B.J. Cumpston.

OTAGO ACCLIMATISATION SOCIETY

UNIVERSITY OF OTAGO

An Investigation of the Stomach Contents of the Black Shag (Phalacrocorax carbo) in the Otago Acclimatisation Society District.

I INTRODUCTION

OBJECTIVES.

The primary objectives of this study are to analyse the stomach contents of inland Black Shags in order to discover the diet of these birds. This was intended to serve as a check upon previous investigations made in this district.

THE ROLE OF THE SHAG IN NATURE

There has been much controversy about the effect of the shag on trout populations in nature. Anglers have condemned these birds as predators while ornithologists tend to regard them as harmless even beneficial. Oliver (1955), for example, states that the Black Shag does much good in destroying eels. He quotes in support of work by D. Cairns (1942) and two investigations by Falla and Stokell (1945) on the stomach contents of sixty-two shags. The present investigation does not lend support for this view in Otago.

Many papers have been published both here and overseas, on this topic, some supporting one view and others the opposite. None, however, have fully elucidated the actual effects on fish populations of predation by the Black Shag, and to resolve this exceedingly difficult and complex problem was certainly beyond the scope of this present work.

II METHOD

FIELD TECHNIQUES.

It was felt that the actual process of sorting, identifying and counting the animals contained in the stomachs would be best carried out in the laboratory. This was because any field investigation, other than mere collection of material and observation, would be hampered in many ways.

Firstly, there would be the lack of time for a detailed investigation. The numbers of shags that are collected at one time are such that they could not be dealt with before most of them deteriorated. Also, it was suspected that digestion carried on after death so making identification more difficult and the analysis figures less accurate. So some method was sought that would halt digestion as soon after death as possible.

Secondly there would be the lack of equipment necessary for any detailed analysis. Most of the shooting sites, such as rookeries and camping areas, are inaccessable except on foot. Thus everything must be carried in manually. This means that heavy pieces of equipment such as microscopes could not be taken.

METHOD USED FOR PRESERVING STOMACHS.

Following a suggestion made by Dr. Scott after the method of Hartley, the best method of dealing with the stomachs was found to be:

(1) Retrieving the birds as soon as possible after they had been shot. A boat was usually used for this.

(2) Dissecting the birds immediately after ascertaining its size, sex and age so as to expose the stomach entirely.

(3) Tying off the oesophagus and duodenum, then cutting the stomach clear from the rest of the gut. Thus the stomach was completely sealed and could be carried in this condition.

(4) Injection of 20 cc of 4% formalin by means of a hypodermic syringe into the stomach cavity thus halting digestion and preserving the stomach contents. This enabled the stomachs to be brought back to the laboratory for detailed analysis.

LABORATORY TECHNIQUE

In the laboratory the stomachs were opened and large, recognisable pieces such as whole fishes were picked out and washed. The fishes were identified, measured and aged (by scale examination). The rest of the stomach contents were put into a beaker and the washings from the fish put in. The mixture was gently stirred, then left to settle when the fluid was decanted off and examined for floating organisms e.g., caddis cases. The sediment was carefully examined in flat glass dishes with a green background under a good light. Fragments of bone, otoliths and invertebrates were separated visually. After this the remaining substance was examined under a low powered binocular microscope when small organisms such as Oxythira and Parnids were sorted out.

The various fragments were then identified and counted.

The identification of fish bones and otoliths was made possible by making a comparative collection of fish bones, otoliths and scales for the native and introduced freshwater fishes that were likely to be encountered during the course of the investigation. E.g., Brown Trout, Perch, Galaxias, Gobiomorphus (Bully), Retropinna (Smelt), Anguilla (eel).

III TRIPS MADE

SHAG VALLEY

A visit was made to the Shag Valley rookery on the 27th October, 1960. There were 14 occupied nests each with a clutch of 4 eggs or young. Thus the probable adult population would be 28 birds. Of these only eight were shot and only two could be recovered. This was because of the very wary behaviour of the birds and the difficult terrain. Most of the birds would not come down to the nests to feed their young but would maintain a circular flight above the rookery and well beyond the range of the guns. Thus only an occasional one or two could be shot and most of these could not be retrieved because they fell into the river and were swept away.

The nests at this rookery were new, some ten yards up the cliff from the old site. The old nests were unoccupied, probably due to the shooting carried out the previous season.

Because the young birds were occupying new nests they appeared to be fairly free from feather fly infection.

A feature noted in this rookery was the disparity in ages of the young in a couple of the nests. In one nest there was a bird of some three weeks old together with three newly hatched chicks.

MAHINERANGI DAM

The next trip was to the Loch Luella arm of the Mahinerangi Dam on the thirteenth of November 1960. This was more successful - nine adults and one nestling being taken out of a population of thirty-six adults occupying nineteen nests.

The rookery was near the wall of Luella on a narrow connecting arm to Mahinerangi. The nests were at the top of dead pine trees on the waters edge. Shooting was difficult because the pine trees obscured flying birds from the shooters. The retrieval of birds was easy, however, owing to the fact that a boat was used.

LAKE WAIHOLA

Lake Waihola was visited on the sixth of December, 1960. Four adult birds were collected. These were shot from a maimai at the northwest corner.

TEVIOT RIVER

On the eighth of December, a trip lasting five days in all was made to the Teviot River. Thirty-six birds were collected: seventeen adults, nine flying young and ten nestlings. There were two rookeries seen on the river, one was some five miles downstream from the dam, the other about three miles down further.

BULLOCK CREEK - POMAHAKA RIVER

The upper Pomahaka River and Bullock Creek were visited on the same day - December 14, 1960. The rookery on Bullock Creek was deserted, although it had been used as a camping area, and the rookery on the upper Pomohaka had only one nest occupied. One bird was shot but not retrieved.

WAIKAIA RIVER

A report of a large number of shags following the spawning trout promted a visit to the Waikaia River on May 27th, 1961. Although three days were spent looking for the birds reported only 35 to 40 were seen. Of these only three were shot but none were recovered owing to the impossibility of crossing the river.

SECOND VISIT TO MAHINERANGI DAM

Mahinerangi Dam was revisited on June 24th, 1961 and eleven adult birds were shot with nine being retrieved.

Table 1 is a summary of the trips made during the period of the investigation and the number of stomachs collected.

TABLE 1.- Summary of trips made and number of Stomachs collected.

Date	Place	No. Stomachs	Time Spent
Oct. 27, 1960	Shag Valley	2	1 day
Nov. 13, 1960	Loch Luella	10	1 "
Dec. 6, 1960	Lake Waihola	4	1 "
Dec.8-12,1960	Teviot River	36	5 days
Dec. 14, 1960	Upper Pomahaka R.	0	1 day
May 27-30,1960	Waikaia River	0	5 days
June 24, 1960	Loch Luella	9	1 day
	Total	61	15 days

IV POPULATION SURVEY FROM THE RANGER'S RECORDS

An approximative survey was compiled for the year beginning October, 1959-60, from the Ranger's records of his and other interested persons' shooting activities.

Falla considers a population survey to be one of the prime prerequisites of any study of the shag but owing to the fact that this is outside the objectives of this present work no personal observations were made and I have relied entirely upon information supplied by the Societie's Ranger. I am indebted to him for this.

The following tables (tables 2, 3 and 4) are not to be regarded as an exact survey for the whole of the district, rather they indicate the effectiveness of the Societie s policy on the shag for the recorded rookeries.

The only accurate method of ascertaining the breeding population is to visit all the rookery sites during the breeding season and to count the numbers of occupied nests. It would also be of great value to band birds both inside and outside the district in order to study the movements of the birds during winter.

Table 4 is interesting as indicating the very high mortality rate in shag populations under the present policy. The mortality rate of the adults is, however, somewhat lower being of the order of 61%. Needless to say the mortality rate of the young in all the rookeries for which we have records is nearly 100%. This is because the recorders deliberately destroy every young individual encountered although some young birds manage to escape by flying.

Probably the biggest factor invalidating this survey as a good census is that after the breeding season the birds disperse and may move about during the winter to the sea coast or vice versa. J.C. Coulson's recently published work (1961) has shown the movements that occur of the English shag (Phalacrocorax aristotelis) and the comorant (P. carbo) during the individuals' life-time. His work is significant in that it indicates that some birds born on the coast disperse inland and in a few cases there may be a definite migration. This may be of great importance in New Zealand and needs further investigation.

TABLE 2.- Number of Black Shags shot from October, 1959 to June, 1960.
(Diary of Mr. H. Sinclair).

1 From Rookeries

Location	?	No.Nests	Adults	Young	Eggs	Total
Deep Stream	1	1	2	0	4	6
	2	4	2	3	12	17
	3	4	3	0	16	21
	1		0			
Upper Waipori	1	11	0	30		30
	1		0	3		3
	2	15	13	7	9	29
	2		5	7	9	21
Meggatburn		35	38	37		75
Shag Valley		20	12	20		32
Loganburn		14(?)	7	24	4	35
Mullocky		5	9	0	20	29
Bullock Creek	1	8	0	20	6	26
	1		2	0	12	14
Pomahaka		1	2	3		5
Maclennan R.		50	100	25		125
Waikaia R.		12	10	29	14	53
Martins Crk.		9	16	24	2	42
			5	5		10
Manuherikia		15	25	6	4	35
			251	245	112	608
2 From Resting Spots			381			381
					TOTAL KILLED	989

TABLE 3.- Rookeries Presumably not shot during period October, 1959 to June, 1960.

Location	No.Nests
Catlins River	14
Teviot River	4
Luella Dam	7

TABLE 4.- Total Population and Mortality of Shags 1959-60.

Total Number of Nests Occupied	229
Estimated Population (6/nest)	1374
Number Killed	989
Number Not Killed	385
Therefore Total Mortality Rate	71.5%

V RESULTS

OVERALL RESULTS OF THE ANALYSIS OF THE STOMACH CONTENTS

Most of the stomachs collected were full. This was due to selective shooting, the birds being shot either coming in to their nests in order to feed their young or coming into their resting places. In both cases they were coming straight from the feeding grounds with the consequence that their stomachs were full. Thus table 5 which expresses the overall condition of the stomachs collected is not a true (i.e., random) sample of the birds in nature.

TABLE 5.- Condition of the Stomachs Collected.

	No. stomachs collected	No. empty	No. containing fish or fish remains	No. of stomachs containing invertebrates only
ADULTS	41	1	39	1
FLYING YOUNG	9	1	6	2
NESTLINGS	11	1	2	8
TOTAL	61	3	47(77.1%)	11(18%)

The complete results of the analysis of all the stomachs is shown in table 6. The column headed "Average number per stomach" means the average number of the organism under consideration for all the stomachs (i.e., 61) not just the number of stomachs in which the organism is found. This method of presenting the results provides us with a model of a "typical stomach".

TABLE 6.- Complete Results of the Analysis of 61 Stomachs.

Species	Total No. Found	No. Stomachs in which found	Max. No. in one	Average No. per stomach	% Age of No. stomachs in which found to all stomachs
Trout	122	45	22	2	73.7%
Perch	123	20	20	2.05	32.8%
Galaxias sp.	27	1	27	0.44	1.6%
Crayfish	2	2	1	0.033	3.2%
Caddis	7068	45	1149	116.0	73.7%
Beetles	433	33	209	7.1	54.1%
Molluscs	216	19	47	3.5	31.2%
Others	127	31	26	2.1	50.9%

Total Number of Animals Found = 8117
Average Number per Stomach = 133.05
Numerical Ratio of Invertebrates to Fish = 28.8 to 1

Nb. If nestlings are excluded from the computation of this last figure the ratio becomes more real.

Therefore corrected numerical ratio of invertebrates to fish = 10.2 to 1
(excluding nestlings).

REGIONAL VARIATIONS

In order to consider regional variations in the diet of the shag it is necessary to present detailed results from the various localities from which the birds were collected.

SHAG RIVER

TABLE 7.- Results of 2 stomachs from Shag River

Species	Total No. Found	No.Stomachs in which found	Max. No. in one	Av. No. per stomach
Trout	3	1	3	1.5
Caddis	157	2	121	78.5
Beetles	10	2	7	5
Others	11	2	6	5.5

LAKE WAIHOLA

TABLE 8.- Results of stomachs from Lake Waihola

Species	Total No. found	No. Stomachs in which found	Max. No. in one	Av. No. per stomach
Trout	2	2	1	0.5
Perch	10	4	5	2.5
Caddis	87	2	69	22
Beetles	11	3	7	2.75
Molluscs	23	2	22	5.75
Other invrs.	6	3	3	1.5

The above two tables are of no value statistically as is shown by the large variance in table 8 with molluscs compared to table 6. This indicates that the sample is too small and so no conclusions can be drawn from them.

MAHINERANGI DAM

TABLE 9.- Results of the Analysis of 19 stomachs, 1 being empty, collected in two trips to Mahinerangi Dam.

Species	Total No. found	No.Stomachs in which found	Max.No. in one	Av.No. per stomach	% Age of No. of stomachs in which found to 19 stomachs
Trout	4	2	3	0.2	10.5%
Perch	113	16	20	5.9	84.2%
Caddis	91	8	23	4.7	42.1%
Beetles	5	4	2	0.26	21.0%
Molluscs	1	1	1	0.05	5.25%
Other Invrs	8	5	3	0.41	26.3%

TEVIOT RIVER

TABLE 10.- Results of the Analysis of 24 Stomachs of Adults from the Teviot River.

Species	Total No. found	No.Stomachs in which found	Max.No. in one	Av.No. per stomach	% Age of stomachs in which found to 24 stomachs
Trout	106	20	22	4.4	83.2%
Galaxias	27	1	27		4.2%
Paranephrops (Crayfish)	1	1	1		4.2%
Caddis	2091	23	134	87	90.8%
Beetles	276	14	209	11.5	58.4%
Molluscs	167	16	47	6.9	61.6%
Other Invrs.	94	18	26	3.9	.75%

TABLE 11.- Results of the Analysis of 10 Stomachs of nestlings from the Teviot River.

Species	Total No. found	No. Stomachs in which found	Max. No. in one	Av. No. per stomach
Trout	7	2	4	0.64
Caddis	4642	10	1149	421
Beetles	131	10	22	11.9
Molluscs	25	2	24	2.3
Others	8	3	3	0.72

VI DISCUSSION OF THESE RESULTS

These results need some explanation. For simplicity, any fish remains, e.g., otoliths, that could be positively identified are included in the appropriate columns. As well as animals, there were stones and pieces of vegetation present in a number of the stomachs. There are not included in the results as they obviously form no part of the diet of the shag.

The samples from the Shag River and Lake Waihola are too small to draw any conclusions. However, when these and the other results are considered together it is possible to distinguish two distinct diets for different types of inland waters.

1. Medium Sized Rivers:
   e.g. Teviot and Shag Rivers. Trout are the main food fish.

2. Lakes:
   e.g. Lake Waihola, Mahinerangi Dam. Perch (if present) form the major part of the diet.

MEDIUM SIZED RIVERS

With the Shag River sample (2), and even the Teviot River sample (36), the numbers are too small and are too restricted in time for full confidence. This is shown by the occurrence of 27 Galaxias in only one individual. This indicates that the sample is too small.

Even with this proviso it is possible that this sort of diet is typical of medium sized rivers containing trout as the dominant fish species. This conclusion is supported by the results obtained by Williams but not by results from workers further north.

LAKES

There is an apparent selection for perch resulting in perch being the dominant food-fish. This is shown by the total number of perch found (113) to the total number of trout found (4) in the stomachs of 23 shags taken from inland lakes. The last trip to Mahinerangi was, however, made during June, so that it is to be expected that the shags would have been feeding mostly on perch. The results show that no trout were taken by the shag at this time. (In all 73 shags were seen on the Dam that day, only 9 of which were collected as a sample).

This selection is only an apparent one. To prove that a selection, or preference, for perch exists was beyond the scope of the present work - it would require a population survey to be made of the trout and perch in the lakes in order to determine the actual ratio of perch to trout in nature. This ratio could then be compared with the ratio obtained by the examination of shag stomachs (113) (28.2 perch to 1 trout) and if the two ratios differed significantly it would indicate that a selection for perch does exist.

DO SHAGS EAT INVERTEBRATES

The large number of Caddis per stomach (116) noted in table 6 need not necessarily be the true figure because this refers to cases, or fragments of cases, and with a caddis such as Pycnocentria one case may fragment into 3 or more parts, thus falsifying the result.

In attampt to resolve the highly controversial problem of whether the shags eat invertebrates or not, every animal found in the stomachs was rated into one of five categories as to its degree of digestion. This was first attempted in New Zealand by Dickinson and my results follow his.

The system of rating used is as follows: