sorghum* this year, Mr. W. F. Buckland kindly undertook to grow half an acre for me on his property at Remuera. The land is a strong volcanic loam, had been under crop for several years, and had a good deal of sorrel in it. Mr. Buckland manured the land with one and a half cwt. of bone dust. On the 20th of October, 1882, he planted exactly half an acre with "Early Amber" *Sorghum* seed supplied by me. The seed was planted in rows 3 feet apart, and about three seeds

* See Trans. N.Z. Inst., vol. xiv., p. 373, and vol. xv., p. 261.