The diet of breeding Dippers in north-west Ireland during the period of incubation

P.Agnew*, K.W. Perry
Department of Biological and Biomedical Sciences,University of Ulster, Coleraine, Co. Londonderry BT52 1XJ
*(*Present address: Experimental Ecology, ETH-Zurich, Grabenstrasse 3, CH-8952 Schlieren, Switzerland)*

The diet of breeding Dippers during the period of incubation was assessed from six sites on the Rivers Roe and Faughan, Co. Londonderry. Faecal pellet collection and macro-invertebrate sampling from the river benthos was used to determine foraging selectivity. May-fly nymphs and caddis-fly larvae formed the bulk of the diet. In general the Dippers preferentially took larger caddis-fly larvae from the environment and took the small may-fly nymphs in relation to their abundance. This contrasts with the period after hatching where adults generally consume may-fly nymphs and preferentially feed their offspring caddis-fly larvae.

Introduction

Several studies have investigated the diet of Dippers *Cinclus cinclus* at various times of the year. These include winter (Ormerod and Tyler 1986), during the moult (Smith and Ormerod 1986) and in the breeding season (Ormerod 1985a, 1985b, Ormerod and Perry 1985, Ormerod, Efteland and Gabrielsen 1987). Many of these investigations have combined faecal pellet analysis with sampling of macro-invertebrates in the environment, e.g. Ormerod 1985b. These studies have been able to show how diet changes with macro-invertebrate abundance and which particular prey types are preferentially taken. For example, may-fly nymphs numerically dominate the diet most of the year but the weight contributed by caddis-fly larvae becomes more important during the breeding season (Ormerod 1985b, Ormerod and Perry 1985, Ormerod et al 1987).

This paper follows a previous investigation of breeding Dipper diet in north-west Ireland (Ormerod

Plate 8 (above). *Dipper with food (Richard T.Mills)* and Perry 1985). Faecal pellet and macro-invertebrate sampling from the environment assessed diet content and selectivity during the breeding season prior to hatching. The results are compared with those of other studies made after hatching.

Study area and methods

County Londonderry's Rivers Roe and Faughan both descend from upland catchments as well aerated, fast flowing streams with abundant riffles. Each river was rated as having good water quality by the Department of the Environment (Northern Ireland) in their 1980 and 1985 river surveys (Department of the Environment 1987). Therefore, the rivers are suited to the ecology of the Dippers and their invertebrate prey (Ormerod, Boilstone and Tyler 1985, Tyler and Ormerod 1985, Vickery 1992).

Macro-invertebrate sampling and faecal pellet collection was undertaken at three nesting sites on each river (Table 1). Each site was sampled on 23 and 30 April 1992. Five nest sites contained eggs during the sampling period. The Tamniarin Bridge site had very young chicks on the first visit, and in this case only faecal pellets from the first visit were considered for analysis and assumed to have been from the period prior to hatching. Possible effects of this are discussed later.

***Table 1.** Locations of the Dipper nest sites in Co. Londonderry sampled for macro-invertebrates, April 1992.*

River	Site	Grid Reference	Altitude above sea-level (m)
Roe	Corick	C751063	170
	Tamniarin	C716068	120
	Owenbeg	C669091	70
Faughan	Tamnagh	C597012	140
	Berrybum	C481125	40
	Drumahoe	C464149	20

Macro-invertebrate abundance and analysis

The six nesting sites were assessed for macro-invertebrate abundance by standardised kick-sampling, lasting 60 s with 20 leg sweeps (Peckarsky 1984). Within each territory three kick-samples were taken from riffles as follows: approximately 50 m upstream, 50 m downstream and near to the nest. Sites were sampled in reverse order on the second visit to reduce any systematic bias of macro-invertebrate abundance in the river benthos due to the time of day. Macro-invertebrate samples were preserved in 70% alcohol and classified to family level in the laboratory (Ormerod 1985b).

Faecal pellet collection and analysis

Faecal pellets were collected from each site on the first visit and were from the same stretches of river sampled for macro-invertebrates. Preference was given to fresh samples. Few samples were collected from the second visit due to low availability after heavy rains. Each pellet was individually preserved and its contents identified to family level, predominantly by mouthparts, against a reference collection (Ormerod 1985b).

Data analysis

The Wilcoxon two-sample test was used to assess differences of macro-invertebrate abundance between sites. Fifteen possible pairwise comparisons can be made for the six sites. Therefore, the 5% significance level needs to be lowered to avoid significant differences falsely arising by chance due to the large number of comparisons made. The appropriate significance level was 3.4% (Sokal and Rohlf 1981). This value was used for pairwise comparisons between sites for: total macro-invertebrate abundance, prey taxa abundance and the abundance of macro-invertebrate remains in faecal pellets.

Correlations were used to assess whether the sampled macro-invertebrate taxa were of a similar representation in each river and in the faecal pellets from each river. Each taxon's numerical representation was calculated as a percentage of the total macro-invertebrate number. These percentage values were then ranked (1st, 2nd, 3rd,..) and the rankings were used for the Spearman's correlations between rivers.

Further analysis was carried out to see if the actual percentage value of each taxon, rather than just their rank ordering, was different in the faeces from each river. For this the G-test was used. The same analysis was used to look for differences of taxa representation in the environment and in faeces from each river. Again, the actual percentage values of each taxon were used.

Dietary selectivity in relation to macro-invertebrate abundance was calculated using Ivlev's Electivity Index (1961):

$$E = (r_i - p_i)/(r_i + p_i)$$

where r_i is the percentage representation of taxon i in the faeces and p_i is its percentage representation in the environment. Values from +1.0 to -1.0 indicate the degree of each taxon's electivity from active selection (+1) to active avoidance (-1). Electivity values were calculated for each taxon based upon its environmental and faecal representation at each of the six sites. Where $p_i < 0.5\%$ within a site the value of E at that site was discounted. This was because very low values of p_i produce extreme values of E (Ormerod 1985b). The valid values of E were then pooled together to produce a mean electivity value for each taxon.

Results

Macro-invertebrate abundance

In total 935 macro-invertebrates were collected, 522 from the River Roe and 413 from the River Faughan, and classified into 26 taxa (Table 2). For all sites together, the most abundant taxa were: true fly larvae Chironomidae (328), may-fly nymphs Baetidae (153) and may-fly nymphs Ecdyonuridae (122). The total number of each taxon collected from both rivers is shown in Table 3.

Pairwise comparisons found no significant differences between any of the sites for the total macro-invertebrate abundance nor for prey taxa abundance alone (Tables 4 and 5). There was a significant correlation for the ranked percentage contribution of each taxon between the rivers (Spearman's rho = 0.625, df = 24, $P < 0.01$).

Faecal pellet analysis

The numbers of faecal pellets collected from each site were: Corick 10, Tamniarin 10, Owenbeg 10, Tamnagh 10, Berryburn 9 and Drumahoe 16. From these 65 pellets 233 macro-invertebrate remains were identified. The most numerous faecal taxa were: may-fly nymphs Baetidae (57), caddis-fly larvae Hydropsychidae (53) and may-fly nymphs Ecdyonuridae (23). The total number of each taxon found in the faeces from both rivers is shown in Table 3.

Pairwise comparisons found no significant differences between the sites for the number of

***Table 2.** Abundance of macro-invertebrates sampled from nesting sites along the Rivers Roe and Faughan, Co. Londonderry. Sampling dates were 23 and 30 April 1992.*

	River Roe			River Faughan					
	Corick	Tamniarin	Owenbeg	Tamnagh	Berryburn	Drumahoe	Total	Mean	SD
Hydrobiidae	0	0	0	0	0	21	21	3.50	7.83
Ancylidae	0	2	1	0	0	0	3	0.50	0.76
Nemetoda	0	1	0	0	0	0	1	0.17	0.37
Hirudinea	0	0	0	1	0	0	1	0.17	0.37
Oligochaeta	0	6	17	3	47	15	88	14.67	15.69
Arachnida	2	5	0	0	1	3	11	1.83	1.77
Gammaridae	0	1	2	0	0	0	3	0.50	0.76
Gerridae	0	1	0	0	0	0	1	0.17	0.37
Baetidae	39	15	58	4	33	4	153	25.50	19.70
Ecdyonuridae	46	36	24	6	0	10	122	20.33	16.55
Ephemerellidae	0	0	0	0	1	0	1	0.17	0.37
Caenidae	1	3	9	0	0	3	16	2.67	3.09
Leuctridae	1	0	0	0	0	0	1	0.17	0.37
Perlodidae	2	3	3	11	2	0	21	3.50	3.50
Perlidae	3	0	0	0	0	0	3	0.50	1.12
Chloroperlidae	3	3	1	12	0	0	19	3.17	4.14
Elminthidae	4	31	32	4	0	5	76	12.67	13.41
Rhyacophilidae	0	0	0	1	0	0	1	0.17	0.37
Glossosomatidae	1	1	0	0	0	0	2	0.33	0.47
Hydropsychidae	4	7	11	2	0	0	24	4.00	3.96
Polycentropidae	0	1	0	0	0	0	1	0.17	0.37
Chrysomelidae	0	1	0	0	0	0	1	0.17	0.37
Dytiscidae	0	1	0	1	0	0	2	0.33	0.47
Chironomidae	32	72	22	22	161	19	328	54.67	50.87
Simuliidae	1	0	7	6	3	1	18	3.00	2.65
Other Diptera	3	1	2	1	6	4	17	2.83	1.77
Total	142	191	189	74	254	85	935	158.83	63.09

***Table 3.** The total numbers of macro-invertebrates sampled from the environment and faecal pellets for the Rivers Roe and Faughan, April 1992. Calculated electivity values with their standard deviations and number of sites used in the calculation of E.*

	River Roe		River Faughan		Total				
	Envirmnt.	Faeces	Envirmnt.	Faeces	Envirmnt.	Faeces	Electivity value E	Standard deviation	Sample size for E
Hydrobiidae	0	0	21	0	21	0	-1.000	-	1
Ancylidae	3	0	0	0	3	0	-1.000	0	2
Nemetoda	1	0	0	0	1	0	-1.000	-	1
Hirudinea	0	0	1	0	1	0	-1.000	-	1
Oligochaeta	23	0	65	0	88	0	-1.000	0	6
Arachnida	7	6	4	0	11	6	-0.468	0.92	3
Gammaridae	3	0	0	0	3	0	-1.000	0	2
Gerridae	1	1	0	0	1	1	-1.000	-	1
Baetidae	112	50	41	7	153	57	0.221	0.33	6
Ecdyonuridae	106	17	16	6	122	23	-0.204	0.33	5
Ephemerellidae	0	0	1	0	1	0	-1.000	0	2
Caenidae	13	0	3	0	16	0	-1.000	0	3
Leuctridae	1	2	0	1	1	3	-1.000	-	1
Perlodidae	8	11	13	6	21	17	-0.329	0.92	5
Perlidae	3	2	0	0	3	2	0.173	-	1
Chloroperlidae	7	3	12	0	19	3	-0.630	0.74	4
Elminthidae	67	1	9	2	76	3	-0.601	0.43	5
Rhyacophilidae	0	12	1	2	1	14	-1.000	-	1
Glossosomatidae	2	3	0	3	2	6	0.608	0.02	2
Hydropsychidae	22	23	2	30	24	53	0.229	0.82	4
Polycentropidae	1	0	0	2	1	2	-1.000	-	1
Chrysomelidae	1	0	0	0	1	0	-1.000	-	1
Dytiscidae	1	7	1	6	2	13	0.113	1.25	2
Chironomidae	126	1	202	5	328	6	-0.894	0.10	6
Simuliidae	8	0	10	0	18	0	-1.000	0	5
Other Diptera	6	11	11	5	17	16	0.151	0.64	6
Totals	522	157	413	76	935	233			

macro-invertebrate remains in the pellets (Table 6). A significant correlation was found for the ranked percentage contribution of each taxon in the faeces between the rivers (Spearman's rho = 0.764, df = 24, $P < 0.01$). The percentage contribution each taxon made to the total macro-invertebrate abundance in each river was significantly different ($G = 47.38$, df = 24, $P < 0.05$).

Dietary selection

There were significant differences between the percentage contribution each taxon made to the environmental and faecal samples for both the River Roe ($G = 97.12$, df = 24, $P < 0.01$) and for the River Faughan ($G = 121.84$, df = 24, $P < 0.01$). Table 3 shows the calculated mean electivity value for each taxon using Ivlev's electivity index (1961). Active selection was seen for the may-fly nymphs Baetidae, stone-fly nymphs Perlidae, caddis-fly larvae of Glossosomatidae and Hydropsychidae. Weak selection was also found for a mixture of true fly larvae (excluding the Chironomidae and Simuliidae). All other taxa showed varying degrees of avoidance.

Discussion

Population studies of the Dipper in north-west Ireland have shown that the Rivers Roe and Faughan support similar numbers of breeding pairs (Perry 1983, Perry and Agnew 1993). As Dipper distribution is known to be related to the availability of feeding sites (Ormerod et al 1985, Vickery 1992) it suggests the two rivers are similar in this respect.

In this study the abundance of macro-invertebrates was found not to vary significantly between the six sites sampled. This was also true when only the abundance of prey taxa was considered. Furthermore, a significant correlation was found between the rivers for the contribution each taxon made to the total abundance. Thus, the two rivers appear to be comparable for macro-

Table 4. *Pairwise comparisons by the Wilcoxon two-sample test between the sites for total macro-invertebrate abundance in the environment. Significance requires P<0.034.*

	Corick	Tamniarin	Owenbeg	Tamnagh	Berryburn
Tamniarin	0.199	-			
Owenbeg	0.462	0.935	-		
Tamnagh	0.432	0.055	0.081	-	
Berryburn	0.424	0.371	0.291	0.864	-
Drumahoe	0.266	0.935	0.040	0.842	0.665

Table 5. *Pairwise comparisons by the Wilcoxon two-sample test between the sites for macro-invertebrate abundance of prey taxa in the environment. Significance requires P < 0.034.*

	Corick	Tamniarin	Owenbeg	Tamnagh	Berryburn
Tamniarin	0.597	-			
Owenbeg	0.609	0.301	-		
Tamnagh	0.131	0.090	0.312	-	
Berryburn	0.129	0.308	0.373	0.722	-
Drumahoe	0.180	0.070	0.050	0.573	0.610

Table 6. *Pairwise comparisons by the Wilcoxon two-sample test between the sites for macro-invertebrate abundance in the faecal pellets. Significance requires P < 0.034.*

	Corick	Tamniarin	Owenbeg	Tamnagh	Berryburn
Tamniarin	0.605	-			
Owenbeg	0.072	0.199	-		
Tamnagh	0.059	0.102	0.324	-	
Berryburn	0.085	0.143	0.441	1.000	-
Drumahoe	0.041	0.045	0.323	0.873	0.942

invertebrate density and population structure.

If foraging Dippers have a general feeding strategy it would be expected that in habitats with similar food resources their diets will be similar. Analysis of faecal pellets from the Rivers Roe and Faughan suggest this is the case. No significant differences were found for the number of macro-invertebrate remains in pellets between the six sites. A significant correlation was found between the rivers for the contribution each taxon made to the faeces. Hence, foraging Dippers appear to be taking similar numbers of macro-invertebrates and taking each taxon to the same degree in each river. The differences seen in the actual percentage contributions each taxon made to the faeces might reflect slight differences between the rivers, e.g. average altitude, but did not affect the overall pattern of taxa in the faeces.

Faecal pellet collection at the Tamniarin site was made with very young chicks in the nest. If any of the pellets were from adults feeding their offspring there is potential for bias in the results. However, chicks of this age are limited in what they can be fed due to their gape size. Ormerod (1985b) reports increasing proportions of larger prey items in offspring diet as their gape size increases. Therefore, any effect on these results is likely to be a dilution of may-fly numbers in the adult diet at the Tamniarin bridge site. In this case their percentage contribution to the taxa and electivity values may be slight underestimates but the rank ordering of taxa is unlikely to change.

Comparing a taxon's representation in the environment and in faecal pellets indicates Dipper feeding strategy. Results here found significant differences between the two, so showing selective foraging. Other studies later in the breeding season, after egg hatching, also found these differences (Ormerod 1985a, 1985b, Ormerod and Perry 1985, Ormerod et al 1987). The may-fly larvae Baetidae and Ecdyonuridae were important contributors to the diet due to their high environmental abundances. The positive selection for Baetidae and negative selection for Ecdyonuridae might indicate the ease with which Dippers are able to find them. The larger caddis-fly larvae Rhyacophilidae, Glossosomatidae and especially Hydropsychidae were important contributors. Unfortunately, only a single Rhyacophilidae was caught from the river benthos so allowing its electivity value to be calculated only at the Tamnagh bridge site. This turned out to be negative. Overall, 14 were found in faeces indicating that Dippers do actively select this caddis-fly larvae.

May-fly nymphs formed 36% of the diet and caddis-fly larvae formed 31% of the diet. Other studies of adult diet after egg hatching indicate may-flies usually form over 60% of the diet while caddis-flies form around 20% (Ormerod 1985a, 1985b, Ormerod and Perry 1985). Electivity values help confirm this switch in adult diet when eggs hatch. Ormerod (1985b) calculated macro-invertebrate electivity values for parental Dippers and their offspring in the River Wye catchment, mid-Wales. The adults had values of 0.58 for Baetidae and 0.21 for Ecdyonuridae, while the values for the offspring over seven days old were 0.01 and -0.08 respectively. Adults had values of 0.07 for the Rhyacophilidae and Hydropsychidae, while their offspring showed values of 0.74 and 0.76 respectively. Thus, adults were generally consuming the small may-flies above their environmental representation and consuming the larger caddis-flies at their environmental representation. In contrast, their offspring were given may-flies in proportion to their environmental representation and caddis-flies well above their environmental representation. Parental provisioning in this manner leads to increased fledging weights and subsequent survival chances (Price and Bock 1983). Many other bird species also have demonstrated this behaviour, e.g. Wheatears *Oenanthe oenanthe* (Brooke 1981), Spotted Flycatchers *Muscicapa striata* (Davies 1977).

In conclusion, breeding Dippers are foraging selectively during the period of incubation. They consume larger prey items, such as caddis-flies, above their environmental representation and smaller prey items, such as may-fly nymphs, around about their environmental representation. Other studies show that after egg hatching the parents continue to forage selectively for larger prey items but preferentially give them to their offspring and make do with the smaller prey items themselves. In doing so they increase their offspring's survival chances.

Acknowledgements

We would like to thank Keith Day, Innes Cuthill, James Power, Steve Ormerod for their advice and comments on various drafts of the manuscript. PA was supported by a graduate grant from the European Social Fund.

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