

The feeding ecology of Merlin *Falco columbarius* during the breeding season in Ireland, and an assessment of current diet analysis methods

Darío Fernández-Bellon*
and John Lusby

*BirdWatch Ireland, Midlands Office,
Crank House, Banagher, Co. Offaly*

* Correspondence author:
dfernandezbellon@gmail.com



The breeding season diet of Merlin *Falco columbarius* was assessed at 11 occupied sites in 2010. Diet was determined via analysis of prey remains. Merlin pellets were also analysed to investigate potential bias in relation to under-recording certain prey groups. The results were compared to those from previous studies in Ireland and Britain. The findings indicate that the source of bias investigated had a negligible effect on results and that analysis of plucking remains is an accurate method for assessing Merlin diet. Open-country passerines comprised the majority of the diet (45% by number and 62% by weight). Predominance of Meadow Pipit *Anthus pratensis* and Skylark *Alauda arvensis*, reported as the main prey species by previous studies, was significantly lower in the current study. This may be linked to population declines of these passerines as a consequence of recent harsh winter weather. Woodland passerines accounted for approximately half of the diet in April with their relative importance declining steadily as the season progressed. Nestling and fledgling passerines were an important food source for Merlin in the later part of the season. Seasonal changes in the diet reflected variations in prey abundance and availability. This study denotes the relevance of moorland and forestry management practices for the conservation of Merlin populations in Ireland.

Introduction

Throughout their breeding range Merlin *Falco columbarius* occupy a wide variety of habitats in or adjacent to open country, preying mainly on small passerines. Prey is usually plucked on prominent features (e.g. moss-covered hummocks, boulders or fence posts) before feeding or subsequent delivery to the nest (Forsman 1999, Hardey *et al.* 2009). Studies during the breeding season of the diet of Merlin

in Ireland and Britain indicate that Meadow Pipit *Anthus pratensis* is generally the dominant prey species both in terms of frequency and biomass. Other passerines, such as Skylark *Alauda arvensis*, Chaffinch *Fringilla coelebs* and Wheatear

Plate 65. Boulder used by Merlin for plucking prey (D. Fernández-Bellon).

Oenanthe oenanthe are of secondary importance (Watson 1979, Newton *et al.* 1984, Bibby 1987, Meek 1988, Partridge and Bellamy 1990, Clarke and Scott 1994, Heavisides *et al.* 1995, Petty *et al.* 1995, McElheron 2005, Rae 2010). Other studies however, propose that Merlin may be more opportunistic, utilising a wider spectrum of prey species than has previously been indicated. For example, Wiklund (2001) suggested that some populations may frequently prey on small mammals, the dietary importance of which could be underestimated by the analysis of plucking remains alone (Watson 1979, Bielefeldt *et al.* 1992).

Previous research on Merlin diet in Ireland has been confined to isolated areas in Counties Wicklow and Dublin and in Northern Ireland (Partridge and Bellamy 1990, Clarke and Scott 1994, McElheron 2005, Pierce and Roe 2006). The aims of this study were to improve on current knowledge of the breeding season diet and feeding ecology of the Irish Merlin population, and to evaluate the effectiveness of current methods used to determine Merlin diet. Potential sources of bias, including under-recording insects and small mammals were considered. This study ran concurrently to the 2010 Pilot Merlin Survey, carried out by BirdWatch Ireland and the National Parks and Wildlife Service to establish an effective protocol for future monitoring of the species in Ireland (Fernández-Bellon *et al.* 2010).

Study areas and methods

Merlin diet was assessed at a geographical spread of traditional sites to determine the overall composition and any seasonal variation. Ten 3 x 3km squares, which incorporated traditional and regularly occupied Merlin territories, were selected for the 2010 pilot survey (Fernández-Bellon *et al.* 2010). Of these, two were located in County Wicklow, three in County Galway and five in County Donegal. Intensive survey work revealed that four of these squares were occupied by non-breeding birds and the remaining six held a total of seven breeding pairs.

Fieldworkers visited each survey square monthly between April and July, with each visit lasting from one to five days. Survey methods involved walking transects within 200m of all points of suitable Merlin habitat as defined by Hardey *et al.* (2009), which included all areas of grass and heather moorland, bracken and open forestry. All prominent features offering suitable plucking perches for Merlin were examined for prey remains (i.e. moth wings, feathers, skulls and leg bones). Collection and analysis of prey remains is considered an accurate means of determining Merlin diet (Watson 1979, Newton *et al.* 1984) and was used to assess diet in the current study. All plucking remains encountered were collected, placed in individual bags and labelled with the date, site name and GPS location. Thereafter, all prey items were identified to

species level with the aid of an identification key (Brown *et al.* 2003) and by detailed comparison to reference collections. The minimum number of individual items was recorded by collating the various body parts collected.

Results are shown by frequency of individual prey items and also by average body mass, which was obtained by assigning a mean weight to each prey species and adjusting where necessary for age differences (Newton *et al.* 1984, BTO Nest Record Scheme Data 2005, BTO Ringing Scheme Data 2005). Differences in the diet between breeding and non-breeding Merlin, and between regions were assessed by comparing results from individual territories. To evaluate prey selection, all avian prey were categorised as either woodland (including scrub and wood edge habitats) or moorland species, following criteria used by Newton *et al.* (1984). The occurrence in the diet of each habitat group was compared across months to highlight any evident seasonal variation. The Merlin is known to prey on nestling and fledgling passerines (Newton *et al.* 1984, Bibby 1987, Sodhi *et al.* 1991, Dickson 1996). To determine the importance of this food source for Irish populations, all avian prey was aged, either as adults (including fully grown juveniles) or fledglings (birds whose flight or tail feathers were only partly grown) (Newton *et al.* 1984) and their relative frequency compared throughout the season.

Analysis of plucked prey remains may result in the underestimation of small mammals in the diet (Watson 1979, Bielefeldt *et al.* 1992). To counter this Ritchie (1982) recommends complementing this method with pellet analysis as a means of detecting prey groups which may otherwise be under-recorded. Breeding Merlin often use the same perches for plucking prey as for casting pellets (pers. obs.). All Merlin pellets (Dickson 1999) found were individually bagged and labelled with the location and date. These were later analysed to a level that would detect mammalian, reptile and amphibian remains (e.g. fur, bones, skulls or reptile scales). In this way, the presence of non-avian prey within the Merlin diet was determined.

Results

Overall diet

A total of 384 prey items were collected from 264 plucking perches. Of all items analysed, 65.9% were birds, 33.1% moths and 1.0% dragonflies (Table 1). No appreciable variation was detected between the diet of breeding and non-breeding Merlin. Similarly, no variation in the diet was recorded between territories in different areas of the country. For this reason, prey records from all sites were pooled.

A total of 24 bird species was recorded. The most frequent prey item was Meadow Pipit (22.9%), followed by Skylark

Table 1. Prey items of Merlin in Ireland recorded during the breeding season of 2010. An asterisk denotes avian species categorised as inhabiting woodland, wood edge and scrub in further analysis following the classification used by Newton *et al.* (1984) (*).

Species	No.	Percentage occurrence	Percentage biomass
Meadow Pipit <i>Anthus pratensis</i>	88	22.9	17.0
Skylark <i>Alauda arvensis</i>	34	8.9	13.2
Swallow <i>Hirundo rustica</i>	18	4.7	3.9
Snipe <i>Gallinago gallinago</i>	15	3.9	17.4
Wheatear <i>Oenanthe oenanthe</i>	13	3.4	3.9
Mistle Thrush <i>Turdus viscivorus</i> *	11	2.9	14.9
Goldfinch <i>Carduelis carduelis</i> *	11	2.9	1.9
Song Thrush <i>Turdus philomelos</i> *	10	2.6	8.1
Chaffinch <i>Fringilla coelebs</i> *	8	2.1	1.9
Wren <i>Troglodytes troglodytes</i> *	4	1.0	0.4
Robin <i>Erithacus rubecula</i> *	4	1.0	0.8
Blackbird <i>Turdus merula</i> *	4	1.0	4.4
House Sparrow <i>Passer domesticus</i> *	3	0.8	0.8
Bullfinch <i>Pyrrhula pyrrhula</i> *	3	0.8	0.7
Red Grouse <i>Lagopus lagopus</i>	2	0.5	3.5
Golden Plover <i>Pluvialis apricaria</i>	1	0.3	2.2
Other identified passerines ¹	13	3.4	1.7
Unidentified passerines ²	11	2.9	– ²
Fox Moth <i>Macrothylacia rubi</i>	65	16.9	1.4
Emperor Moth <i>Saturnia pavonia</i>	47	12.2	1.5
Northern Eggar <i>Lasiocampa quercus</i>	15	3.9	0.3
Dragonfly <i>Odonata</i> sp.	4	1.0	<0.1
Totals	384	100.0	100.0

¹ Passerine species accounting for 0.5% or less of the diet by number or weight are excluded from the table. These species (and numbers recorded) were Goldcrest *Regulus regulus** (2), Blue Tit *Cyanistes caeruleus** (2), Great Tit *Parus major** (1), Willow Warbler *Phylloscopus trochilus** (1), Grasshopper Warbler *Locustella naevia** (2), Sedge Warbler *Acrocephalus schoenobaenus** (2), Treecreeper *Certhia familiaris** (1), Pied Wagtail *Motacilla alba* (2).

² Biomass could not be estimated for unidentified species.

(8.9%), Swallow *Hirundo rustica* (4.7%), Snipe *Gallinago gallinago* (3.9%) and Wheatear (3.4%). Of the remaining 19 bird species identified, each represented less than 3% of the diet by frequency of occurrence. Three species of moth were detected, which together comprised 33.1% of the diet. These included Fox Moth *Macrothylacia rubi* (16.9%), Emperor Moth *Saturnia pavonia* (12.2%) and Northern Eggar *Lasiocampa quercus* (3.9%). Dragonfly wings of undetermined species were collected on four occasions (1%). When the diet was assessed in relation to biomass, Snipe and Meadow Pipit emerged as the most important prey species, accounting for 17.4 and 17.0% of the diet respectively, followed by Mistle Thrush *Turdus viscivorus* (14.9%), Skylark (13.2%) and Song Thrush *Turdus philomelos* (8.1%). The three species of moth combined comprised only 3.2% of the diet by biomass.

A comparison of Merlin diet composition by frequency of occurrence and by biomass between the present and previous

studies is shown in Table 2. Meadow Pipit and Skylark have been reported as the predominant prey species of Merlin by previous research in Ireland and Britain (Watson 1979, Newton *et al.* 1984, Bibby 1987, Meek 1988, Partridge and Bellamy 1990, Clarke and Scott 1994, Heavisides *et al.* 1995, Petty *et al.* 1995, Rae 2010). Table 3 shows the combined relative importance of these two species (by frequency and percentage biomass) recorded in this and previous studies. In the current study, Meadow Pipit and Skylark combined accounted for less than a third of the diet by frequency, significantly less than in previous studies ($\chi^2_9 = 63.28$, $P < 0.01$).

Seasonal variation

Two seasonal changes in the diet of Merlin were recorded. In April, the proportion of woodland and moorland bird prey species taken was similar (Figure 1). However, as the season progressed, the frequency of woodland species declined in

Table 2. Relative importance of the four most common bird prey species by percentage occurrence and biomass in Merlin diet in Ireland during the breeding season of 2010, and compared with other studies.

Species	This study ¹	Northern Ireland ²	Northern Ireland ³	Orkney ⁴	NW Scotland ⁵	SW Scotland ⁶	SE Scotland ⁷	NE England ⁸	NE England ⁹	Wales ¹⁰
Percentage occurrence										
Meadow Pipit	22.9	44.9	46.6	38.9	45.9	45.3	62.9	55.8	59.3	60.5
Skylark	8.9	21.4	25.0	20.5	8.2	24.2	9.3	11.8	8.0	2.8
Swallow	4.7	5.1	10.8	0.1	0	0	0.1	0.4	0.5	2.3
Snipe	3.9	<0.1	0.3	0.6	1	1.9	2.3	1.1	0.3	<0.1
Percentage biomass										
Meadow Pipit	17.0	-	36.3	25.5	-	-	37.7	36.8	-	52.1
Skylark	13.2	-	36.0	24.8	-	-	10.8	15.6	-	4.5
Snipe	17.4	-	1.1	2.1	-	-	8.1	3.8	-	<0.2
Mistle Thrush	14.9	-	2.5	0.5	-	-	0.8	0.9	-	<0.2

¹ Fernández Bellon and Lusby (This study), (n = 384)

² Clarke and Scott (1994), (n = 98)

³ Partridge and Bellamy (1990), (n = 371)

⁴ Meek (1988), (n = 845)

⁵ Rae (2010), (n = 930)

⁶ Watson (1979), (n = 161)

⁷ Heavisides *et al.* (1995), (n = 2040)

⁸ Newton *et al.* (1984), (n = 1917)

⁹ Petty *et al.* (1995), (n = 880)

¹⁰ Bibby (1987), (n = 6363)

Table 3. Comparison of the combined importance of the two predominant bird prey species (Meadow Pipit and Skylark) by percentage occurrence and biomass in Merlin diet in Ireland during the breeding season of 2010, and compared with other studies.

	This study ¹	Northern Ireland ²	Northern Ireland ³	Orkney ⁴	NW Scotland ⁵	SW Scotland ⁶	SE Scotland ⁷	NE England ⁸	NE England ⁹	Wales ¹⁰
Percentage number*	31.8	66.3	71.6	59.4	54.1	69.5	72.2	67.6	67.3	63.3
Percentage weight	30.2	-	72.3	50.3	-	-	48.5	52.4	-	56.6

¹ Fernández Bellon and Lusby (This study), (n = 384)

² Clarke and Scott (1994), (n = 98)

³ Partridge and Bellamy (1990), (n = 371)

⁴ Meek (1988), (n = 845)

⁵ Rae (2010), (n = 930)

⁶ Watson (1979), (n = 161)

⁷ Heavisides *et al.* (1995), (n = 2040)

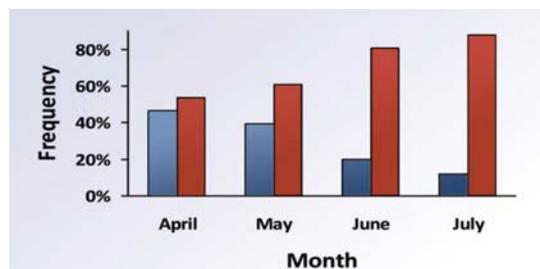
⁸ Newton *et al.* (1984), (n = 1917)

⁹ Petty *et al.* (1995), (n = 880)

¹⁰ Bibby (1987), (n = 6363)

* Values for this study were significantly lower than those reported by previous studies, $\chi^2_3 = 63.28$; $P < 0.01$

Figure 1. Percentage of woodland¹ (blue bars) and moorland (red bars) bird prey in Merlin diet in Ireland during the breeding season of 2010².



¹ Including wood edge and scrub habitat species.

² Significant variation was found between months, $\chi^2_3 = 27.11$; $P < 0.01$.

the diet until July, when only 12.0% of the birds taken were associated with this habitat type. Throughout the season, woodland species made up 28.5% of the overall diet in this study.

The relative importance of nestling and fledgling passerines as a food source for Merlin was reflected by seasonal variation in the proportion of this age class in the diet. All avian prey remains recorded in April were of adult birds. However, in May, 2.8% were fledglings and nestlings, increasing to 11.9% in June and to 27.9% in July, resulting in significant variations in the proportion of adult and young prey between months ($\chi^2_3 = 53.36$, $P < 0.01$). Overall, fledglings and nestlings represented 9.9% of all avian prey recorded during the season.



Plate 66. Plucking remains of Merlin prey on hummock (D. Fernández-Bellon).

Pellet content analysis

A total of 70 Merlin pellets from five territories were collected and analysed. Feathers and other bird remains were present in all pellets. No mammalian prey remains were recorded. In addition, the majority of pellets ($n = 58$) contained small fragments of insects which were most likely associated with foods of predated passerines (Newton *et al.* 1984, Clarke and Scott 1994).

Discussion

The present study analysed the largest sample size of Merlin prey items in Ireland published to date. Results from pellet analysis indicate that any bias arising from underestimating non-avian prey due to reliance on plucked prey remains can be considered minimal. In the context of the present study, the methodology is considered to be a reliable means of determining Merlin diet.

The predominance of Meadow Pipit and Skylark in the diet in the present study is not as pronounced as in previous studies in Ireland and Britain in relation to biomass, and is significantly lower by frequency. All previous studies found that these two species accounted for over half of the prey items recorded, whereas in the present study they accounted for less than a third of prey items. Preliminary results from the Countryside Bird Survey (CBS) and Breeding Bird Atlas 2007-2011 suggest a considerable reduction of certain passerine populations in upland habitats in Ireland during 2010, most likely a consequence of the harsh winter of 2009/10. Some of the most important prey species for Merlin, including Meadow Pipit, are likely to have suffered declines in breeding numbers in some areas of the country (D. Coombes pers. comm., B. Caffrey pers. comm.). Previous studies have found that the

main factors determining prey selection by Merlin are prey availability and abundance (Newton *et al.* 1984, Sodhi and Oliphant 1993, Wiklund 2001). Thus, the lower frequency of common upland bird species recorded as prey items in this study relative to other studies may be due to a reduction in their abundance after the harsh winter.

Based on data from two sites, Clarke and Scott (1994) suggested that the pattern of decline in the proportion of woodland prey in favour of moorland species as the breeding season progressed, as observed in Britain (Watson 1979, Newton *et al.* 1984, Bibby 1987), may also occur in Ireland. Data from this study, covering ten sites throughout the Merlin range in Ireland, confirms this. This trend also reflects changes in the availability of different types of prey and selection by Merlin. In early spring, moorland species are less abundant in Merlin breeding habitat (Newton *et al.* 1984, Thirgood *et al.* 1995), with woodland species featuring more prominently in the diet at this time. As moorland species become more abundant during the season, their importance in the diet increases. Results also indicate that the increase in predation of young passerines towards the later part of the season as observed in Britain (Newton *et al.* 1984, Bibby 1987, Rae 2010), also applies to the diet of Irish Merlin.

Overall, this study confirms that Merlin prey predominantly on open-country bird species. However, alternative prey may be taken according to their availability and abundance, resulting in seasonal (and possibly inter-annual) changes in diet. Reliance on woodland passerines at the start of the season by breeding Merlin suggests that the presence of these prey populations may be a requirement of suitable nesting habitat for this raptor. Further research is necessary to study variation in the diet between years and in areas not covered by this study to assess the relationship between prey populations and breeding Merlin.

Implications for conservation

Results from this study confirm that, despite breeding predominantly in plantation forests in Ireland (Haworth 1985, McElheron 2005, Fernández-Bellon *et al.* 2010), moorlands are vital hunting habitats for Merlin. It has been suggested that Merlin prey species populations benefit from management promoting heterogeneity in moorland vegetation (Vanhinsberg and Chamberlain 2001, Buchanan *et al.* 2006, Evans *et al.* 2006, Pearce-Higgins and Grant 2006). Similarly, populations of woodland passerines are affected by forestry management practices (Patterson *et al.* 1995, Fahy and Foley 2002, Fuller and Brown 2003). In addition, disturbance (heather burning, grazing and turf extraction in moorlands and logging in plantations) is likely to affect passerine populations in both habitats. The successful design and implementation of measures for the conservation of Merlin

populations in Ireland requires an understanding of the direct and indirect relationships between this species and its habitat. To this effect, it is essential to conduct research on the effects of habitat disturbance and management practices on this raptor and on the passerine prey populations it depends on.

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