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The Food of the Black Shag (*Phalacrocorax carbo novaehollandiae*) in Otago Inland Waters

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Abstract

ANALYSIS of 74 stomachs and 90 pellets of the black shag (*Phalacrocorax carbo*) showed that, in Otago, brown trout (*Salmo trutta*), perch (*Perca fluviatilis*) and crayfish (*Paranephrops zealandicus*) were the main food items. Adult birds select small fish and eat approximately 300 to 400g of fish at one time. The stomachs of nestlings are useless for quantitative food analysis. There is no evidence that the birds eat small invertebrates, any present in the stomachs having been released from the stomachs of fish eaten by shags.

INTRODUCTION

SINCE the introduction of freshwater game fishes a century ago, there has been much controversy over the effect of predation by black shags (*Phalacrocorax carbo*) on these fishes, especially the two trout species—*Salmo trutta* and *S. gairdnerii*. The factual basis of this controversy is limited as very few studies have been made of the shags' diet and none on the effect of its predation on trout.

Williams (1945) collected 2,833 analyses of shag stomach contents made by numerous individuals. This data showed that brown trout (*S. trutta*) was the main food species of shags in Otago inland waters. Eels were a very minor part of the diet. Stokell (1952) has criticised this work because Williams did not count the small invertebrates present in the stomachs.

Falla and Stokell (1945) analysed 62 stomachs taken from various localities at different times of the year. They found that trout and eels (*Anguilla* spp.) were the main fish species eaten. These results have often been extrapolated to situations not covered in their work. In particular they have been used to criticise Williams' conclusions.

Dickinson (1950) analysed 29 stomachs taken from the Rotorua–Taupo district during July. The native bully (*Gobiomorphus* sp.), carp (*Carassius* sp.) and crayfish were the main food items, while rainbow trout (*Salmo gairdnerii*; Dickinson's *S. irideus*) was very infrequent.

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Boud and Eldon (1950) took 18 birds from Lake Ellesmere during January. Native fishes were the most common food items in their sample.

It is obvious that none of these studies meet the requirements for assessing the effects of predation outlined by Duncan (1967). They are either not extensive enough (in time or numbers) or do not provide essential information on the population dynamics of the prey.

The present work attempts to provide a partial analysis of the interactions of predator (shags) and prey (fish) for Lake Mahinerangi. Information on one of the prey species, perch (*Perca fluviatilis*), has already been published (Duncan, 1967). Aspects of the trout population and the results of an experiment on the regulation of the fish populations by shags will be published on a future occasion.

METHODS

The birds sampled were shot in pursuance of the Otago Acclimatisation Society's shag destruction policy.* Each bird was opened almost immediately after death; the oesophagus and duodenum were tied off and the stomach injected with 20cc of four percent formalin to both preserve it and to reduce post-mortem digestion.

During the breeding season the nestlings were used to lure the adults into gunshot range. In consequence they were starved for most of the day and so were useless for analysis.

The method of removing and counting the stomach contents was standardised as much as possible. The stomachs were slit lengthwise and the distribution and degree of digestion of the various food items was noted. Large, easily recognised pieces such as fish, were picked out, identified and measured. Particular note was taken of whether or not the contents of the fishes' stomachs had been liberated into the lumen of the shag's stomach. The remaining material was inspected under a low powered stereoscopic microscope. The identification of fish remains was made possible by comparing them with a reference collection of bones, otoliths and scales.

The degree of digestion of each food item was estimated using the digestion index outlined in Table I.

TABLE I.—Rating system for the degree of digestion.

Index	Fish	Crustacea	Trichoptera Larvae	Coleoptera	Mollusca
A	Intact	Intact	Intact	Intact	Intact
B	Skin of head digested	" Loose jointed "	" Loose jointed "	" Loose jointed "	" Loose jointed "
C	Bones of head exposed. Stomach contents released into shag's stomach	Flesh partly digested	Case firm-flesh gone	Head, thorax, abdomen separated	Shell hard—flesh gone
D	Otoliths, tail-pieces, bones only	Joints separated	Case " soft "	Elytra intact	Shell " soft "
E	Otoliths, bones only	Fragments and gastroliths	Fragments	Fragments	Fragments

Regurgitated pellets from the Luella rookery at Lake Mahinerangi were examined to supplement the stomach analyses from this area. These pellets are the

* This policy has now been revised and the bounty on shags removed (Otago Acclimatisation Society; Annual Report for 1965).

indigestible remains of prey bound in a mucous envelope which are periodically regurgitated when the bird is at roost.

Stomach contents were recorded and assessed by counting each individual of each food species (Hartley, 1948). The live weights of ingested trout and perch were estimated indirectly by using the appropriate regressions of weight on length.

RESULTS

1. POPULATION CENSUS

Falla (1937) considered a population survey to be one of the prime requisites of any study of the shag, but lack of time and transport severely limited any census work during this study. An approximate survey of the Otago inland shag population was compiled for the year beginning October, 1959 (Table II), partly from personal observation and partly from Acclimatisation Society records.

TABLE II.—Census of Inland Black Shags from October, 1959, to June, 1960.

Location	Number of Nests*	Number of Adults Killed	Number of Young Killed	Number of Eggs Killed	Total Number Killed
BIRDS SHOT AT ROOKERIES					
Deep Stream 1	1	2	0	4	6
2	4	2	3	12	17
3	4	3	0	16	19
Upper Waipori 1	11	0	33	0	33
River 2	15	18	14	18	50
Meggatburn	35	38	37	0	75
Shag Valley	20	12	20	0	32
Loganburn	14(?)	7	24	4	35
Mullocky	5	9	0	20	29
Bullock Creek	8	2	20	18	40
Pomahaka R.	1	2	3	0	5
Maclennan R.	50	100	25	0	125
Waikaia R.	12	10	29	14	53
Martins Creek	9	21	29	2	52
Manuherikia	15	25	6	4	35
Subtotals	204	251	243	112	606
BIRDS FROM ROOKERIES NOT SHOT					
Catlins R.	14				
Teviot R.	4				
Luella (Lake Mahinerangi)	7				
Subtotal	25				
BIRDS SHOT AT ROOST OUT OF BREEDING SEASON					
		381			381
Totals	229	632	243	112	987

Total Number of Nests* = 229.
Estimated Adult Population (at 2/ nest)** = 458.
Estimated Total Population (at 6/ nest) + = 1,374.
Percentage Mortality of Young (chicks and nestlings) = 39% ÷.
Percentage Mortality of Adults (breeding season) = 55%.
Total Percentage Mortality Throughout Year = 71.8%.

* Possibly inaccurate as it is often difficult to determine whether a nest has been occupied earlier in the season or if it has been deserted all season. Inaccuracies in this value will affect the percentage mortalities.

** Assuming no double-nesting or multiple mating.

\+ Assuming an average clutch of four eggs.

÷ Obviously an underestimate as it is unlikely that young (or eggs) whose parents have been killed will survive. The true value will lie between this and 89 percent—the latter being derived from the number of nests "shot" times 4, divided by the total number of nests times 4.

2. Areas Sampled and Condition of the Stomachs

Great difficulty was experienced in obtaining large enough samples. The low numbers in the samples reflects the small population of shags in Otago due to the local Acclimatisation Society's shag destruction policy during that period. Table III gives information on sampling places and dates. Many more rookeries were visited than those listed but most of these had been deserted.

Table III.—Sampling Sites and Number of Samples Collected.

Date	Locality	Number of Stomachs Collected
27.X.1960	Shag Valley	2
13.XI.1960	Luella (Lake Mahinerangi)	10
6.XII.1960	Lake Waihola	4
8–12.XII.1960	Teviot R.	35
21.X.1961	Luella (Lake Mahinerangi)	10
18.XII.1961	Lake Onslow	10
29.V.1962	Luella (Lake Mahinerangi)	3
	Subtotal	74
		Number of Pellets Collected
21.XII.1962	Lake Mahinerangi	17
30.XI.1963	"	10
9.X.1964	"	18
25.XI.1965	"	13
18.X.1966	"	11
17.X.1967	"	21
	Subtotal	90

Most of the adults' stomachs collected were full because the birds were shot flying either into their nests or into roosting spots (Table IV).

Table IV.—Condition of the Stomachs.

	Number of Stomachs	Number Empty	Number Containing Fish	No. Containing Inverterbrates Only
Adults	55	1	52	2
Flying young	8	0	6	2
Nestlings	11	1	3	7
Total	74	2	61	11

3. Stomach Analyses

A summary of the stomach analyses is presented in Table V and the raw data are given in the Appendix. The figures for caddis and molluscs must be treated with caution. Caddis cases fragment in the stomachs so that the numbers entered in the table represent particles, not necessarily whole cases. Molluscs tend to break up rapidly during digestion so the recorded numbers are probably an underestimate.

4. Size of Prey and Amount of Food Eaten

The fork lengths of perch and trout found in the stomachs are shown in Figure 1 as percentage frequency distributions. Also shown in this figure are the fork lengths of perch and trout taken by seining and angling from Lake Mahinerangi. The mean lengths (arithmetic) of perch and trout eaten by shags are 14.85cm and 12.69cm respectively.

The weight of food eaten at one time was estimated from the lengths of the fish found in the stomachs. Regressions of weight on length were established by least squares for trout and perch from Lake Mahinerangi and for trout from the Teviot River. Table VII shows the total weight of fish in those stomachs which had all of

TABLE V.—Analysis of the Important Elements found in the Stomachs of all Birds Sampled.

Species	Total No. Found	No. of Stomachs in Which Found	Highest No. in One	Average No. Per Total No. of Stomachs	Average No. Per No. of Stomachs in Which Found
Salmo trutta	151	37	22	2.0	4.1
Perca fluviatilis	173	24	20	2.3	7.2
Galaxias sp.	27	1	27	—	—
Unidentified fishes	21	10	5	0.3	2.1
Paranephrops zealandicus	4	4	1	0.5	1.0
Trichoptera larvae	6,820	56	1,244	92.2	12.2
Other aquatic insects	260	46	26	3.5	5.7
Terrestrial insects	241	39	40	3.3	6.2
Molluscs	280	24	47	3.8	11.5

Average number of organisms per stomach = 107.8. The ratio of invertebrates to fish is 20.7:1; excluding nestlings this ratio becomes 7.5:1.

TABLE VI.—Regional Variation in Diet.

Species (Average No. Per Bird)	Shag R.	Lake Waihola	Teviot R.		Lake Onslow	Lake Mahinerangi
			Adults	Nestlings		
Salmo trutta	1.5	0.5	4.4	0.6	3.0	0.13
Perca fluviatilis	0	2.5	0	0	0	6.73
Galaxias sp.	0	0	1.1	0	0	0
Paranephrops	0	0	0.08	0	0.1	0.05

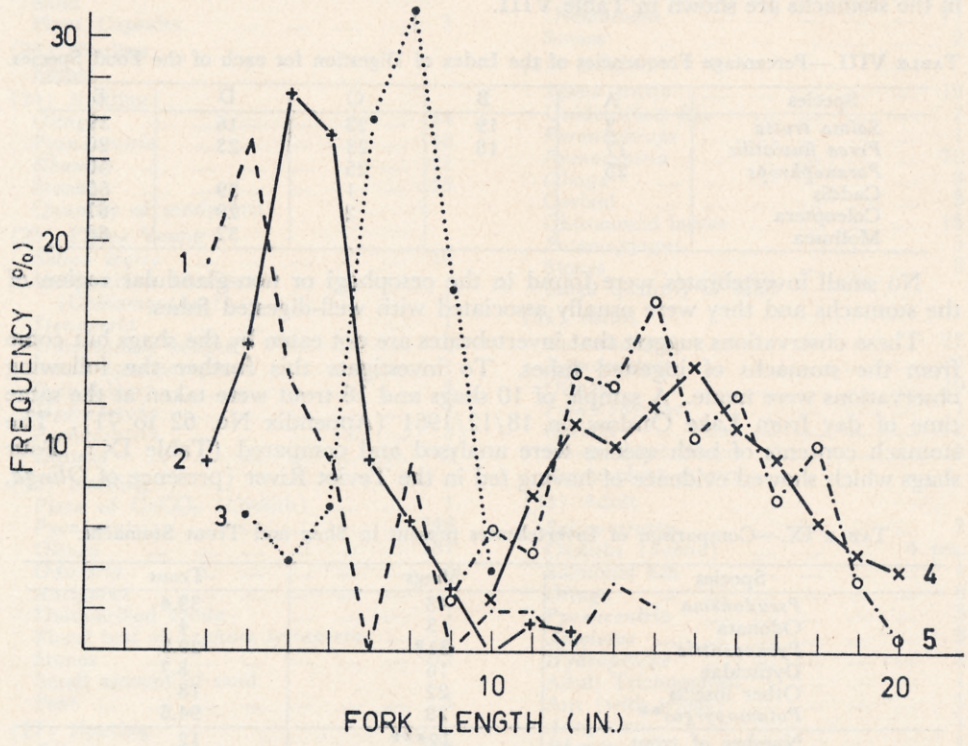

FIG. 1.—Length distributions of trout and perch. (1) Perch eaten by shags in Lake Mahinerangi. (2) Trout eaten by shags throughout sampling region. (3) Perch from Lake Mahinerangi; caught by seining. (4) Trout from Lake Mahinerangi; caught by anglers, 1950-53. (5) Trout from Lake Mahinerangi; caught by seining, 1961-62.

the ingested food in a measureable condition. The average total weight of trout per stomach is 316g while the greatest weight found was 880g. The average weight of perch per stomach was 378g.

TABLE VII.—Weight of Food in Shag Stomachs.

Stomachs Containing Perch		Stomachs Containing Trout	
Number of Fish Found	Weight (g)	Number of Fish Found	Weight (g)
8	442	3	880
4	418	10	170
5	245	6	290
10	339	18	360
5	306	3	215
2	90	2	88
7	244	3	111
1	250	7	300
1	214	2	220
3	80		
1	78		
7	258		
3	385		
Mean	378		316

5. ORIGIN OF THE SMALL INVERTEBRATES FOUND IN THE STOMACHS

The results of the arbitrary rating of the degree of digestion for each item found in the stomachs are shown in Table VIII.

TABLE VIII.—Percentage Frequencies of the Index of Digestion for each of the Food Species.

Species	A	B	C	D	E
Salmo trutta	3	19	23	16	39
Perca fluviatilis	17	18	23	23	20
Paranephrops	25		25		50
Caddis			1	39	60
Coleoptera			2	29	67
Mollusca				32	68

No small invertebrates were found in the oesophagi or non-glandular region of the stomachs and they were usually associated with well-digested fishes.

These observations suggest that invertebrates are not eaten by the shags but come from the stomachs of ingested fishes. To investigate this further the following observations were made. A sample of 10 shags and 18 trout were taken at the same time of day from Lake Onslow on 18/12/1961 (Appendix No. 62 to 71). The stomach contents of both species were analysed and compared (Table IX). Four shags which showed evidence of having fed in the Teviot River (presence of *Olinga,*

TABLE IX.—Comparison of Invertebrates present in Shag and Trout Stomachs.

Species	Shags	Trout
Pseudonema	43	39.4
Odonata	3	4
Pycnocentria	31*	29.3
Dytiscidae	16	8.7
Other insects	22	18
*Potamopyrgus***	28	94.6
Number of trout	12***	12

* Fragmentation of the cases made numeration difficult—only posterior ends were counted.

** Molluscs appear to digest very quickly and leave no recognisable remains.

*** Excluding trout which had not released their stomach contents.

Ephemeroptera, *Helicopsyche,* and *Hydropsyche* in their stomachs) have been excluded from the comparison. The number of trout present which had released their stomach contents into the shags' stomachs were totalled for the remaining six shags. The number of invertebrates present were then compared with the number expected due to release from the stomachs of the ingested trout—the "expected number" being derived from the stomach analyses of the trout sample.

Table IX shows that the only really divergent item is *Potamopyrgus;* it being much less numerous in shags' stomachs than in trout. Statistical comparison of the other entries in Table IX shows that there is no significant difference between them ($P_{(x^2)} = 0.2$).

A similar comparison for Lake Mahinerangi is presented in Table X, but here the comparison is less valid than that in Table IX because:

(1) Perch show a major diet change from plankton-feeding to benthos-feeding when they reach 11 to 13cm in length (Allen, 1935; Duncan, 1967)—a large number of the perch eaten by shags are smaller than this. It was impossible to count the planktonic organisms in the shags' stomachs and so, because the data for the "perch" column are derived solely from benthos-feeders, the "expected number" of invertebrates is far higher than the observed.

(2) The samples were not taken at the same time.

(3) The means of perch lengths differed for the two samples. Perch taken by seining had a mean length of 19.8cm while perch caught by shags had a mean length of 14.85cm. Because of their smaller size the amount of food must be less in those perch caught by shags than in the perch taken by seining. However, Table X does show that the temporal occurrence of the different species of invertebrates in shags follows the same seasonal pattern as the diet of perch.

TABLE X.—Comparison of Invertebrates present in Shag and Perch Stomachs.

	Species	Shags	Perch	
Summer	caddis	38	214	57 perch from 10 stomachs
	Pyronota festiva	2	37	
	Water beetles	1	14	
	Odonata	5	64	
	Unidentified insects	10	2	
Winter	*Pycnocentria*	2	0	68 perch from 13 stomachs
	chironomids	numerous	2,400	

6. PELLET ANALYSIS

The pellets consisted mainly of bones, scales and otoliths of trout and perch and ectoskeletons and gastroliths of *Paranephrops* (Scott and Duncan, 1967). Very few

TABLE XI.—Pellet and Stomach Analysis of Adult Shags from Lake Mahinerangi.

Year	Season	No. in Sample		Mean No. Per Stomach or Pellet		
		Stomachs	Pellets	Trout	Perch	Crayfish
1960-61	Breeding	19		0.21*	6.73	0.16
1962	Winter	3		0	11.6	0
1962	Breeding		17	0	1.24	0.12
1963	Breeding		10	0.2	7.1	0.3
1964	Breeding		18	0.06	5.6	0.2
1965	Breeding		13	0	7.4	0.15
1966	Breeding		11	0.18	3.7	0.09
1967	Breeding		22	0.045	5.05	0.045

* None of these were lake fish. The invertebrates present in the shags' stomachs were river dwellers (see Appendix No. 3 and 7), indicating that the shags had been feeding in the surrounding rivers. It is possible that the trout recorded in pellets were also river fish but there is no way of checking this point.

invertebrate remains, other than *Paranephrops*, were present. The results of the analyses are shown in Table XI, together with the stomach analyses of Mahinerangi shags.

The figures quoted for mean numbers per pellet in Table XI are unreliable as some of the pellets were disintegrating and only a part of these may have been collected.

Discussion and Conclusions

1. Population Census

The data presented in Table II should not be regarded as accurate as many approximations and assumptions have been made in its compilation. Furthermore, only about one half of the rookeries were visited by the author—the rest of the data coming from Acclimatisation Society records. It seems likely, however, that it is as reliable as those censuses recorded by Williams (1945). Comparison of his data with Table II shows that the population in 1959-60 was very much smaller than earlier.

Year	Source	Number of nests
1926-27	Williams (1945)	1,273
1936-37	,,	428
1942	,,	1,753
1959-60	present work	228

The decrease in numbers is the result of intensive shag destruction. In view of the high mortality it is probable that the inland population was not self-maintaining in 1959-60 but depended upon recruitment from maritime rookeries. These recruits may have been young birds following the spawning migrations of trout, eels and lampreys.

Since the change in the Acclimatisation Society's policy on black shags the population on Lake Mahinerangi has increased rapidly. This will be discussed in a future publication together with an assessment of the effect of shag predation on fishes.

2. Food of the Shag

The diet of shags, as shown in the present work, is very similar to that listed by Williams (1945) with trout being the most important food species in rivers and perch in lakes. Eels are an insignificant part of the diet of Otago inland shags. The author has seen only one eel taken by shags during this study—it was a half-digested 18 inch specimen found at the Luella rookery in 1964. A small number of crayfish are eaten as are native fishes.

The agreement of these results with those of Williams are also reasonable with respect to quantity of fish taken (4 to 7), and length of fish selected, so that the criticisms of Williams' results are discounted. However, the author contends that Williams' conclusions are not justified by his data because he has only shown that the black shag eats a certain number of prey species. This is not sufficient evidence to justify a value judgment as there are numerous cases in which predation is beneficial (Duncan, 1967).

The amount of food per stomach (Table VII) agrees fairly well with the values published by Mattingley (1927), Madsen and Sparck (1950), van Dobben (1952) and McNally (1957) being about 350g per fishing period. Ward (1924), Collinge (1927) and Williams (1945), however, all consider that the shag takes between five and ten times as much per day. The maximum amount of fish present was 880g which agrees well with Madsen's (1950) and van Dobben's (1952) estimate of about 770g.

3. ORIGIN OF THE INVERTEBRATES FOUND IN THE STOMACHS

There is no evidence that black shags eat small invertebrates in Otago. The observations leading to this conclusion are listed below.

1. No small invertebrates were found in the oesophagi or non-glandular region of the stomachs.

2. Any invertebrates found in the shags' stomachs were well digested. The results of rating the degree of digestion for each item (Table VIII) suggests that some degree of predigestion of invertebrates has occurred.

3. There is no significant difference between the number of invertebrates found in shags' stomachs and the number expected due to release from the stomachs of ingested fish.

4. The seasonal occurrence of invertebrates in the Mahinerangi birds follows the dietary pattern of perch. If shags were eating small invertebrates there would be no such correlation as their winter food pattern would be much the same as in summer. This is not so for perch as their habit of migrating to deeper water in winter causes a change in their diet—they can utilise the restricted (in species) bottom fauna of deeper waters only.

5. The stomachs of birds shot flying in to feed their young contained many fish but only a few invertebrates (e.g., Appendix No. 2) while those shot off the nest after a period of incubation or feeding their young have no *whole* fish present and numerous invertebrates (e.g., Appendix No. 1).

The high number of invertebrates present in nestlings (noted also by Falla and Stokell, 1945) suggests that young birds cannot rid themselves of undigested remains for some time or can only do so at infrequent intervals. The rare occurrence of recognisable fish remains in the stomachs of nestlings is not surprising in view of the way the adult feeds its young (Oliver, 1955: 214) and the selective shooting methods usually employed. The young are fed on predigested fishes from which the heads, containing all the easily recognisable parts, may have dropped off. So these recognisable parts are not likely to be transferred from parent to young. Amalgamation of the results from nestling stomachs with analyses of adult stomachs (as is done in Table V), will, therefore, give a biased picture by under-estimating the number of fish per stomach.

APPENDIX

Details of the stomach contents

Location—Shag Valley Rookery
Date—27/10/1960
No. Collected—Two Adults
Contents—

(1) Adult

Helicopsyche	50
Olinga feredayi	19
Pycnocentria	52
Coleoptera	7
Unidentified insects	6
Stones	6
Peat	2

(2) Adult

Salmo trutta	3
Hydropsyche	1
Pycnocentria	16
Coleoptera	3
Ameletus	1
Adult Trichoptera	19
Ephemeroptera	7
Unidentified insects	4

Location—Lake Luella
Date—13/11/1960
No. Collected—Nine Adults, one Nestling
Contents—

(3) Adult

Perca fluviatilis	1
Salmo trutta	1
Limnaea	1
Coleoptera	1
Hydropsyche	5
Olinga	11
Nematode	1
Otoliths	1 pr.

(4) Adult

Perca fluviatilis	7
Pycnocentria	3
Olinga	2

Adult Trichoptera 1
Nematode 1

(5) Adult
Perca fluviatilis 4
Otoliths—*Perca* ..... 5 prs.
Total *Perca* 6
Pyronota festiva 1
Unidentified insects 3

(6) Adult
Empty

(7) Adult
Salmo trutta 3
Paraneophrops 1
Olinga 19
Pycnocentria 4
Pyronota 1
Unidentified insects 1

(8) Adult
Perca 3
Pycnocentria 1
Olinga 1
Unidentified insects 1
Otoliths ..... 7 prs.

(9) Adult
Perca 4
Otoliths—perch ..... 14 prs.
Total perch 20
Unidentified fish 1
Pycnocentria 3
Olinga 4
Coleoptera 1
Stick 1

(10) Nestling
Pycnocentria 4
Trichoptera 4
Pine stems 20
Pieces of bark 27
Nematode 2

(11) Adult
Perca 4
Ephemeroptera 1
Pycnocentria 15
Olinga 2
Sheep droppings 2
Otoliths—perch ..... 5 prs.
Total perch 6

(12) Adult
Perca 2
Pyronota 1
Olinga 3
Pycnocentria 5
Adult Trichoptera 2
Unidentified insects 2
Otoliths—*Perca* ..... 10 prs.
Total *Perca* 11

Location—N.W. Corner, Lake Waihola

Date—6/12/1960

No. Collected—Four Adults

Contents—

(13) Adult
Perca 1
Otoliths ..... 1 pr.
Coleoptera 1
Unidentified insects 2
Quantity sand and mud

(14) Adult
Salmo trutta 1
Otoliths—*Perca* ..... 2 prs.
Pycnocentria 55
Olinga 4
Pseudonema amabilis 1
Corixid 1
Archichauliodes 1
Pyronota festiva 1
Odontria 1
Odonata larva 1
Planorbis 1
Potamopyrgus 15
Limnaea 6

(15) Adult
Perca 2
Chironomid larva 6
Coleoptera 1
Simulid 1
Unidentified 1
Otoliths—*Perca* ..... 2 prs.
Total *Perca* 2

(16) Adult
Salmo trutta 1
Perca 1
Otoliths—*Perca* ..... 4 prs.
Total *Perca* 5
Pycnocentria 25
Odontria 1
Potamopyrgus 1

Location—Teviot River; one mile down from Wall

Date—8-12/12/1960

No. Collected—17 Adults, eight Flying Young, ten Nestlings

Contents—

(17) Flying Young
Salmo trutta 1
Olinga 23
Pseudonema amabilis 3
Pycnocentria 69
Rhantus 1
Unidentified Coleoptera 3
Grass stem 10
Stones 33
Large quantity sandy grit
Antiporus 2

(18) Adult
Otolith (unidentified) 1
Olinga 57
Pycnocentria 74
Antiporus 3
Rhantus 1
Bronscini (*Mecodema?*) 1
Unidentified Coleoptera 1
Grass stems 5
Stones 68
Large quantity sandy grit

(19) Flying Young
Otoliths (Trout) ..... 2 prs.
Olinga ..... 3 prs.
Pycnocentria 40
Odontria 1
Antiporus 2
Unidentified Coleoptera 3
Green capsules 3

Stones 24
Sandy grit

(20) Adult
Salmo trutta 1
Otoliths (*Salmo*) ..... 1 pr.
Olinga 10
Pycnocentria 23
Archichauliodes 1
Antiporus 1
Unidentified insects 3
Grass seed head
Stones 19

(21) Adult
Salmo trutta 1
Otoliths (*Salmo*) ..... 1 pr.
Pycnocentria 191
Pseudonema amabilis 17
Hydropsyche 1
Potamopyrgus 11
Peat 1
Quantity of sand

(22) Nestling
Olinga 38
Rhantus 5
Broscini Beetle 2
Antiporus 2
Potamopyrgus 1
Stones 29
Sand
Plant Capsules 3

(23) Nestling
Empty

(24) Nestling
Olinga 24
Pycnocentria 48
Rhantus 22
Stones 35
Quantity of sandy grit

(25) Flying Young
Salmo trutta 10
Unidentified Maxilla (*Gobiomorphus?*) 1
Stenoperla 1
Unidentified beetles 2
Adult Ephemeroptera 1
Parnid larva 5
Hydropsyche 1
Pycnocentria 3
Diptera 2

(26) Nestling
Piece of $CaCO_3$ (Otolith) 1
Pycnocentria 246
Olinga 181
Odontria 2
Antiporus 1
Unidentified beetle 1
Floral bud of *Sophora tetraptera* 1
Stones 12
Small amount of sand
Peat 1

(27) Nestling
Olinga 104
Pycnocentria 98
Antiporus 1
Rhantus pulverosus 3
Pieces of wood 2

(28) Adult
Salmo trutta 6
Otoliths (*Salmo*) ..... 4 prs.
Pyronota festiva 199
Potamopyrgus 47
Odontria 2
Wood borer beetle 6
Carabidae 1
Adult Ephemeroptera 1
Dytiscidae 1
Unidentified insects 4
Olinga 1
Pycnocentria 4

(29) Adult
Salmo trutta 2
Otoliths (*Salmo*) 3
Pycnocentria 12
Pseudonema amabilis 18
Potamopyrgus 4
Simulid larva 1
Stones

(30) Adult
Salmo trutta 18
Otoliths (*Salmo*) ..... 12 prs.
Olinga 3
Pycnocentria 14
Pseudonema 11
Tipulid larva 26
Potamopyrgus 2
(Nematodes ..... 7)
Stones 2

(31) Adult
Salmo trutta 19
Unidentified fish 2
Paranephrops 1
Pycnocentria 70
Olinga 3
Corixid 3
Chironomid larvae 15
Potamopyrgus 5
Stones 5
Small quantity of sand

(32) Adult
Galaxias sp. 27
Pycnocentria 17
Olinga 10
Potamopyrgus 1
Corixid 2
Unidentified insects 5
Green plant matter

(33) Adult
Salmo trutta 3
Otoliths (*Salmo*) ..... 4 prs.
Salmonid fish 1
Olinga 8
Pycnocentria 5
Ameletus 3
Hydropsyche 2
Adult Trichopteran 1
Ant (with wings) 1
Antiporus 1
Rhantus 1
Schist 3
Quartz 4
Shot 1
(Nematode ..... 1)

(34) Flying Young
- *Salmo trutta* 22
- Unidentified fish 5
- Paranephrops 1
- *Olinga* 8
- *Pycnocentria* 43
- *Pseudonema* 16
- *Rhantus* 2
- *Antiporus* 1
- Ant 1
- Chironomid adults 3
- Parnid larvae 2
- *Potamopyrgus* 29
- Odonata larva 1
- Sticks (Manuka and Matagouri)
- Grass stems 5
- Mass of grass roots
- (Nematodes ..... 1)
- Small amount of sand
- Otoliths (*Salmo*) ..... 3 prs.

(35) Adult
- *Salmo trutta* 2
- Otoliths ..... 2 prs.
- Unidentified fish 1
- *Pseudonema* 5
- *Pycnocentria* 4
- *Potamopyrgus* 8
- Unidentified Trichoptera adult 1
- Unidentified Trichoptera larva 1
- Small stones

(36) Adult
- *Salmo trutta* 3
- *Olinga* 2
- *Pycnocentria* 6
- Borer 2
- Dytiscid 1
- *Potamopyrgus* 10
- Peat 2
- Otoliths (*Salmo*) ..... 1 pr.

(37) Adult
- *Salmo trutta* 2
- Otoliths (*Salmo*) ..... 1 pr.
- Simulid adults 12
- Simulid larvae 2
- Parnid larvae 2
- Droppings 2
- Stone 1
- Grass seed head

(38) Flying Young
- *Salmo trutta* 2
- Unidentified fish 2
- Otoliths ..... 5 prs.
- *Pseudonema amabilis* 31
- *P. obsoleta*
- *Pycnocentria* 49
- *Olinga* 9
- *Odontria* 3
- *Rhantus* 1
- Parnid larvae 2
- *Limnaea* 1
- *Potamopyrgus* 24
- Unidentified insects 1
- Sticks and grass stems 6
- *Ceratophyllum* ..... 2 pieces
- Droppings 2
- Stones 5
- Small quantity sand

(39) Nestling
- *Pycnocentria* 199
- *Olinga* 102
- *Oxythira albiceps* 3
- *Pyronota festiva* 1
- *Rhantus* 1
- *Hydora* 1
- *Odontria* 2
- Unidentified Coleoptera 3
- Twigs 4
- Large amount grass roots

(40) Nestling
- *Salmo trutta* 2
- Otoliths (*Salmo*) ..... 2 prs.
- *Pycnocentria* 581
- *Olinga* 228
- *Pseudonema amabilis* 17
- *Odontria* 7
- *Rhantus* 1
- *Pyronota festiva* 6
- Unidentified Coleoptera 15
- *Archichauliodes diversus* 1
- Lepidoptera 1
- Arachnida 1
- *Potamopyrgus* 24
- Nematodes 6
- Pieces of peat 2
- Twigs (cases of *Pseudonema*) 4
- Grass stem and roots
- Stones 49
- Sand

(41) Nestling
- *Pycnocentria* 681
- *Olinga* 397
- *Pseudonema amabilis* 1
- *Oxythira albiceps* 70
- *Odontria* 4
- *Hydora* 9
- *Pyronota* 1
- Unidentified Coleoptera 6
- *Rhantus* 1
- Twigs 1
- Clump of roots
- Sand

(42) Nestling
- *Salmo trutta* 1
- Nerve cord of ? 4
- *Pycnocentria* 795
- *Olinga* 305
- *Pseudonema amabilis* 6
- *Oxythira albiceps* 38
- *Odontria* 16
- Parnids (*Hydora* 2) 5
- *Pyronota festiva* 1
- Unidentified Coleoptera 3
- Grass stems 3
- Stones 20

(43) Flying Young
- *Pycnocentria* 24
- Dytiscid 1
- Quantity of coarse sand

(44) Flying Young
- *Pycnocentria* 17
- Unidentified insect 1
- *Potamogeton* (1 piece)
- Few small stones

(45) Adult
- *Salmo trutta* 2
- *Pycnocentria* 46
- *Pseudonema amabilis* 8
- *Oxythira albiceps* 3
- Amphipod 1
- Unidentified insect 1
- *Potamopyrgus* 5
- Twig 1
- Plant stem
- Small stones 5

(46) Adult
- *Salmo trutta* 1
- Otoliths of above ..... 1 pr.
- *Potamopyrgus* 1
- *Odontria* 25

(47) Adult
- *Salmo trutta* 2
- *Pycnocentria* 27
- *Ameletus* (?) 1
- *Coccinella* 1
- *Potamopyrgus* 2
- Dipteran 1
- Large amount of feathers (shag?)

(48) Adult
- *Salmo trutta* 5
- Otoliths (*Salmo*) ..... 3 prs
- Total *Salmo* 5
- *Antiporus wakefieldi* 37
- *Pycnocentria* 24
- *Olinga* 30
- *Helicopsyche* 24
- *Pseudonema amabilis* 58
- *Planorbis* 1
- *Potamopyrgus* 4
- *Limnaea* 6
- Chironomid 1
- Unidentified insects 3
- (Nematodes ..... 6)

(49) Nestling
- *Pycnocentria* 365
- *Olinga* 39
- *Helicopsyche* 2
- *Oxythira albiceps* 44
- *Pseudonema amabilis* 23
- Twigs (cases of *P. obsoleta?*) 7
- *Archichauliodes diversus* 1
- Small amount of plant matter
- *Rhantus* 1
- *Hydora*
- Feather fly 1

(50) Flying Young
- *Salmo trutta* 2
- *Pycnocentria* 49
- *Olinga* 10
- *Helicopsyche* 10
- *Dytiscus* 1
- *Hydora* 2
- Unidentified larva 1
- *Potamopyrgus* 12

(51) Adult
- *Salmo trutta* 3
- *Pycnocentria* 79
- *Pseudonema amabilis* 10
- Odonata nymph 1
- *Rhantus* 2
- Dytiscidae 1
- Ichneumonidae 1
- *Potamopyrgus* 1
- *Potamogeton* 1
- Twig

Location—Lake Luella

Date—21/5/1961

Contents—

(52) Adult
- *Perca* 10
- Otoliths *Perca* ..... 6 prs.
- Total *Perca* 13
- *Potampyrgus* 1
- Dytiscid 1
- Twig (Triplectides case) 1

(53) Adult
- *Perca* 11
- Otoliths *Perca* ..... 10 prs.
- Total *Perca* 11

(54) Adult
- *Perca* 3
- Otoliths *Perca* 3
- Total *Perca* 3

(55) Adult
- *Perca* 3
- Otoliths *Perca* 3
- Total *Perca* 4

(56) Adult
- *Perca* 5
- Otoliths *Perca* 5
- Total *Perca* 5

(57) Adult
- *Perca* 2
- Otoliths *Perca* 2
- Total *Perca* 2
- *Pycnocentria* 2
- Amphipod 1

(58) Adult
- *Perca* 7
- Otoliths *Perca* ..... 5 prs.
- Total *Perca* 7

(59) Adult
- *Perca* 6
- Otoliths *Perca* ..... 3 prs.
- Total *Perca* 6

(60) Adult
- *Perca* 9
- Otoliths *Perca* 6
- Total *Perca* 9

(61) Adult
- *Perca* 3
- Otoliths *Perca* 9
- Total *Perca* 10
- *Potamopyrgus* 1

Location—Lake Onslow

Date—18/12/1961

Contents—

(62) Male
- *Salmo trutta* 7
- *Oxythira albiceps* 5
- *Pseudonema amabilis* 5
- *Olinga feredayi* 6
- *Pycnocentria (evecta?)* 214
- *Pyronota festiva* 1
- *Odontria* sp. 1

Dytiscid 15
Aeschnid 1
Moth larva 1
Moth adult 1
Neuroptera (*Archicauliodes* sp.) 1
Otoliths *Salmo* ..... 2 prs.
Total *Salmo trutta* 7
Ranunculus tip

(63) Female
Salmo trutta 3
Olinga 1
Pycnocentria 24
Pseudonema amabilis 3
Dytiscid 4
Odonata nymphs 2
Ichneumon 1
Potamopyrgus 6
Paranephrops zealandicus 1

(64) Female
Salmo trutta 1
Otoliths *Salmo* 1
Total *Salmo trutta* 1
Odonata nymphs 2
Odontria sp. 1
Potamopyrgus sp. 24
Pseudonema amabilis 35

(65) Male
Salmo trutta 2
Olinga feredayi 25
Pycnocentria evecta 97
Oxythira albiceps 2
Coleoptera 6
Potamopyrgus sp. 20
Peat
Nitella

(66) Female
Odontria sp. 2
Pycnocentria evecta 5
Pseudonema obsoleta 2
Parnid 1
Oxythira albiceps 1
Twigs (*Pseudonema* cases?) 3
Nostoc

(67) Female
Salmo trutta 8
Unidentified fishes (trout?) 3
Pyronota festiva 1
Caedicia olivacea 1
Triplectides amabilis 6
Dytiscid 1
Weevil 1
Neuroptera wings ..... 2 prs.
Parnid 2
Unidentified insects 5

(68) Male
Salmo trutta 2
Otoliths *Salmo* 3
Total *Salmo trutta* 3
Pycnocentria evecta 288
Olinga feredayi 30
Helicopsyche sp. 2
Hydropsyche sp. 1
Archichauliodes 1
Pyronota festiva 6
Odontria sp. 4
Odonata 2
Potamoprgus 10

(69) Male
Salmo trutta 4
Otoliths *Salmo* ..... 3 prs.
Total *Salmo trutta* 4
Pycnocentria evecta 45
Dytiscid 4
Prenolepsis longicornis 1
Austrolperla cyrene 1
Plecoptera 2
Liodessus plicatus larva 1
Hemiptera 1
Unidentified insects 12

(70) Female
Salmo trutta 1
Unidentified fish 1
Dytiscid 6
Potamopyrgus 4
Unidentified insect 1
Odontria sp. 1
Plecoptera 1
Pycnocentria evecta 3

(71) Adult
Salmo trutta 1

Location—Lake Luella

Date—29/5/1962

Contents—

(72) Adult
Perca 11
Chironomid heads present

(73) Adult
Perca 8
Chironomid larvae heads present

(74) Adult
Perca 16
Chironomid larvae heads present

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