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Edited by Stephanie J. Tyler

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Welsh translations by Rhion Pritchard

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EDITORIAL

This is my sixth year of editing the Welsh Ornithological Society's journal and I am always amazed at how many contributors send in papers and notes. Several 'in the pipeline' for this issue are being held over for the 2015 journal. I am pleased to include several important papers in this issue of Birds in Wales, all of which have involved many hours and days of fieldwork over a number of years. Firstly there is one by John Lawton Roberts, a regular contributor to *Birds in Wales / Welsh Birds* on his long-term studies on Ruabon Mountain in north-east Wales. His findings of reduced numbers or the disappearance of upland specialists and increased numbers of more generalist species seems to be typical throughout Wales. Then there is a paper by David Smith who carried out surveys for Ring Ouzels in the Rhinog Mountains over a three year period from 2009 to 2011 and compared his results with those of a study between 1966 and 1975 by Peter Hope Jones. Sadly a marked decline was evident. Phil Warren and Dave Baines report on their work in the Berwyns where rather similar results in the changing fortunes of various species were found to those on Ruabon Mountain; they make some telling but controversial conclusions about the reasons for widespread declines of many species.

There are interesting notes on Golden Plovers re-using a nest scape on moorland at Mynydd Du in Carmarthenshire by Colin Richards and on a strange feeding technique by Goosanders observed by Rhion Pritchard at Llyn Padarn. It seems that in other parts of Wales Goosanders are becoming quite tame; certainly birds at the River Monnow confluence with the Wye at Monmouth also take bread from people feeding ducks. At sites where they are persecuted Goosanders are by contrast quite shy. Licences were given by NRW to a number of angling associations throughout Wales to shoot Goosanders (and Cormorants) during early 2014 and undoubtedly some illegal shooting also occurs. WOS has been questioning the rationale for the licences and asking NRW for evidence of the serious damage claimed by anglers.

Finally I am delighted to include a paper by Stacey Melia who won the WOS Student award in 2013 for her work on Ospreys and their diet at the Dyfi nest site and a report by Chris Taylor, one of the three recipients of WOS Conservation awards in 2014, on his attempts to find an effective way of monitoring Lesser Black-backed Gulls on Skomer. The reports by the other two recipients will be published next year.

I wish to acknowledge the huge amount of work that Ian Spence has done to complete the layout and design of this issue of Birds in Wales. Thanks Ian.

Steph Tyler

Short and long term changes in breeding bird abundance on a grouse moor in north-east Wales, 1979-2003

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Summary

I counted breeding birds on Ruabon Mountain SSSI in north-east Wales in 1979, 1981 and 1982, using 100m-apart transects. Species on the current Welsh Red List numbered 13. Between-year change in status occurred in Curlew, Lapwing, Tree Pipit, Wren, Whinchat, Linnet and Reed Bunting. Influence of two severe winters and a major fire was thought likely in some cases.

A re-survey in 2003 found increases in Wren, Stonechat, Wheatear, Linnet and Reed Bunting, decreases in Curlew and cessation of breeding by Golden Plover, Ring Ouzel and Yellowhammer. Separate studies, involving annual monitoring in 1979-2003, showed increases of Peregrine, Buzzard and Raven and decline of Red Grouse and Merlin.

Overall, numbers of most larger moorland 'specialists' declined, whilst those of 'generalist' predators, and most passerines also occurring in lowlands, rose or remained strong.While these findings broadly match those from elsewhere in Wales, increase of Black Grouse occurred only on Ruabon Mountain.

Crynodeb

Cyfrifais adar yn nythu ar ADdGA Mynydd Rhiwabon yng ngogledd-ddwyrain Cymru yn 1979, 1981 a 1982, yn defnyddio transectau oedd a 100m rhyngddynt. Roedd yno 13 rhywogaeth sydd ar y Rhestr Goch Gymreig gyfredol. Bu newid rhwng blynyddoedd yn statws y Gylfinir, y Gornchwiglen, Corhedydd y Coed, Dryw, Crec yr Eithin, Llinos a Bras y Cyrs. Credir fod dau aeaf caled a thân ar raddfa fawr wedi effeithio ar rai ohonynt.

Dangosodd ail arolwg yn 2003 fod Dryw, Clochdar y Cerrig, Tinwen y Garn, Llinos a Bras y Cyrs wedi cynyddu, fod y Gylfinir wedi lleihau ac nad oedd y Cwtiad Aur, Mwyalchen y Mynydd a'r Bras Melyn yn nythu bellach. Dangosodd arolygon ar wahân, gyda monitro blynyddol yn 1979-2003, gynnydd yn niferoedd Hebog Tramor, Bwncath a Chigfran a lleihad yn niferoedd y Rugiar a Chudyll Bach.

Yn gyffredinol, bu lleihad yn niferoedd y rhan fwyaf o'r 'arbenigwyr' rhostir mwyaf, tra bu cynnydd, neu ddim gostyngiad, yn niferoedd adar rheibus 'cyffredinol', a'r rhan fwyaf o adar clwydo sydd hefyd i'w cael ar dir isel. Tra mae hyn yn debyg i ganlyniadau o fannau eraill yng Nghymru, dim ond ar Fynydd Rhiwabon y bu cynnydd yn nifer y Rugiar Ddu.

Introduction

The upland bird communities of Wales have long been a valued part of its avifauna (Lovegrove et al. 1994). There, several of the species involved are close to the south-western limit of their range, making their abundance status a useful indicator of the health of their overall population. Furthermore, the semi-natural habitats that moorland comprises can be a refuge for once common farmland species, whose lowland populations have been depleted by agricultural intensification (Calladine & Bray 2012).

Between 1976 and 1985, in response to perceived declines in waders in the Welsh uplands and threats to their habitat from afforestation and agricultural 'improvement', the Royal Society for the Protection of Birds (RSPB) and Nature Conservancy Council (NCC) conducted surveys of most upland moors in the Principality. This led to the designation of several Sites of Special Scientific Interest (SSSIs).

During the 1990s, continuing concerns about the status of upland birds in Wales, including Red Grouse *Lagopus l. scoticus* and Black Grouse *Tetrao tetrix* and certain raptors and passerines, led to further studies which confirmed widespread steep decline in a range of species (Tyler 1991, Lovegrove et al. 1994, Shrubb et al. 1997, O'Brien et al. 1998). In 2002, as part of a UK-wide survey programme, sample sections of two Welsh uplands, Migneint and Berwyn, were re-surveyed in the Repeat Upland Bird Surveys (RUBS), strictly replicating the methods used by the NCC Upland Birds Surveys of the 1980s (Sim et al. 2005, I.M.W.Sim in litt.). Pumlumon was re-surveyed in 2011 (Crump & Green 2012).

The most north-easterly moor in Wales, Mynydd Rhiwabon (Ruabon Mountain), was not formally included in the above survey programmes. Instead, in 1979, 1981 and 1982 I made full map surveys of the breeding birds of the site and followed these, in 2003, with a survey of a third of the moor's area, commissioned by Wrexham County Borough Biodiversity Group. Here I compare the findings of the two surveys, complementing work already published on bird population trends outside the breeding season on the same upland (Roberts 2010).

Methods

Study area: position, physical features, vegetation

Ruabon Mountain SSSI centres at c. 30 08' W, 530 01' N, a few km south-west of the town of Wrexham. It comprises c. 33 km^2 of relatively dry unfenced upland, mostly Heather *Calluna vulgaris* dominated, but with considerable cover of Bilberry *Vaccinium myrtillus* and Bracken *Pteridium aquilinum*. Wet flushes, varying in size, mark the heads and tributaries of the several streams, with one sizeable area of degraded blanket bog. Drainage, and thus orientation, is predominantly between east and south. Soils are richer and better drained on the eastern half of the moor, where forms of millstone grit predominate, underlain by limestone which extrudes in the mid-western edge in a series of buttresses up to 30m sheer. To the north and west, shales are prevalent.

In 1980 a major fire removed the vegetation cover from around half the moor. Re-growth of Bilberry and Heather was strikingly rapid (gamekeeper pers. comm.), but the proportion of Bracken and Bilberry to Heather increased markedly over the area affected by the fire, particularly on the moor's fringes. Thereafter, progressive reductions in burning and grazing led to a situation where by 2003 large swathes of middle and higher ground were covered in dense, tall Heather. In two areas in particular, large scale invasion by conifers had occurred.

Land use
The moor was managed for driven Red Grouse shooting from the late 19th century. Up to three gamekeepers practised rotational heather burning and predator control, whilst grazing by sheep was strictly limited. In terms of numbers of Red Grouse shot annually, it was Wales's most productive moor.

Further description of the study area and of surrounding moors, as well as details of the history of grouse shooting there, is given in Roberts (2010).

Study methods
First surveys (1979, 1981 and 1982, hereafter '1979-1982')
The aim of the first surveys of Ruabon Mountain was to locate all pairs of birds potentially breeding on the moor, apart from Meadow Pipits *Anthus pratensis*. It involved walking transects in roughly parallel lines about 100m apart, with less time spent in extensive banks of uniform dense heather and more in areas of muirburn and flushes and other areas, damp or dry, with more varied vegetation. Conditions of heavy rain, wind stronger than Beaufort Force 3 and poor visibility were mostly avoided.

Most of the surveying was done in April-June. As the 34 hours spent surveying in July 1979 added few new records, minimal time was spent in 1981-82 in this month. Of 693 survey hours in the three years, 43% were in May, 31% in June and 19% in April. This excludes time spent finding and recording nests of Merlins *Falco columbarius*, Short-eared Owls *Asio flammeus* and Hen Harriers *Circus cyaneus* as part of separate long-term studies (see below, under Species excluded or surveyed by other methods).

An average of 70% of survey time fell between 04.35h and 11.40h. Reed et al. (1984) found that counts made between 06.15h and 11.40h came closer to total populations of upland breeding waders than counts made later in the day.

Most parts of the moor were visited more than once, reducing the likelihood of overlooking species like Whinchat *Saxicola rubetra* which become more conspicuous once eggs hatch (pers.obs.). Areas attractive to summer visitor passerines – water courses and moor edges with mixed vegetation, including Bracken and scattered saplings – were mostly revisited during June. Ground suitable for Golden Plovers *Pluvialis apricarius*, and Lapwings *Vanellus vanellus* was checked in April and then in late May, or June. Reports from the head gamekeeper, a keen and accurate observer, were followed up and added. Recording was both aural and visual. I walked slowly, scanning well ahead and to the side through 10x binoculars and with naked eye at closer range. Each registration was marked in pencil on 1:25,000 maps in one of two categories: P - pair present, or singing male behaving as if paired; and B - pair alarm-calling or carrying food, or nest or fledged brood seen. These records were also entered in a field log, with 6-figure grid references, along with positions of birds hunting or passing overhead. As no GPS was available, grid references, especially on uniform open ground, were approximate. At the end of the field season records were transferred to a 1:10,000 scale map and tabulated as number of territories per 1km grid square.

Second survey: 2003

Due to constraints of time, the 2003 survey was done on a sample basis and covered one third of the moor's area, amounting to c. 10.5 sq. km. To avoid bias, a random selection of 1km grid squares, including squares only partly moorland, comprising the required area, was made using the computer programme Excel.

The survey was more standardised than in 1979-1982, its mapping accuracy enhanced by the use of a GPS 320 (Magellan Corporation, USA). Between 18 May and 12 June, each selected 1km square, or section of it within the moor, was surveyed once, by walking straight-line, parallel transects, 100m apart – 10 per whole square, pro rata for squares only partly inside the moor. The survey took 80.5 hours and 80% was conducted between 05.30h and 11.40h. Records were entered in a field log and, later, transferred to maps and tabulated by 1km squares, as in the earlier surveys.

Species excluded or surveyed by other methods

No attempt was made to determine numbers of Meadow Pipits, a species notoriously difficult to census (Buchanan et al. 2006) and usually counted using more specialized techniques (Thirgood et al. 1995).

Red Grouse were counted in 2003 only, when their low numbers and the single-visit method made assigning birds to pairs or territories easier. In 1979-1982, though I noted locations of all 'contacts', including the characteristic droppings ('clockers') produced by incubating females, the spread of many sightings over more than one visit made determining numbers of pairs almost impossible. An index of population change has therefore been taken from fixed-route 14-km transects walked annually under standard conditions between late September and late March in the period 1978-2005 (Roberts 2010). There, the maximum autumn count is used for comparison between years. For Blackgame and Cuckoo *Cuculus canorus*, the survey method used was not well suited, the first being most effectively counted in early morning on leks (Cayford & Walker 2001) and the latter, largely confined to the moor edge, requiring simultaneous coverage by at least two observers spaced well apart to avoid duplication of records (pers. obs.).

Certain uncommon species recorded in both surveys have been the subject of separate long-term studies, enabling numbers over the whole study area to be compared. Nests of these were actively searched for and their histories recorded, as part of ongoing studies of spacing, breeding production and, in some cases, food. Species involved are Hen Harrier, Merlin and Short-eared Owl, as also Peregrine *Falco peregrinus* and Raven *Corvus corax*, which regularly feed on the moor but are, to varying degree, constrained by nest site requirements to breed on surrounding ground.

Skylarks *Alauda arvensis* were omitted from the 1979 survey, but included in all other years. Tree Pipit *Anthus trivialis* and Yellowhammer *Emberiza citrinella* totals include birds with territories spanning the moor's boundaries.

Treatment of data
Paired t-tests, 2-tailed, are used to test for significant change of status between samples, where totals from each of the 18 1km squares covered wholly or partly in 2003 are compared with totals from the same squares in 1979-1982. Chi-square tests at 1df have Yates's correction applied.

Results

Species abundance, 1979-1982
Of species recorded in the early counts, 13, marked in bold on Table 1, figure on the current Welsh Red List (Johnstone et al. 2010). A further two, Hen Harrier and Short-eared Owl, were counted by different survey methods (see below). Count totals varied significantly within the three years for seven species. All wader numbers rose between 1979 and 1981, those for Curlew *Numenius arquata* and Lapwing significantly. Numbers of resident passerines also changed in this period, those of Wrens *Troglodytes troglodytes* falling, while numbers of Linnets *Carduelis cannabina* and Reed Buntings *Emberiza schoeniclus* rose – significantly, in all cases. Patterns for migrant passerines varied – for Tree Pipits rising steadily, for Whinchat rising and falling, in both cases significantly, while the fall in Whitethroat *Sylvia communis* numbers just missed significance. Overall, for species numbering 10 or more in any one year, numbers rose in 13 cases and fell in only two.

Changes in abundance in breeding birds between 1979-1982 and 2003
Because of the relatively small area (10.5 km sq) of moor re-surveyed in 2003, rather few changes in status achieved statistical significance (Table 2). Of larger species, Curlew declined by 81%, whilst in passerines increases occurred for Wren (3443%), Stonechat *Saxicola torquata* (1467%), Wheatear *Oenanthe oenanthe* (251%), Linnet (121%) and Reed Bunting (26%). For Tree Pipit the maximum early period count exceeded that in 2003, whilst the average fell below this. In addition, Golden Plover, Ring Ouzel Turdus torquatus and Yellowhammer were not found in the 2003 re-survey and were known to have ceased breeding on the moor.

Table 1. Species abundance, 1979, 1981 and 1982
Species in bold are on the current Wales Red List; those in italic were recorded in the transect surveys but the counts were believed not to represent numbers of pairs or territories
1 Chi sq tests for differences between years: * P<0.05, ** P<0.01; levels in parenthesis are approached but not reached; NA = not applicable

	Total pairs				P values[1]			
	1979	1981	1982	Ave	All years	1979, 1981	1979, 1982	1981, 1982
Teal	1	0	0					
Mallard	10	13	8	10.33				
Black Grouse	NA	NA	NA					
Red Grouse	NA	NA	NA					
Grey Partridge	3	1	1					
Quail	1	1	0					
Golden Plover	9	15	19	14.3			(*)	
Lapwing	28	53	52	44.3	(**)	**	**	
Curlew	92	133	128	119	(**)	**	*	
Snipe	5	9	7	7				
Cuckoo	NA	NA	NA					
Skylark	NA	72	86	79				
Tree Pipit	33	41	66	46.7	**		**	*
Wren	10	3	3	5.3	*	*	*	
Whinchat	146	127	189	154	**		*	**
Stonechat	5	7	8	6.7				
Wheatear	20	31	32	27.7				
Ring Ouzel	6	13	14	11				
Blackbird	14	16	13	14.3				
Grasshopper Warbler	5	1	2	2.7				
Willow Warbler	4	10	9	11.7				
Whitethroat	17	8	10	7.7		(*)		
Linnet	17	40	42	33	*	**	**	
Twite	1	0	0					
Yellowhammer	7	9	11					
Reed Bunting	46	67	33	48.7	**	*		**

Table 2. Bird abundance on Ruabon Mountain in 2003 compared with 1979-1982. Totals from each of the 18 1km squares covered wholly or partly in 2003 are compared with averages from the same squares in 1979-1982. The total area surveyed in 2003 was 10.5km^2. Tests for significant change - using Student's paired t-tests at 17df were applied where >9 pairs were recorded in at least one survey period.
+ uses average from 1979-1982; ++ average of 1981 and 1982 only. NA – not applicable

	1979, 1981, 1982		2003			
	Average pairs	Maximum pairs	Total pairs	% change +	t	P=
Mallard	4	4	1	-75%		
Red Grouse	NA	NA	16			
Golden Plover	3.7	6	0			
Lapwing	8.67	15	4	-54%	.845	.410
Curlew	42	59	8	-81%	4.104	.001
Snipe	2.7	4	1	-63%		
Skylark++	41.5	48	33	-20%	-515	.613
Tree Pipit	12	21	17	+42%	-.359	.724
Wren	3.33	5	118	+3443%	-4.73	.000
Whinchat	74	105	60	-19%	1.525	.146
Stonechat	3	4	47	+1467%	2.496	.023
Wheatear	3.7	6	13	+251%	-3.556	.002
Ring Ouzel	1.7	3	0			
Blackbird	7	9	7	0%		
Grasshopper Warbler	1.7	3	6	+253%		
Whitethroat	9.33	11	13	+39%	-1.511	.149
Willow Warbler	3.33	4	20	+501%	-.607	.552
Linnet	8.3	11	22	+121%	-2.409	.028
Reed Bunting	24.3	34	38	+26%	-2.181	.043
Yellowhammer	1.7	2	0			

Species monitored by other methods

As with the NCC counts in the 1980s (I.M.W. Sim in litt.), my transect surveys were not suited to monitoring breeding grouse, raptors and Ravens. However, results of annual monitoring using different methods yielded indices of population trends for these species and, except for Red and Black Grouse, breeding totals.

Red Grouse

In multiple annual September-March counts along a standard 13km route, Red Grouse maximum autumn count totals fell from an average of 208 in 1979-1982 to only four in

2002; the decline with year was highly significant: rs = 0.976, P<0.0001 (Roberts 2010). Shooting 'bags' declined in strict synchrony with my counts during the period 1979 to 1993 (rs = 0.913, n = 14, P< 0.0001), resulting in cessation of shooting thereafter to conserve stocks (Roberts 2010).

Raptors and Raven

Five raptor species and Raven were the subjects of ongoing studies of breeding biology from 1979 or before, conducted by the author and, from 1988, by M.S. Jones (Table 3). Attempts were made to locate all breeding pairs and, where possible, their nests. Of three moorland 'specialists', numbers of breeding Short-eared Owls and Merlins declined sharply after 1979. In the mid-late 1970s, the Ruabon Mountain Merlin population was one of the densest recorded in Britain (Roberts & Green 1983, Roberts & Bowman 1986, Roberts & Jones 1999a). The decline in Merlin numbers with year is significant (rs = -0.430, df 25, P< 0.05). Hen Harriers resumed breeding on the moor in the mid-1970s but no more than one male was known with certainty to breed there, apparently mated to up to three breeding females (unpubl. data).

Table 3. Abundance changes of breeding raptors and Ravens on Ruabon Mountain and surrounds, 1979-2003. Values are numbers of breeding pairs, for Hen Harrier of breeding females.
Species in bold are on the current Welsh Red List (Johnstone et al. 2010)

Distances of nest from moor edge: * 0-0.9 km; ** 1-1.5km; *** + = increase; - = decrease; 1 excludes N and NE section of moor.

	1979	1981	1982	2003		Status***
				<1 km*	<1.5km**	
Hen Harrier	1	2	1	0		
Buzzard [i]				23	8	+
Merlin	7	3	1	2		-
Peregrine	1	1	1	7	1	+
Short-eared Owl	3	2	1	1		-
Raven	1	1	1	12		+

Of the two generalist raptors, Peregrines breeding in quarries and cliffs on the moor's periphery increased sharply in the study period (Roberts & Jones 2004). The increase to 2003 is highly significant: rs = 0.937, n=24, P< 0.01. Numbers of Buzzards were not monitored on all fringes of the moor, but undoubtedly grew greatly after the late 1970s (Roberts & Jones 2009). By 2003 three or more pairs bred on the edge of Llandegla Forest, where trees were now large enough to support Buzzards' nests; several pairs bred along the eastern fringe of the moor, where few or none nested in the 1970s (Tony Jackson, pers. comm.); in the west and south-west surrounds of the moor, the Buzzard's stronghold since the 1970s, on-going study showed a marked and continuing densening of population (unpubl. data). With one exception, all nests were outside the moor's boundary, but by 2003 31 pairs bred within 1.5 km of the moor along c. 22 km of its c. 36km perimeter. The species was often seen hunting the moor (pers. obs.)

A similar increase, over the same period, occurred with Ravens, also generalist predators and scavengers (Table 3). Numbers breeding close to or on the moor edge rose from an average of one in the early 1980s (Roberts & Jones 1999b) to 12 breeding pairs in 2003. The increase with year was highly significant ($r_s = 0.925$, $n=24$, $P<0.01$).

Species breeding rarely or not detected in the present surveys
Certain species are known to have bred on the moor at some time between 1979 and 2003, but remained undetected in either the early or late surveys, or in both. A pair of Teal *Anas crecca* bred in 1979 but probably not since. Four pairs of Grey Partridges *Perdix perdix* were recorded in 1979 on the moorland fringe and one pair in each of 1981 and 1982, but no known wild pair was seen in 2003. A Quail *Coturnix coturnix* was heard in 1981 and one was seen in 1982. Redshank *Tringa totanus* bred in 1974 and once in the early 1990s (Ian McNeish, pers. comm.), but were recorded neither in the interim nor since. Long-eared Owls *Asio otus*, rare birds in Wales (Johnstone et al. 2010), wintered in one moor-edge plantation at least from 1990 to 2002, breeding there at least twice, while breeding occurred in a different plantation in 1998 and 2003 (Roberts & Bowman 2000). Three pairs of Wood Pigeons *Columba palumbus* bred on the ground on steep banks in 1979 and nests were found in earlier years in similar situations (unpubl. data), but no evidence of breeding was found in 2003.

Several Twite *Carduelis flavirostris* were seen in 1979 and a pair was watched carrying nest material. In 1982 a flock of nine was seen on 2 May, but not subsequently. Nests were found in 1990 and 1991 (pers.obs.). Yellowhammers occurred in small numbers in the early study, mostly outside the moor boundary, or in the small area of gorse and bracken in the extreme south-east (Table 1). None was recorded in the 2003 survey in four of the 12 1979-1982 squares with records of the species (Table 2).

Two feral goose species occurred within the study period. Canada Geese *Branta canadensis* were prospecting the moor by the mid-1980s and first bred, to my knowledge, in 1988. The next known (to me) breeding was in 2000, following a build-up of summering birds on reservoirs on the moor-edge. In 2003 at least two pairs bred on the moor itself and three pairs on adjacent reservoirs, where a flock of 39 non- or failed breeders was counted. A pair of Greylag Geese *Anser anser* flew low above the moor in 2002 and pairs were seen on lakes on adjacent Llandegla Moor, where breeding occurred in 2004 (pers.obs., Wrexham Birdwatchers Annual Reports).

Discussion

Strengths and limitations of my surveys
The 1979-1982 surveys provided comprehensive coverage, surveying to within 50m of all parts of the site over a wide spread of months. My 15 years' prior knowledge of the moor and the contribution of the gamekeeper, a keen and experienced observer, are likely to have enhanced the accuracy of the counts. The majority of my time spent counting fell

within (or before) the 'early' range of 06.15-11.40h, given in Reed et al. (1984) as the period of maximum detectability of upland waders.

My 2003 re-survey gave the same close coverage, but involved one visit only, between May 18 and June 12 and covered only a third of the original survey area. The timing could result in missing pairs of waders that left the moor after failed breeding attempts, or could have coincided with periods of lowest detectability for some species. However, wader numbers were known already to be extremely low, particularly those of Golden Plovers and Lapwings (Roberts 2010, pers. obs., gamekeepers, pers. comm.), while the seasons of lowest detectability for Curlew and Stonechat in a study in south-west Scotland (Calladine et al. 2009) fell outside the dates of my study. For Golden Plover, these authors gave 12-27 May as the period of lowest detectability. However, on Ruabon Mountain the species becomes most conspicuous after the young hatch (pers. obs.), which usually occurs well before the end of May, probably earlier than in Scotland, given the difference in latitude.

Calladine et al. (2009) recommended use of a four-visit survey to maximise the accuracy of counting of a broad spectrum of species on moorland. However, this involved using the 'constant-effort' method advocated by Brown & Shepherd (1993), where 80-100 minutes are spent in each 1km square, the observer approaching to within 100m of every point. In my 2003 survey, an average of more than seven hours was spent in each 1km square and every point was passed within 50m, making detection of less conspicuous species more likely.

The small area covered in my re-survey reduced the sample size and numbers of observations to a point where significant abundance changes could mostly apply only to the most numerous species. However, for Golden Plover, Lapwing and Ring Ouzel at least, other evidence confirmed that real decline had occurred. Similarly, for raptors, Red Grouse and Raven, intensive annual studies (or sampling, for Red Grouse) demonstrated changes or stability in status. These are considered in more detail below.

Changes in bird abundance between 1979-1982 and 2003

Changes in abundance of waders, 1979-1982 to 2003

Only Curlews declined significantly between the two survey periods but for Lapwing and, especially Golden Plover, the small sample of occupied squares in either survey period (respectively six and two) and small count totals made detection of significant decline unlikely. However, the decline in February-March arrivals on the moor of both species between 1979 and 2003 was very highly significant (Roberts 2010) and by the mid-1990s Golden Plovers no longer bred regularly on the moor (pers. obs., gamekeepers pers. comm.) With Lapwing, apart from the four pairs encountered in the 2003 survey, only one other pair was known to breed in that year on the whole moor (pers. obs, gamekeeper pers. comm). The re-survey sample thus over-represented the species' abundance.

The situation of these three waders was mirrored in the RUBS results for Migneint and Berwyn, with declines between the 1980s and 2002 surveys of 83%, 75% and from 19 to 0 for Curlew, Golden Plover and Lapwing respectively (Sim et al. 2005). On Mynydd

Hiraethog between 1977 and 1994, Curlew numbers had fallen from 64 to 38 (41%) and Golden Plovers by 83% (Thomas & Young 1994). Even in a section of their Welsh stronghold, the Elenydd, Golden Plovers declined from 102 pairs in 1982, to 37 in 1995 to 11 in 2007, an overall decline of 89% (Johnstone & Dyda 2010).

Changes in abundance of passerines, 1979-1982 to 2003

Fewer negative changes were found in passerine numbers than in waders, involving only Yellowhammer and Ring Ouzel. The early surveys' maximum Ring Ouzel count was 14 probable breeding pairs, this including seven pairs in mid-moor gulleys away from the species' limestone escarpment stronghold and probably sub-optimal habitat. Several pairs also bred in the nearby Horseshoe Pass slate quarries, just outside Ruabon Mountain. Despite regular visits to these areas checking Peregrine, Raven and Merlin nest sites, by 2002 we no longer found breeding Ring Ouzels on Ruabon Mountain itself and since 2003 the species has apparently ceased breeding in the quarries (JLR & M.S. Jones pers. obs.). The species still occurs annually on passage, often in traditional breeding sites.

The RUBS on Berwyn and Migneint showed an 80% decline in Ring Ouzels, though there, too, the numbers involved were small (Sim et al. 2005). Over a shorter period, 1999-2006, a 69% decline was detected in 26 tetrads in seven Welsh counties surveyed in both years (Green 2007). In the South Shropshire Hills, near the Welsh border, Leo Smith (in litt.) reported cessation of breeding by Ring Ouzels from 2004. In contrast, two studies in rugged, mountainous areas in north-west Wales found apparently stable populations. Driver (2011) and Smith (2011), working respectively in Snowdonia and on Cadair Idris, identified 164 and 23-25 occupied territories respectively. The mean altitude of nests in the Snowdonia study was 530m and on Cadair Idris 65% of nests were above 500m.

Suggested contributors to declines in Ring Ouzels in Wales include predation by Peregrines, competition with Blackbirds *Turdus merula*, disturbance by walkers and climbers and climate change, the last resulting in a withdrawal of the breeding population to rugged, high-altitude mountain areas with ample rocky gullies and long heather (Beale et al. 2006, Driver 2011, Hurford 1996, Tyler & Green 1989). On the section of Ruabon Mountain and neighbouring quarries where most Ring Ouzels bred, only one pair of Peregrines was present between 1973 and 1986, rearing young in only five years; by 1995 there were five pairs in the same area (Roberts & Jones 2004). Hurford (1996) found an association between increase in Peregrines and the demise of Ring Ouzels in Glamorgan, though causality could not be demonstrated. In the present study, no increase occurred in Blackbirds on Ruabon Mountain (Table 2).

The limestone section of Ruabon Mountain has become increasingly popular with climbers and walkers; two much-used footpaths pass close to traditional Ring Ouzel nest sites and only two of the neighbouring five quarries previously occupied by the species are not subject to disturbance by tourists or slate-extraction. The RUBS found greater per annum decline towards the southern limits of their British breeding range for Ring Ouzels (Sim et al. 2005). Most nests on Ruabon Mountain and nearby were below 450m. The moor is markedly milder and drier than Snowdonia and Cadair Idris and the cessation of breeding there and in Shropshire could support the climate change theory.

Yellowhammers, birds of predominantly south- or east-facing ffridd or new plantations on Ruabon Mountain, were not detected in the 2003 survey, despite coverage, during other monitoring, of all areas where the species was present in the early period. Wrexham Birdwatchers Annual Reports from the early 1990s to 2003 show a steady decline in the proportion of records from uplands, compared with the mixed arable/grazing land in the lower Dee plain. The BBS index declined by 39% in Wales between 1994 and 2003 (Raven et al. 2004).

The statistically unchanged status of Skylarks and Whinchats on Ruabon Mountain matches the findings of the RUBS for North Wales (Sim et al. 2005). That fewer Skylarks were counted in 2003 in my study probably results from reductions in heather management in the preceding 15 years: the species favours short, open vegetation (Pierce-Higgins & Grant 2006, pers. obs.). BBS indices showed a 10% reduction between 1994 and 2003 (Raven et al. 2004), but the majority of these losses may have occurred on lowland farmland (Shrubb et al. 1997). Whinchat numbers in my study were also rather lower in 2003 and Green (2002) mentions 'a suggestion of decline' in Whinchats in Wales based on counts in the late 1990s. In view of this, the 118% increase found by the RUBS in North Wales (Sim et al. 2005) is hard to explain. However, counts of Whinchats from four sites in South Wales during the 1990s show considerable annual fluctuations (Green 2002), as do those from Ruabon Mountain in 1979-1982 (Table 1).

The large increases recorded for Wren and Stonechat in my study even exceed those in the RUBS for North Wales: 3443% vs. 806%, and 1467% vs. 1088% for the two species and sites respectively (I.M.W. Sim in litt.). Increase with year of birds present outside the breeding season and with diminishing degrees of frost in the current and previous winter showed high statistical significance for both species (Roberts 2010). For Wren, CBC and BBS indices were strongly correlated with Ruabon Mountain data (Roberts 2010). There can be little doubt that the increase of both species is due to the rise in winter temperatures.

Wheatears increased significantly on Ruabon Mountain, as compared with a non-significant decrease in North Wales in the RUBS (Sim et al. 2005). However, in my study area the species' distribution is highly localised, possibly giving rise to sampling error, a possibility enhanced by the small totals for both periods.

More Willow Warblers *Phylloscopus trochilus* were found in my re-survey than in 1979-1982 and a significant increase in the RUBS on the Berwyn Special Protection Area (SPA) was noted by Warren & Baines (2012). On Ruabon Mountain the species is now frequent at least 1km into the moor, mostly by stream courses. Numbers in one such site rose from an average of two in the earlier surveys to seven in 2003. The species may have benefitted from the spread of sapling birch and Rowan resulting from falling sheep numbers and reduced burning from the late 1980s. Warren & Baines (2012) point to the same factors as possible causes of increase in this species, Wren, Whitethroat and Grasshopper Warbler *Locustella naevia* on the Berwyn SPA.

Whitethroat numbers in 2003 on Ruabon Mountain suggest a return to the situation before the conflagration of 1980, where moorland hollows with deep, dense Heather, usually with Bilberry and Bracken nearby, made suitable breeding habitat for the species, which occurred commonly there as far back as 1965 (Roberts 1983). As with Skylark, the decline of 10% recorded in the BBS (Raven et al. 2004) may have involved lowland agricultural habitats.

A proportionally large rise in (the very small) numbers of Grasshopper Warblers on Ruabon Mountain is in line with an increase from 0 to 10 in the RUBS in North Wales (I.M.W. Sim in litt.). Numbers arriving on Ruabon Mountain appear to have increased, probably since the early 1990s (pers. obs.). The occurrence of six individuals, after mid-May, on only a third of the moor's area in 2003 suggests that these were not passage birds.

The increase in Linnets on Ruabon Mountain is perhaps surprising, as the RUBS for Berwyn and Migneint found a (non-significant) reduction of 31% (I. M. W. Sim in litt) . By contrast, the BBS index for 1994-2003 showed an increase, also non-significant, of 26% (Raven et al. 2004). Changes in numbers in my early period surveys on Ruabon Mountain might suggest a link with winter temperatures (see Results) and a long succession of mild winters preceded 2003. Overall, Linnets continue to be seen in the same gorsy areas of moorland fringe and ffridd as in the past, but given their habit of feeding in flocks, often considerable distances from clusters of nests, fairly intensive observation is needed to avoid mis-estimation of numbers (pers. obs.).

Not surprisingly, Reed Buntings, susceptible to low winter temperatures (Marchant et al. 1990), increased between survey periods. Similarly, the increase with year in March and September numbers between 1979 and 2005 was highly significant (Roberts 2010). Numbers of the species found by the RSPB Welsh upland surveys, in the relatively mild 1970s, were much above those for the same uplands in the 1980s surveys performed by the NCC, during a period of severe winters (NCC and RSPB data via P.E. Davis in litt). The RUBS registered a 233% increase on Berwyn and Migneint, though numbers were too small to reach significance (I.M.W.Simm in litt.) That the average count in my study area in 1979-1982 was 3.5-fold higher than the sum of counts on eight Welsh uplands in 1981-1984 (NCC data via P.E. Davis in litt.) suggests that Ruabon Mountain is exceptionally attractive to Reed Buntings.

Species less well covered by the transect surveys

Black Grouse are not satisfactorily counted by the transect method (Cayford & Walker 1991) and systematic, coordinated counts of lekking males did not begin until after the time of this study. Coordinated lek counts were started, by RSPB, in 1997. Displaying males rose from 17 within the boundaries of Ruabon Mountain in that year to 67 in 2002 (RSPB data via P. Lindley). However, while there is little doubt that an increase took place, it is likely that some leks with few displaying males were overlooked in the early years and that, as numbers of counters (and searchers) increased, other small leks became known.

I did not try to count lekking males in the early survey period, but recorded flock numbers in areas which included sites of all but one of the major leks counted from 1997. In the period 1979-1985, the sum of the maximum flocks encountered at all sites was 34 (unpubl. data). In 1991, I performed dawn counts at all leks known to me and found a total of 24 males. Thus a decline probably took place, as happened on north Berwyn in the same period (Williams 1996).

For Cuckoos, despite the risk of double-counting males, which use widely scattered song-posts, decline is argued for by the situation at World's End, where I listened for males 'answering' each other between 1997 and 2003 along the 5.3km of valley-head moor edge. In 1997 2-3 males held territory where in 2003 there was only one. A probable minimum of seven males held territory on the moor's perimeter in 2003.

In all survey years, Carrion Crows *Corvus corone* attempted to nest in two sites at least 1km into the moor, whilst hunting ranges of many others included sections of open moor. I did not try to find nests of the latter, but numbers encountered in the breeding season seemed to be similar throughout. Heavy culling by gamekeepers was standard.

Species covered by annual surveys

The strong increase in Ravens, Buzzards and Peregrines breeding close to or on the moor between the two survey periods is in line with those found close to the Welsh border, where persecution is believed to have suppressed numbers or prevented colonization until fairly recently (for Buzzard: Sim et al 2000, Barber & Hargreaves 2001, Prytherch 2013; for Raven: Green 2002, Wall 2003; for Peregrine: Thorpe & Young 2004, Tucker 1998.)

Numbers of two specialist upland raptors, Merlin and Short-eared Owl, declined between the survey periods. The decline in both species coincided with the large fire in 1980 which destroyed the heather in six favoured breeding valleys or banks. Numbers of Merlins elsewhere in Wales were believed to have declined up to the early 1980s then increased since the later years of the decade. However, there is some uncertainty about the extent of the decline, or even whether it happened (Williams & Parr 1995). Between 1995 and 1998, with 15+ years of heather growth on traditional nesting banks, numbers rose briefly on Ruabon Mountain, but in the period 1999-2003 only six known breeding attempts were made (unpubl. data).

Breeding numbers of Short-eared Owls in Wales were believed to have changed little between 1992 and 2000 (Green 2002), but on heather-dominated moors there is little evidence of the stability of numbers typical of the Ruabon Mountain birds prior to the 1980 fire (Roberts & Bowman 1986).

Red Grouse declined steadily throughout Wales from the end of the First World War, as documented by estate shooting 'bags' (Williams et al. 1991, Shrubb et al. 1997, Warren & Baines 2012). Likely explanations of the decline on Ruabon Mountain are discussed in Roberts (2010). These include damaging effects of the 1980 conflagration, isolation and fragmentation of habitat, heavy sheep tick burdens, increases in predators fuelled by absence of keepering on surrounding ground and decline of muirburn leading to overgrowth of heather.

Variation in numbers within 1979-1982

Between 1979 and 1982 numbers of 11 species showed marked changes, seven of these reaching significance (Table 2). How typical these short-term patterns of change were for Wales or Britain generally is not clear, as few upland data from sites of comparable size are available from these years (Marchant et al. 1990). On Ruabon Mountain two factors probably contributed to the changes: the major fire in April 1980 (see Methods, Study area) and relative winter severity in the study period (Roberts 2010). The first factor applied locally, the second nationally.

The winters of 1978-79 and 1981-82 were exceptionally severe; 1979 saw the coldest January since 1963 and the December of 1981 was the coldest for 103 years (Meteorological Office data from the Hadley Centre in Central England). Both winters saw lasting and deep snow cover even at low altitudes. The two intervening winters were much milder.

Numbers of all four waders rose between 1979 and 1981. The major fire of 1980 created large areas of short vegetation suited to the breeding requirements of Golden Plovers and Lapwings (Pierce-Higgins & Grant 2006; pers. obs.). Reduced cover, making Snipe *Gallinago gallinago* and incubating Curlews easier to flush, may have boosted totals of these. Numbers of waders remained high into 1982, suggesting that severe winter weather was not a factor.

The sudden fall in Whitethroat numbers after 1979 countered the Common Birds Census (CBC) trends reported in Marchant et al. (1990). This was almost certainly a result of the 1980 fire. In 1979 Whitethroats were confined to stream courses in the eastern part of the moor. Four shallow valleys held around half the species' population and one deep, long valley system held the remainder. The latter site escaped the fire and its Whitethroat numbers were unchanged in 1981; the other four hollows, stripped by the fire of tall, dense heather, held no Whitethroats.

The initial fall in Whinchat numbers may also have been a reaction to the sparse vegetation cover present in 1981. However, unlike Whitethroats, Whinchats nest at ground level, often under relatively short vegetation (pers. obs.) and by 1982 the rapid re-growth of Bilberry and Bracken may have provided adequate cover. Two early arriving migrants, Ring Ouzel and Wheatear, could have benefitted from the fire's removal of dense cover, providing easier access to earthworms, major prey for both. That their numbers do not tally with national indices (Marchant et al. 1990), points to a localised cause of change.

Migrants whose numbers on Ruabon Mountain, albeit small in both cases, varied roughly in tandem with CBC or other annually derived indices, include Willow Warbler and Grasshopper Warbler (Marchant et al. 1990). For Tree Pipit, whose numbers were higher, a part-tally with the CBC index was apparent. The changes involved could derive from factors operating outside the breeding grounds.

Reed Bunting abundance changes matched those in the CBC, where effects of severe winters were implicated (Marchant et al. 1990). Numbers of this largely resident species

(Wernham et al. 2002) dipped sharply, rose and then fell, in alignment with temperatures in preceding winters. The pattern was similar with Linnet numbers, though the dip in 1982 was less severe. Ringing recoveries suggest that many British Linnets winter on the western side of Continental Europe, but information from Wales is sparse (Wernham et al. 2002). It is thus possible that winter temperatures influenced numbers of this species also. Numbers of Wrens and Stonechats, insectivores particularly vulnerable to low temperatures, remained consistently low from 1979 to 1982, in line with national populations (Wernham et al. 2002, Roberts 2010).

Conclusions

In 1979-1982 Ruabon Mountain was perhaps the richest moor, birdwise, in all Wales (Peter Davis and Roger Lovegrove, pers. com.). It is disappointing, therefore, that its continuing management by gamekeepers and the strong populations of key moorland species that it held then, did not buffer the site against the declines and losses reported for upland specialist (and some generalist) species throughout Wales.

Increase was largely limited to passerines recovering during the long spell of mild winters after 1987 and to generalist raptors and Raven, following relaxation of persecution and, perhaps, a wider decline in gamekeeping. Whilst these increases apply throughout Wales, the high numbers and rate of increase of Blackgame on Ruabon Mountain are unparalleled in Wales and southern Britain. Also encouraging is the present apparently healthy status of passerines that have declined sharply in intensively farmed lowlands, notably Skylark, Whinchat, Whitethroat, Willow Warbler, Linnet and Reed Bunting.

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Tree Pipit. Photo: Dave Brassey

The Ring Ouzel *Turdus torquatus* on the Rhinog Mountains: a 40 year perspective

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Summary

A survey for Ring Ouzel territories was conducted on the Rhinog Mountains during the three years 2009 to 2011. The primary aim of this survey effort was to compare population status and distribution with that described by Peter Hope Jones for the period 1966-75. 20, 17 and 18 Ring Ouzel territories were located in each year respectively, compared to the 36 territories mapped by Hope Jones. Direct comparison with the Hope Jones territories alone suggests a 50% decline over the forty year period. Four tetrads covered on the range during the 1999 National Survey were also re-surveyed, declines noted in all but one, a total possible decline of 59% recorded for these four tetrads. 67% of the Hope Jones territories were still being utilised, revealing a high degree of site faithfulness within this population and demonstrating that habitat condition remains favourable for nesting across a large extent of the site. Site occupancy proved dynamic and shifting however, with only a small number occupied in all years of this survey. Habitat loss or degradation only partly explained the desertion of some sites and vacancy did not appear related to altitude.

Crynodeb

Cynhaliwyd arolwg o diriogaethau Mwyalchen y Mynydd ar y Rhinogydd yn ystod y tair blynedd 2009 hyd 2011. Prif amcan yr arolwg oedd cymharu statws a dosbarthiad y boblogaeth â'r hyn a ddisgrifiwyd gan Peter Hope Jones am y cyfnod 1966-75. Cafwyd hyd i 20, 17 a 18 o diriogaethau Mwyalchen y Mynydd yn y blynyddoedd hyn, o'i gymharu â'r 36 tiriogaeth a fapiwyd gan Hope Jones. Awgryma cymhariaeth uniongyrchol â thiriogaethau Hope Jones yn unig i'r boblogaeth ostwng o 50% dros y cyfnod o ddeugain mlynedd. Gwnaed ail arolwg hefyd o bedwar tetrad a archwiliwyd yma yn Arolwg Cenedlaethol 1999, a nodwyd gostyngiad ymhobman heblaw am un, gostyngiad posibl o 59% yn y pedwar tetrad yma. Roedd 67% o detradau Hope Jones yn parhau i gael eu defnyddio, sy'n dangos lefel uchel o ffyddlondeb safle o fewn y boblogaeth, ac yn dangos fod cyflwr y cynefin yn parhau yn addas ar gyfer nythu mewn rhan helaeth o'r safle. Fodd bynnag, gwelwyd fod y defnydd o safleoedd yn ddeinamig a chyfnewidiol, a dim ond nifer fechan a ddefnyddiwyd bob blwyddyn yn ystod yr arolwg. Dim ond yn rhannol yr oedd colled neu ddirywiad y cynefin yn egluro'r ffaith fod rhai safleoedd wedi eu gadael, ac nid yw'n ymddangos fod uchder yn dylanwadu ar hyn.

Introduction

The decline in numbers of the Ring Ouzel *Turdus torquatus* across its breeding range in the UK has been well documented. The most comprehensive published data-set, produced by the 1999 national survey, suggested severe declines in those areas occupied during the 1988-91 Breeding Atlas period (Wotton et al. 2002). Surveys conducted in Wales during 2006 suggested further severe declines in the Welsh uplands, with a possible 69% decline in breeding pairs across 26 of the 35 tetrads covered in the 1999 national survey (Green 2007). More recent survey work in North Wales has been more encouraging, showing that good numbers remain in the higher regions of Snowdonia (Driver 2011, Smith 2011), with the population on Cadair Idris, at least, relatively stable since the 1999 national survey. Nationally, the most recent Breeding Atlas has confirmed the serious long-term decline however, recording a 43% decrease in range size in Britain and 57% in Ireland since the first 1968-72 Atlas (Balmer et al. 2013).

The rugged upland landscape of Merioneth has long been considered a stronghold for the species (Lovegrove et al. 1994). Breeding historically recorded across the county, from the higher mountains of the Cadair Idris, Rhinogau, Moelwyn and Aran ranges, to the more open, rolling terrain of the Migneint and Berwyn moors in the east. The earliest published survey data for Ring Ouzels in Meirionnydd documented their breeding status on the Rhinog Mountains in the west of the county, in the late 1960s and early 1970s (Hope Jones 1980). 36 breeding sites were recorded here over the years 1966-75, with occupancy described as ‘remarkably consistent from year to year’.

The primary aim of this survey was to repeat this earlier assessment of status by Hope Jones on the Rhinogs, analysing current status and comparing distribution with that of forty years previous.

This assessment was made in each of the three breeding seasons 2009 to 2011.

Study Area

The Rhinogs are a chain of hills which run parallel with the Cardigan Bay coastline in northern Meirionnydd. Lying just a short distance inland, they extend from the Dwyryd Estuary in the north, to the Mawddach Estuary in the south, a distance of some 20 kilometres. These hills are lower than many of the main Snowdonia ranges, reaching a high point of 720m on Rhinog Fawr. Of the nine main summits along the chain, seven rise to over 600m. What they lack in altitude they make up for with their renowned and almost unparalleled ruggedness. Carved out of the hard, acidic Cambrian grits of the Harlech dome, much of the range is characterised by slopes, faces and plateaux of broken rock and block scree, cloaked with deep heather. A mosaic of dry heath, wet heath and blanket mire is present, with extensive areas of unimproved acid grassland, particularly in the northern regions and the lower ridge-lines in the south. Sheep grazing is highly extensive, or even absent, over much of the higher ground, a large population of feral goats replacing sheep in many areas. This history of low-level grazing has resulted in the largest expanse of mature heath outside Scotland and this is of European importance. Only the few valley-bottom pastures, which penetrate the range in places, have undergone some agricultural improvement, though many of these enclosed grasslands would be classed as semi-improved. Belts of upland oak woodland and 'ffridd' extend along the flanks of these valleys, with two large conifer plantations on lower ground to the east and south of the range.

The Rhinogs are well recognised as an area of upland Wales which has largely escaped the impacts of both agricultural modification and afforestation and any habitat change over the period of this assessment is likely to have been subtle and localised.

Methods

Design
The original summary map of Rhinog territories produced by Hope Jones was analysed, with breeding sites re-plotted at 1:25 000 scale, allowing accurate assessment and targeted effort in the field. Survey focussed on these 36 breeding sites, visits being made to all in each of the three years 2009-2011, breeding status being assessed as described in the standard survey criteria for the species (Gilbert et al.1998). Any territories located were plotted, with locations compared to those shown on Hope Jones's summary map.

Tetrads covered on the Rhinog range during the 1999 national survey were also re-surveyed, assessing any change, using directly comparable methodology. A maximum of 17 territories were recorded in the four tetrads surveyed by the RSPB in 1999 (including many not identified by Hope Jones), providing an excellent opportunity for re-assessment following a ten year period. Field data was sourced from the RSPB for these four tetrads (SH6622, SH6224, SH6230 and SH6834). All territories recorded in these tetrads were surveyed in each year, to allow comparison. Any additional, 'new' territories located during the survey were also plotted and re-surveyed in subsequent years.

All suitable habitat on the range was covered at least once during the three years, though survey emphasis was dictated by previous knowledge of Ring Ouzel distribution in the area.

Field Methods
A tape-lure was used to mount searches in all of the previously recorded territories and other suitable habitat. This method was found to be the most efficient in previous survey effort (Smith 2011) and allowed the best use of limited survey time available. Playback also allowed direct comparison to be made with the tetrad survey of 1999, during which the same methodology was adopted. Survey work was conducted between mid-April and late-June in each of the three years.

Results

Territories
Small inter-annual fluctuations in overall breeding numbers were noted over the three years 2009 to 2011, with 20, 17 and 18 occupied territories located in each year respectively. Breeding was 'probable' or 'confirmed' in all except one of these territories,

following standard criteria, with the one ‘possible’ territory recorded in 2009 (a male recorded singing on one date at a traditional site). Three previously unrecorded territories (i.e. non-Hope Jones/1999 survey territories) were located, though one of these was lost to agricultural heather burning in 2010.

A total of 28 different territories were utilised by Ring Ouzels over the three years of the survey, occupancy proving dynamic and variable between years. Nine were occupied in each of the three years of survey, nine in two years and ten in just the one year.

Approximately 37.27km² of suitable breeding habitat was surveyed, generating a maximum overall breeding density of 0.5 pairs/km² for the three year period covered. The highest breeding concentration recorded during the survey was that found in the Cwm Bychan area in 2009, with six occupied territories recorded in c.3.17km², a density of 1.89 pairs/km².

Overall, mean nearest neighbour distance was 1394m (range 260-4010), some pairs breeding in relative isolation from the main breeding range.

Comparison with the Hope Jones Territories

Twenty four of the 36 territories recorded by Hope Jones between 1966 and 1975 were still in usage during this survey. Only eight were occupied in each of the three years however, seven occupied in two years (not always consecutively) and nine in the one year only. Twelve were vacant in all years.

The apparent location of breeding activity in the 24 occupied territories was remarkably consistent with that mapped by Hope Jones, the majority lying in the exact location mapped some forty years previous. Some small-scale movement was noted in six areas, with deviation of up to 590m recorded (considered an acceptable deviation over a 40 year period), though all these birds were still using the same topographical feature (escarpment, cliff complex, small valley etc.). One of these movements appeared to have been caused by heather loss on one of the lower ridges on the range, the territory retreating to nearby steeper ground still holding heather, some 450m away from the site mapped by Hope Jones. A second movement may have occurred as a result of the maturation of an adjacent conifer plantation (established within 250m of the original territory location), the territory moving some 590m, away from the forest edge, along the same escarpment.

When comparing the 36 Hope Jones territories alone, the maximum number occupied in any of the three seasons of this survey (18 in 2009) represents a 50% decline on the late 1960’s/early 1970’s population estimate.

The overall maximum number of territories located in any one year during this survey (i.e. including the non-Hope Jones territories), 20 in 2009, still represents a 45% decline on Hope Jones’s population estimate.

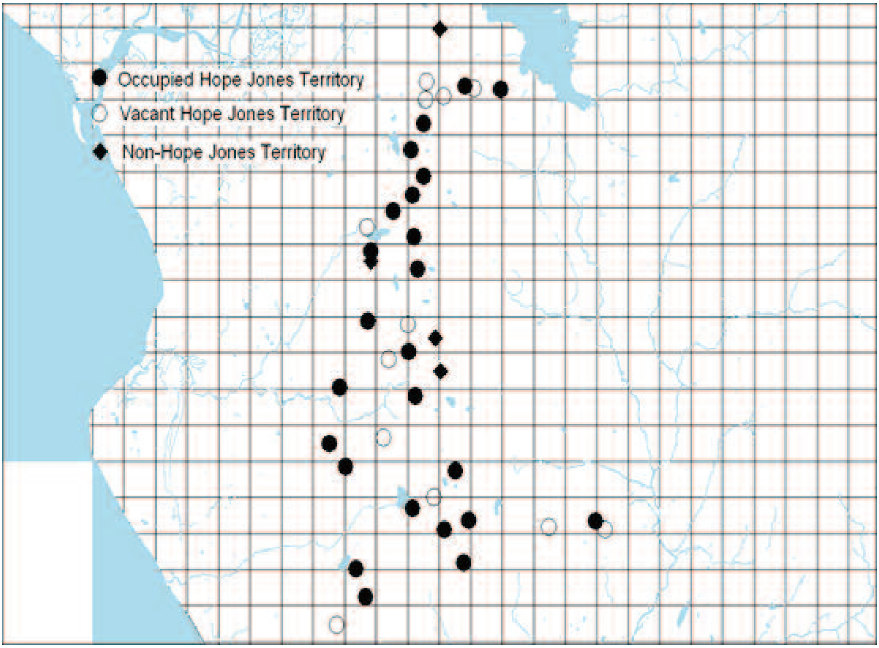

Figure 1. Ring Ouzel Territories on the Rhinog Mountains 2009 – 2011

The figure shows those Hope Jones territories occupied at least once during the three years of this survey and those which were vacant in all three years. The non-Hope Jones territories (i.e. previously unrecorded or occupied 1999 territories) are also plotted.

The 1999 National Survey Tetrads
Declines were recorded in all but one of the four tetrads covered in the 1999 national survey:

SH62R
Five to eight territories were recorded here in 1999 (i.e. 5 probable/confirmed and 3 possible). Three of these territories were occupied in 2010, one in 2009 and one in 2011.

SH62H
Three to five territories were recorded in 1999. Only one territory was occupied here in each of the three years, though two of the 1999 territory locations were utilised.

SH63F
Two to three territories recorded in 1999. One territory was occupied in 2009 and 2010, two used in 2011.

SH63X
The one territory located in 1999 was used in all three years of this survey.

Comparison between the maximum estimate of breeding pairs present in 1999 (possible, probable and confirmed) and the maximum numbers of pairs present during the three years of this survey (all were probable/confirmed), generates a total possible decline of 59% in these four tetrads. The minimum estimate for 1999 still represents a decline of 36% for current status.

Altitude and Aspect
Altitude of the occupied territories ranged widely from 230 to 670m, average altitude being 402m. Over two-thirds (67%) of the territories were located between 300 and 500m, 17% below 300m and 14% above 500m.

Exactly half of the territories held northerly aspects, 32% southerly, 14% facing due east, 3% due west.

Territory Habitat Selection
Broad-scale characteristics of these territories were variable, though all were associated with mature Heather Calluna vulgaris cover and broken rocky terrain, with sparse, or no, tree cover. Gradients within the territories varied. Twelve of the occupied territories were located on terrain where an intimate mosaic of small rock outcrops, rock shelves and block scree, set amongst deep heather on moderate slopes, was typical. Eight of the occupied territories were found on the steeper, large cliff complexes, with extensive, open rock faces, narrow gullies and associated scree. Three were found on smaller crags, with well vegetated fissures and shelves. Two were on the upper reaches of steep escarpment ground, with variable amounts of rock outcropping and gullies with deep heather cover. A small, narrow stream valley was utilised at another site, lying on moderate gradients, though again with extensive mature heather-clad sides and largely free of tree cover. Old mine workings were central to two territories, holding a mosaic of small rock outcrops, adits, tailings, small derelict buildings and stone-walls, set amongst mature heath on gentle to moderate gradients.

The presence and extent of pasture foraging habitat within these territories is variable, reflecting the lightly grazed nature of much of the range. The majority held access to extensive tracts (10ha or more) of dry unimproved or semi-improved pasture within a kilometre of what was considered to be the nesting area. Five territories were over a kilometre (up to 1.6km) away from this more extensive, presumably optimal, foraging habitat however, nine lying over 500m away from this habitat type. More intimate, small-scale heather/grass mosaics were generally present in all territories. A Ring Ouzel was observed flying 1.2km from one of these heather-dominated territories to unenclosed, unimproved grassland habitat, demonstrating that such distances are not a deterrent to site occupancy in this population.

During this survey, Ring Ouzels were observed feeding on short-sward, unimproved acid grassland, both extensive swards (enclosed and unenclosed) and small-patch mosaics amongst heathland. The latter including grass covered tracks, paths, bracken patches, mine tailings and scree amongst otherwise heather-dominated hillside. Short-sward flushes and springs were also used. One pair were observed utilising improved pasture for foraging, within 600m of the nesting area, this habitat type being scarce on the Rhinogs and generally lying a considerable distance from the vast majority of territories present.

Nest Sites
No concerted effort was made to find nests during this study, though eight nest locations were established. Two nests were noted in steep gullies on large cliff complexes, two on small crags (both on small, narrow heather-clad shelves set into an open rock face) and two in block scree/small outcrop mosaics on steep gradients, with deep heather. One was placed under very deep heather on the lower region of a large broken cliff face, again on very steep ground. A small, narrow stream valley held a nest set into the sheer, heather-clad slope on the one valley side.

Discussion

Status
The breeding population of Ring Ouzels on the Rhinog Mountains has clearly undergone a severe decline. A comparison of the average status between 2009 and 2011 and that of the Hope Jones study, suggests a 49% decline since 1966-75. Whilst consistent with current UK-wide assessments of the declining status of this species (Balmer et al. 2013), the decline confirmed by this study is of note when considering the more encouraging recent published studies of Snowdonia populations (Driver 2011, Smith 2011). It serves to re-affirm the concern over the long-term future of Ring Ouzels in the Welsh uplands, particularly perhaps on these lower altitude ranges.

Hope Jones Territories
Whilst the level of occupancy obviously doesn't match that of the late 1960's and early 1970's, the fact that 67% of the Hope Jones territories were still being utilised some forty years later is of considerable interest. Other studies have suggested a high degree of site faithfulness in the species (Durman 1978; Appleyard 1994; Arthur & White 2001), this habit being particularly marked in high-density populations where competition for nest sites is intense. Little data exists for site fidelity over such a long period of time, particularly in low-density populations such as this.

The precise pattern of site occupancy is also of note, taking the form of a dynamic, shifting mosaic, varying between years, the same suite of traditional sites being used by the population, though only a small number holding pairs in consecutive years. This pattern of inter-annual mobility has been observed in other areas, in both apparently stable populations, such as that documented in the Pentland hills in the mid-1980's (Poxton 1986) and declining populations, such as that of the Moorfoots in the late 1990's (Burfield 2002).

The mechanisms which might determine these patterns of occupancy on the Rhinogs are unclear. The nine sites selected for breeding in all three years of this study (presumably the higher quality sites) are of variable character. Four of these territories are what could be considered typical large upland cliff sites, with associated gullies and scree complexes. Four are small outcrop/scree/deep heather mosaics on moderate gradients, the remaining site centred around old mine adits and tailings, again on moderate gradients. Mature heather cover is abundant in all, the availability of, or proximity to, grassland foraging habitat being variable and comparable to the less frequently occupied breeding sites. Altitude ranges from 235 to 670m, averaging 412m. Seven hold northerly aspects, one apiece facing south and east. There would seem little therefore, in broad-scale terms at least, to determine any well defined site selection preferences at play in any hierarchy of optimal sites.

The 12 Hope Jones territories found to be vacant in each year of this survey are also of variable character and only partly distinguish potential habitat related drivers for the decline. Five of these vacant sites do not appear to currently hold heather cover of sufficient extent and condition for breeding to occur. Heather was either absent, suppressed or extremely limited in both the quantity and quality required for nest concealment. This finding is consistent with other long-term assessments of Ring Ouzels populations which have found heather loss to be a likely driver for site desertion (Sim et al. 2007). Interestingly, analysis of historic aerial photographs from the late 1950’s and 1960’s would suggest that these five sites always lay on the fringes of the main heather cover on the range and, as a result, may well have been some of the most vulnerable to increases in grazing pressure or heather burning practice. Heather loss from increased grazing pressure is often most marked in fine-scale mosaics of heather and grass (Clarke et al. 1995) and these sites may well have suffered as sheep numbers increased significantly during the late 1970’s and 1980’s in upland Wales. As mentioned previously though, much of the Rhinog massif does not lend itself to intensive sheep farming and the remaining seven vacant territories still appear to hold habitat condition suitable for breeding, with extensive, mature heather cover present in all and no immediately discernible difference in condition to the occupied sites. This clearly demonstrates that loss of heather cover is not the sole, or main, cause of site desertion on this range and that additional factors are involved.

The average altitude of these vacant sites is 420m (range 200-545m), slightly higher than both that of the constantly occupied sites and the overall average of the occupied territories, eight of these unoccupied sites lying over 400m. A slow shift to the higher altitude territories would not appear to be occurring on the Rhinogs. This is in contrast to studies of Ring Ouzel populations in areas of Scotland, where desertion of traditional breeding sites was found to be more likely at lower altitudes (Buchanan et al. 2003, Sim et al. 2007). It is perhaps fair to say however, that the pressures of agricultural intensification prevalent in many lower-altitude moorland edge areas across upland Britain have been less marked and influential in habitat change on the Rhinog massif and, whilst some habitat degradation is evident on the lower fringes of the range here, overall trends for habitat loss and site desertion would not appear to be altitude related.

1999 National Survey Tetrads

Analysis of the 1999 national survey tetrad data is interesting on two accounts. Firstly, it would suggest that Hope Jones had probably under-estimated the size of the breeding population, with all bar one of the four tetrads holding more territories in 1999 than he had recorded in the late 1960's/early 1970's. This is not surprising perhaps in that the tape-lure methodology used in the latter survey has been shown to be more effective than basic observational survey, particularly where multiple territories are located within a short distance of one another (Burfield 2002, Smith 2011).

Secondly, comparison with the results of the present survey, might suggest that the decline in numbers of breeding Ring Ouzels on this range has been particularly marked since 1999. This in contrast to the nearby higher altitude Cadair Idris range, where survey in 2008 found a population level largely consistent with that of 1999 (Smith 2011).

Conclusion

It would seem the last 40 years has seen the Ring Ouzel population on the Rhinog Mountains decrease by half, at least. The rugged and truly wild nature of the terrain on much of this range, has largely provided immunity from the advances of modern agriculture and forestry and habitat change over this period will have been slight as a result. This decline, whilst not surprising perhaps, is particularly worrying in this context.

The strongly traditional, though dynamic, nature of site occupancy on this massif is fascinating. To the human eye at least, much of the Rhinogs would appear suitable for breeding Ring Ouzels, with its vast expanse of mature heath and jagged geology. This population appears to repeatedly return to the same suite of sites however, though only a few being favoured in each year, some possibly unoccupied for a number of years, before holding a pair again. This species clearly holds a very strong visual imprint of optimal breeding site characteristics, both on this massif and beyond.

Whilst its decline is undeniable and severe, this population is still significant in a Welsh context and should be recognised as such. Populations in many areas of similar altitudes in Wales (Clwydian Range and Berwyn for example) have crashed to the verge of local extinction (Brenchley et al. 2013). The Rhinog population does appear a little more robust perhaps.

The fact that breeding was still occurring at altitudes as low as 230m during this study is of interest, five of the occupied territories lying some way below 300m, two of these holding pairs in all three years. There would not appear to be any obvious, slow creep to higher altitudes within this population therefore and the lower traditional sites still appear suitable for breeding. It is important to stress obviously, that no assessment of productivity was made during this study and a thorough assessment of this aspect of these lower-altitude Welsh populations would certainly be worthwhile.

What is certain, is that this charismatic species remains a widespread feature of this rugged landscape and as Peter Hope Jones himself declared, some 34 years ago, 'long may it continue to do so'.

Acknowledgements

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Changes in the abundance and distribution of upland breeding birds in the Berwyn Special Protection Area, North Wales 1983-2002

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Summary

The Berwyn Special Area for Conservation (SAC) is the most extensive blanket bog and upland heath in Wales. The site was also designated in 1998 as a Special Protection Area (SPA) for its internationally significant numbers of Hen Harrier *Circus cyaneus*, Merlin *Falco columbarius*, Peregrine *Falco peregrinus* and Red Kite *Milvus milvus*. Following the Second World War, moorland management for Red Grouse *Lagopus lagopus scoticus* declined and by the late 1990s driven grouse shooting had ceased. Numbers of Red Grouse shot peaked in the early 1900s, but declined thereafter. Red Grouse densities between 1995 and 2010 varied between moors, but not between years or through time. Between initial surveys in 1983-5 and a further survey in 2002, Lapwing *Vanellus vanellus* were lost, Golden Plover *Pluvialis apricaria* declined by 90% and Curlew *Numenius arquata* by 79%. In contrast, increases were seen in Carrion Crow *Corvus corone* (529%), Raven *Corvus corax* (308%), Buzzard *Buteo buteo* (150%) and Peregrine (700%). Numbers of Hen Harriers declined by 49%. There were no significant changes in Merlin and Red Kite. Meadow Pipits *Anthus pratensis* increased (103%), as did Whinchat *Saxicola rubetra* (123%) and Stonechat *Saxicola torquata* (986%). Ring Ouzel *Turdus torquatus* declined by 80%. Changes in distribution were observed in Red Grouse and Curlew, occupying 40% and 57% fewer study plots in 2002. Study plots occupied by Stonechat increased by 333%. Raven occupancy increased (140%), as did Buzzard (63%) and Peregrine (500%). To restore numbers of key species of ground-nesting birds, we recommend a repeat survey of ground nesting birds in the Berwyn SPA, and targeted moorland management which includes habitat enhancements and the control of generalist predators.

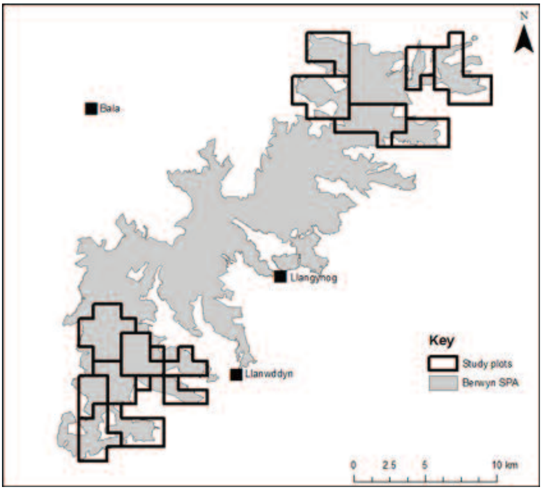
Introduction

Heather *Calluna vulgaris* dominated uplands in the United Kingdom are of high international conservation importance for a range of birds species (Thompson et al. 1995). In Wales, the Berwyn is an important area for blanket bog and heathland and upland birds and was designated as both a Special Area for Conservation (SAC) and Special Protection Area (SPA), the latter in recognition of the internationally important populations of Hen Harrier, Merlin, Peregrine and Red Kite. The Berwyn is also designated as a Site of Special Scientific Interest (SSSI) for its upland bird assemblage, which includes Black Grouse Tetrao tetrix, Golden Plover and Curlew.

Between 1946 and 1984, 46% of heather moorland in Wales (Lovegrove et al. 1995) and 39% in the Berwyn had been lost from either overgrazing by sheep or commercial afforestation (CCW, 2008). Similarly, there has been a decline in moorland management for Red Grouse, where gamekeepers are employed to burn heather and control predators to produce surpluses for shooting (Hudson 1992). In the Berwyn SPA, two-thirds of the moorland is nature reserve, either Vyrnwy managed by Severn Trent Water/RSPB or Pale, North Berwyn managed by the Countryside Council for Wales (CCW, now Natural Resources Wales). In this study, we quantify changes in numbers of Red Grouse from shooting records and recent surveys; and other moorland birds from a survey in 1983-5, repeated in 2002 (Sim et al. 2005).

Methods

The Berwyn is 242 km^2 of moorland running south-west from Llangollen in the north-east to Mallwyd in the south-west (Figure 1). Habitats in the Berwyn grade from the ffridd(upland fringes) on the lower slopes (300m) through acid grassland, dry heath up to blanket bog on the higher levels peaking at 830m. It forms the most extensive blanket bog (National Vegetation Classification (NVC) type M19 Calluna vulgaris- cotton grass Eriophorum vaginatum) in Wales. It also contains the largest stand of upland European dry heath (NVC type H12 Calluna vulgaris- bilberry Vaccinium myrtillus heath) (CCW,



2008).

Figure 1. Location of the 14 upland bird survey plots in the Berwyn SPA surveyed in 1983-5 and repeated in 2002.

We assessed Red Grouse abundance from the Game & Wildlife Conservation Trust's (GWCT) shooting records between 1880 and 2011 for three Berwyn moors and one on the neighbouring Ruabon Mountain (Aebischer & Baines, 2008). Due to incomplete time series, we expressed annual numbers of grouse as the mean number shot per km^2 of heather for each moor.

Red Grouse were also surveyed using pointing dogs in late-July and early-August within sample $1km^2$ blocks on three moors in the Berwyn (six blocks on two moors and two on the other) and one on the neighbouring Ruabon Mountain (two blocks) between 1995 and 2010. All four moors were surveyed annually up until 2000, but between 2001 and 2010, one moor was surveyed in seven out of 10 years, one in five years and two in two years. Coveys of grouse when flushed were sexed and aged. We assessed differences in densities and breeding success between moors and years using a generalised linear model (GLM) in Genstat 12 (Payne et al. 2009). The response variables 'numbers of grouse per km^2' and 'chicks per hen' were entered into separate models with moor and year as categorical variables. Trends in summer density on each moor through time were assessed by linear regression.

Data from upland bird surveys of the Berwyn in 1983-5 and 2002 were provided under licence from NRW. In 1983-5 surveys were conducted across the whole of the Berwyn, but field maps were only available to allow repeat surveys in 2002 on 14 distinct plots situated in the north east and south west (Figure 1). Study plots were on average $7.6km^2$ (range $4\text{-}14km^2$) defined by boundaries of landownership, which in total covered 107, 1-km^2 grid squares. Plots were surveyed by two observers walking parallel line transects placed 200 m apart within 1-km^2 grid squares. Surveys were undertaken between 08.30 and 18.00 hours BST to avoid the main periods of rapidly changing bird activity (Reed et al. 1985). Surveys were not carried out in high winds greater than 35 km/hour, heavy rain or poor visibility. All bird sightings were mapped on to 1:10,000 or 1:25,000 maps. Two visits were made to each plot. In the original survey, the first visit was between 29 April and 14 May and the second between 7 June and 21 June. The method used was designed primarily for upland waders but other species such as raptors and gamebirds were also recorded (Sim et al. 2005). The repeat surveys in 2002 were undertaken within seven days of the original survey dates (Sim et al. 2005).

Analyses of bird abundance used the maximum of the two counts from each study plot, but excluded flocks of five or more waders. Skylark *Alauda arvensis* and Meadow Pipit were only counted across both periods in six of the 14 study plots (52, $1km^2$ grid squares). We assessed changes in the numbers of each species at the level of the study plot using GLMs with a Poisson error distribution and a logarithm link function, with number of birds as the dependent variable and survey period (1983-5 and 2002) as the categorical independent variable. Changes in distribution between the 1983-5 and 2002 surveys were tested by logistic regression, with the dependent variable being the presence or absence within survey plots and the independent variable being survey period.

Results

Changes in abundance

Red Grouse

In the early 1900s Red Grouse shot peaked at a mean 250 birds km^{-2} across the four moors, but subsequently declined, with little shooting during the Second World War (Figure 2). Following the Second World War, numbers shot increased, peaking in the 1970s at 43 grouse km^{-2} but by the early 1990s this declined to < 5 grouse shot per km^2. Only one moor reported shooting Red Grouse in 2011. Densities of Red Grouse differed between moors (Table 1 - tables are at the end of the text) but not between years or over time (Table 2) and ranged from 5.9 to 20.6 grouse km^{-2} (Figure 3). Breeding success did not differ between moors or between years. Between bird surveys in 1983-5 and 2002 the numbers of Red Grouse observed were 54% fewer (Table 3).

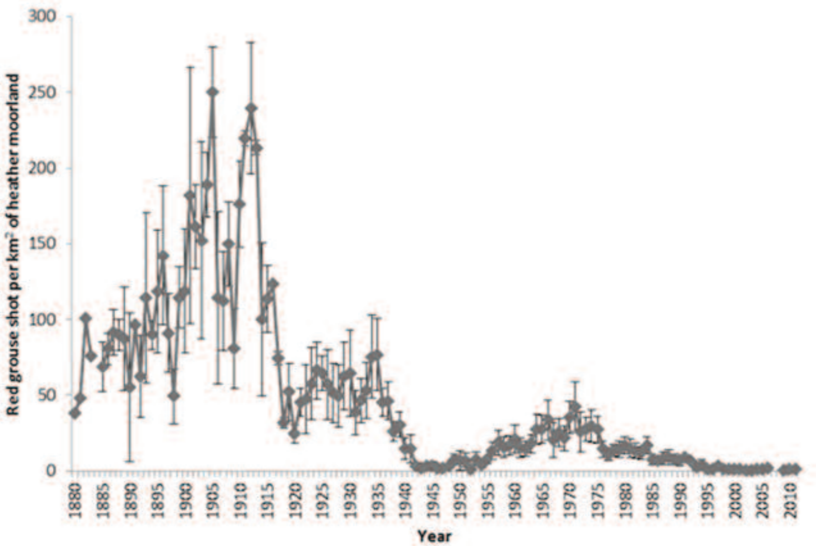


Figure 2. Mean (+SE) Red Grouse shot per km2 of heather moorland on three moors in the Berwyn and one on the neighbouring Ruabon mountain (1880- 2011).

Other moorland birds

Between surveys, Lapwing declined by 100%, Golden Plover by 90% and Curlew by 79% (Table 3). Numbers of Meadow Pipits and whinchat increased by 103% and 124% respectively and stonechat increased 986%. Ring ouzel declined by 80%. There were no differences in the numbers of Skylark or Wheatear *Oenanthe oenanthe*. Carrion Crow

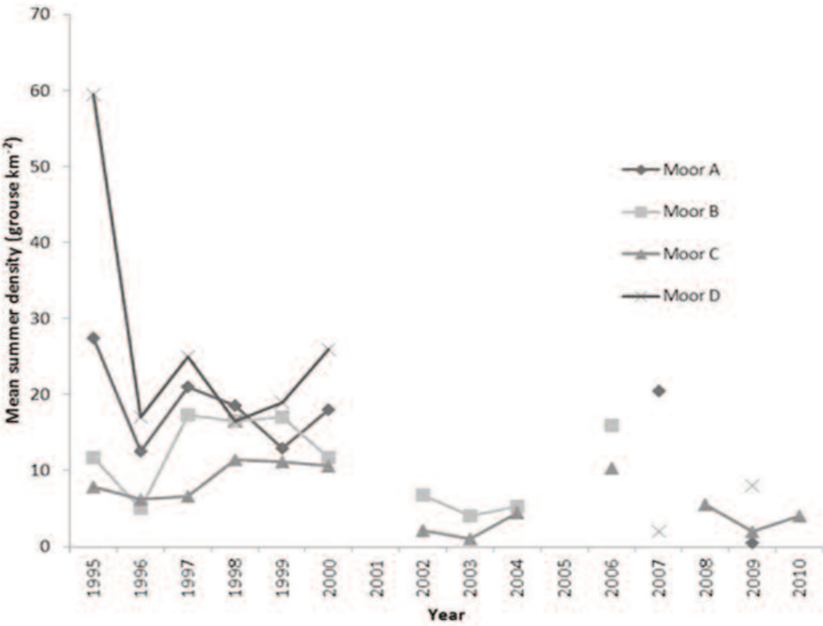


Figure 3. Red Grouse summer densities (grouse km^{-2}) on three moors in the Berwyn SPA and one on the neighbouring Ruabon Mountain between 1995 and 2010.

increased by 529% and Raven 308%. Buzzards increased by 150%, Peregrines by 700%, whilst Hen Harrier numbers declined by 49%. There were no changes in Merlin, Red Kite, Short-eared Owl *Asio flammeus*, and Kestrel *Falco tinnunculus*. Numbers of Black Grouse were 77% fewer.

Changes in distribution

Between surveys, study plots occupied by Red Grouse declined by 40% (Table 4). Lapwing were absent in 2002, and the number of plots occupied by Curlew declined by 57%. The number of plots occupied by Stonechat increased 333%. Raven occupancy increased by 140%, Buzzard 63% and Peregrine 500%. Between 1983-5 and 2002 two thirds of red-listed species in Wales (those which are globally threatened, or have historically or recently shown severe decline) (Johnstone et al. 2011) declined in abundance (Table 5).

Discussion

In 1994, there were 10 recognised grouse moors in Berwyn (Walker & Kenmir 1994). Of the nine where management data were available, gamekeepers were employed on only five (four part-time and one full-time). Grouse shooting was by driving on two, was walked-up on five moors and grouse were no longer shot on the remaining two moors. By the late 1990s, driven shooting had ceased (Offord 2002, Whitfield & Fielding 2009). Shooting is now restricted to walked-up following good breeding years (Sotherton et al. 2009). Red Grouse are now considered critically endangered in Wales following a rapid decline in range and abundance (Johnstone et al. 2011). This situation contrasts quite markedly with the situation in northern England, where over an equivalent period densities averaged 177 grouse km-2, peaking in 2011 at 318 grouse km-2, the highest density recorded in 30 years (Baines et al. 2011).

Between survey years, Buzzard and Peregrine increased in Berwyn, which reflects the wider UK trend of a 435% increase in Buzzards between 1970 and 2010, and a 194% increase in Peregrine between 1970 and 2002 (Banks et al. 2002, Eaton et al. 2011). The Berwyn SPA was designated for Hen Harrier, Merlin, Peregrine and Red Kite. Peregrine have increased, but Hen Harrier numbers have fluctuated, increasing from five pairs in 1983, peaking at 18 pairs in 1988, declining back to five pairs in 2000 (Offord 2002), before recovering to 13 pairs in 2004, as part of a wider increase in Wales (Whitfield & Fielding 2009) of 33% between 2004 and 2010 (Hayhow et al. 2013). Nesting on the ground, Hen Harrier, and possibly Merlin, can be vulnerable to predation by Red Fox *Vulpes vulpes* (Baines et al. 2008).

Breeding waders are in severe decline in many of the UK's uplands (Sim et al. 2005; Balmer et al. 2013). Causes may vary, but include commercial afforestation, drainage, increases in generalist predators, changes in livestock grazing patterns and a decline in grouse moor management (Sim et al. 2005, Douglas et al. 2014). In Berwyn, the declines observed are synonymous with wider declines recorded throughout Wales, with Curlew declining by 81% between 1993 and 2006, Golden Plover by 83% between 1982 and 2007, and Lapwing by 77% between 1987 and 1998 (Johnstone et al. 2012). Large scale afforestation can be detrimental through the loss of moorland habitats, but also by providing cover for predators (Douglas et al. 2014) and has been implicated in declines in Wales (Shrubb et al. 1997). Similarly, changes in grazing patterns may be a contributing factor, with reduced grazing and heather burning leading to the development of taller rank vegetation which is avoided by breeding birds such as Golden Plover which prefer short heather for breeding (Gibbons et al. 1993, Whittingham et al. 2000). Similarly, agricultural improvements on moorland fringe pastures through drainage and increased grazing may have also contributed, with Golden Plover and Lapwing both foraging on earthworm rich pasture (Whittingham et al. 2000).

Densities of breeding waders in parts of northern England and Scotland were three to five-fold greater on managed grouse moors than on unmanaged moorland (Tharme et al. 2001). The likely cause of this difference has been experimentally demonstrated in Northumberland to be predation by foxes and crows, which when removed, resulted in a three-fold increase in breeding success of waders and grouse and subsequent increases in numbers of breeding pairs (Fletcher et al. 2010). Similar changes, but in reverse, were observed following the cessation of grouse moor management at Langholm Moor SPA in south-west Scotland, where Carrion Crow and foxes increased, and ground-nesting birds, Red Grouse, Curlew, Lapwing, Golden Plover, Skylark and Hen Harrier all declined (Baines et al. 2008).

At Pale Moor in Berwyn, employment of gamekeepers between 1995 and 2000 failed to restore Red Grouse numbers (GWCT 2000) but was associated with an increase from eight to 24 male Black Grouse and an improvement in Hen Harrier breeding success. Although not demonstrating a response from Red Grouse, this was thought to be due to sheep ticks parasitizing their chicks and transmitting louping virus, which in laboratory trials kills 85% of infected chicks (Reid 1975).

The decline of waders in Berwyn is of major conservation concern and in this long-lived group is likely to reflect long-term poor breeding success and a lack of recruitment into the breeding population (Johnstone et al. 2006). Lapwing may already be extinct as a breeding species, but to prevent further localised species extinctions and to restore previous status, urgent conservation management is needed. This should include a repeat survey of ground-nesting birds in the Berwyn SPA and targeted moorland management that includes both attention to habitat requirements and the control of generalist predators.

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Table 1. Results from the GLMs testing for differences in mean Red Grouse densities (birds km^{-2}) and breeding success (chicks per hen) in July between year (1995 to 2010) and moors (three moors in the Berwyn SPA and one in the near vicinity).

Parameters		**Df**	**Mean squares**	**F**	**P**
(a) Density in July (birds km^{-2})	Moor	3	309.99	4.89	0.009
	Year	13	122.39	1.93	0.082
	Error	23	63.45		
(b) Breeding success (chicks per hen)	Moor	3	0.13	0.08	0.972
	Year	13	2.94	1.75	0.126
	Error	23	1.68		

Table 5. Trends in numbers of birds within the Berwyn SPA in relation to their conservation status in Wales (Johnstone et al. 2011).

Trend	**Conservation status in Wales**		
	RED	**AMBER**	**GREEN**
Decreasing	Lapwing		
	Curlew		
	Golden Plover		
	Ring ouzel		
	Black Grouse		
	Red Grouse		
Stable	Short-eared owl	Red Kite	
	Hen Harrier	Merlin	
	Kestrel	Snipe	
		Skylark	
		Wheatear	
Increasing		Meadow Pipit	Whinchat
			Stonechat
			Raven
			Carrion crow
			Peregrine
			Buzzard

Table 3. The total numbers and mean density of birds (birds km^{-2}) in the Berwyn SPA survey areas in 1983-5 and 2002. Changes in numbers between survey years are based on differences between the 14 plots *(*skylark and Meadow Pipit were only surveyed in six plots across both survey years).

	Species	**Total number (density - birds km^{-2})**		**Change (%)**	$F_{1,26}$	**P**
		1983-5	**2002**			
Breeding waders	Lapwing	14 (0.13)	0 (0)	-100	19.41	<0.001
	Curlew	148 (1.38)	31 (0.29)	-79	83.14	<0.001
	Golden Plover	10 (0.09)	1 (0.01)	-90	8.55	0.003
	Snipe	9 (0.08)	4 (0.05)	-56	1.97	0.160
	All waders	**181 (1.69)**	**36 (0.34)**	**-80**	**105.82**	**<0.001**
Passerines	Skylark*	53 (1.02)	63 (1.21)	+19	0.86	0.353
	Meadow Pipit*	602 (11.58)	1220 (23.46)	+103	213.83	<0.001
	Whinchat	84 (0.79)	187 (1.75)	+123	40.15	<0.001
	Stonechat	7 (0.07)	76 (0.71)	+986	67.05	<0.001
	Wheatear	25 (0.23)	24 (0.22)	-4	0.02	0.89
	Ring ouzel	10 (0.09)	2 (0.02)	-80	5.82	0.016
	All passerines	**(13.78)**	**(27.37)**	**+106**	**384.57**	**<0.001**
Corvids	Raven	12 (0.11)	49 (0.46)	+308	24.07	<0.001
	Carrion crow	49 (0.46)	308 (2.88)	+529	209.35	<0.001
	All corvids	**61 (0.57)**	**357 (3.34)**	**+485**	**232.04**	**<0.001**
Raptors	Hen Harrier	35 (0.33)	18 (0.17)	-49	5.55	0.018
	Buzzard	14 (0.13)	35 (0.33)	+150	9.30	0.002
	Merlin	10 (0.09)	14 (0.13)	+40	0.67	0.413
	Red Kite	2 (0.02)	4 (0.04)	+100	0.68	0.410
	Peregrine	1 (0.01)	8 (0.07)	+700	6.20	0.013
	Short-eared owl	3 (0.03)	2 (0.02)	-33	0.20	0.654
	Kestrel	18 (0.17)	15(0.14)	-17	0.27	0.601
	All raptors	**83 (0.78)**	**96 (0.90)**	**+16**	**1.24**	**0.27**
Gamebirds	Red Grouse	117 (1.09)	54 (0.50)	-54	23.77	<0.001
	Black Grouse	111 (1.04)	25 (0.23)	-77	58.76	<0.001
	All gamebirds	**228 (2.13)**	**79 (0.74)**	**-65**	**75.46**	**<0.001**

Table 2. Mean (SE) Red Grouse densities (birds km-2) and breeding success (chicks per hen) in July on three moors in the Berwyn SPA and one in the near vicinity between 1995 and 2010.

Moor	**Density**	**Breeding success**	**Trend (1995-2010)**		
			Slope	**R2**	**P**
Moor A	15.5 (3.2)	3.0 (0.6)	-0.91	0.34	0.126
Moor B	5.9 (2.3)	2.5 (0.4)	-0.31	0.04	0.558
Moor C	9.4 (2.6)	2.5 (0.4)	-0.33	0.21	0.116
Moor D	20.6 (3.2)	2.7 (0.5)	-2.32	0.47	0.059

Table 4. Changes in the distribution of birds in the Berwyn SPA between 1983-5 and 2002. Changes in distribution are based on differences in occupancy between the 14 plots (*Skylark and Meadow Pipit were only surveyed in six plots across both survey years).

		Survey plots occupied				
		1983-5	2002	% change	X^2_1	P
Breeding waders	Lapwing	2	0	-100	2.93	0.087
	Curlew	14	6	-57	14.38	<0.001
	Golden Plover	4	1	-75	2.32	0.128
	Snipe	4	2	-50	0.86	0.353
Passerines	Skylark*	4 (6)	5 (6)	+254	0.45	0.502
	Meadow Pipit*	6 (6)	6 (6)	-		
	Whinchat	13	14	+7	1.42	0.233
	Stonechat	3	13	+333	16.49	<0.001
	Wheatear	9	8	-11	0.15	0.699
	Ring ouzel	6	2	-67	2.89	0.089
Corvids	Carrion crow	10	13	+30	2.29	0.128
	Raven	5	12	+140	7.79	0.005
Raptors	Hen Harrier	12	9	-25	1.76	0.185
	Buzzard	8	13	+63	5.16	0.023
	Merlin	7	11	+57	2.54	0.111
	Red Kite	2	4	+100	5.16	0.353
	Peregrine	1	6	+500	5.16	0.023
	Short-eared Owl	2	1	-50	0.38	0.538
	Kestrel	9	10	+11	0.16	0.686
Gamebirds	Red Grouse	14	10	-40	6.22	0.013
	Black Grouse	7	7	-		

Skylark. Photo: Dave Brassey

The effect of environmental conditions on Osprey *Pandion haliaetus* chick diet

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Summary

The diet of an Osprey chick on the Dyfi estuary was examined in 2012 in order to assess the effect of environmental conditions on chick diet. Fish were identified using footage from nest cameras and biomass was determined using image analysis. Environmental conditions including cloud cover, rainfall, temperature, moon phase, wind direction, tidal depth, pressure and wind speed were recorded by staff and volunteers at the Osprey project. The relationship between the conditions and diet was tested using DistLM and CAP multivariate analysis.

1. Grey Mullet *Mugil cephalus* was the most common fish delivered to the nest, with the average weight of all fish being 183.6g.
2. Calorific requirements of the female and chick were only met on 30% of the days analysed, which may be attributed to the poor weather that season.
3. The male Osprey had a significant preference for foraging between tidal depths of 1.5-2.0m and 3.0-4.5m.
4. CAP and DistLM analysis showed the overall effect of environmental conditions on Osprey chick diet to be not significant.

Crynodeb

Archwiliwyd ymborth cyw Gwalch y Pysgod ger aber Afon Dyfi yn 2012 er mwyn asesu effaith amodau amgylcheddol ar fwyd y cyw. Enwyd y pysgod trwy ddefnyddio ffilm o gamerâu nyth, ac amcangyfrifwyd bio-mas trwy ddadansoddi delweddau. Cofnodwyd amodau amgylcheddol megis gorchudd cymylau, glaw, tymheredd, cyfnod y lleuad, cyfeiriad y gwynt, dyfnder y llanw, gwasgedd atmosfferig a chryfder y gwynt gan staff a gwirfoddolwyr y prosiect Gweilch y Pysgod. Archwiliwyd y berthynas rhwng yr amodau hyn a'r ymborth gan ddefnyddio dadansoddiad amryw ffactorau DistLM a CAP.

1. Yr Hyrddyn Llwyd *Mugil cephalus* oedd y pysgodyn a gludwyd i'r nyth amlaf, gyda phwysau'r holl bysgod ar gyfartaledd yn 183.6g.
2. Dim ond ar 30% o'r dyddiau a archwiliwyd y cafwyd digon ar gyfer anghenion caloriffig yr iâr a'r cyw, efallai oherwydd y tywydd gwael yn ystod y tymor.
3. Roedd y ceiliog Gwalch fel rheol yn chwilio am bysgod rhwng dyfnderoedd llanw o 1.5-2.0m a 3.0-4.5m.
4. Dangosodd dadansoddiad CAP a DistLM nad oedd effaith amodau amgylcheddol yn eu cyfanrwydd ar ymborth y cyw yn arwyddocaol.

Introduction

The Osprey *Pandion haliaetus* is a piscivorous, long lived raptor with almost worldwide distribution (Grove et al.). Ospreys are visual, diurnal predators (Thibault & Patrimonio 1991) with their predatory abilities depending on prey location and movement, water depth, their height above the water and their dive speed (Lee & Reddish 1981).

Foraging

Successful capture of fish in the species is very high. In two studies during 1972 it was found that 83% of 158 fishing attempts and 80% of 25 fishing attempts were successful (MacCarter 1972; Garber 1972). Studies that have investigated the average weight and length of fish caught by Ospreys from different populations have found that the maximum length appears to be 35cm, with the smallest length being 11cm. Corresponding weights that have been calculated from the length of the fish are between 150-350g irrespective of) Osprey breeding season (Häkkinen 1978; Vandaele & Vandaele 1982).

Energy Requirements

The number of fish the male brings to the nest each day increases rapidly upon hatching of the chicks. Male ospreys provisioning a single chick brood have a mean DEE of 259 kcal per day (Green & Ydenberg 1994). It has been calculated that adults have a metabolizable energy intake (ME) of 286 kcal per day, nestlings 127kcal fledglings 254kcal and juveniles 280kcal (Lind 1976 cited in (Vandaele & Vandaele 1982). It is estimated that fish contain 1 kcal per gram of body weight (Winberg 1960 cited in Vandaele & Vandaele 1982) meaning that a male Osprey supplying food for himself, his mate and one nestling would need to catch approximately 699g of fish per day to meet each individual's energy requirements.

Environmental Effects

There has previously been much interest in the way in which the environment affects avian foraging behaviour. Research has shown much variation in the preferred depth and direction of tide favoured by foraging Ospreys and other raptors. Ospreys foraging on a reservoir system in Idaho took significantly more squawfish *Ptychocheilus oregonensis* when the tide was low compared to when the tide was high (Vandaele & Vandaele 1982). Conversely Ospreys in Nova Scotia had the highest dive success at mid-tide (Flemming & Smith 1990). This variation in preferences is likely to be due to prey behaviour in different habitats. In terms of water surface conditions, a study investigating how weather influenced foraging behaviour of breeding male Ospreys found that a deterioration in surface conditions such as increased rippling resulted in longer hunts and reduction of dive success (Machmer & Ydenberg 1990). As well as this, it has been found that under cloudy conditions Osprey foraging changed significantly with the rate of fish capture cut by two thirds and diving rate by half (Grubb 1977b).

Aims

This study aimed to investigate Osprey feeding behaviour, with an emphasis on determining the effects of environmental conditions on prey choice in 2012.

Methods

A single nest site, located on the Cors Dyfi nature reserve was examined, however due to adverse weather conditions experienced in 2012, and technical issues, the cameras were not always functional. Staff and volunteers at the Dyfi Osprey Project were responsible for collecting the data used in analysis. Upon a fish being brought to the nest, a still image was taken from the video footage. This image needed to have both the female's darvic ring and as much of the fish in the photo as possible, as both were essential for later analysis. As well as an image being taken, information was also recorded on a feeding record which included the date, time, species of fish, size of fish, first Osprey to eat and duration, first feeding location, barometric pressure, cloud cover, wind speed, direction and temperature, ambient temperature, precipitation, rainfall, moon phase, tidal phase and tidal depth. Data was collected continuously from chick hatch date to fledge date. Additionally, on certain occasions it was not possible to obtain images of the prey due to technical issues with the cameras. This resulted in there being two final datasets. One data set contained all environmental data and species of fish caught, with the other containing environmental data, species of fish and biomass of fish.

Upon a fish being brought to the nest, a still image was taken. It was then possible from this image to establish the length of the fish in centimetres. In order to ascertain the length, images were analysed using ImageJ software (http://rsb.info.nih.gov/ij/). Length of the fish was derived from another known length in the image, the darvic ring. In this study, the female osprey had a white darvic ring with the numbers "03", and as we knew the width of the ring (20.5mm) it was possible to use the ring as a means to measure the fish brought to the nest. In measuring the ring as a "known distance" the ruler always intersected the number 3 in order to avoid measuring at an angle, thus reinforcing accuracy (Figure 1).

Figure 1. Intersection of numbers on darvic ring to avoid measuring at an angle.

Following the measurement of the ring, standard length (SL) of the fish in the image was measured. SL of a fish refers to its most anterior point to the base of the hypural plate at caudal flexion; in essence it excludes the length of the caudal fin (Harvey et al. 2000).

Fish length-weight relationships are useful for converting length observations into weight estimates in order to provide some measure of biomass (Froese 2007). Here, SL was converted to biomass using the equation W= aLb (Froese 2006), where a and b are different weight-length parameters for each species of fish, W is weight and L is length. The a and b parameters were based on figures provided by FishBase (http://www.fishbase.org), which have been used in previous publications (Harrison 2001).Parameters for each species can be found in Table 1.

Table 1. A and B parameters for each species of fish

Species	Common name	A	B
Platichthys flesus	Flounder	0.0142	3.132
Salmo trutta	Brown Trout	0.0201	2.960
Salmo trutta (anadromous form)	Sea Trout	0.0201	2.960

In order to determine the average weight and lengths of each species, and to investigate any differences between them, average weights and lengths were taken for each species and tested using ANOVA to establish if there were differences in the average size of species being caught. To investigate whether there was a preference for a particular fish the frequency of each species caught was calculated. Frequencies were tested using the chi-squared test. The same method was used to test for tidal preference.

Calorific Intake

Given that it had been established that 1g of fish was equivalent to 1kcal (Winberg 1960 cited in Vandaele & Vandaele 1982), the calorific intake of the birds in the nest could also be calculated. As the male osprey usually ate his share of the fish before returning to the nest, only the fish bought to the nest and consumed by the female and nestling were analysed for calorific purposes. Due to technical issues with the cameras, there were only 23 days over the season in which full days of biomass data was available. Total number of calories consumed on these days were calculated and displayed as percentages.

Multivariate Analysis

Both the dataset containing biomass data and the complete data set with all species were analysed using the programme PERMANOVA (PRIMER-E Ltd). Both CAP (canonical analysis of principal coordinates) and DistLM (distance-based linear models) were used to investigate the influence of environmental conditions on the species and biomass of fish caught. Draftsman plots were used to visually examine pair-wise relationships between the different environmental variables, and to establish if the data needed transforming.

DistLM and CAP analysis

The purpose of CAP analysis was to find axes through the multivariate cloud of points that have the strongest correlation with some other set of variables (Anderson et al. 2008), in this case fish species caught. It was undertaken to test for relationships between species and biomass, and the environmental factors of wind direction, moon phase, pressure, temperature, rainfall, and tidal depth. Significance was determined using 9999 permutations of raw data, resulting in a graph showing which environmental variables were associated with which species. To establish how much of an affect the environmental variables had on the species and biomass of fish caught, DistLM was used. The procedure performs a multivariate multiple regression on the basis of any distance measure, in this case Bray-Curtis similarity. A forward selection which chooses the predictor variable with the best value for selection criterion first, followed by the variable that together with the first, improves the selection criterion the most, and so on (Anderson et al. 2008) was used, based on 9999 permutations with r2 values used as a significance test.

Results

Eight species were brought back to the nest by the male Osprey. Figure 2 shows the frequency of each species caught with a red line indicating the "expected" frequency of each species. Grey Mullet was the most common species caught with a frequency of 113. The least common species included Perch *Perca fluviatilis* (1), Garfish *Belone belone* (1), Rainbow Trout *Oncorhynchus mykiss* (4) and Sea Bass *Dicentrarchus labrax* (2), and were included as "other fish" in these analyses. Analysis using the chi-squared test showed there to be a significant difference between the frequency categories (c2 = 158.9, df =4, p = <0.001), with Grey Mullet being the preferred species.

Average weight of fish

Due to there being two data sets there was no biomass data for Perch, Garfish, Rainbow Trout or Sea Bass, consequently analysis relating to biomass was only performed on the four most common species Grey Mullet, Brown Trout, Flounder and Sea Trout. The averages were analysed using one way, unstacked ANOVA. The results of the ANOVA were not significant (NS)(p = >0.05). Weights for ranged from 7.1-676.7g with the overall average weight of fish caught being 183.6g.

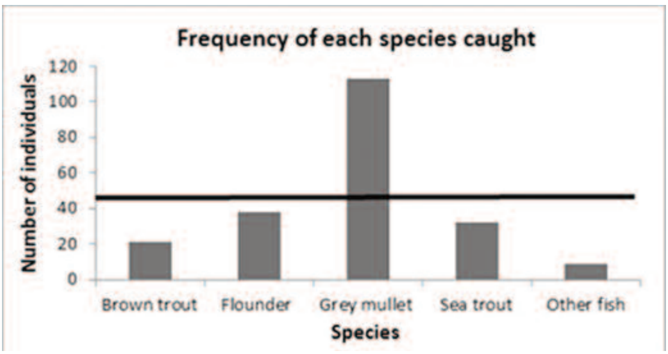

Figure 2. Frequency of Brown Trout, Flounder, Grey Mullet, Sea Trout and "other fish" caught. Black line indicates "expected" frequency of fish.

Calorific intake

Previous calculations indicated that daily calorific intake for the female Osprey and the nestling should have been approximately 413 kcal per day (Lind 1976 cited in Vandaele & Vandaele 1982). Figure 3 illustrates the fulfilment of calorie requirements as a percentage on 23 days from the period of June-August 2013 (413kcal =0%). The graph shows that calorific requirement is only met or exceeded on seven out of the 23 days displayed (30%). On four occasions available calories were less than 150kcal.

Tidal preference

To investigate feeding patterns related to tide throughout the day, frequency of fish caught at different tidal depths was displayed in a stacked bar chart, with the tidal depth split into groups of 0.5 metres from 0.5-5.0 metres (Figure 4). Freshwater species such as brown trout were not included in this analysis. Figure 8 shows a peak in fish caught between depths of 1.5-2.0m and 3.0-4.5m, which chi squared showed to be significant (c2 = 26.6 df =8, p = <0.001). Proportion of species caught at each depth can be seen in each bar.

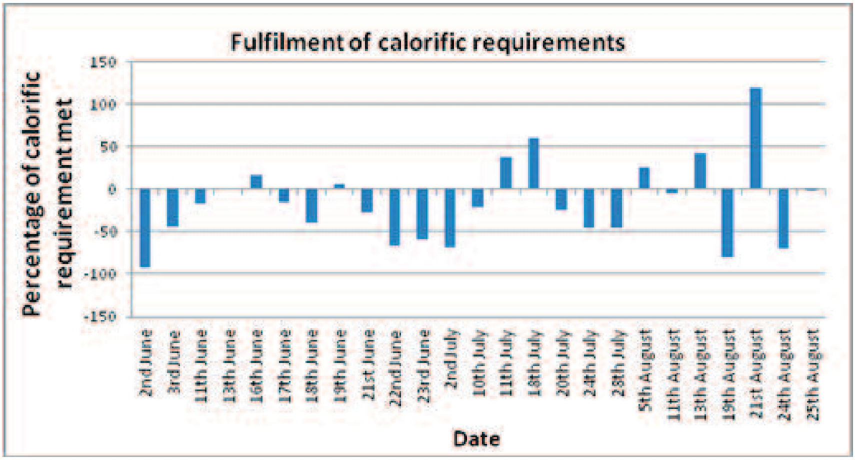

Figure 3. Fulfilment of calorific requirements shown as percentages where zero represents fulfilment of requirements, on 23 dates between June and August 2012.

It can be seen that very few Flounder are caught at low tidal depths. Table 2 shows the depths at which Grey Mullet, Sea Trout and Flounder were caught at, as investigated using chi squared analysis.

Table 2. Tidal depths at which Grey Mullet, Sea Trout and Flounder were preferentially caught.

Species	Df	X^2	P-value	Preferred depth (m)
Grey Mullet	8	27.3	<0.001	1.5-2.0
Sea Trout	8	13.6	<0.05	1.5-2.0 3.0-3.5 4.0-4.5
Flounder	8	9.4	<0.50	2.0-2.5 2.5-3.0 4.0-4.5

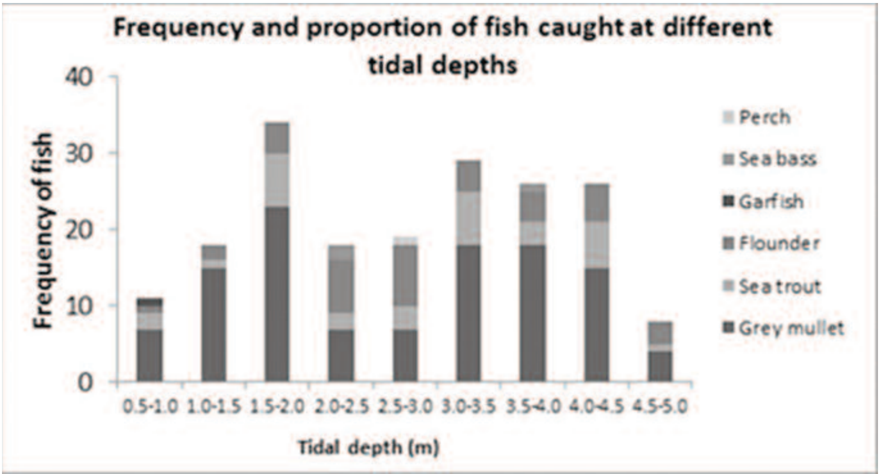

Figure 4. Frequency of fish caught at tidal depths 0.5-5.0m, with proportion of each species represented.

CAP analysis of biomass and environmental factors
Figure 5 shows CAP analysis for species and environmental factors. The plot indicates a relationship between southerly winds and Flounder, north westerly winds and Brown Trout, Rainbow Trout and Grey Mullet as well as air pressure and Sea Trout. The strength of the relationship is indicated by the length of the lines and as Figure 9 shows none of the relationships are particularly strong.

DistLM analysis of all species and environmental factors
Table 3 shows the results from the DistLM marginal test. It illustrates how much each variable explains alone, ignoring all the other variables. Significant environmental factors include cloud cover which explained 2.4% of the variability in species choice (p= 0.0031), temperature which explained 1.8% of species choice (p = 0.012) and rainfall which explained 1.5% of species choice (p =0.0277). Therefore although a significant relationship between some environmental variables and prey choice was found, the environmental variables actually accounted for very little of the variability.

Results from the DistLM sequential test, in which all variables appearing above a particular variable are fitted as covariates, and each test examines whether adding that particular variable contributes significantly to the explained variation (Anderson et al. 2008), are shown in table 4. Wind direction is shown to contribute the most to the variation (6.6%) but this is not significant (p=0.2187). Cloud cover adds 2% to the explained variation in species choice (p = 0.0074), with the other environmental variables not contributing significantly. The environmental factors investigated contributed 12.7% towards explaining species choice in the Osprey diet, but this is not statistically significant (p = 0.744).

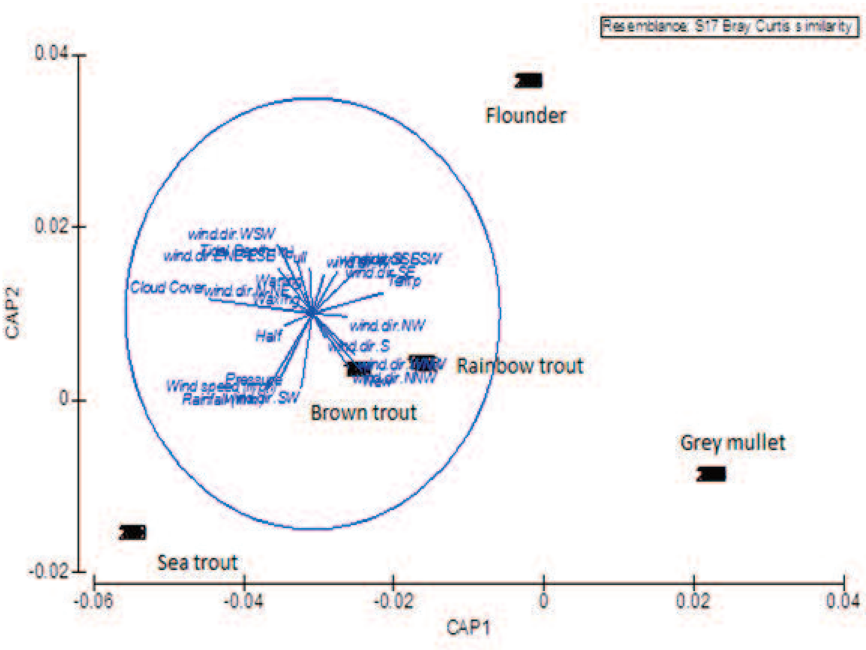

Figure 5. CAP plot relating environmental factors to species of fish. Length of lines represents strength of relationship

Table 3. Results from DistLM marginal test showing the effect of environmental factors on species caught. Analyses were based on the forward selection criteria and significance determined using r2 tests on Bray-Curtis similarity data and 9999 permutations.Significant relationships ($p = <0.05$) are highlighted in bold

Marginal Tests				
Group	**SS(trace)**	**Pseudo-F**	**P-value**	**Proportion contribution**
Pressure	2942.9	0.88878	0.4346	4.1946E-3
Cloud cover	**16917**	**5.2135**	**0.0031**	**2.4113E-2**
Wind speed	3652.4	1.1042	0.3317	5.2059E-3
Wind direction	46414	1.1807	0.2132	6.6154E-2
Temperature	**12662**	**3.878**	**0.012**	**1.8047E-2**
Rainfall	**10245**	**3.1268**	**0.0277**	**1.4603E-2**
Moon phase	16361	1.2416	0.2333	2.332E-2
Tidal depth	2339.8	0.70602	0.5421	3.3349E-3

Table 4. Results from DistLM sequential test showing the effect of environmental factors on species caught. Analyses were based on the forward selection criteria and significance determined using r2 tests on Bray-Curtis similarity data and 9999 permutations. Includes the cumulative effect of each factor. Significant relationships (p= <0.05) are highlighted in bold.

Sequential Test						
Group	**R2**	**SS (trace)**	**Pseudo-F**	**P- value**	**Proportion contribution**	**Cumulative**
+Wind direction	6.6154E-2	46414	1.1807	0.2187	6.6154E-2	6.6154E-2
+Cloud cover	**8.5758E-2**	**13754**	**4.267**	**0.0074**	**1.9603E-2**	**8.5758E-2**
+Moon phase	0.10311	12174	0.94313	0.4971	1.7352E-2	0.10311
+Rainfall	0.11136	5787.5	1.8009	0.1356	8.249E-3	0.1136
+Temperature	0.11852	5026	1.5685	0.1809	7.1636E-3	0.11852
+Wind speed	0.1219	2371.1	0.73895	0.5281	3.3795E-3	0.1219
+Pressure	0.12513	2265.3	0.7049	0.5405	3.2288E-3	0.12513
+Tidal depth	0.1272	1453	0.45085	0.744	2.071E-3	0.1272

Discussion

Through multivariate analysis it has been possible to establish if, and which environmental factors had an influence on Osprey chick diet. Pressure and tidal depth both had a significant effect on the biomass of the fish caught. However, when tested cumulatively the effect of the environmental factors on biomass was found to be not significant. The male Osprey had a significant preference for Grey Mullet and for foraging at specific tidal depths. Average weight of fish caught was very similar among species varying by only 7.8g. Although consistent with the weight of fish being caught over the season the male Osprey only met or exceeded daily calorific requirements recommended by Lind (1976) cited in Vandaele & Vandaele 1982) on 30% of the days analysed.

Effect of environmental factors
CAP analysis showed there to be a relationship between both Brown Trout and Rainbow Trout being caught with north westerly winds. As well as this a relationship was shown between north westerly winds and the biomass of brown trout. In most cases birds fly perpendicular to wind direction (Van Eerden & Voslamber 1995; Spear & Ainley 1997), which in the case of a NW wind direction would result in the bird flying in a NE or SW direction. This NW wind direction could have resulted in the male osprey foraging on inland rivers which contained freshwater species such as brown trout and rainbow trout. Similarly there is a correlation between Flounder being caught and southerly winds. Perpendicular to this wind direction would be both westerly and easterly winds, making it more likely for the male Osprey to forage on the estuary where Flounder are commonly found. However this reasoning does not explain the association between NW winds and Grey Mullet.

DistLM marginal analysis showed cloud cover, temperature and rainfall to all have a significant effect on the species caught, albeit each explaining less than 3% to the total variability. However, much of the literature on weather dependent foraging in ospreys focuses on the positive and negative effects of certain conditions on foraging success, rather than how they affect diet composition (Machmer & Ydenberg 1990; Bovino & Burtt 1979; Grubb 1977b; Sergio 2003; Stinson 1980). More investigation and further analysis would be required to ascertain why certain species are associated with particular weather conditions. Overall analysis showed the collective effect of the environmental conditions investigated to have no significant effect on the species of fish caught. This suggests that there may be an alternative explanation for the variation in diet composition.

Alternative explanations

It was noted on numerous occasions that upon the male bringing Flounder to the nest, the female bird would reject the fish and become aggressive towards the male (Emyr Evans, pers.obs.). It is a possibility that the female bird had an aversion to Flounder, due to diet preferences transferred to her through social learning. It has been shown in a number of species of birds, though not raptors as of yet, that food preferences can be gained from conspecifics. Red winged Blackbirds Agelaius phoeniceus have been shown to develop food preferences and aversions just through observing conspecifics (Mason et al. 1984).This lends one possible explanation as to why Grey Mullet is significantly preferred, and could be a major factor influencing diet composition.

Another factor known to influence diet composition of raptors is the abundance of prey species. In Ospreys in Florida, Bass were captured in proportion to their abundance, and the birds exhibited a preference for sunfish Lepomis spp. and shad Dorosoma spp. when they were highest in numbers – concurrently when abundance in one species declined, the Ospreys switched to the other most abundant species (Edwards Jr 1988). It may be that the abundance of species on the Dyfi Estuary had a more significant effect on the diet composition of the Osprey chicks than did environmental conditions. To ascertain whether Grey Mullet was the most abundant species further investigation would need to be carried out.

Tidal Preference

The male Osprey had a preference for foraging on estuarine fish during tidal depths of 1.5-2m and 3-4.5m. These results are similar to those found in Ospreys in Nova Scotia whose highest foraging success rate was at mid tide, due to their prey- the Winter Flounder being a bottom feeder that is too difficult to see at high tide and is absent at low tide (Flemming & Smith 1990). Consistent with this, very few Flounder were caught at low tide by the male in this investigation, with the highest proportion being caught between depths of 2-3m. The variety of species caught on the estuary is consistent with Osprey diet of a breeding pair in Scotland, who fed their young mainly on different species of marine fish. This variety of species including Grey Mullet, Garfish and Flatfish enabled them to feed on the estuary throughout the entire day due to different fish being taken at different times in the tidal cycle (Marquiss et al. 2007).

Biomass and Calorific Requirements

The average weights for each species of fish fit within a very narrow range of 179.1g-186.9g with the overall average weight of fish brought to the nest being 183.6g. Although different methods were used to determine fish biomass the results correspond with data in other papers investigating weights of fish caught by Ospreys which state a range of between 150-350g (Häkkinen 1978; Vandaele & Vandaele 1982).

The weights calculated here were from only fish brought to the nest, rather than all fish caught in total as it was the diet of the chick which was the focus of the study. A recommended daily calorie requirement of 413kcal was calculated for the female and single chick from the literature (Lind 1976 cited in Vandaele & Vandaele 1982), and in this case it was found that this requirement was met on only 30% of the days analysed. Weather in the summer of 2012 was extremely poor, raining for several days on end on some occasions. This lends one explanation as to why the calorific requirement was not met so frequently, and for the loss of two of the three chicks. As noted by Poole (1982) the generally observed effect of extreme under feeding in ospreys has been an increased mortality of chicks

Conclusions

Overall the results of this study indicate that together, environmental factors investigated have no significant effect on Osprey chick diet, although some factors acting alone do have a very small significant effect. These findings were surprising considering the vast amount of literature providing evidence for environmental effects on foraging success. It may be the case that whilst environmental conditions do play a very large role in foraging success, other factors are more important in determining diet composition.

Further work
Investigation into calorie intake of the female and nestling were based on previous studies that stated 1g of fish equated to 1kcal. It would be interesting to investigate the exact calorific content of each fish species that were consumed. This could be done by obtaining samples of each species from the estuary and calculating the species specific kcal per gram. This can be done in a number of ways including component analysis, wet oxidation, and the most practical; the bomb calorimeter (Paine 1971). Another line of investigation would be to examine the abundance of prey in the estuary and surrounding lakes and rivers and compare this to the abundance of prey caught. This would make it possible to determine whether they show some level of electivity in their diet.

Acknowledgements

I would like to thank Dr. Pippa Moore for all her invaluable help during this project. I would also like to thank Emyr Evans and Vicky King for always being on hand to answer any of my questions, as well as all the staff and volunteers at the Dyfi Osprey Project for their contribution to the data collection. This task would not have been possible without the Dyfi Osprey Project, and so I would also like to thank the Montgomeryshire Wildlife Trust for running such an amazing project.

On a more personal note I would like to thank my parents, Paul and Lisa Melia for their constant support throughout my time at university and especially during this project. Finally, I would like to thank Joe Matthews, Hannah Jones and Luanne Bellis. Without them, their entertainment, and support I would not have made it through the stressful, yet enjoyable time spent working on this report.

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Whinchat. Photo: Dave Brassey

Repeat use of nest scrape by Golden Plover *Pluvialis apricaria* at the southern extreme of their range in Wales

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On 12th May 2012 whilst checking a Dotterel *Charadrius morinellus* passage site at Mynydd Du, Carmarthenshire, I flushed a hen Golden Plover *Pluvialis apricaria* from a nest containing three eggs. On previous visits to this hill I had seen the occasional cock Golden Plover performing its aerial stiff-winged song-flighting display and also found an empty scrape, but there was no evidence of successful breeding. Signs of both Badger *Meles meles* and Red Fox *Vulpes vulpes* occupation were found, so any possible breeding attempt in the recent past may well have resulted in predation of the clutch. Avian predators such as Raven *Corvus corax* and Peregrine *Falco peregrinus* also patrol the area with active eyries of both species nearby.

The nest was rechecked on 28th May and contained four eggs, the full clutch. A final visit on 21st July confirmed that the eggs had hatched successfully with the remains of egg membranes still in the scrape. The rather worn plumaged adult pair and two juveniles of the year were found nearby.

Golden Plover eggs. Photo: Colin Richards

I returned to this hill the following spring and checked the same nest scrape on 15th April 2013. Although no plovers were present on this occasion, the nest site had been visited recently and the scrape raked out. Another visit the following week confirmed that the plovers were still in the area, and, although again not seen, birds had been working on the nest with tiny pieces of tubular thallus from *Cladonia* spp. lichen added. Two metres away was another recently made scrape. On 11th May the nest contained three eggs, the same hen using the same scrape as the previous year, identified by her distinctively marked eggs. A further visit on the 23rd and the nest was empty, possibly predated by Ravens as birds had been seen roaming the hill on both April visits.

Golden Plover eggs. Photo: Colin Richards

Out of 84 Golden Plover nests I have examined since 2002, this is the only pair that has used the same scrape in two consecutive seasons. Two Northumbrian hens used the same territory in three consecutive years on two different moors. The nest scrapes were approximately 15, 35 and 100 metres apart, both birds once again identified by their distinctive egg types. In Sutherland and the Spey Valley, Golden Plovers have occasionally laid in the same scrape in two or more consecutive years (Nethersole-Thompson, 1986). Similarly, on Blanchland Moor in Northumberland, a bird used the same scrape in successive years, while on the same moor a plover made a new scrape immediately alongside and almost touching that of the previous year (Trobe, 2008). There are indications that individual pairs returning in successive years tend to nest closer to the site of the previous year – sometimes actually in the identical scrape – than do new birds. On Alston Moor in the north Pennines, R. Stokoe found that a hen used a scrape for six consecutive years but this is exceptional (Ratcliffe, 1976). Female Golden Plover are probably more likely to reuse a successful nest scrape than a failed one. Also, re-use of the scrape by an isolated pair as in the birds on Mynydd Du would indicate a return of both male and female – the male must establish a territory in the same place and make scrapes for the female to select. The egg type identifies the same female.

In Wales, Golden Plover breed mainly on upland bog habitats with their range being largely restricted to a number of upland sites. The small Welsh population now represents the southerly extremity of the birds' breeding range in Britain, the species having ceased breeding on Dartmoor in southern England in 2010 with no breeding birds in the intervening years (Jon Avon per comm.), thus the small population in southwest England appears all but extinct, with no confirmed breeding during 2008-11 (Bird Atlas 2007-2011). Lovegrove et al, 1994 stated that 213-224 breeding pairs were found by RSPB field surveys between 1975 and 1978. This figure had dropped dramatically to no more than 100 pairs by 1990 and by 2000 the total Welsh population was thought to number no more than 80 pairs (Green, 2002). The latest figures suggest a further decline by 2007 when a joint funded RSPB/CCW survey located only 36 breeding pairs (Johnstone, Dyda & Lindley, 2007).

In Carmarthenshire the Golden Plover has never been a common or regular breeder. A few pairs were thought to breed on the high moorland west of the upper Towy valley in the 1920s and 1940s. Another record from the 1940s suggested that a few used to breed at the eastern side of the county (Ingram & Morrey-Salmon, 1954), this probably refers to the Mynydd Du (Black Mountain) area.

Flocks of passage Golden Plover in early spring are a regular sight on Mynydd Du. Rumours of occasional nesting pairs persisted for some years and a number of RSPB surveys found two pairs in 1978 (Davies, 1978) and one pair in 1992 (Harris, 1992). However, a further survey in 1996 concluded that the species was extinct as a breeding bird (Harris & Young, 1996).

I believe the Mynydd Du birds may well represent one of, if not the most southerly breeding pairs of Golden Plover in the United Kingdom, indeed Europe.

Habitat management that specifically meets the needs of breeding Golden Plover should be introduced on Mynydd Du and other similar commons across South Wales.

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Golden Plover. Photo: Colin Richards

Fishing technique of Goosander

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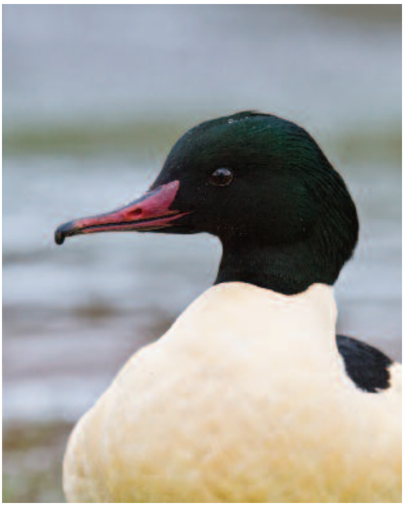
On 30th July 2014 I visited Llyn Padarn near Llanberis. When I arrived at the south end of the lake, near the outflow of Afon Rhythallt, a group of children were swimming and splashing around in shallow water. It did not seem likely that there would be many birds around here, as the children were making a good deal of noise, but there were two Goosanders *Mergus merganser*, a female and a well-grown juvenile, swimming very close to some of the children.

Initially, I thought they might be hoping for a handout of bread, as several Goosanders at this lake have learnt to come to bread over the last few years. However, these two birds were busy fishing, and were coming very close to the children in the process. The female regularly came to within about two metres of them, and the juvenile once came to within less than a metre of one child. When their dives after fish took them away from the children, they immediately swam back to them. Watching them for a while, it became evident that the children were flushing small fish from the water weed growing on the bed of the lake here, and the Goosanders were taking advantage of this to catch them. As soon as the children departed, the Goosanders also left the area. It seemed an interesting example of the birds taking advantage of human disturbance, perhaps only possible at a site like Llyn Padarn where the birds have become used to humans.



Goosander. Photo: Ashley Cohen

The use of Thermal Imaging in monitoring Lesser Black-backed Gulls on Skomer, 2014

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Aim To access the effectiveness of thermal imaging in the monitoring of Lesser Black-backed Gulls Larus fuscus using Skomer Island's gull colonies as a pilot study.

Introduction

Lesser Black-backed Gulls *Larus fuscus* are recognised as an "Amber" species on the list of Birds of Conservation Concern (Eaton et al., 2009). Their population historically has increased from 1986 to 1993, stabilised, and then decreased between 2000 and 2003; thereafter remained relatively stable but appears to be declining again (JNCC 2013). See Figure 1. On Skomer this population change has mirrored the national decline coupled with low breeding success for the last 15 years – ranging from 0 – 0.6 per pair (Taylor 2012). The variation in monitoring methods has been a cause for concern. Thus having a robust and reliable monitoring method has never been of such importance.

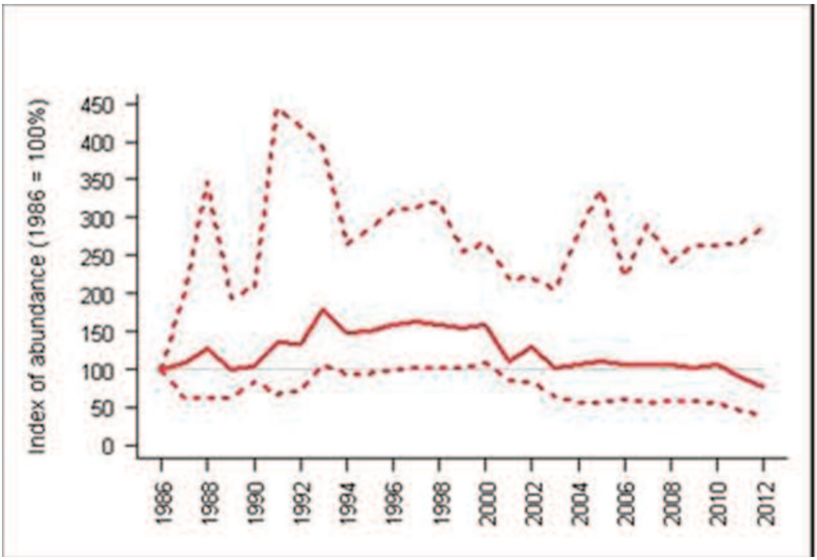


Figure 1. Trend in UK abundance index (solid line) of Lesser Black-backed Gull 1986-2012 with 95% confidence limits (dotted lines). Based on SMP data. JNCC http://jncc.defra.gov.uk/page-2886

Current monitoring methods
Currently the methods of monitoring Lesser Black-backed Gulls vary widely. The Seabird Monitoring Handbook has five recommended options – including vantage point counts, sample quadrat counts, transect counts, flush counts and photography/aerial counts (Walsh 1995). Any method that involves disturbing the birds leads to predation of eggs and chicks (Perrins, Wood, Taylor and Bueche pers. comms.) and disturbance to other birds (e.g. Manx Shearwater, pers. obs.). Observation during the day can lead to mis-identification of apparently occupied nests by even trained and experienced observers (Walsh 1995) leading to further inaccuracies if correction factors by ground truthing are later applied.

One theory that has been suggested is that gulls sit tightly on their nests at night whilst the non-breeders obviously do not (C. Perrins pers comm.) If this is true then monitoring gulls at night has the potential to be a reliable method of assessing Apparently Occupied Nests.

Observations of animals at night have been carried out using a variety of technologies. "Image intensifiers" produce a variable image quality depending on amount of light available. Active infra-red cameras rely on infrared light being emitted and reflected from objects (which has a limited range). These traditional devices are limited in their scale, temporal and spatial resolution. Thermal imaging can produce a much more standardised picture at much higher resolution and at greater range (Hristov et al. 2008).

Thermal imaging has been used fairly widely in studies of thermal physiology and metabolism of captive and wild birds (e.g. McCafferty 2011). One study has used thermal imaging cameras in the detection of collisions at wind farms (Desholm 2006). Thermal imaging has also proved useful in monitoring the flight activity of bats (Hristov et al. 2008). A wide variety of mammal groups have also been monitored via thermal imaging with mixed success (Ciluko 2013). The technology has the potential for further behavioural and ecological studies on wild populations, including population studies (Heath 2013).

Objectives and Methods

1) *Assess the effectiveness of thermal imaging cameras to monitor Lesser Black-backed Gulls.*

Eight study plots were established across the island. Five counts per site were carried out by day by eye, thermal camera and normal vision and at night again by thermal imaging camera. Any camera captured counts were counted once returned from the study site. Counts were carried out between 26 and 29 May.

Both counts and behavioural observations were attempted.

2) *Explore the use of thermal imaging in assessing temperature of nests to distinguish between breeders and non-breeders.*
Carry out prolonged observations of birds to confirm breeding and use the thermal

imaging camera to measure nest temperature.

Results

1) *Assess the effectiveness of thermal imaging cameras to monitor Lesser Black-backed Gulls.*

1.2 *Counts*

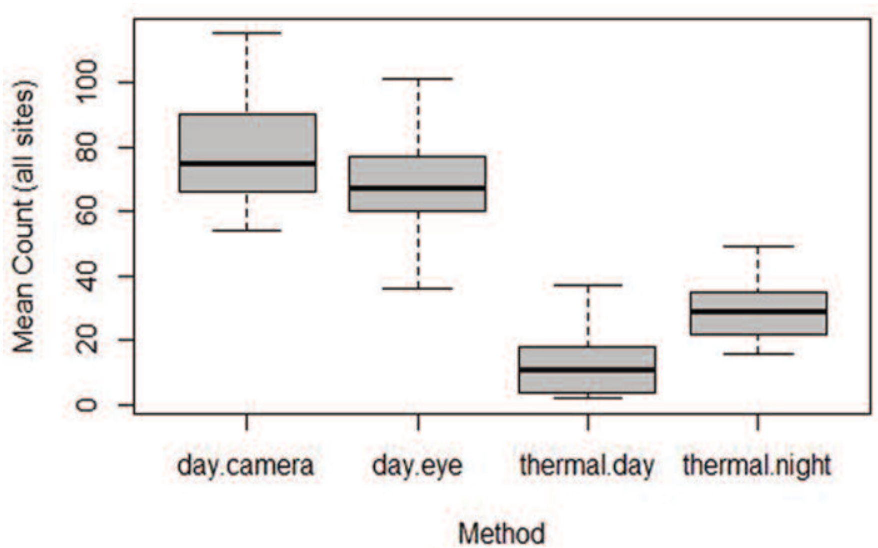


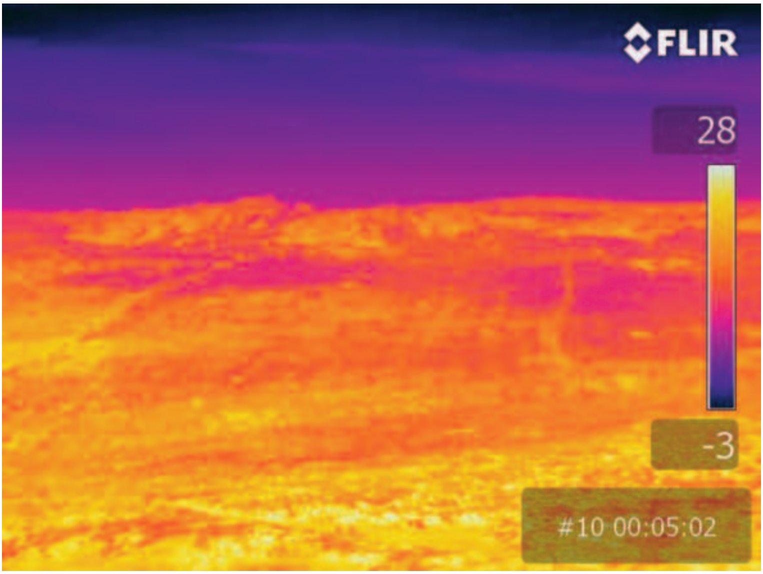
Figure 2. Mean counts from all areas (black line) the minimum and maximum counts (dashed lines).

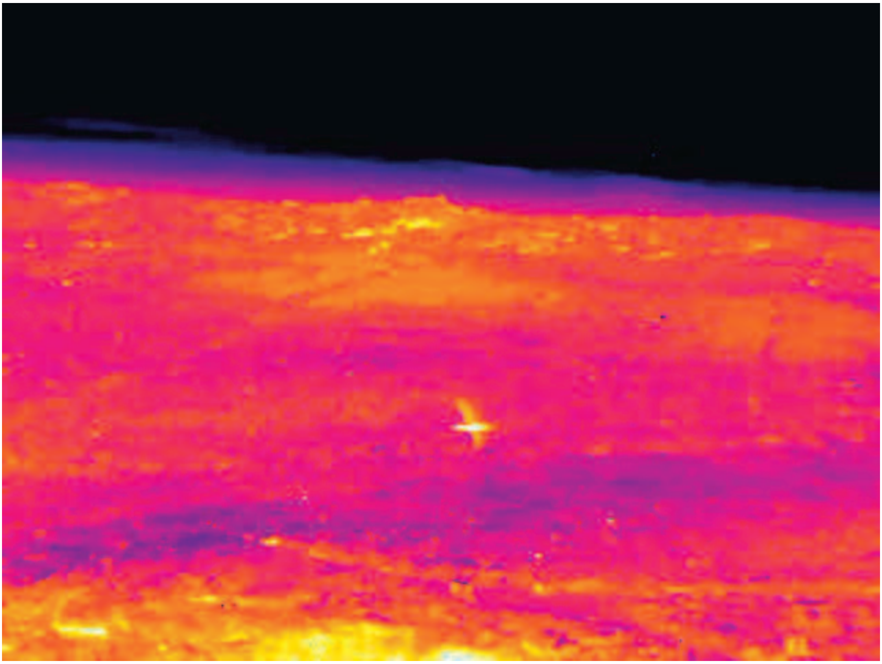
A one-way between groups ANOVA was conducted to compare the means of four counting methods. There was a significant effect of the number of birds recoded in the different methods ($F_{3,160}$=78.87, P=<0.01). Post hoc comparisons using Tukey HSD test (P=<0.05) indicated that there was no significant different between counts during the day by camera (mean=80.6, s.d.=19.01) or by eye (mean=76.7, s.d.=34.2). Differences of counting by thermal camera both at night (mean=34.3, s.d.=18.9) and day (mean=15.9, s.d.=14.7) were significantly lower than counts carried out using normal vision.

1.2 and 2 *Behavioural observations and nest temperature recordings*
Resolution was too low for detailed observation of gull behaviour. Observations using the thermal imaging camera at night as a result were very difficult to obtain as there was a lot of "noise" which you could not obviously screen out. The majority of the noise was Manx Shearwaters, but also included rabbits and humans. There was also no way of

distinguishing between breeding gulls and roosting non-breeding gulls.

Wick Valley by day normal vision (above) by day thermal vision (below) and night (next page). The middle image shows no gulls while the third image has many points but identification is impossible.





Discussion and future work

The results suggest that the current resolution of field thermal imaging cameras is too low and will not improve counting methods.

Table 1. Summary of the different methods carried out in the study.

Method	Positives	Negatives
Day – Eye	Fast counting done in the field with minimal homework needed	No annual visual record of colony
Day – Camera	Marginally improved counts	Time consuming counting when finished fieldwork
Day – Thermal		Temperature difference impossible to distinguish most gulls
Night Thermal		Resolution too low to enable definite identification.

If further development of the technologies continues and practical and affordable field thermal imaging cameras are developed there could be a future for night-time counting.

This would be further improved by increased elevation through the use of a field kite or drone. The count by camera showed a slight improvement on eye observation and the next stage for this project is to test a camera mounted on a lifting kite or the deployment of a drone, but this may have a too large effect on gull behaviour.

Equipment used
FLIR T620: Effective range for gull monitoring c.50m. Battery life 4 hours.

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