Fat.

The ethereal extract of the dry-fish powder was used, since that is usually reckoned as fat in the analysis of foodstuffs. The following values were obtained:—

TABLE I.

Fish.	No.	Caloric Value of Fat per Gramme.	Remarks.
Kingfish (haku; *Seriola lalandii*)	1	8·796 calories.. 8·822 8·805 (average)	Fat extracted from dried-fish powder.
Kingfish ..	2	8·857	Same.
Groper (hapuku; *Oligorus gigas*)	5	8·670 8·678 8·674 (average)	Same.
Groper ..	X	9·059 9·045 9·052 (average)	Fat extracted from alcohol-dried fish, low temperature; old.
Groper ..	Y	9·842	Same, but fresh.

These results indicate that during the drying of the fish (but probably in greater degree during its storage)—exposed to the light and to a certain amount of air—some oxidation occurs, sufficient to reduce the caloric value from 9·8 to 8·6. It would be interesting to find out how much depreciation of the fuel-value occurs in the cooking of fish, and how fish-fats compare with other fats in this respect.

Unsaponifiable Matter.

When the ethereal extract of fish is saponified with alcoholic potash, a certain amount of fatty material, soluble in ether, remains unattacked. This consists of cholesterols and other alcohols which replace the glycerol of the ordinary fats. We have reason to believe that little, if any, of this unsaponifiable matter is digested or absorbed in the human alimentary tract, and the caloric value of this part of the fat should therefore be subtracted in order to arrive at the true or utilizable fuel-value of the ethereal extract. In the specimen of groper-fat X in Table I the caloric value of the unsaponifiable material was found to be 10·4 calories. In quantity it amounted to about 10 per cent. of the fat, so that while the total fuel-value of the fat was 9·05 calories the true value was only 8·01.

These two considerations—viz., depreciated value on heating and drying, and the presence of a relatively large amount of unsaponifiable matter—both tend to reduce the standard figure (9·1) for caloric value of fat. When applied to fish-fats our estimations indicate a net value not above 8·0 calories per gramme.

Extractives.

In a weak alcoholic extract of the dried-fish powder we obtained a caloric value of 5·3 per gramme. The figure usually given for caloric value of meat-extract is 3·15. That the higher value in our case was due to substances soluble in ether, and presumably also dissolved out by the alcohol, is shown by the fact that on extracting with ether the caloric value was 3·52. We have not investigated the matter further, but we think it likely that an extract of fish prepared in the same way as commercial extracts of meat would probably have a higher caloric value.

PROTEIN.

A few estimations of the caloric value of the proteins of fish gave an average figure of 5·43—calculated for the water—and ash-free substance. This corresponds closely to the figure for mammalian protein.

ACKNOWLEDGMENTS.

We again beg to acknowledge the grant of money from the Government, through the New Zealand Institute, which made this research possible; also the hospitality of the University of Otago in granting us working-space, gas, light, water, &c.

SUMMARY.

In calculating the fuel-values of fish fats and oils the ease of oxidation before ingestion and the presence of considerable amounts of unsaponifiable matter should be taken into account. Instead of the standard figure, 9·1 calories per gramme, the observations here recorded would indicate a figure about 8·0 calories.

PART 4: COMPOSITION OF THE PAUA *(HALIOTIS IRIS).*

This paper gives an account of some analyses of the shell-fish paua (in this case *Haliotis iris*), which was used as food by the Maori and is also frequently used by Europeans.

The chemistry of molluscs in general has already attracted some attention, but our knowledge of the biochemical processes occurring in them, and especially in the marine forms, is still very meagre. The *Haliotis* has been shown to contain substances rarely met with in the composition of ordinary foodstuffs, or met with in smaller concentration. These comprise taurine (although there are no bile-salts), chlorophyll, haemocyanin, and, among the inorganic constituents, zinc. At the very outset we were impressed with the need for care in applying standard methods of diet-analysis to such material. One reason for this is that the part of the shell-fish used as food includes the alimentary canal and its contents, the glands, heart, and sexual organs; whereas in vertebrate animals used as food only the muscles and certain organs are eaten. The results are that in shell-fish we have a more heterogeneous mixture of materials, the non-protein nitrogen is high, the substances soluble in ether are by no means all fat, and the percentage of unclassified material ("extractives") is considerable.

Our investigations were chiefly directed to the determination of the relative amounts of protein, carbohydrate, fat, and ash.

The paua were obtained from the shore at Pounawea. They were alive when received in the laboratory, and were kindly identified for us by Professor Benham as *Haliotis iris*.

For the purposes of analysis some were divided into a "visceral" part and a "muscle" part, before being dried in an oven at about 55° C. Others were dried similarly without separation into parts, and some were used fresh for glycogen estimation.

Protein.

The usual method of estimating protein in food is to multiply the nitrogen by the factor 6·25 or 6·37. This method is based on the assumptions that most of the nitrogen is in the form of proteins, and that the proteins contain an average of about 16 per cent. nitrogen. Of these assumptions the first, at any rate, cannot be held without reserve in the case of these shell-fish, as the following figures show:—

In one sample of dried paua, "visceral" part, the total nitrogen was found to be 9·0 per cent.; in another sample of the same powder the nitrogen present in an extract made with repeated quantities of strong alcohol followed by a small amount of watery trichloracetic acid was 2·95 per cent.; while that of the residue was 6·35 per cent. The figure 2·95 is due to substances of non-protein nature. If we were to proceed in the orthodox way to calculate the protein percentage from the total nitrogen we should get 58·1 (9·3 × 6·25), or about 15 per cent. of the fresh material. If, on the other hand, we were to take only the nitrogen that is insoluble when treated as described above we should get 39·7 per cent. protein (6·35 × 6·25), or about 10 per cent. of the fresh "viscera." The true figure lies somewhere between these extremes, for some of the nitrogen of the extract may be due to amino acids split off from protein by autolytic changes in the earlier stages of drying, and such amino acids cannot be regarded as entirely valueless.

The above figures refer to the "viscera." A somewhat similar result is given by the "muscle" part, where the total nitrogen was 12·2 per cent. of the solids, and this consisted of 7·54 per cent. insoluble and 4·70 per cent. soluble in strong alcohol. In each case 30 to 40 per cent. of the total nitrogen was not in true protein form, and in such cases it is therefore incorrect to use the factor 6·25.

Carbohydrate.

Using Pflueger's method of estimation, we obtained the following figures for the glycogen percentage of freshly treated *Haliotis iris*:—

Table II.

Sample.	Part.	Weight in Grammes.	Amount used (Grammes).	Percentage of Glycogen.
I ..	Muscle ..	156	100	1·20
	Viscera ..	104	104	0·54
II ..	Muscle ..	160	100	2·01
	Viscera ..	135	125	0·50

An attempt was made to obtain a clear watery extract for estimation of glucose, so that we might find the total percentage of carbohydrate present, but in spite of various devices the filtration proved so slow that the material began to decompose and had to be abandoned. The cause of the slow filtration was undoubtedly the large amount of slimy mucus that was present. Glucose could easily be detected in the crude extract.

The glycogen from paua "muscle" gave the usual qualitative tests, and on hydrolysis yielded glucose—at least, so far as we could judge from the fermentation and phenyl-hydrazine tests—but the glycogen from the "viscera" did not react in a typical way. The result of its hydrolysis did not reduce so readily as glucose solutions do, and in one test it failed to ferment with yeast. Unfortunately the time at our disposal did not allow of further investigation while the material was fresh. The origin of the glycogen found in marine shell-fish is worth investigating; for, unlike the terrestrial plants which contain starch, the seaweeds on which the paua, &c., feed contain chiefly pentosanes, methyl pentoses, and pentoses; and the transformation of these into glycogen does not occur readily, if at all, in the vertebrates.

In carrying out Pflueger's method for glycogen (heating for several hours with 30 per cent. KOH) it was found that the glycogen, when precipitated with alcohol, carried down with it a certain amount of greasy material which retarded the filtration. This was almost certainly some of the unsaponifiable fatty matter which had withstood the action of the alkali.

FAT.

In the usual method of analysing foods, the weight of the ethereal extract is returned as "fat." Although it is well known that ether does not extract all the fat, and that it extracts substances that are not fat, yet the method is convenient and suitable when dealing with vertebrate material. In the paua, and presumably in molluscs generally, the faults of the method are more obvious, as can be seen from the following data: The dried visceral portion of paua 3 was extracted with hot alcohol, and then with ether; the alcohol was driven off and its residue extracted with ether; the combined ethereal extract gave, we may presume, all the ether-soluble material as usually estimated. It had a green colour, due to chlorophyll, and amounted to 7·04 per cent. of the solids. This was saponified, and the fatty acids separated, washed, and ultimately weighed. The fatty acid in the ethereal extract was about 73 per cent., whereas in ordinary fats it is about 90 per cent.

In the case of the muscle portion the amount dissolved out by the alcohol and subsequently extracted with ether was between 80 and 90 per cent. of the total fat, whereas in a fish-powder (groper) treated in the same way only 70 per cent. of the fat was extracted by the alcohol.

These observations indicate that the ethereal extract does not represent the true fat-value.

ASH.

The paua is comparatively rich in inorganic salts. The muscle part gave 6·17 per cent. and the whole paua 7·5 per cent., indicating an ash content in the fresh material of from 1·5 to nearly 2 per cent. A qualitative examination of a small quantity of the ash was kindly made for us in the Chemistry Department by Mr. Penseler, under Professor Inglis's directions. The usual elements were found, but in addition Mr. Penseler noted a strong suspicion of the presence of zinc, although he was unaware that that element has been shown to be fairly common in marine shell-fish.

Unidentified Material.

In Table III we give a summary of the analyses of one paua, so far as our analyses were carried. The results show a deficit which is very large in the case of the visceral part. Some of this is no doubt due to the glucose and to remains of vegetable food in the alimentary tract, but these cannot account for more than a small part of the large deficit. The large percentage of material soluble in alcohol in the following sample also indicates the unusual nature of this food: Paua 4 solids, 23·1 per cent. Of the solids, 8·14 per cent. = fat, 7·5 per cent. = ash, and approximately 28 per cent. was soluble in 96 per cent. alcohol, but insoluble in ether.

Table III.

	Visceral Part. Grammes.	Muscle Part. Grammes.
(1.) Fresh weight of edible portion	91·00	104·00
(2.) Water percentage	75·70	74·20
(3.) Solids by difference	24·30	25 80
Percentage composition of the solids—		
(4.) Total nitrogen	9·30	12·24
(5.) Non-protein nitrogen	2 95	4·70
(6.) Nitrogen insoluble in alcohol	6·35	7·54
(7.) Protein [maximal = (4) × 6·25]	58·10	76·30
(8.) Protein [minimal = (6) × 6·25]	39·70	47·00
(9.) Glycogen by calculation from Table II	(2·36)	(5·95)
(10.) Fat (ethereal extract)	7·04	6 57
(11.) Ash	*circa* 7·00	6·17
(12.) Minimal deficit 100 − [(7) + (9) + (10) + (11)]	25·50	3·50
(12.) Maximal deficit 100 − [(8) + (9) + (10) + (11)]	43·90	34·30

Remarks.

The foregoing observations indicate that the paua has a considerable value as a food. An adult specimen weighing, say, 200 grm. is probably as much as one would care to eat at a time. It would yield about 2·5 grm. glycogen, 5 grm. fat, 4 grm. to 5 grm. inorganic matter, and, say, 28 grm. protein. The remainder, about 10 grm. solids, consists mostly of substances of uncertain value as food. What has been said above in regard to the unreliability of the standard methods when applied to this shellfish probably holds good for most other invertebrate foods; and, although at first sight it might appear that the investigation of such material is of little consequence on account of the relatively small amount used as human food, yet the analysis of the lower forms of marine life has an important bearing on the question of the food of fishes. For example, it is known that in some cases, such as the herring, the fats of the minute crustaceans on which the fish lives are deposited under the skin with little or no change in chemical character, and there is no doubt that the simultaneous analysis of the fish-fats and of the fats of the lower forms of life found in the same waters would yield important information as to the feeding-habits of the fish.

In conclusion, we beg to thank the University of Otago for facilities in carrying on this work, and to acknowledge again the financial assistance of the research grant from the New Zealand Institute which made it possible.

Reference.

P. G. Allrecht, Marine Mollusks of the Pacific Coast, *Jour. Biolog. Chem.*, vol. 45, 1920, p. 395.

Food-supply and Deterioration of Trout in the Thermal Lakes District, North Island, New Zealand.

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INTRODUCTION.

THE following paper comprises a section of the results of an investigation on trout food-supply and trout-deterioration, together with a brief notice of other works on these subjects published in various parts of the world. Food-supply for trout is largely dependent on local conditions, and it is only by a study of all interdependent associations, organic or inorganic, which bear on the question that the economic zoologist will be able to decide on an effective manner of increasing the food-supply of a given locality. Owing to continuous destruction of trout food by the Maori, and the presence of various aquatic birds, the study of this subject may become considerably involved. The birds may prey either on the enemies of the trout or the trout themselves, or may in various ways lessen the available food-supply. Accordingly a general survey of the habits of the birds becomes necessary, and also a consideration of the relative depredations of each species.

I have been able to conduct an investigation over a limited period only, and realize that the results so obtained cannot be regarded as fully conclusive. Generally speaking, large lake trout were found to be feeding on fishes, while stream and many inshore trout were found to prefer insects, crayfish, plants, &c. Microscopical slides of stomach-contents were taken immediately after capture of the trout, for as a rule the digestive fluid acts quickly on unicellular organisms, and renders their outline indistinguishable. Except where otherwise signified, all trout dealt with belonged to the rainbow series, and were over two years of age.

I wish to thank Messrs. W. R. B. Oliver and H. Hamilton for their co-operation in determining certain of the species in the table. Mr. Oliver assisted by identifying a number of the plants, while Mr. Hamilton examined the insects. I have also to acknowledge my indebtedness to Professor H. B. Kirk, Victoria University College, Wellington, for his interest and kindly criticisms. Further, my thanks are due to those gentlemen in the Rotorua district who assisted me in securing trout for examination.

SUMMARY OF ANALYSIS OF TROUT STOMACH-CONTENTS.

Altogether 89 trout-stomachs were examined, the contents of which may be summarized as follows: 56 contained fish or fish-remains; 32 contained insects or insect-larvae; 17 contained molluscs; 11 contained crayfish; 31 contained plants; 44 contained microscopical organisms; 33 had stones, sand, or gravel in stomach or intestine; 8 contained the parasitic worm *Histrichus* sp.