Food supplies at black stilt nest sites

SCIENCE FOR CONSERVATION: 58

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Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

Science for Conservation presents the results of investigations by DoC staff, and by contracted science providers outside the Department of Conservation. Publications in this series are internally and externally peer reviewed.

ISSN 1173-2946
ISBN 0-478-01931-9

This publication originated from work done under Department of Conservation Investigation no. , carried out by Mark D. Sanders, Department of Zoology, University of Canterbury, Private Bag 4800, Christchurch, New Zealand. Current address: Department of Conservation, Private Bag, Twizel. It was approved for publication by the Director, Science and Research Division, Department of Conservation, Wellington.

Cataloguing in Publication

Sanders, Mark D. (Mark David)
Food supplies at black stilt nest sites / Mark D. Sanders. Wellington, N. Z. : Dept. of Conservation, 1997.
1 v. ; 30 cm. (Science for Conservation, 1173-2946 ; 58.)
Includes bibliographical references.
ISBN 0478019319
1. Kaki. 2. Himantopus novaezelandiae. 3. Aquatic invertebrates--New Zealand--Upper Waitaki River Basin. I. New Zealand. Dept. of Conservation. II. Title. III. Series: Science for conservation (Wellington, N. Z.) ; 58.
598.33099388 20
zbn97-069501

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Abstract

Aquatic invertebrate community composition and biomass was measured at six lotic and three lentic sites in the Upper Waitaki Basin, adjacent to nests of the endangered black stilt. Invertebrate communities at lotic sites were dominated by larvae of the mayfly, *Deleatidium* spp. ($\leq$3240 m^{-2}) and larvae of the beetle family, Elmidae ($\leq$3210 m^{-2}), while communities at lentic sites were dominated by oligochaete worms ($\leq$2550 m^{-2}). Invertebrate biomass ranged from 0.36 $\pm$ 0.077 to 4.60 $\pm$ 1.00 $g.m^{-2}$ (mean $\pm$ SE, N = 5). Mean invertebrate biomass in samples from all nests combined was 1.71 $g.m^{-2}$ dry mass. The results of this survey provide a basis for the evaluation of food supplies for black stilts in constructed and modified wetlands.

1. Introduction

The black stilt (*Himantopus novaezelandiae* Gould, 1841) is one of New Zealand's most endangered birds (Bell 1986; Molloy *et al.* 1994), and is possibly the world's rarest wading bird (Hayman *et al.* 1986). Black stilts were once widespread throughout most of New Zealand, but are now almost entirely restricted to the Upper Waitaki River Basin, where they inhabit braided riverbeds, lake deltas, ponds, swamps and tarns (Pierce 1982a, 1984). The reduction in numbers and range of black stilts resulted primarily from predation by introduced mammals, combined with and exacerbated by loss and degradation of habitat (Pierce 1984, 1986a, 1996).

A shared aim of the Department of Conservation's Black Stilt Recovery Programme and Project River Recovery is to establish breeding pairs of black stilts in wetlands where the risk of predation has been reduced by electric-fencing, poisoning or trapping. Constructing physically suitable wetlands (i.e., shallow water with low islands and spits, surrounded by sparsely vegetated, flat land) is straightforward. However, to be useful, constructed wetlands must be selected as nesting sites by black stilts. The Department is attempting to encourage black stilts to use predator-protected wetlands in several ways, including developing wetlands at suitable locations, and releasing captive-reared black stilts at the wetlands. Another potential technique for encouraging black stilts to use wetlands may be to improve foraging conditions by manipulating the type, amount and availability of the aquatic macroinvertebrates on which the stilts prey.

Although the influence of food supply on nest site selection by black stilts has not been formally investigated, current knowledge suggests that stilts are more likely to nest at sites with an abundant food supply. For example, Sanders (1996) found that, within a wetland of several hectares, pied stilts nested where invertebrate standing crop was greatest. Further, Pierce (1982a) observed that black stilts nested in the Cass Valley only where food was plentiful, and postulated a possible minimum threshold for nesting of 1.0 $g.m^{-2}$ invertebrate dry mass. Many other studies of birds have shown a positive relationship between invertebrate food supplies and the number of birds nesting, or their breeding success (e.g., Danell and Sjöberg 1977, 1982; Street 1977; Murkin *et al.* 1982; Gardarrsson and Einarson 1994; for reviews see Chapter 9 in Hale 1980; Puttick 1984; Goss-Custard 1984, and Cody 1985).

The type, amount and availability of the aquatic macroinvertebrates in wetlands can be manipulated using several techniques, such as adding substrata (Sanders and Maloney 1994; Sanders 1996; Street 1983), disturbing the substratum (Sanders 1996), and managing water levels (Fredrickson and Reid 1988; Fredrickson 1991; Helmers 1992; Kelley *et al.* 1993). These techniques are currently being tested in wetlands in the Upper Waitaki Basin (Sanders and Maloney 1994; Sanders 1996). To evaluate these techniques it is necessary to compare food supplies at black stilt nest sites with those in manipulated wetlands. However, apart from very general studies by Budgeon (1977), Dunbar (1978), Merton (1977) and Pierce (1982a, 1982b, 1983), little is known about the type and amount of food supplies at black stilt nest sites. The objective of this study was to measure the abundance and biomass of aquatic invertebrates at black stilt nest sites.

2. Methods

Black stilts usually nest between September and late December (Pierce 1983, 1986a), at a variety of lotic and lentic aquatic habitats throughout the Upper Waitaki Basin. Nests are monitored at irregular intervals using a telescope, and most nest sites are visited once or twice to place dummy eggs, or to band chicks. These visits provided opportunities to sample aquatic habitats near nests with minimal extra disturbance to the birds.

Aquatic invertebrates were sampled at one nest in the 1992/1993 season and eight nests in the 1993/1994 season, between 28 September and 8 December (Table 1). Six of the nests were adjacent to rivers or streams, two were adjacent to semi-permanently flooded pasture, and one was on a clump of vegetation in a muddy swamp. Five samples were taken at each nest site by placing a 0.1 m^2 stainless steel cylinder in the substratum and rotating it so that it cut 5 cm into the substrate. The bottom edge of the cylinder cut through most detritus and vegetation. A sieve (0.8 mm mesh, 200 mm diameter, 50 mm deep) was passed quickly and repeatedly through the water within the cylinder using one hand, while the water and substratum were stirred vigorously with the other hand. The sieve was emptied every few seconds into a bucket attached to the outside of the cylinder. Detritus and vegetation, and soft or loose substrate to a maximum depth of 5 cm (approximate depth to which black stilts probe) were also removed and placed in the bucket. Gradations on the bucket allowed a double check of the volume of substrate removed; 0.1 m^2 to 5 cm depth yields 5 litres. Preliminary tests of this method (appendix 4 in Sanders 1996) showed that it effectively sampled invertebrates in a precisely delimited area and in a wide range of substrata, including mud, macrophytes and stone.

Samples were preserved in 15% formalin and transported back to the laboratory where invertebrates were sorted, identified, counted, dried at 60°C, and weighed to the nearest milligram. A high concentration of formalin was used because some samples contained large quantities of organic matter. Invertebrates in each sample were separated into 'hard-shelled' invertebrates (snails and cased caddisflies), and 'soft-bodied' invertebrates (aquatic insects and segmented worms). Body mass of hard-shelled invertebrates (i.e., mass excluding shells and cases) was estimated by multiplying total mass by 0.25, except for total mass of *Potamopyrgus antipodarum*, which was multiplied by 0.10 (Michaelis 1974). Conversion factors for all other species were determined by weighing shells, cases and bodies of subsamples of animals.

3. Results and discussion

Numerically, invertebrates in most samples from lotic habitats were dominated by larvae of the mayfly, *Deleatidium* spp. (≤3240 m^{-2}), or *Deleatidium* spp. and larvae of the beetle family, Elmidae (≤3210 m^{-2}) (see Appendix 1 for abundance and biomass data). An exception was Glentanner Stream, where the most abundant taxa were larval Tanypodinae (non-biting midges) and Oligochaeta, which were present at maximum densities of 460 m^{-2} and 270 m^{-2}, respectively. Most other taxa occurred in relatively low numbers in most samples, although larvae of a cased caddisfly, *Pycnocentrodes* sp., were abundant (>700 m^{-2}) in samples from Lower Ahuriri River 1, and the snail, *Potamopyrgus antipodarum,* was abundant (≤600 m^{-2}) in some samples taken from the East Ahuriri River in 1992.

TABLE 1. NEST SITES AT WHICH AQUATIC INVERTEBRATES WERE SURVEYED. THE PAIR NUMBERS REFER TO DEPARTMENT OF CONSERVATION IDENTIFICATION RECORDS, HELD AT THE TWIZEL FIELD CENTRE.

NEST SITE	DATE SAMPLED	PAIR NO.	BRIEF DESCRIPTION OF AQUATIC HABITAT
Lower Ohau	28/9/93	93/3	Stable river, channel c. 10 m wide, mainly cobbles
Lower Ahuriri 1	29/9/93	93/5A	River channel c. 10 m wide, cobbles & gravel
Lower Ahuriri 2	29/9/93	93/1	River channel c. 10 m wide, cobbles & gravel
East Ahuriri 92	8/12/92	92/5	Stable side stream on terrace, 1-3 m wide.
East Ahuriri 93	10/11/93	93/11A	River c. 10 m wide, cobbles & gravel
Glentanner Stream	12/11/93	93/12	Small stream, gravels and small cobbles
Coal Creek	11/11/93	93/9	Muddy swamp, some flowing water
Glencairn Irrigation 1	28/9/93	93/2A	Muddy pools and stream in flooded pasture
Glencairn Irrigation 2	28/9/93	93/4A	Muddy pools and stream in flooded pasture

Samples from lentic habitats were dominated numerically by Oligochaeta, which were present in densities of up to 2550 m^{-2}. Tanypodinae were also abundant (≤2070 m^{-2}) in samples from Coal Creek. The remainder of the fauna in samples from lentic habitats were present in low numbers (usually <50 m^{-2}), and consisted mainly of dipteran larvae (e.g., *Chironomus zealandicus*, Stratiomyidae, *Ephydrella* sp. and *Paralimnophila skusei*). Other insect orders, (Coleoptera, Hemiptera, Odonata, Trichoptera) were represented by only a few individuals.

Although abundant in lentic habitats, oligochaete worms may not be a major component of the diet of black stilts, because they burrow out of sight in the sediment. Black stilts feeding in lentic habitats, including the sites surveyed in this study, usually use visual feeding behaviours, rather than tactile ones (Pierce 1982a, 1985, 1986b; pers. obs.). This suggests that they are feeding on invertebrates other than oligochaete worms, a contention that is supported by the very low numbers of oligochaete worms in stomach samples taken from pied and black stilts at lentic habitats where oligochaetes are known to be abundant (appendices 3 and 7 in Pierce 1982a).

Invertebrate biomass in all samples taken from nest sites was dominated by soft-bodied invertebrates (Figure 1). Mean total biomass (±SE) ranged from 0.36 (±0.077) $g.m^{-2}$ at Glencairn Irrigation 2, to 4.60 (±1.00) $g.m^{-2}$ in the Lower Ohau River. The grand mean of invertebrate biomass in all samples was 1.71 $g.m^{-2}$. At two sites, Glentanner Stream and Glencairn Irrigation 2, mean biomass was significantly less than the 1.0 $g.m^{-2}$ nesting threshold suggested by Pierce (1982a). [$P < 0.05$, 1-tailed t-test, Bonferroni's correction for multiple (9) tests applied — a one-tailed test was used because I was interested only in

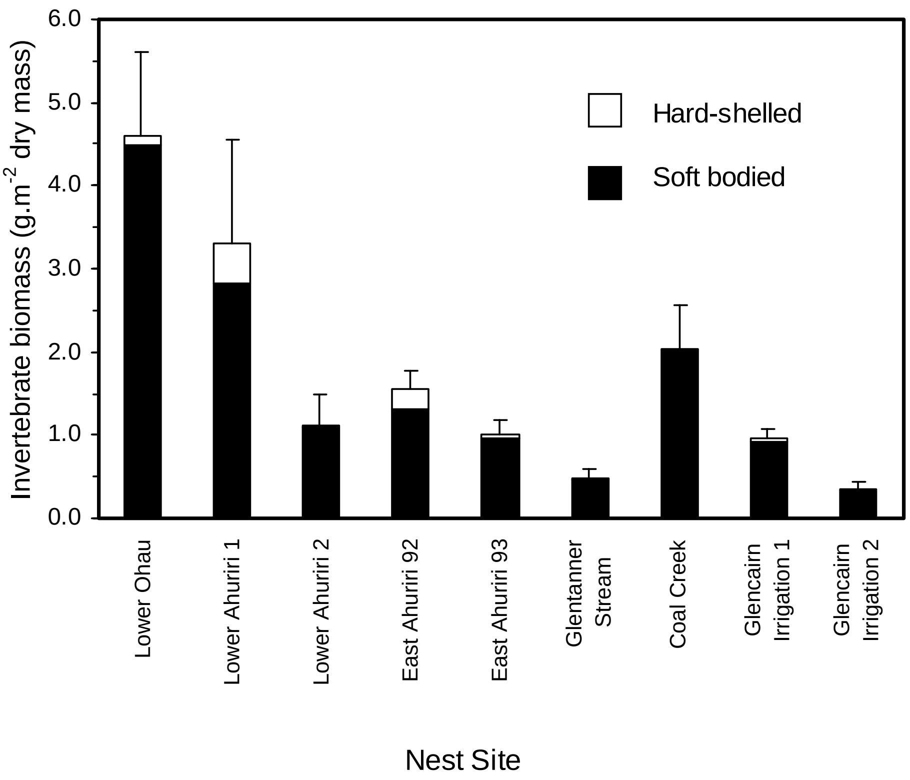

Figure 1. Mean biomass (+1 SE) of aquatic invertebrates at black stilt nest sites sampled during the 1992/1993 and 1993/1994 nesting seasons.

whether mean biomass was less than 1.0 g.m^{-2}.] On the other hand, biomass at the other seven sites was greater than, or not significantly less than, 1.0 g.m^{-2}.

The results of this survey provide a basis for the evaluation of constructed and modified wetlands as habitat for black stilts. Results of large-scale substratum manipulation experiments (Sanders 1996; see also Street 1983) suggest that, by using appropriate construction techniques, and by adding barley straw where appropriate, some wetlands can provide invertebrate biomass of *c.* 2–6 g.m^{-2} — more than that at most nest sites surveyed in this study. The use of such techniques should encourage black stilts to nest in managed, predator-protected wetlands. Moreover, field and aviary observations (Sanders 1996) suggest that the invertebrates produced in such wetlands are attractive prey for black stilt adults and chicks.

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Appendix 1

Abundance and dry mass of aquatic invertebrates per 0.1m² sample taken from streams and wetlands near black stilt nest sites.

Note that, because the main aim of this study was to measure biomass, I present estimates (<10, 10–50, or >50) of the abundance of some taxa in some samples, rather than counts.

SITE: LOWER OHAU. DATE SAMPLED: 28/09/93

SAMPLE NO.	1	2	3	4	5	MEAN	SE
OLIGOCHAETA	0	14	0	0	0	2.8	2.80
COLEOPTERA							
Elmidae	6	7	23	0	12	9.6	3.85
DIPTERA							
Chironomus zealandicus	10	62	4	7	120	40.6	22.54
Muscidae	1	0	1	0	1	0.6	0.244
Simuliidae: *Austrosimulium* sp.	0	2	0	0	0	0.4	0.40
EMPHEMEROPTERA							
Deleatidium spp.	222	102	324	171	48	173.4	47.89
PLECOPTERA							
Stenoperla prasina	0	0	0	0	1	0.2	0.20
TRICHOPTERA							
Aoteapsyche colonica	1	8	1	0	0	2	1.52
Hydrobiosis parumbripennis	2	1	1	0	0	0.8	0.37
Hydrobiosidae unident.	0	0	1	0	0	0.2	0.20
Psilochorema nemorale	8	1	10	0	0	3.8	2.1
Psilochorema bidens	0	0	0	0	1	0.2	0.20
Plectrocnemia maclachlani	14	1	22	5	0	8.4	4.20
Pycnocentrodes	4	5	3	4	5	4.2	0.37
Hudsonema amabilis	1	0	0	0	1	0.4	0.24
Olinga feredayi	3	3	8	16	8	7.6	2.38
Oxyethira albiceps	0	0	1	0	16	3.4	3.16
MOLLUSCA							
Potamopyrgus antipodarum	10	32	3	0	1	9.2	5.96
Lymnaea sp.	0	0	0	0	1	0.2	0.20
BIOMASS mg/0.1m²							
Soft-bodied	427	342	815	456	210	450	100.76
Hard-shelled (corrected)	11.1	15.3	6.4	6.3	9.8	9.78	1.67
TOTAL BIOMASS mg/0.1m²	438.1	357.3	821.4	462.3	219.8	459.78	99.84

SITE: LOWER AHURIRI 1	DATE SAMPLED: 29/09/93						
SAMPLE NO.	1	2	3	4	5	MEAN	SE
OLIGOCHAETA	1	0	0	0	0	0.2	0.20
COLEOPTERA							
Berosus sp.	3	<10	<10	0	0		
Elmidae	90	>50	>50	>50	>50		
DIPTERA							
Chironomus zealandica	2	0	0	0	0	0.5	0.45
Stratiomyidae	0	1	0	0	0	0.2	0.20
Simuliidae: *Austrosimulium* sp.	13	0	0	<10	<10		
Diptera sp. 7	1	0	0	0	0	0.2	0.20
Deleatidium spp.	4	<10	10-50	<10	0		
MEGALOPTERA							
Archichauliodes diversus	1	1	3	1	0	1.2	0.49
TRICHOPTERA							
Aoteapsyche colonica	13	0	10-50	0	<10		
Hydrobiosis parumbripennis	1	0	0	0	0		
Psilochorema nemorale	1	2	0	0	0	1.5	0.32
Pycnocentrodes	69	>50	>50	>50	>50		
Olinga feredayi	1	0	0	0	0	0.2	0.20
Physa acuta	1	0	0	1	0	0.4	0.24
BIOMASS							
Soft-bodied	180	156	754	239	82	282.2	120.61
Hard-shelled (corrected)	58	34	74	28	43	47.4	8.35
TOTAL BIOMASS mg/0.1m^2	238	190	828	267	125	329.6	126.90

SITE: LOWER AHURIRI 2	DATE SAMPLED: 29/09/93						
SAMPLE NO.	1	2	3	4	5	MEAN	SE
OLIGOCHAETA	1	10-50	<10	<10	10-50		
COLEOPTERA							
Elmidae	321	10-50	>50	10-50	>50		
DIPTERA							
Ceratopogonidae	6	0	0	<10	0		
Stratiomyidae	0	0	1	0	0	0.2	0.20
Simuliidae: *Austrosimulium* sp.	1	10-50	0	<10	0		
Eriopterini	1	0	0	0	0	0.2	0.20
Diptera sp. 7	1	0	0	0	0	0.2	0.20
EMPHEMEROPTERA							
Deleatidium spp.	16	10-50	>50	<10	>50		
PLECOPTERA							
Zelandobius furcillatus	5	>50	<10	<10	<10		
TRICHOPTERA							
Aoteapsyche colonica	14	0	<10	0	0		
Hydrobiosis clavigera	2	<10	<10	0	<10		
Psilochorema nemorale	1	0	0	0	<10		
Pycnocentrodes	14	0	<10	0	10-50		

BIOMASS							
Soft-bodied	135	46	88	37	246	110.4	38.10
Hard-shelled (corrected)	2	0	0	0	0	0.4	0.40
TOTAL BIOMASS mg/0.1m^2	137	46	88	37	246	110.8	38.17

SITE:EAST AHURIRI 92 DATE SAMPLED: 8/12/92

SAMPLE NO.	1	2	3	4	5	MEAN	SE
COLEOPTERA							
Elmidae	70	18	0	33	105	45.2	18.87
Deleatidium spp.	63	28	54	10	17	34.4	10.35
PLECOPTERA							
Zelandobius furcillatus	0	11	5	20	40	15.2	7.04
TRICHOPTERA							
Hydrobiosis sp.	3	0	0	0	0	0.6	0.60
Pycnocentrodes	33	5	36	6	10	18	6.80
Potamopyrgus antipodarum	6	6	60	25	46	28.6	10.78
BIOMASS							
Soft-bodied	175	132	162	79	108	131.2	17.51
Hard-shelled (corrected)	13	5	58	15	27	23.6	9.29
TOTAL BIOMASS mg/0.1m^2	188	137	220	94	135	154.8	22.09

SITE: EAST AHURIRI 93 DATE SAMPLED: 10/11/93

SAMPLE NO.	1	2	3	4	5	MEAN	SE
OLIGOCHAETA	1	1	2	2	0	1.2	0.37
COLEOPTERA							
Elmidae	3	11	4	5	6	5.8	1.39
DIPTERA							
Chironomus zealandicus	13	3	0	10	24	10	4.21
Tanypodinae	0	0	1	0	0	0.2	0.20
Muscidae	0	1	1	0	0	0.4	0.24
Eriopterini	0	1	1	0	0	0.4	0.24
EMPHEMEROPTERA							
Deleatidium spp.	20	7	11	10	30	15.6	4.20
PLECOPTERA							
Zelandobius furcillatus	0	1	11	0	0	2.4	2.159
TRICHOPTERA							
Aoteapsyche colonica	3	0	0	5	4	2.4	1.03
Hydrobiosis parumbripennis	4	0	1	1	2	1.6	0.68
Psilochorema nemorale	2	0	0	0	0	0.4	0.40
Pycnocentria funera	0	0	0	4	0	0.8	0.80
Pycnocentrodes	2	9	1	4	5	4.2	1.39
Potamopyrgus antipodarum	0	0	2	0	0	0.4	0.40

BIOMASS							
Soft-bodied	141	48	99	67	123	95.6	17.19
Hard-shelled (corrected)	0	5.5	0	16.5	7.3	5.86	3.03
TOTAL BIOMASS mg/0.1m^2	141	53.5	99	83.5	130.3	101.46	15.85

SITE: GLENTANNER STREAM DATE SAMPLED: 12/11/93

SAMPLE NO.	1	2	3	4	5	MEAN	SE
OLIGOCHAETA	27	4	9	7	2	9.8	4.47
COLEOPTERA							
Elmidae	0	4	1	8	1	2.8	1.46
DIPTERA							
Tanypodinae	46	9	7	20	0	16.4	8.07
Muscidae	0	1	0	2	0	0.6	0.40
EMPHEMEROPTERA							
Deleatidium spp.	0	0	6	9	0	3	1.90
PLECOPTERA							
Zelandobius confusus	1	0	0	0	0	0.2	0.20
TRICHOPTERA							
Hydrobiosidae unident.	0	0	0	3	0	0.6	0.60
Pycnocentrodes	0	0	0	1	0	0.2	0.20
Hudsonema amabilis	0	1	1	0	0	0.4	0.24
Oxyethira albiceps	0	1	0	1	1	0.6	0.24
MOLLUSCA							
Potamopyrgus antipodarum	4	0	0	1	1	1.2	0.73
BIOMASS							
Soft-bodied	45	29	36	90	26	45.2	11.67
Hard-shelled (corrected)	3.5	1	0.8	4	0.5	1.96	0.74
TOTAL BIOMASS mg/0.1m^2	48.5	30	36.8	94	26.5	47.16	12.30

SITE: COAL CREEK DATE SAMPLED: 11/11/93

SAMPLE NO.	1	2	3	4	5	MEAN	SE
OLIGOCHAETA	37	131	225	30	15	87.6	39.95
COLEOPTERA							
Rhantus pulverosus	1	1	1	0	0	0.6	0.24
DIPTERA							
Chironomus zealandicus	2	0	0	14	159	35	31.11
Tanypodinae	207	131	44	15	33	86	36.25
Syrphidae	0	0	0	1	0	0.2	0.20
Stratiomyidae	0	0	9	0	0	1.8	1.80
Simuliidae: *Austrosimulium* sp.	0	8	10	0	0	3.6	2.23
Ephydrella ?aquaria	0	0	1	1	0	0.4	0.24
Paralimnophila skusei	2	2	0	0	0	0.8	0.49

TRICHOPTERA							
Hydrobiosidae unident.	0	0	0	1	0	0.2	0.20
Oxyethira albiceps	0	7	6	0	0		
HEMIPTERA							
Sigara sp.	0	0	0	2	0	0.4	0.40
Microvelia ?macgregori	0	0	0	0	1	0.2	0.20
Liodessus plicatus	0	0	0	1	0	0.2	0.20
BIOMASS							
Soft-bodied	90	259	357	85	226	203.4	52.00
TOTAL BIOMASS mg/0.1m^2	90	259	357	85	226	203.4	52.00

SITE: GLENCAIRN IRRIGATION 1 DATE SAMPLED: 28/09/93

SAMPLE NO.	1	2	3	4	5	MEAN	SE
OLIGOCHAETA	86	255	91	26	197	131	41.46
ODONATA							
Xanthocnemis zealandica	1	0	0	0	0	0.2	0.20
DIPTERA							
Chironomus zealandicus	1	0	0	0	0	0.2	0.20
Ceratopogonidae	0	0	0	1	0	0.2	0.20
Syrphidae	0	1	0	0	0	0.2	0.20
Stratiomyidae	1	0	0	23	0	4.8	4.55
Stratiomyidae sp. 9	0	0	0	1	0	0.2	0.20
Zelandotipula sp 1.	1	0	0	1	0	0.4	0.24
Zelandotipula sp 2.	0	0	0	1	0	0.2	0.20
Paralimnophila skusei	2	0	2	0	1	1	0.45
Diptera pupa 15	2	0	0	1	0	0.6	0.40
Diptera sp. 4	0	0	0	0	1	0.2	0.20
Adult Diptera	0	0	0	0	3	0.6	0.60
TRICHOPTERA							
Hudsonema amabilis	2	0	0	0	0	0.4	0.40
MOLLUSCA							
Physa acuta	9	0	0	2	0	2.2	1.74
Potamopyrgus antipodarum	0	0	0	1	0	0.2	0.20
BIOMASS							
Soft-bodied	58	125	84	115	74	91.2	12.57
Hard-shelled (corrected)	23	0	0	3	0	5.2	4.49
TOTAL BIOMASS mg/0.1m^2	81	125	84	118	74	96.4	10.43

SITE: GLENCAIRN IRRIGATION 2	DATE SAMPLED: 28/09/93					
SAMPLE NO.	1	2	3	4	5	MEAN	SE

SAMPLE NO.	1	2	3	4	5	MEAN	SE
OLIGOCHAETA	13	13	12	5	13	11.2	1.56
DIPTERA							
Staphylinidae	0	0	1	3	0	0.8	0.58
Rhantus pulverosus	0	0	0	0	1	0.2	0.20
DIPTERA							
Chironomus zealandicus	1	0	3	1	0	1	0.55
Stratiomyidae	0	0	4	4	2	2	0.89
Ephydrella ?aquaria	7	5	16	0	1	5.8	2.85
Tipulidae sp. 11	1	1	0	0	0	0.4	0.24
Diptera pupa 18	0	2	4	12	1	3.8	2.15
Diptera sp. 10	0	0	1	0	1	0.4	0.24
Diptera sp. 11	0	0	0	0	1	0.2	0.20
TRICHOPTERA							
Oxyethira albiceps	0	0	1	0	0	0.2	0.20
HEMIPTERA							
Liodessus plicatus	0	0	2	2	0	0.8	0.49
BIOMASS							
Soft-bodied							
Hard-shelled (corrected)							
TOTAL BIOMASS mg/0.1m^2	21	21	60	30	47	35.8	7.69